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Connecting the Goals

Arif Hasan
Christian Benimana
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Design for Health

Proceedings of the UIA World Congress of Architects Copenhagen 2023

Springer

Sustainable Development Goals Series

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Preface

Introduction

In the autumn of 2022, as part of the preparations for the UIA World Congress of Architects 2023 Copenhagen we invited Panel Chair and MASS Design Group architect Christian Benimana to Copenhagen to speak to our collegiate and students. In his introduction, he outlined the dramatic land use change in Rwanda following the country's population growth over the last 50 years. Pointing to the maps, he argued that we have passed a tipping point and that our given societal infrastructures cannot simply be extended or optimized to support this new situation. We cannot build 500 universities or 600 hospitals, he said, instead we need systemic change to rethink what a university is, what a hospital can be. We need to question how our institutions, infrastructures, and communities can change in the way they address those in need and what access can be, and therefore, also how architecture, its practices, embedded knowledge, and products can be methods of instigating change.

The present proceedings presents six volumes examining the knowledge foundation for such change. As proceedings for the Science Track of the UIA World Congress of Architects 2023 Copenhagen Sustainable Futures—Leave No One Behind, they contain a total of 296 papers investigating, showcasing and arguing for how change can be imagined across the built environment. By asking how architecture can help in achieving the UN Sustainable Development Goals (SDGs), the presented papers collect the research- and practice-based results of a global community. Together they ask what the future of the built environment can be and how design as action and as knowledge can create new roles for architecture and the communities it serves.

This preface starts with the articulation of our profound gratitude to the Scientific Committee and the community of submitting authors and peer reviewers that have been part of this effort. During the last two and half years, we have worked together with the Scientific Committee's Panel Chairs and Special Advisors to form a vision for the Science Track. The process has been an education. Not only in our understanding of the SDGs, the transformative power of design creation or the wider societal role of the built environment, but also in keeping our minds open to the many positions that architecture can be thought through and its critical role in engaging—

interfacing, informing, and developing—different knowledge cultures and perspectives. We therefore start by thanking the 17 members of the Scientific Committee, the contributing 656 authors of the 296 accepted papers, the 1486 authors of the more than 750 paper submissions, and the 536 peer reviewers that have all made this project possible.

Platform

The UIA World Congress 2023 Copenhagen starts with an ambition. Pitched in 2017, only one year after the launch of the UN Sustainable Development Goals, the central nerve is the articulation of the profound agency of architecture and how it plays an acute role in achieving the SDGs. In the congress, the Science Track is given a particular role. Initiated early in the planning process, the aim has been to place the Science Track at the heart of the congress in order to collect its underpinning knowledge foundation and shape its criticality through a broad outreach to a global community. Sustainability, like architecture, is a wicked problem. Its solutions are dependent on the way we ask, the methods we use, and the contexts in which we work. To ask how architecture can be part of the dynamic fulfilment of the UN SDGs is to ask: who are the communities we design with and for, what is the knowledge we draw upon, and how can its sharing change how we think about what our built environment can be.

One of the central drivers in our preparatory work for the Science Track has been the realizations of the blindness of the UN SDGs to the agency of architecture. The SDGs seek to steer behaviour both through impacting legislation and wider societal value sets. They establish priorities and galvanize efforts across communities by identifying targets and providing shared yardsticks in the form of indicators. In doing so, they inscribe a world view of its defining actors; the governmental bodies, industries, and communities that can be leveraged upon to instigate change. And in this world view, architecture is strangely absent. At present, none of the UN SDGs declare targets that directly articulate architecture as a driver for change nor are there any indicators that evaluate its role. The built environment is only mentioned as a driver for resilient communities but without real value setting of the role of planning and design. This despite the extensive and complex impact architecture holds on human and non-human well-being; the way we live our lives, shape equity, and use our resources.

For us, this realization has led to the overarching aim of using the congress to build awareness. To argue for and demonstrate how architecture has the ability to afford change in the way we understand and construct the world around us and therefore how it as a situated practice engaging directly with both legislation, industry and the communities in which architecture *takes place* can become a direct way of effecting change.

Vision

The Science Track is formed around six panels of which this volume is one. The vision of the six panels is to articulate six differentiated perspectives onto how architecture can be part of achieving the SDGs while reinforcing their interconnectedness. The panels are in part mapped to existing fields while at the same time suggesting new. By bringing together otherwise fragmented knowledge across the breadth of architecture's research and practices, the aim is to bring together knowledge across research, practice, and education to provoke new perspectives, new alliances, and concrete action. In articulating the panels, the Scientific Committee asks pertinent and provocative questions that challenge the field and position the SDGs as active goal posts. These questions form the chapters of each volume asking how architectural knowledge creation can innovate the thinking, design, and making of architecture.

– ***Design for Climate Adaptation***
  With profound urgency, global communities are acting and adapting to the earth's changing climate. Our built environment, the most common habitat of humans, should interact with the earth's ecosystems and climates in a sustainable and regenerative way. 'Design for Climate Adaptation' emphasizes people, multiple forms of research, knowledges, and action for high and low-tech solutions that make buildings, neighbourhoods, landscapes, cities, and regions regenerative, resilient and adaptive to climate change impacts.
– ***Design for Rethinking Resources***
  Design shapes our world, from the places we live in to objects we use every day. As we grow more aware of the limits of our planet's resources, shifting from an exploitative to a restorative, regenerative, and circular design ideology becomes fundamental. 'Design for Rethinking Resources' examines approaches to resourcefulness in architecture; how sustainability challenges the foundations of our material practices, and how they can change with it.
– ***Design for Resilient Communities***
  A resilient community anticipates, adapts to, and recovers from adversity. Climate change, the global pandemic, and political upheavals in many countries have revealed social, economic, and environmental inequalities that threaten communities worldwide. These fault lines disproportionately impact the poor, people of colour, the racially or ethnically marginalized, and women. 'Design for Resilient Communities' encourages innovative solutions and facilitates the development of knowledge and skills necessary for adaptation and recovery.
– ***Design for Health***
  Architecture and health are inseparable. From the direct design of hospitals and places for healing to the strategic design of infrastructures and city planning, architecture affects physical and mental health of individuals and communities. 'Design for Health' asks how architecture can reconceive health as a design issue. How land rights impact healthy

living, how legislation, planning and building impact inequality and access to water, and how single buildings and the civic construction of hospitals, health clinics, and community buildings can operate in unison with local environments and ecologies to create a safe and healthy space for all.

- ***Design for Inclusivity***
  No individual deserves to experience space in a manner that is less safe, less comfortable, or less accessible as a result of their identity or challenges. Sustainability, in its most holistic definition, cannot be achieved without a collective act. 'Design for Inclusivity' aims to critically define the constructs and categories of who exactly we are excluding, and why, in order to mindfully develop strategies to mitigate this exclusion.
- ***Design for Partnerships for Change***
  'Design for Partnerships' is about recognizing the asymmetrical relationships between states, public spaces, civil societies, and private domains to find new balances for the existing power structures. By challenging the ontology of universalism, it examines how architecture and the built environment can play an essential role in creating a ground for care through local governance, space making practices, imaginaries, and scenarios of plural(istic) political, socially and ecologically sustainable futures.

Critical Positions

The two and half years of preparation has been an inspiring experience through which we have witnessed the power of architectural thinking in action—its interweaving of the critical and the creative ideation as well as its inherent inventiveness orientation towards the future. As part of the curation of this work, we have defined a series of critical positions by which to understand the correlation between architectural thinking and the UN SDGs. A first position has been to challenge the inherent anthropocentrism and perceived lack of hierarchy between the goals; the Tabula Rasa effect as Johan Rockström names it (Rockström 2016). The SDGs have been criticized for failing to recognize that planetary, people, and prosperity concerns are interconnected (Kotzé 2022). In forming the six panels of the Science Track, we seek to position a rupture to the modernist axiom that the environment is situated outside of us. Instead, we understand the SDGs as a balancing between planetary and human needs which needs to be holistically addressed.

A second position is the critical appreciation that the SDGs retain an adherence to an underlying model of growth. The Science Track asks what the future practices of architecture can be, what the ethical roles of architectural design are, and how architecture knowledge can create change in how architecture is produced both within and without of models of growth. It seeks to identify who the partners of architecture practice can be both through grassroot community action and through industry-based models.

A third position is the challenge of the embedded universalism within the SDGs. The SDGs maintain a universalism that is common to the UN system and underlies much of UN's work. However, this fundamentally modernist position of understanding sustainability as 'a problem to be solved' and placing agency with legislation leaves questions of agency, voice, and power unchallenged. The Science Track seeks to incorporate this criticism through the panel calls and their associated sub-questions by provoking reflection on the perceived neutrality of architecture's own humanist traditions and insist on the query of how architecture is produced, by people and for people.

The challenge to universalism has also led to a review of the scientific practice of knowledge dissemination. The call for papers deliberately encourages exchanges and learnings across different knowledge and practice silos. This is effected through differentiated publication formats that include scientific knowledge production as well as design-based knowledge production, narrative formats such as oral history, visual essays, as well as dialogue-based exchanges and argumentative essays. The aim of these formats is to expand the possibility of transdisciplinary knowledge exchange and include voices that are not commonly part of academic and professional discourse.

The fourth and final position is to understand the SDGs as part of a changing world. The SDGs set out a 14-year-long project. Any project of that length needs to build in methods of reviewing its own fundamental value sets and core conceptual foundation. The intensifying and accumulating effects of climate change, the aftermath of the COVID-19 pandemic, the continued stress on the world's resources, and the increasingly multi-partisan war in Ukraine have deep and unequal repercussions on global communities. To engage with the SDGs is to correlate the goals to a changeable understanding of both needs and means. It is to commit to a continual address of both the contexts and instruments of change-making. In the Science Track, our focus on the concrete and the actionable through presentations of cutting-edge research, real-world case studies and near future focussed arguments, argue for a situated understanding of the SDGs. This emphasis contextualizes the SDGs within the multiple and diverse practices of architecture as well as the disparate places in which architecture takes place. The perspectives, methods, and means are purposefully broad. They seek to represent the breadth of the solution space needed for the systemic change needed. They also purposefully include different voices and different styles to make present the different actors, different knowledge streams, and different institutions that create this change.

Perspective

The result is a six-volume proceedings tracking a wide and multifarious interpretation on how architecture can be part of achieving the SDGs. Across their individual chapters, we see a breadth of enquiries asking who the communities are, who the actors are, and what the means of architectural production are. They ask how we can shape the methods of architectural thinking as well as their associated technologies, how they can be distributed, and what is the consequence of their sharing.

The proceedings instantiates a moment in time. As research strands, they are part of larger trajectories of knowledge creation. Where our aim for the World Congress is to facilitate new discussions and exchange enabling synergy across silos and geographies, it is clear that the full potential of this conversation is only just beginning. The World Congress coincides with the half-way mark of the SDGs. Launched in 2016 and with a projected completion date of 2030, we need to transition from a place of planning and speculating to one of action. The work of the Science Track is therefore marked by a sense of urgency. The desire is to define the effort of this work not in terms of their individual results, but more as a launchpad for future exchange and collaboration. We hope that what is created here is a community of dedicated actors all with a shared stake in the well-being of future generations. Our hope is that the legacy of this project will be that we can retain this commitment and grow its stakeholders to mature these propositions into actionable change.

We profoundly thank the Scientific Committee for their immense effort and profound engagement in shaping the Science Track. Thank you to: Billie Faircloth, Maibritt Pedersen Zari, Carlo Ratti, Anna Rubbo, Juan Du, Arif Hasan, Christian Benimana, Magda Mostafa, Ruth Baumeister, Sandi Hilal, Merve Bedir, Katherine Richardson, Chris Luebkeman, Thomas Bo Jensen, and Camilla Ryhl.

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Mette Ramsgaard Thomsen, General Reporter
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Editorial

Design for Health

Architecture and health are inseparable and the UIA World Congress of Architects Copenhagen 2023 comes as an opportunity to discuss broadly the future of the profession of architecture and how it is impacting health. It is also a good time to question the knowledge and competencies acquired by architecture and design professionals, how they acquire them, and their relevance to the global issues affecting the world today and tomorrow.

In the aftermath of the COVID-19 pandemic, it became clear that we should start questioning the nature of the spaces we occupy as this pandemic has highlighted the vulnerabilities of the systems we rely on in our daily lives. From the design of healthcare facilities, places for healing, and the strategic design of infrastructures and the planning of the cities that we live in, architecture affects the physical and mental health of individuals and communities.

For a very long time, architecture has been blamed for the social failures that societies are experiencing like poor access to basic services and climatic change conditions. Although architecture has been concerned with the physical world, it is also a reflection of society; its culture, behaviours, and other notions about life.

In societies where there is inequity and major social differences, there is usually a very strong anti-poor bias in planning. As a result, few healthcare institutions are built in the poorest settlements, who then have to travel long distances to access health care. Also, insufficient funds are provided for the maintenance and management of these healthcare units, considerably lowering their efficiency and outreach.

The majority of the global population lives in poor, unserviced or semi-serviced settlements which, as a result, have poor quality and quantity of water, absence of sewage disposal and draining causing epidemics, and resulting in high child mortality and morbidity rates.

To cope with these challenges, many solutions are being proposed. However, a very important question related to land rights is not being answered. There is a huge gap between housing supply and demand, as a result of which poor populations are forced to squat on land which is not theirs and, hence, they have no tenure security. This absence of security restricts their upward mobility, and the constant fear of eviction creates a mentally disturbed society. In addition, low-income settlements in the Global South have no parks, open spaces, wide enough roads for vehicular movement, and high densities. Given these realities, the WHO Standard Operating Procedures (SOPs) for COVID-19 could not be followed in these settlements. In planning for the future, these aspects will have to be taken into consideration. Legislation making housing rights a fundamental right for all will have to be enacted and implemented.

The *Design for Health* panel seeks to question not only what fell short or what went wrong in the response to COVID-19, or how to build resilience in the current setting, but also serves as a time to dig deeper and question whether the foundations of the practice are not fundamentally flawed so much so that seeking efficiency of existing solutions is insufficient to achieve the desired outcomes. One of the most important things in determining the efficiency, the location of health facilities, their design parameters, and scale is the involvement of the communities in the neighbourhood. These issues cannot be left simply to planners and bureaucrats, but also in the management of these facilities, there should be community participation.

Formal developments of those on highways and major roads affect land values as a result of which the land of many informal settlements increases and the private commercial sector pressurizes the residents of these settlements to leave, thus creating increased homelessness, poverty, and disease.

As a result, the *Design for Health* panel asks how architecture can reconceive health as a design issue, how land rights impact healthy living, how legislation, planning, and building impact inequality and access to water, and finally how the single building and the civic construction of hospitals, health clinics, and community buildings can operate in unison with local environments and ecologies to create a safe and healthy space for all.

In the design of individual buildings, the pandemic has created new requirements. These are for additional space to cater to a larger number of patients, housing for paramedics during the pandemic, and training spaces for community workers. Similarly, community centres now have to be designed in a manner that they can be converted into COVID-19 wards.

Also, health buildings should be colourful instead of white and the furniture should be designed for the ease of patients and not simply for the ease of medical staff. Cross-ventilation and direct sunlight should be an essential part of the design, along with insulation against heat and cold so as to make the buildings livable.

For residential architecture (and for other architecture as well), factors influenced by climate change have to be taken into consideration—and through research and an agenda, materials and methods of construction that reduce the carbon footprint of buildings need to be evolved.

The most important part of change has to be in the training of professionals and technicians. So far, most training in the world is around curative methods. The preventive health sector, such as the public health engineering departments, needs to be developed, both in government agencies and in academia. It is also a point of concern that physical infrastructure budgets of international financial institutions and governments are much higher than those for research and extension of preventive medicine.

All the above concerns and recommendations can be applied to new planning and, with limited retrofitting, to existing cities. However, the existing city in most cases is far larger than the new areas that will crop up. A major challenge is, what can one do with the old city, where in most cases, only very limited resources are available? It calls for reblocking of certain areas to create parks and sports facilities, health and community buildings, and transport facilities. A new world of relevant building bye laws and zoning regulations will have to be created with community-friendly procedures.

This volume contains 34 chapters, spread out over five parts, which deal with the issues that have been summarized above. Each part contains a maximum of eight chapters that, broadly speaking, investigate the challenges posed to public health by architecture and propose strategies to aid healthy living through architectural practices. The purpose of this publication is to encourage practitioners of architecture—and those of other disciplines whose work intersects with architecture—to innovate new methods of doing things and produce new knowledge about the linkages between land, water, spatial and socioeconomic accessibility, planning, education, the economy, architecture, and health.

The submitted chapters range from a wide variety of disciplines and practices including architecture, social work, civil engineering, geography, ecological restoration, geosciences and spatial planning, and what is bringing them together is their commitment to understand how architecture and the built environment are intertwined with health and what is fundamentally wrong that needs change.

The five parts are named as follows:

Part I. Land, Water, Economy and Health
Part II. Health as Consequence of Design
Part III. COVID-19
Part IV. Planning for Healthy Environments
Part V. Healing through Design and Academic Research.

Part I: Land, Water, Economy and Health

Land is a health issue, and its availability, location, and quality directly affect the life of the population. As stated by the UN HABITAT (2008), access to land is a fundamental basis for human shelter, food production, and other economic activity. By 2050, 68% of the world population will be living in urban areas with 90% of this rise occurring in Asian and African cities (United Nations 2018). What does this mean? As cities are expanding, the population number is increasing, and access to land is becoming more expensive. This inaccessibility of land pushes the urban poor to build on unstable lands that are prone to climatic change catastrophes, or they choose to live in unplanned settlements that are faced with many problems. These populations are vulnerable because they do not have access to land tenure.

In addition to land, access to clean water has a considerable impact on the population. Poor access to water and poor sanitation are directly linked to the spread of diseases such as cholera, diarrhoea and other diseases. In many parts of the world, access to safe water still remains a challenge and climate change will continue to make it harder and harder if no measures are taken.

This part will look at the intersections of resources like land and water with health and their interaction with the economy as part of a complex ecosystem. It will discuss the one paper we have on land use and identify why land use is important and how it links with a range of other subjects related to health and architecture. The following four chapters will talk about issues related to water and health. This includes how inadequate water, sewage, and surface drainage are a major detriment to social well-being and the cause of the spread of disease. The absence of sewage and drainage also makes streets and public spaces unusable; children and women are most affected by this. The next chapter will add another intersection of the ecosystem into the equation by analysing a variable like age distribution and its impact on accessing land for a healthy living. Finally, the last chapter will consolidate the discussion by focussing on health, economy, and ecology.

Part II: Health as Consequence of Design

All over the world, mostly in low-income informal settlements in the Global South, there is rampant disease. The absence of open spaces and high densities make it difficult for people to access unpolluted air, exercise, and heat extremes in the absence of insulation. High densities overflow into the hospitals, dispensaries, and schools. Bad and expensive transport and long distances to health facilities make the curative side of health care almost non-accessible. This part will talk about the implications of poor planning on health outcomes and vice versa and will also include thermal design in the discussion.

Part III: COVID-19

In the aftermath of the COVID-19 pandemic, it became clear that we should start questioning spaces that we occupy and their impact on our health. The built environment has always been affected by infectious diseases long ago, and the design of cities has been dictated by the outbreak of pandemics (Frumkin 2021).

In the time of industrialization, the health of the population was affected by infectious diseases including cholera, plague, yellow fever, and tuberculosis, and this has led to the reform of urban planning policies (W. C. Perdue et al. 2011). From the design of sanitary sewerage systems, the improvement in building designs including factors of fresh air and natural light, housing zones, and the creation of green urban spaces, the built environment has been changing to suit the healthy living conditions of the population (W. C. Perdue et al. 2011).

For long, the population has relied on the established systems until the break of COVID-19, where everything became questionable. Cities were the easy target of COVID-19, and people living in poor urban settlements became the victims (Frumkin 2021). Unplanned urban settlements which are characterized by a high density with inadequate access to running water and sanitation with limited healthcare facilities, it became apparent that measures put in place to stop the spread of COVID-19 were impossible; the health of the population was at stake.

As a result of COVID-19, a number of new requirements for urban planning and housing have emerged. For one, the SOPs developed by WHO cannot be practised in low-income settlements which house over 50% of the world's population. This is because of high densities and the absence of open spaces. Poor students cannot study online because their families cannot afford to buy smartphones or computers and also because their areas do not have Wi-Fi arrangements. Surveys reveal that as a result, a large section of poor households has not been able to educate their children during COVID-19. Apart from density, there are issues of adding to the number of patients during a pandemic, and for this, extra space requirements become necessary. Space for the training of mid-level medical staff and the storage of special equipment such as ventilators and oxygen tanks also becomes crucial. This part will seek to address these issues through its five chapters along with bringing to light the problems that an unprecedented health crisis like COVID-19 has created for architects. It will also give examples of how resilient communities are in tackling issues related to COVID-19 in the clinics in their neighbourhoods and the role of industrial workers in regenerating old community ties which had been disrupted by the pandemic.

Part IV: Planning for Healthy Environments

Planning for healthy environments is a multidimensional exercise. It includes planning for city layouts with an environmentally friendly land use, effective public health engineering inputs, accommodating socioeconomic conditions of the lowest income groups, designing schools, and community spaces through which health can be promoted, locating health facilities in easily accessible locations, providing the possibility of using non-mechanized transport such as bicycles, and developing an environment which is pro-pedestrian, pro-street, pro-mixed land use, and pro-dissolved space. Thus, planning for healthy environments is, to a great extent, determined by appropriate building by laws and zoning regulations—which, in many countries of the Global South, belong to the colonial era and are inappropriate not only for the cities of the south but also for cities all over the world.

This part will look at the various strategies through which planning can be undertaken to nurture healthy environments, not just from a physical health perspective but also of mental and social health and well-being. The last chapter of this part will provide a smooth transition to the panel's final part.

Part V: Healing through Design and Academic Research

Architecture plays an important role in the process of healing—both in curative and preventive medicine. Combining academic research and design elements to heal communities through architecture is, thus, a subject of immense significance to this panel and the UIA World Congress of Architects CPH 2023 at large and will consolidate the problems and solutions identified in the parts before this.

While a lot of academic work has been done on the relationship between health, living conditions, and their socioeconomic implications, much of this work remains in the libraries of universities and research organizations and is seldom discussed in the public domain. It also does not feed into policy and has little or no influence on the culture of planning. There are those who believe that the fault also lies with the research agenda, which looks for ideal solutions rather than developing an understanding of the existing environment. Issues related to revenue generation, management, maintenance, and operation are generally not given sufficient importance and nor do the opinions of the community form the basis of much of the evaluations. To remedy this, it is important to look at how academic research can play a positive part in healing—which is what the first three chapters of this part will discuss.

The final four chapters will dive into designing for healing. The planning of a settlement or a city has health implications related to orientation, air pollution, transport-appropriateness, safety, energy, and the design of homes in a manner that they receive light and air and are insulated against the extremes of climate. Peaceful spaces, soothing colours and textures, patient-friendly furniture and fixtures, the visibility of green spaces, easy access to health facilities, and the coordination of the built environment with public health engineering are salient features of the process through which healing can be centred in architectural designs.

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Part I

Land, Water, Economy and Health

1 Urban Regeneration and Green Spaces System: São Paulo Metropolitan Area

Daniela Maria Eigenheer

Abstract

This paper aims to reflect about urban green spaces role as an important regeneration element to restore urban landscapes in a decline process. The urban landscape is understood here as an interactive system between natural processes and human impacts. The study object is an area located in Guarulhos city, belonging to São Paulo metropolitan area and surrounded by important infrastructures, as Guarulhos international airport and Dutra regional highway. The area also contains established precarious settlements on protected floodplains; unqualified green spaces and riverbanks in process of illegal settlements; and a lack of basic sanitation services and silted streams that contribute to the floods occurrence in a local and metropolitan dimension. The study attempts to mitigate the conflict between infrastructure, environment and social dimension, which are so precariously articulated in this urban landscape, through a system of strategically planned green spaces, in order to achieve urban and metropolitan sustainability goals. Based on theoretical support, cartography and empirical observations, it aims to understand the logic of this territorial occupation and also recognize, recover and integrate urban green areas in order to set an urban plan proposal. Finally, the paper tries to achieve population better quality of life, reduction a local and regional environmental impacts and political awareness to set public policies able to regenerate this territory in a process of urban and environmental decline.

Keywords

Urban and metropolitan regeneration · Landscape · Green spaces system

1.1 Introduction

In the twentieth century, the relation between man and nature resulted in socio-environmental impacts from the Industrial Revolution that encouraged technological advances and economic growth instead of sustainable development. This advanced process throughout the last century led us to a serious situation of urban and environmental decline, which requires new practices and approaches that allow urban regeneration of contemporary metropolis.

The issues discussed here, urban and metropolitan regeneration, green spaces, landscape degeneration, infrastructure and precarious

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housing, emerged from the Industrial Revolution context and were discussed by many authors a century ago. Although in another context, these conflicts are still current and have been affected mainly developing countries as Brazil. As consequence of congested cities with precarious public health condition the green spaces initially used for beautifully and health started to be inserted to recovery the quality of life and for structure the cities (Benevolo 2019). While the new urbanism was concerned with the chaos of the tenement town of the nineteenth century, the city has sprawled and became less concentrated. From the nineteenth to twentieth century the new transport technologies allowed a huge process of suburbanization mainly in London and New York, where the production forces were more aggressive (Hall 2009). A new urban dimension with conflicts between nature, infrastructure and housing emerged from a result of capitalist production system. Production, exchange and consumption relations define capitalist space. Technological advancements and transport infrastructures are strategically planned to support and expand these capitalist relations and structure this space (Reis 2006). In addition to urban reconfiguration and expansion, infrastructure produces new locations, real estate appreciation and environmental impacts. This process also produces an unequal land use and unsuitable living conditions. According to Reis (2006), every time there is an intervention in an urban area, must be understood that it is structured by an economic development related to a specific infrastructure, and the area is changed, overlapped and, therefore, is in a constant process of transformation. It could be urban progress or urban decline. The study area is on this context of urban decline and needs to be regenerated. It means to establish integrated actions in order to improve its social, physical and environmental aspects to ensure its sustainable recovery. One of these actions could be to requalify urban green spaces through an urban plan and participatory urban projects. Urban green spaces refer to all urban land covered by vegetation of any kind, gardens, squares, parks, forests, farmland, treeline streets, riverbanks and floodplains. It contains a variety of benefits including physical health benefits, psychological health benefits, socioeconomic benefits and environmental benefits.

The study area is located in Pimentas district, Guarulhos city, São Paulo metropolitan area, between Presidente Dutra and Ayrton Senna highways, adjacent to Guarulhos International Airport. It is also inserted in the Baquirivu-Guaçu watershed, an area of great urban precariousness, vulnerability and importance for Master Plan of Macro Drainage of Upper Tietê (PDMAT), which covers the entire metropolitan area of São Paulo. Guarulhos city has 1.4 million inhabitants and it is considered the most populous municipality in São Paulo metropolitan area, which has approximately 22 million inhabitants. São Paulo capital has 12.3 million inhabitants (Ibge 2022).

Although Guarulhos is characterized by a strong economy with an expressive industrial production, with the second largest GDP of the state (second only to the capital), it displays low social development standards. A large part of Guarulhos population lives in informal settlements whose presence is directly associated as unequal process of occupation. The implementation of transport infrastructures allowed new connections and a rapid suburbanization process in fragile and low-cost lands. The study area has approximately five million square meters and consists of many precarious settlements with high density and located in insecure tenure without a proper sanitation services and with higher risk of flood events. In the face of these urban landscape conflicts and considering the existence of natural and tropical green areas with potential to be qualify and integrate, this paper presents a green spaces plan, in order to try to mitigate these conflicts and regenerate this area. The urban regeneration idea here is to recovery urban landscape in a process of decline.

Through theoretical support, cartography and empirical observations, the paper is structured in introduction plus five issues. The first one describes some authors, ideas and projects that influenced the thinking about urban green areas, in Brazil and in the world. The second focus on

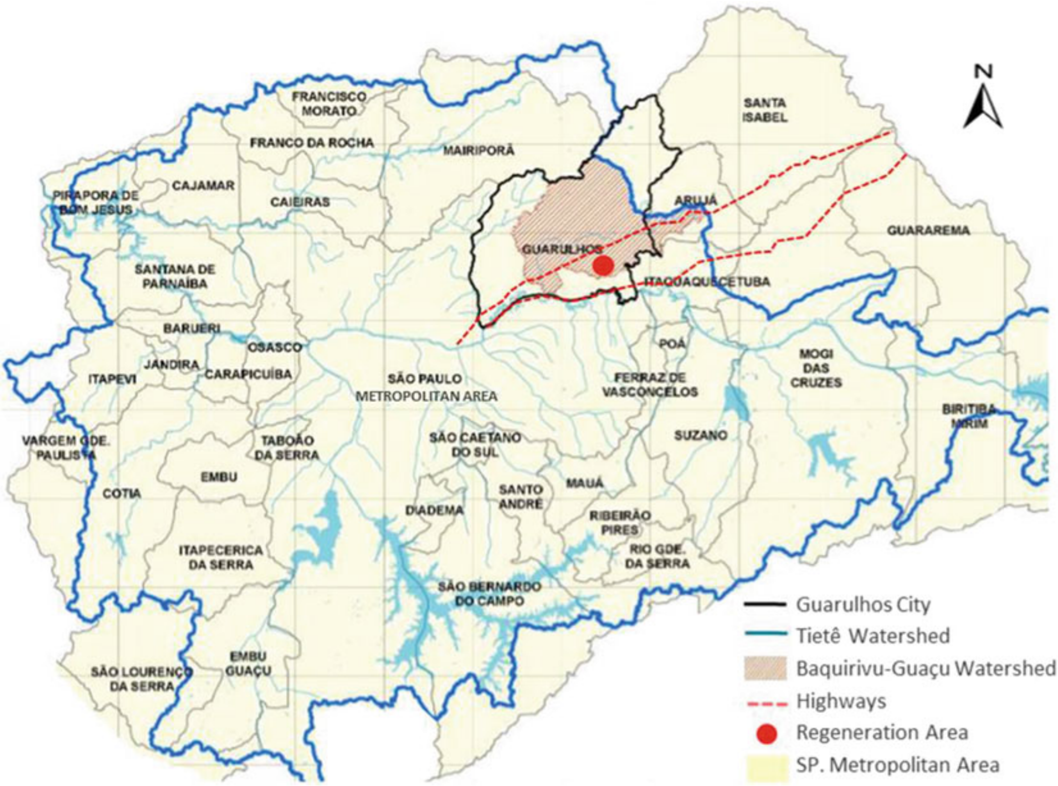

Fig. 1.1 Study area in metropolitan dimension. *Source* Modified from Emplasageo site accessed in oct. 2022 (www.emplasageo.com.br)

the Guarulhos city growth always related to the SP metropolitan area and their infrastructures. The third and fourth items focus on the Guarulhos environmental and housing problems. And the last one proposes a green space system plan based on empirical surveys and theoretical support (Figs. 1.1 and 1.2).

1.2 Green Spaces System

The function and arrangement of green areas are transformed according to the political and economic context of each time. In the industrial and liberal city green spaces were isolated islands in a compact urban fabric, while in the modern city they shaped a unique space, where all other elements are freely distributed: the city becomes a park where the various functions of urban life are established. This process shows the transition from the private appropriation of the territory, to the recuperation of public control over the city space (Benevolo 2019). The chaos arising from the industrial revolution and the increase population in cities with precarious conditions, mainly for the working classes, led to social and environmental impacts and the reduction of green spaces in large industrialized cities (Benevolo 2019). In this context the green areas, initially conceived with an esthetic function, begin to have a sanitary function in order to reduce the health problems of the industrial city and guarantee a better quality of life for the population (Hall 2009). In the mid-nineteenth century, romantic and naturalist ideals, disseminated from Europe, led North Americans to the development of the Park Movement. This important landscape movement was against the low quality of life in American cities. However, this Movement, which intended to think about the city plan from

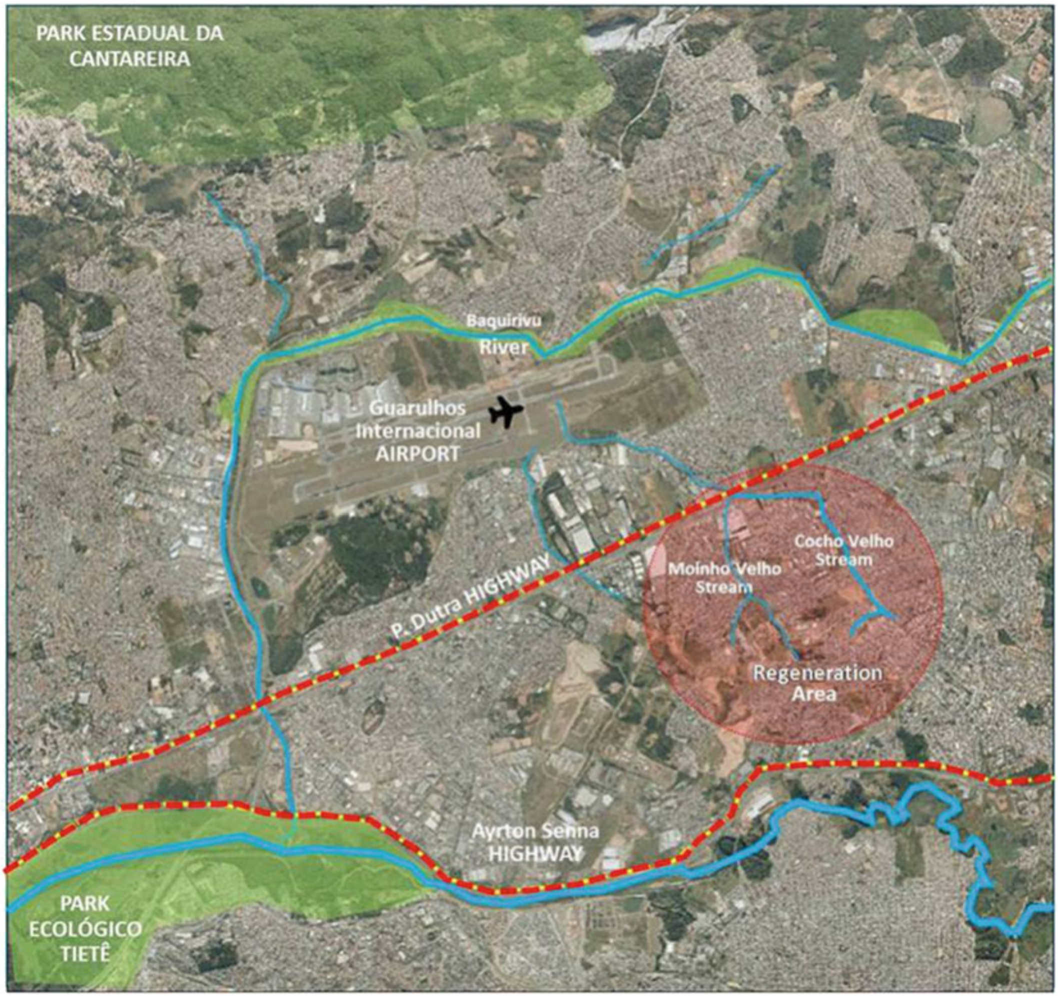

Fig. 1.2 Study area in urban dimension. *Source* Made from Emplasageo site accessed in oct. 2022 (www.emplasageo.com.br)

a system of open spaces, did not manage to control the city as an urban and architectural complex (Schenk 2008). From this movement, at the turn of the nineteenth to the twentieth century the landscape architect Frederick law Olmstead (1822–1905) was a pioneer in considering the relation between landscape and territorial planning for a balanced urban development. He established the basis of Landscape Architecture, and his ideas have influenced many urban planners and trends. Green spaces started to have a function of structuring the urban growth, linking technical advances to esthetic values, and in this way creating spaces of sociability (Schenk 2008). In 1857, Olmsted became Superintendent of the Central Park in New York. Between 1865 and 1874 he produced his most important projects as Prospect Park in Brooklyn; the Boston Park System (Emerald Necklace); and Riverside in Chicago. Observing the tenements towns at the time, he argued that parks were necessary to civilize urban life and that they would only make sense if they became public, open to the entire population, with pedagogical functions and strategies to guarantee quality use of spaces. His goal was to educate through the place. Frederick Law Olmsted saw the landscape from the sensations it provided. For him the relationship between man and nature would be vital for human health (Schenk 2008). In 1870, Olmsted wrote "Public Parks and the Enlargement of Towns". He presents the idea of the plan articulating free spaces, large and small parks and the streets and avenues system (parkways). The quality design of these elements would promote a pleasant displacement shaded and could form part of a system of parks. He defended the parks importance as a symbol of a new community life and the landscape to improve the fast pace of urban life (Schenk 2008). Emerald Necklace in Boston was an implementation of a connected system of green areas for Boston city in USA. Designed between 1878 and 1895, Olmstead did not make large concrete reservoirs, but an underground system of intercommunicating lakes that directed waste water to the sea, connected parks instead of large reservoirs. This space was forested, transforming people's lives. This historical and lasting plan of integrating open areas has become a reference when we discuss landscape design (Schenk 2008). This intervention plan was a precursor to contemporary practices such as the connection of parks and green areas, the requalification of waterways, the creation of green corridors within the urban areas, recreation, environmental conservation and especially sanitation service and flood control solutions through urban infrastructures that were designed as landscapes. In other words, the integration of landscape with hydraulic and sanitary engineering through the installation of vegetated strips along streams; the connection of the city center to the countryside through parkways; the creation of green belts around the city; the water regime as a basis for the design of lakes and waterways; and finally the restoration of mangroves and river courses are old and valid practices that should be further explored nowadays. This is a project that displays the advantage that large infrastructure obtains when its esthetic dimension is not overlooked and when regional urban planning and landscape designs are integrated.

In London of 1880 e 1890 the urban planner Ebenezer Howard (1850–1928), influenced by the landscaper Frederick Law Olmsted, wanted to link the benefits of the countryside with the city benefits through a garden cities proposal and an urban planning on a regional dimension (Hall 2009). Howard conceives his garden city ideals, linking the economic and social opportunities of the city with the pleasures and environmental quality of the countryside, but not only. Actually, he aimed rebuild capitalist society progressively within an infinity of cooperative communities (Hall 2009). Howard was more concerned to social processes than to the physical form of cities. His goal was to ensure the better quality of life of the workers and that they became owners of their lands. Although his thinking has been considered utopic, he broke with the current city model and influenced on later urban movements (Hall 2009). Almost a century later, McHarg (1920–2001) also defended the importance of human development in harmony with nature, indicating that urban planning should pay attention to landscape natural processes (McHarg 2000). He reinforced the relevance of human development in harmony with nature and the need for urban planning to consider the natural processes of the landscape, in particular the relationship between man and open spaces not built and with natural spaces.

The fields of Architecture and Urbanism, Landscaping and Ecology, through their respective approaches, define and analyze the physical structure and the socio-cultural relations established between the territory and the people who live there. In this way, urbanization must observe the place function, aiming to protect natural processes and the population urban life (McHarg 2000). These ideas have still influenced the current works.

In Brazil, landscape integrated into urban planning occurred from an esthetic point of view, then technical considerations and, finally, under an environmental-ecological orientation. Through the twentieth century, São Paulo city began to disregard their rivers and floodplains. São Paulo watercourses have always played an important role in the development of the city, providing food, circulation and recreation. Also they had the function of taking away garbage and sewage, which became a problem with the city growth. With the floods increase, the floodplains areas admired for their nature and landscape become focus of diseases. The riverbanks have lost their charm, and the rivers have become urban barriers. From this moment, the main rivers that structure the city begin to have their course aligned in order to allow drained water as quickly as possible (Golveia 2016). The solution for the problems related to water epidemics, floods and pollution would be solved by engineering works that consisted of draining wetlands, channeling and plugging rivers, building galleries and pools for rainwater. However, these interventions caused changes in the natural landscape. The idea of gray engineering, pipes, galleries and plugs has remained for a long time and has been the basis of technical urban drainage projects in most Brazilian cities.

In 1930, the architect and mayor Prestes Maia (1896–1965) proposed his main project to São Paulo city. The Avenue Plan was based on the opening of fast avenues in order to develop and structure the city. However, to channeling and plugging rivers of valley bottom to open big avenues in their banks increased the problems of flooding and have reduced the chances of São Paulo becoming a green and fluvial metropolis. At the same time the sanitary engineer Saturnino Brito (1864–1929) carried out many studies of sanitation and urbanism in the country. He was against the occupation and defended the preservation of Tietê river floodplain that crosses São Paulo capital. He designed the rectification of the river and his plan included a park that would be the largest river park in the world and would avoid floods during the great rains. It was not implemented, and today there are more than six fast lanes in each side of the river, even more if we consider the local lanes. This practice was encouraged by politic interests in the real estate and in the automobile industry (Golveia 2016).

From the 1970s, better and more sustainable urban drainage practices focused on river renaturalization and on restoring the natural hydrological cycle became trends in the world (McHarg 2000). Currently new approaches were introduced in public policies debate to deal with the relationship between rivers, floodplains and urban areas in São Paulo city. The results have changed the way of understanding the urbanization and the water system from the municipal and state levels. However, the interventions are not integrated yet, resulting in actions that are often incomplete and not responding the needs. Finally, the first great Brazilian character in the history of the landscape in a different way was Roberto Burle Marx (1909–1994). By the hands of Burle Marx nature never was designed only as scenery, and it was completely integrated in Brazilian modern architecture. However, his scientific and technical knowledge came from a botanical and not from the urban field, and his greatest contribution refers to esthetic and environmental issues, what makes him different from Olmsted. His Landscape was not a structuring element of urban interventions. Quantitative, practical and functional urbanism stands out in American territory. The Landscape idea based on issues of humanistic and natural orders revealed fragile in face of modern development (Schenk 2008).

The authors above show how it is important to reinforce the importance of Landscape Planning or Landscape Architecture. To look not only at the urban but at the territory and landscape, considering planning and designing of open spaces such as streets, sidewalks, avenues, squares and parks. Several studies, such as those by Schenk (2008), conclude that green areas and open spaces can produce positive effects on urban quality and on population living conditions. They are important elements of climate adaptation in cities. Urban open spaces make up a complex system connected to other systems. Among their multiple functions are leisure, circulation, flood mitigation, environmental conservation and social interaction. Among its numerous benefits, the following stand out: the reduction of rainwater runoff; temperature reduction; improved air quality; greater diversity of flora and fauna, increased biodiversity corridors; improved landscape; provision of recreational spaces; encouragement of educational activities; increased social interaction; improved psychological health of the population; and appreciation of the cultural heritage. Some strategic actions are: Trying to keep the soil permeable, green areas free, keeping small farms producing food, not interrupting the water cycle, not occupying floodplains (especially in tropical countries whose rivers produce many floods), mitigating the negative impacts that infrastructure causes when they change nature cycles. For these spaces to be set as a system, they must be qualified, integrated and connected, even if they were not planned or implemented as such. Through the requalification and integration of the green areas perhaps we can mitigate the conflict between infrastructure, social dimension and environment impacts.

Recovering authors and their ideals could help to educate, raise awareness and strengthen a culture that gives importance to green public spaces and finally, to reinforce the cities potential when they are planned based on green systems.

1.3 Urban Evolution and Infrastructures

Different economic cycles are supported by the strategic and technical progress of transport infrastructures which allow enlarge social relations and a continuous advancement in the urbanization process (Reis 2006). According to Hall (2009) the city of 1900 de-concentrated due to new transport technologies, the electric tram, the electric train, the subway, the bus, allowed new connections and a process of suburbanization to take place, new homes and factories were built on its periphery.

Inaugurated in 1950 Dutra Highway notably boosted the industrial and suburban development in Guarulhos territory. New development opportunities in Guarulhos city due to a better connection enabled its integration into the metropolitan area of São Paulo, modifying his urban landscape. During the 1950s and 1970s Guarulhos had an industrial economic growth that exceeded the capital and the industrial suburbs of the capital. The industries began to dominate not only the highway axis, but also to attract sprawl settlements away from the highway axis (Langenbuch 1971). Because of its proximity to the capital, it became a commuter town for industrial workers, with implemented settlements without urban and environmental quality. The city had a fast urban, industrial and population growth. The construction of Dutra highway, later extended, was justified by the need of developing the country's industrialization and to promote more efficient road connection between the two largest Brazilian cities—São Paulo and Rio de Janeiro. The highway construction, the city industrialization and the role that Guarulhos played in the metropolitan area of São Paulo were decisive to a population explosion in the following three decades. Between the 1980s and 1990s, other major projects have affected the arrangement of Guarulhos urban territory, the construction of Guarulhos/São Paulo International Airport and the Ayrton Senna Highway. The airport construction was implemented in order to expand the country's economic development because Congonhas Airport in São Paulo has already exceeded its operational capacity to transport passengers and goods. Inaugurated in 1985, Guarulhos airport has intensified the process of urban settlement in its surroundings areas due to the greater offer of jobs and income opportunities, such as Pimentas neighborhood, the study area location. The Baquirivu river floodplains, on which the airport was built, were environmentally fragile with precarious sanitary service and with low land value. Furthermore, the lack of control of urban legislation attracted the low-income population to this area. In the same period besides the international airport and to complement Dutra highway was inaugurated Ayrton Senna Highway to improve the access to the international airport and the traffic on Dutra Highway. These infrastructures result from investments to increase better connections and to insert Guarulhos in an important strategic area, unfortunately without worrying about the urban and environmental impacts of it.

From 1990, with the productive restructuring and the highways modernization, have begun an attraction process of large supply centers and logistic condominiums along Dutra Highway. According to Eigenheer (2018), the intensification of the urban sprawl dynamics in the twenty-first century, now related to the tertiary sector, has caused the merging of sprawl urban areas, and it has established a new and complex metropolitan dimension that demands attention. As pointed out Guarulhos territory is crossed by important connecting roads and has an international airport in the center of its territory—infrastructures of regional and national importance, which fragment this territory and also allows regional dynamics, as Dutra Highway used as a daily connection between Guarulhos city and its surroundings. These transport infrastructures were not implemented by the Guarulhos municipality. The decisions, investments and construction came from the state and federal government. Some of these infrastructures in addition of a great impact in the territory have no relation with the city's urban dynamics, as Guarulhos Airport. Besides reconfiguring and urban sprawl, these infrastructures change the natural cycles of nature and cause strong environmental effects. In addition, they have a strong esthetic influence on the landscape, so their projects could be part of a process that integrates regional urban planning and landscape.

1.4 Environmental Fragility

Patrick Geddes (1854–1932) points out the complex issue of the urban planning limits and defends the planning of the region that surrounds the city, covering a natural region, a watershed or a geographic unit with the same regional culture (Hall 2009).

Baquirivu-Guaçu basin is located northeast of Upper Tietê Basin (BAT), a large part of which is inserted in Guarulhos city. The study area includes two tributaries of Baquirivu river: Cocho Velho stream and Moinho Velho stream. Large industries, different configurations of housing developments, educational institutions, services and illegal settlements are occupying the floodplains of these streams silted up with waste.

According to Campos and Oliveira (2014), in Cocho Velho stream floods occur every two years and sometimes reach and block Dutra highway. In 1999, floods blocked the airport because the waters of the Cocho Velho stream, which also cross the airport site, reached the runways.

During the urbanization process of this area, its rivers and streams received informal settlements in their floodplain areas, which even today contribute to the process of degradation of water bodies and of flood occurrence. Until today, the municipality of Guarulhos has a precarious sanitation service. The main function of the streams in the study area is to receive waste disposal and illegal constructions or avenues to solve connection problems. Unfortunately, there seems to be no interest in their landscape treatment or their incorporation to the city through implementation of parks and urban furniture. According to Campos and Oliveira (2014), the construction of airport in the 1980s on the left bank of Baquirivu river, led to a more recent urbanization process in its floodplain, changing the fluvial geomorphology and the flood regime; however, the existence of natural vegetation and floodplains suggests strategies to protect these residual areas in order to control flood occurrence. Considered as one of the most vulnerable areas of the metropolitan area, Baquirivu river basin is importance for Macrodrainage Master Plan of the Upper Tietê Basin (PDMAT). Storm water contention should be carried out in the territory of all basins and not only in floodable areas to ensure the maximum flow capacity of the main rivers.

In the 1970s, drainage and sanitation service systems were planned from the regional scale by São Paulo Metropolitan Planning Company (Emplasa), with environmental conservation strategies and considering the watershed as the planning unit. For politics decision, Emplasa company does not exist anymore, and the current urban plans hardly consider watersheds as structuring elements for territorial urban planning. Floods are one of the main natural disasters that impact cities. These phenomena often occur because of rapid and heavy rains, intensified by soil sealing, straightening of watercourses and reduction of runoff from channels due to silting. Because of their urban complexity, metropolitan areas are more impacted by floods and require greater attention to mitigating risks due to climate change. Therefore, public policies of intervention in valley bottoms, such as the creation of open areas, linear green parks, and sanitation service and drainage systems integrated into the landscape, are strategies to retain and control water, to prevent flooding, to address unequal land use and, finally, to strengthen the production of healthy environments.

1.5 Housing Precariousness

From the nineteenth to twentieth century English urban planners already defended the importance of avoiding the total separation of different social classes in city and land planning, as well as the guarantee of land ownership to citizens (Hall 2009). Brazil has an extensive legislation favorable to the provision of social housing and the land tenure regularization and however still lacks political efforts and interest. Due to the large housing deficit and many informal settlements in the country, the most recent legislation has become more flexible in order to provide the incorporation of these settlements into the urban territory and the titling of their occupants. Currently, the city is allowed to promote land tenure regularization in preservation areas (APPs), as long as there are no settlements in the risk areas and there are improvements of urban environmental sustainability conditions in relation to the previous situation.

In Brazil there is a critical situation of Environmental and Social Fragility. The country has the largest social and territorial inequality, which means deficit and precarious housing, at the same time, an exclusive territory, where the opportunities are unequal and the social classes occupy segregated spaces. This situation makes environmental disasters frequent, because many low-income population lives in the risk areas due to the lack of public housing policies. Besides, the climate change will occur with increasing frequency and periodicity, as well as the temperature increase and the intense rainfall.

Regarding the Housing Deficit, Guarulhos had in 2000 a deficit amounting to 6.8% of the total of São Paulo metropolitan area. The city has many families in precarious situation, amounting to 16.54% of the total number of families in the city. The housing demand in the city is directly related to precarious land occupation (PMG 2011). In the metropolitan context, Guarulhos has a proportionally higher percentage than São Paulo metropolitan area (13.42%) and São Paulo city capital (12.55%). According to PMG (2011), Quantitative Housing Deficit in Guarulhos is 48.043 new homes. The precarious settlements or Qualitative Housing Deficit is 48.464 units that need legal regularization; 9433 units that need simple urbanization; 32,953 units that need complex urbanization; and 24,804 units to be removed for being in risk areas or preservation areas. “Simple urbanization” is understood as those in which one of the infrastructure items is missing and where 5–10% of removal is possible with small contention works and “complex urbanization” as those with a high rate of removal due to risk and with a lack of infrastructure, more than one item.

According to municipal information, the first reference to precarious settlements in the municipality of Guarulhos dates back to 1970. From that time on, the illegal settlements have become an option for low-income families. Most of these settlements are in floodable areas, in areas of high slopes or in public areas. In the 1980s, the popular movement for housing started in Guarulhos as a way to pressure the communities to take part in the governmental decisions in the housing sector; however, unfortunately the public housing policies are still unable to face the precarious urban situation in Guarulhos. In 2015, the United Member States defined seventeen Sustainable Development Goals (SDGs) in order to end extreme poverty, reduce inequality and protect the planet by 2030. The eleventh goal focuses in make cities and human settlements inclusive, safe, resilient and sustainable. In addition to the objectives defined here, this paper aims to contribute and to be aligned with the world’s sustainable development agenda (Fig. 1.3).

Fig. 1.3 Settlements at Cocho Velho stream. *Source* Made from Google maps view

1.6 Methods

According Geddes, the planning should begin with the survey of the resources of a natural region. The data collection precedes the plan (Hall 2009). Three important actions were established to propose a system of green spaces in Guarulhos city, as well as, to foresee its future development and monitoring: Recognition, Requalification and Integration.

The first action was to recognize an urban landscape with socio-environmental conflict with urban and metropolitan impact. Next step was identified in the landscape, strategic green spaces with the potential to recover it, as gardens, squares, parks, floodplain areas, riverbanks, tree-lined avenues, urban voids, public spaces and void private space subject to expropriation or exchange to other locations. The second action proposes the requalification of the identified green spaces through participatory urban projects that identify the urban and environmental potential of each green space. It is necessary to be clear about the demand of users and the role that each space will play. Each green space must be analyzed in order to propose a consistent function with its physical and environmental structure. The third action proposes to consider the integration of the green spaces recovered in the urban project. To consider the existing territorial occupation is important to avoid expropriations. Bike lane, pedestrian path, linear parks, tree-line streets, sidewalks and public transports may be strategically connected to establish green corridors.

These connections aim to establish a well-articulated system capable of providing mobility, social interaction and a strong identification of the landscape, preventing its disqualifications and future deterioration. Green spaces do not assume value and little qualify the territory when isolated, but when they are somehow integrated with other free spaces, they assume an important environmental function and could regenerate the territory. Regarding the first action, green spaces were revealed through the empirical and cartographic analysis of the area then a system of green spaces was established from the empirical and morphological analysis of Guarulhos territory. In a second step, the goal will be connect the green spaces system to other large green areas that structure the city area, as Baquirivu River Linear Park, Cantareira Mountains and Tietê Ecological Park (see Fig. 1.2). Maps of environmental vulnerabilities were analyzed to implement the Green Spaces System. An urban growth in areas with great socio-environmental complexity was observed. Sectors in where there are low-income urban settlements on fragile soils and floodplain areas, which require removal, as Jardim Ansalco case (Fig. 1.4). As pointed out above risk areas are along the banks of Baquirivu river tributaries, mainly Cocho Velho stream that has a medium risk of flooding (Figs. 1.5 and 1.6).

The spatial analysis made possible to define the main conflicts, pointing out the critical landscapes and the places where it is important to concentrate efforts. Regarding flood areas, medium risk areas were pointed out. A few stretches of canalized and rectified streams were observed, all with open section. However, most stretches of streams that cross the study area are in natural state, with undermining and siltation, at the same time, they still present natural vegetation. The characteristics of Guarulhos urban drainage, the under-dimensioning and precariousness of the micro- and macrodrainage systems added to the silting up of the rivers, indicate fragility for floods events. This process is triggered by historically high-intensity rainfall. The morphological analysis of the area was carried

Fig. 1.4 Risk area mapping. *Source* Made from CPRM Serviço Geológico do Brasil in 2014

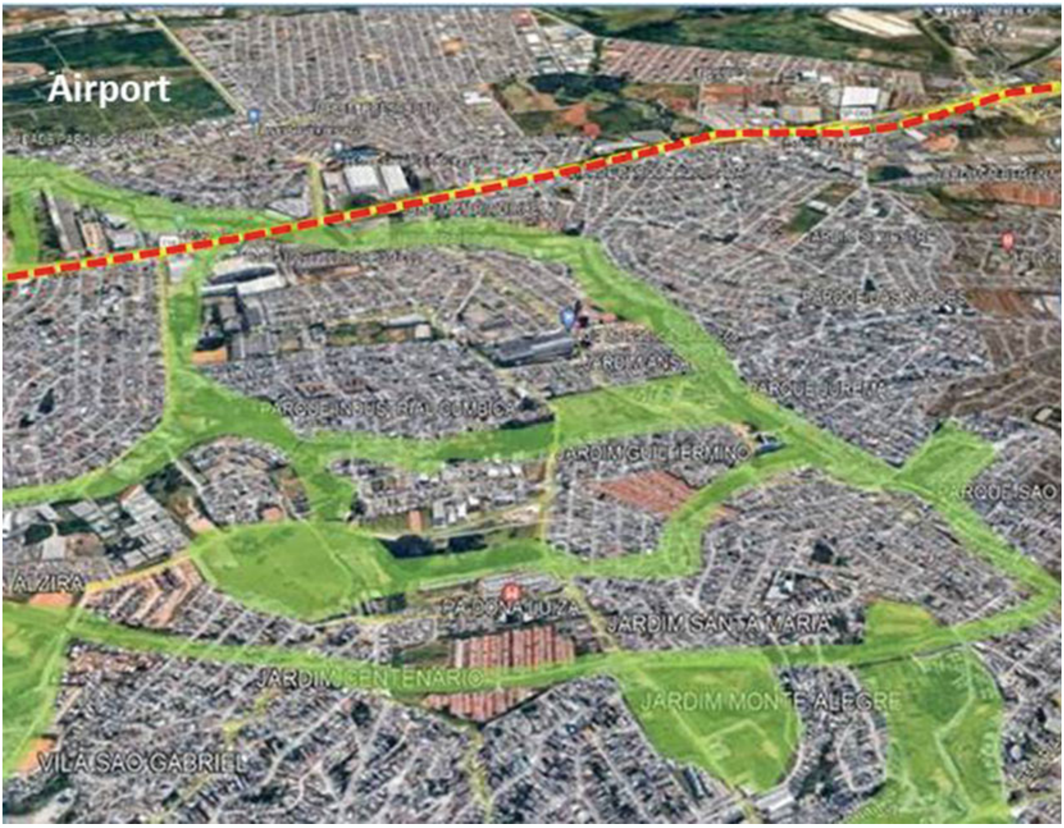

Fig. 1.5 Green spaces system implemented in the study area. *Source* Made from Google Earth base

Fig. 1.6 Jardim Ansalca in a floodplain area. *Source* Made from Google Earth base

out based on the empirical and satellite observations. The physical elements pointed out were essential for approaching and complemented the landscape and the green spaces revealed. These elements were divided into two groups. The first one consists of transportation infrastructure, environment (urban parks, squares, floodplain areas, private land) and hydrography, here called continuous elements. The second group consists of urban settlements (housing, industry, productive facilities, commerce, urban and social equipment), which are distributed discontinuously throughout the territory, and are called discontinuous elements. These elements, environment, transportation, hydrography and urban settlements, together with the theoretical analysis, help to establish the challenges to be mitigated. A plan was proposed based on the mapping carried out.

According Viganò (2010), to set a territorial plan, at the same time, conceptual, where proximity relations are set and conflicts are inserted contribute to structure strategies for a large scale of urban planning, capable of regenerating metropolitan territories, starting from the local scale but also affecting regional scale. The urban plan proposes a natural and qualitative evolution of this area based on the challenges found. Next step now is to move from plan scale to a participatory urban project scale. Just an integrated plan of green spaces is not capable of solving the complex urban problems of housing, poverty and environmental degradation. Complementary actions, political and economic, are essentials. The real state sector should be connected with these conflicts and should be more controlled by urban legislation. However, through a plan could be possible to identify, mitigate and avoid the proliferation of new conflicts, especially when it has an urban landscape multi-scalar vision that goes from the plan to the project scale (Fig. 1.7).

Fig. 1.7 Urban plan proposal. *Source* Made by the author

1.7 Final Comments

Currently, in addition to the esthetic, sanitary, integrative and structuring function, green spaces may assume an important function as regenerating element of the urban landscape, with the ability to mitigate socio-environmental conflicts when they are well qualified. Besides a green space system another actions would be essentials to regenerate this area: to link infrastructure with the landscape natural process, to plan in a local and metropolitan dimension and finally to set housing and land tenure public policies to achieve the great demand of the low-income population. In this way it would be avoided that green spaces without proper use in countries with a large housing deficit, such as Brazil, become attraction elements for informal and precarious settlements instead of elements of urban and metropolitan regeneration.

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2 Water Efficiency Strategies for Improving Sustainability in Social Housing: Comparative Analysis Between Cairo and São-Paulo

Esraa Elazab and Ahmed Eltawil

Abstract

Water shortage is a major problem in many megacities, especially those in developing countries; its impact is largely felt in the residential sector, particularly social housing. This study introduces a framework for assessing water efficiency in social housing projects to measure the effectiveness of using water conservation strategies. This study also addresses the relation between the water efficiency in such projects and the urban water situation in their countries. The research methodology involves a comparative study of two megacities, Cairo and São Paulo, which are facing increasing water challenges. The comparison focuses on one social housing project in each city to study the opportunities for improving water efficiency and the challenges affecting water efficiency in each project. Water use reduction calculators are used to provide indications about water consumption. The assessments show that the average water consumption/person in the case study of Cairo is 67% higher than the average water consumption/person in the case study of São Paulo due to the differences in the adopted water strategies and the water use behaviors. Results also show that reducing costs while developing social housing projects isn't the optimal solution, as water conservation could be of greater value in the long-term. Thus, water conservation must be considered from the early stages of planning and design of social housing projects.

Keywords

Water use · Social housing · Sustainable architecture

2.1 Introduction

The water crisis has many effects on the future sustainability, especially sustainable urbanism. Water scarcity affects four out of ten people around the world, and it's projected that by 2050 about 3.9 billion of the world's population will live in water-stressed river basins (Guppy and Anderson 2017). For each degree of global warming, approximately7% of the global population will be exposed to a decrease of renewable water resources of at least 20% (Döll et al. 2015). Furthermore; urbanization is increasing in many megacities and leads to huge water demand which is increasingly difficult to supply, this is

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exemplified by the recently avoided Day Zero event in Cape Town (2018) and the water crisis in Chennai, India. Despite that; water infrastructure systems are deteriorated in many countries, for example, 30% of the global water abstraction is lost through leakage and about 80% of wastewater flows back into the ecosystem without being treated (Guppy and Anderson 2017). Worldwide, domestic sector consumes about 10% of the total water consumption, although households are the smallest consumer of water, but it has an enormous potential impact and water use in this sector is expected to go upward by 80% over the next 25 years (Danielsson 2019). Water shortage in many world countries is considered to be one of the most challenging constraints of achieving sustainability in social housing projects. This is even more acute in developing countries, especially megacities where there is a mismatch between population and housing supply (Nasr et al. 2017).

As a way of codifying sustainability in buildings, certain measures are incorporated in the form of green building rating systems. Green certified buildings saved an average of 37.6% compared with the baseline water usage rate for all buildings (Cheng and Peng 2016). Leadership in Energy and Environmental Design (LEED) rating system; developed by the United States Green Building Council; is the most common rating system around the world. LEED rating system consists of six main categories: sustainable site planning, energy efficiency, indoor environmental quality, materials and water efficiency (USGBC 2014). The water efficiency credits in LEED v4 focus on reducing indoor and outdoor water consumption in buildings, requiring prerequisite baseline achievement for each. The main indoor water use reduction method is to upgrade baseline appliances to more water efficient products. Outdoor water reduction methods include limiting the amount of irrigated landscape, switching to water efficient plant species, using alternative water resources, and completely eliminating an irrigation system (Greer et al. 2019).

To make buildings water efficient, the *Reduce*, *Replace* and *Reuse* approaches should be adopted. Under the *Reduce* approach, buildings should have a monitoring system, employ water efficient products and design a leak-free system; in addition, there should be *Replacement* for the use of potable water with seawater or rainwater for non-potable uses. Finally, there should be a *Reuse* mechanism like the implementation of a graywater system (Marinoski et al. 2018). To solve the water problem, it is necessary to consider the water supply services. Furthermore, the design of the built environment, the open spaces and the water infrastructures, integrating between gray and green infrastructures is important to achieve sustainable development (Tahvonena and Airaksinenb 2018).

The research aim is to study the water efficiency in social housing projects and to measure the efficiency of using the available water conservation strategies; taking into consideration the special circumstances of each project. The gap in currently existing literature is represented in rarely considering the assessment of water efficiency in social housing projects; in addition to not addressing the combination between all the available water efficient strategies and how they could be integrated.

2.2 Methodology

The paper is adopting an analytical comparison study between two social housing projects in Cairo and São-Paulo; as two megacities facing water challenges; the comparison is considering the water efficient requirement in sustainable housing projects. The two case studies were selected in two countries with convergence in the economic and social situations; in addition to the variations in the experiences of each country. The first case study in Cairo is New-Cairo social housing project, which is located in New-Cairo district, which is considered as an urban extension for Cairo city; the project is selected as it represents a typical example for most of the social housing projects in Egypt. The second case study in São-Paulo is *Paraisópolis* social housing complex, which is located in *Paraisópolis slum*; the project is selected as it represents a sample of social housing projects in Brazil and it followed some water efficiency regulations. The two projects have some variances in the locations, urban context and design; and this will help in providing more detailed observations on water efficiency related to the different aspects of each project. The research followed some steps to evaluate the water situation in the two projects; first is studying the water problems affecting the sustainability of water resources in each country in order to analyze the predicted future challenges. Second is the water efficiency assessment for the two case studies through the field studies, surveys and questionnaires. Third is studying the available opportunities for improving water efficiency; to show how some water efficient strategies could be integrated in the design in order to improve water efficiency and achieve sustainability. Finally, comparing the results of the two projects to show how environmental, social and economic conditions aspects affected the water consumption and efficiency in each project.

2.3 Case Study 1—New-Cairo Social Housing Project in Cairo, Egypt

Egypt is 96% dependent on Nile River as the major source of water supply. This water is bounded by international treaties and so the quota of Egypt, which represents 55.5 billion m^3/year; may be affected by many variables such as the Ethiopian Renaissance dam, which may cause the Nile's fresh water flow to Egypt to be cut down by 25%. Egypt is located in arid climate, the annual average of rainfall is 12 mm and ranges from 0 mm/year in the desert to 200 mm/year in the north coastal region. In Cairo the average rainfall is 25 mm/year. In Egypt today, 104 billion m^3 of water are required to cover the country water needs. Renewable water, coming from the Nile River, rain and underground water, only reached 62 billion m^3. Egypt currently covers its shortage of water through reuse of agricultural drainage water which reached 20 billion m^3. Meanwhile, Egypt suffers from a shortage of 42 billion m^3. Egypt now is under the poverty water line with 600 m^3/capita/year and is predicted to be 350 m^3/capita by 2050, while the water poverty line is 1000 m^3/capita/year. The overall country average/capita usage of drinking water is about 300 L/day. The amount of drinking water produced in the year 2017 was about 9.3 billion m^3 and the loss rate of it reached 29.7% due to the leakage. The case study is located in New-Cairo district, which is east of Cairo. The average annual temperature is 20.8 °C in New-Cairo and about 28 mm of precipitation falls annually. The stormwater system and infrastructure in New-Cairo isn't qualified to hold extreme rain events as flash floods and inundations occur in many areas each year during specific storms (Gado and El-gha 2019).

2.3.1 Water Efficiency Assessment of New-Cairo Social Housing Project

The project was carried out through two phases, the research focuses on the second phase shown in Fig. 2.1 which is more recent, and began operation in 2016; Table 2.1 shows some data about it.

From the field survey and questionnaire to residents some problems are found to be affecting the water efficiency of the project. For example; wide asphalt roads and impervious areas increase the heat island effect in addition to increasing the stormwater runoff. Another example is that green areas are deteriorated due to the lack of irrigation. Furthermore, the main pipelines for water supply are suffering from repeated leakage problems and this causes higher maintenance cost and more excavation works to detect the problems in the pipelines; not only this, but also leakage affects the water supply efficiency in the residential units and the quality of the open spaces as leakage merges them, as shown in Fig. 2.2. There are also leakages in the indoor pipelines which is obvious in the deteriorated finishing materials of the buildings' façades, as shown in Fig. 2.3. The rainwater infrastructure also isn't sufficient and after an event of rain; stormwater floods the spaces as shown in Fig. 2.4. Water sub-metering isn't used for all the residential units and the average water consumption for each unit is

Fig. 2.1 New-Cairo social housing layout, second phase highlighted (Google Earth 2019)

Table 2.1 Data about Phase 2 of New-Cairo social housing project

Total area	141,640 m^2
Number of buildings	71 Buildings
Number of residential units/building	24 Units
Area of residential unit	90 m^2
Area of one building	360 m^2
Number of floors/building	6 floors
Total area of the buildings/total area	20%
Impervious spaces/total area	66%
Pervious areas/total area	14%

Fig. 2.2 Leakage merging spaces (Author 2019)

estimated to be 30 m^3/month, approximately 250 L/person/day; all residential units must pay for 30m^3/month although there is no water sub-metering. From questionnaires it was found that most units didn't have meters yet, and this makes residents don't give interest to the amount of water they consume because whether the consumption is high or low; the same amount of money must be paid.

According to the survey and field measurements it's found that the devices used for each unit are 1 bathroom tap 8.3 L/min, 1 kitchen tap 8.3 L/min, 1 shower 9.4 L/min, 1 single flush

Fig. 2.3 Deteriorated facade (Author 2019)

Fig. 2.4 Rainwater flooding spaces (Author 2019)

toilet 6 L/flush and 1 toilet tap 3 L/min. By using LEED indoor water use reduction calculator and assuming four persons in each residential unit and using the default time of use and number of uses, it was found that the baseline water consumption is about 188 L/day/person. From questionnaire to residents it was found that the water use is more than that amount, and is almost the same as the data approved by the water company. It was found that the average of the actual water number of uses and time of uses for the faucets was higher than the defaults of the LEED indoor water use reduction calculator and by entering those data to the calculator, it was found that the average water consumption/person is 238 L/day and for each residential unit is about 952 L/day; as shown in Table 2.2.

The green areas in the project are deteriorated but it has an area of about 54,000 m^2. By using LEED V4 outdoor water calculator and entering the monthly precipitation rates in Cairo, which ranges from 7 mm in January to 0 mm in August, in addition to areas of 12,000 m^2 trees, 15,000 m^2 shrubs and 27,000 m^2 turf grass and fixed-spray for irrigation, it's found that 348,923 L is the water requirement/month; and the percentage of reduction from baseline is − 157%, according to the LEED V4 calculator; as shown in Table 2.3 and this explains the reason behind its deterioration.

2.3.2 Opportunities for Improving Water Efficiency in New-Cairo Social Housing Project

There are some strategies that could be implemented in this project to improve water efficiency. In the case of using bathroom tap aerators 3.8 L/min and shower aerator 6 L/min and dual flush 3 and 6 L/day; the total water use/unit will be 630 L/day/unit, which is a 34% saving from the actual water use, as calculated by LEED v4 indoor water use reduction calculator as shown in Table 2.4. From the accounting of the LEED indoor water reduction calculator; the actual water consumption for lavatory tap and shower tap is 636 L/day/unit; so this amount of water could be considered graywater and could be replaced with the potable water used for flushing which is120 liters/day/unit; and for irrigation.

Although the precipitation in Cairo is considered rare but it couldn't be neglected as it causes serious problems and loads on the infrastructure, the precipitation is 28 mm/year which is 28 L/m^2. Assuming using a rainwater harvesting system with efficiency of 75% and as

Table 2.2 Actual water consumption/residential unit in New-Cairo social housing

Fixture type	Actual (s)	Baseline flow rate (L/min)	Design flow rate (L/min)	Actual daily uses	Default water use (L/day)
Lavatory faucet	120	8.30	8.30	20	332
Toilet faucet	30	8.3	3	20	30
Showerhead	480	9.50	9.50	4	304
Kitchen faucet	60	8.30	8.30	20	166
Toilets		6(L/flush)	6(L/flush)	20 flushes	120
Actual water consumption/unit (4 persons) = 952 L/day					

Table 2.3 Outdoor water consumption for the total landscape area for New-Cairo social housing

Landscape area (m^2)	Plant-type	Water requirement	Irrigation-type	Distribution uniformity	Water requirement (L/month)
12,000	Trees	Medium	Fixed-spray	65%	64,615
15,000	Shrubs	Medium	Fixed-spray	65%	80,769
27,000	Turf grass	Medium	Fixed-spray	65%	203,538
Landscape water requirement based on the site’s peak watering month (l/month)					348,923
Landscape water baseline					135,800
% reduction from the baseline					− 157%

Table 2.4 Water consumption when using aerators and dual flush for New-Cairo social housing

Fixture type	Actual-(s)	Baseline flow rate (L/min)	Design flow rate (L/min)	Actual daily uses	Default water use (L/day)
Lavatory faucet	120	8.30	3.8	20	152
Toilet faucet	30	8.3	3	20	30
Showerhead	480	9.50	6	4	192
Kitchen faucet	60	8.30	3.8	20	76
Toilets		6(L/flush)	6 and 3 (L/flush)	20 flushes	90
Total water consumption/unit(4 persons) when using aerators and dual flush = 540L/day					

each building roof has an area of 360m^2; so the amount of rainwater harvested from the building’s roof is about 7560 L/year/building; theoretically this represents 21.6 L/day/building and 0.9 L/day/unit. The impervious areas in the project represent 42% of the total area which is about 59,488 m^2; by assuming using a stormwater harvesting system with an efficiency of 75%; so theoretically 1,249,248 L/year could be available for non-potable water use annually.

When adopting efficient landscaping; LEED V4 outdoor water use reduction calculator showed that in the case of using only drip irrigation the amount of water needed for irrigation will be 252,000 L/month. While in the case of using drip irrigation and replacing turf grass with ground cover and using native plants which had a low water demand, the water demand will be 168,000 L/month and percentage reduction from the baseline is – 24%; as shown in Table 2.5.

Table 2.5 Water consumption for irrigation in the case of adopting efficient landscaping for New-Cairo social housing

Landscape area (m^2)	Plant-type	Water requirement	Irrigation-type	Distribution uniformity	Water requirement (L/month)
12,000	Trees	Low	Drip irrigation	90%	46,667
15,000	Shrubs	Low	Drip irrigation	90%	58,333
27,000	groundcover	Low	Drip irrigation	90%	105,000
Landscape water requirement based on the site's peak watering month (liters/m)					168,000
Landscape water baseline					135,800
% reduction from the baseline					− 24%

2.4 Case Study 2—Paraisópolis Social Housing Project in São-Paulo, Brazil

Brazil holds 12% of the world's freshwater resources and has a water availability of 41,603 m^3/capita/year. Freshwater resources distribution is unequal; 70% of the available freshwater resources are located in the Amazon basin, where less than 7% of the population live, while more than half of the Brazilian population lives in the catchments of the Atlantic coast and faces water scarcity problems (Milano and Reynard 2018). In the state of São-Paulo the water balance is critical due to high demographic density, insufficient infrastructure, poor water quality and the effects of climate change. São-Paulo, where more than 20 million people live, was affected by an unpredictable drought during 2014 and resulted in urban water supply shortages in 2015. In 2014, the state of São-Paulo recorded the driest and warmest year since 1961; the precipitation was 830 mm compared with 1681 mm on average over the 1981–2010 and a mean maximum temperature of 31.4 °C in comparison with 28.7 °C on average during the period from 1961 to 2015. Combined with high evaporation rates as reservoirs aren't covered, this resulted in low water levels, fluctuating around 5–15% of their full capacity. In addition to that; polluted water from domestic and industrial effluents are flowing into water bodies. According to some studies the water/capita usage in Sao-Paulo in 2011 was about 180 L/day, and in 2016 was about 120 L/capita/day. São-Paulo loses over 20% of its treated water due to the leakage from pipes before it reaches the taps of the residents (Biswas and Tortajada 2016).

The case study is located in the Paraisópolis neighborhood in the south of São-Paulo city. The climate in São-Paulo is subtropical. The average annual temperature is 19.3 °C; the annual precipitation is 1454.8 mm. Due to climatic changes; wet season has shortened and less rain falls each year. During the wet season, floods occur throughout the city, but in the dry season the entire city suffers from drought. Paraisópolis neighborhood is informal and so most of the infrastructure isn't regulated as it's in the rest of the city. Most houses are connected to the water grid, but not all connections are legal and safe, and not all houses are connected to the sewerage (Velden 2016).

2.4.1 Water Efficiency Assessment of Paraisópolis Social Housing Project

The Paraisópolis social housing complex was developed as a part of the inventory project carried out by São -Paulo city hall as a part of the urban development plan. The project consists of seven condominiums, the first five A, B, C, D and F were delivered between 2009 and 2011 and condominiums E and G were delivered in 2013 and 2012, shown in Fig. 2.5.

The design of the condominiums is formed by linear blocks divided into connected modules and having varying heights, depend on the relation of the building with the land slope, all buildings

Fig. 2.5 Paraisópolis social housing layout, condominiums E and G highlighted (Google Earth 2019)

have at least four floors above the ground floor and one to four floors below the stepped ground floor. Condominiums E and G are gold certified by "Selo Casa Azul" and the study will focus on those two condominiums; Table 2.6 gives some data about it. The project followed some criteria for water management; some are mandatory for the certification; like water sub-metering, dual flush toilets and permeable areas; while some are optional like rainwater retention system, water flow regulator and tap aerators (Carvalho 2018).

The design of condominiums E and G aimed at decreasing the area of the impervious surfaces and not providing spaces for car parking or car access inside the condominiums while limiting the impervious areas to the main road between the condominiums and small areas of concrete pedestrian paths, as shown in Fig. 2.6. This was done to not only achieve water management, but also to encourage using public transport and reduce pollution. There is a rainwater and stormwater retention system as shown in Fig. 2.7; but unfortunately the water harvested isn't reused as this system is limited to retain the water in order to prevent flooding. Water sub-metering is used for each residential unit; in addition to separated meters for the irrigation. From the field surveys it was found that apparently there are no problems with water efficiency and from questionnaire to residents it was also found that there are no leakage problems or problems related to rainwater or stormwater management.

From field measurements for condominiums E and G, it's found that the water devices used in each residential unit are 1 lavatory faucet with aerator 3.8 L/min, 1 kitchen faucet with aerator 3.8 L/min, 1 low flow showerhead 6 L/minute and dual flush toilet. By using LEED indoor water use reduction calculator and assuming 4 persons for each residential unit and using the default time of use and the number of uses of the calculator, it was found that the average of the default water consumption/person is about 108.5 L/day. From questionnaire to residents and water bills; it was found that the actual water consumption is lower than the default water consumption; and by using LEED V4 indoor water use reduction calculator, it was found that the average water consumption/person is about 77.2 L/day as given in Table 2.7.

The green area is about 3000 m^2 for condominium E and G, when considering having 600 m^2 trees, 1000 shrubs and 1200 m^2 turf grass and fixed-spray for irrigation. By using LEED V4 outdoor water calculator and entering the monthly precipitation rates in São-Paulo which ranges from 293 mm in January to 39 mm in

Table 2.6 Data about condominiums E and G in Paraisópolis social housing project

Total area	4440 m^2
Number of buildings in condominiums E and G	7
Area of each building	240 m^2
Number of floors/building	From 6 to 9
Number of residential units/building	Average 24 units
Area of residential unit	50m^2
Area of the buildings/total area	38%
Impervious spaces/total area	20%
Pervious areas/total area	42%

Fig. 2.6 Green areas and narrow pedestrian walks (Author 2019)

August; it was found that the water requirement for irrigation is about 96,923 L/month and the percentage reduction from baseline is 94%, as given in Table 2.8.

2.4.2 Opportunities for Improving Water Efficiency in Paraisópolis Social Housing Project

Water efficiency is considered in the project, stormwater is well managed and indoor water use is regulated, despite that there are some strategies which could increase the water efficiency. According to Table 2.7, the graywater available from showers and lavatory taps in each residential unit is about 158 L/day/unit; this amount of water could be used for flushing which are 90L/day/unit or for irrigation. When using a rainwater harvesting system for the roofs with an efficiency of 75% and where the area of the roofs is about 200m^2 and the annual precipitation is 1454.8 mm, so the amount of water collected for each building is 283,686 L/year which is 11,626 L/unit/year; and this water could be used for flushing or irrigation. In the case of using drip irrigation, there will be a saving of about 28%, according to the results of LEED V4 outdoor water use reduction calculator; as the landscape water requirement will be 70,000 L/month; as given in Table 2.9.

2.5 Results

In New-Cairo case study, it was found that some strategies could be integrated to reduce indoor water use. The most effective strategy in reducing indoor water use was using efficient devices as this will reduce the actual water use by 34%, second was the graywater reuse for flushing by a

Fig. 2.7 Stormwater collection (Author, 2019)

Table 2.7 Actual water consumption/residential unit in condominiums E and G

Fixture type	Default-(s)	Baseline flow rate (L/m)	Design flow rate (L/m)	Default daily uses	Default water use (l/day)
Lavatory faucet	30	8.30	3.8	20	38
Showerhead	300	9.50	6	4	120
Kitchen faucet	60	8.30	3.8	12	45.6
Washing-faucet	60	8.30	3.8	4	15.2
Toilets		6&3 (l/flush)	6&3 (l/fush)	20 flushes	90
Total water consumption/unit (4 persons) = 308.8 L/day					

Table 2.8 Outdoor water consumption for the total landscape area for condominiums E and G

Landscape area (m^2)	Plant-type	Water requirement	Irrigation-type	Distribution uniformity	Water requirement (L/month)
600	Trees	Medium	Fixed-spray	65%	19,385
1000	Shrubs	Medium	Fixed-spray	65%	32,308
1400	Groundcover	Medium	Fixed-spray	65%	45,231
Landscape water requirement based on the site's peak watering month [liters/month]					96,923
Landscape water baseline					1,552,000
% Reduction from the baseline					94%

Table 2.9 Water needed for irrigation when using drip irrigation in condominiums E and G

Landscape area (m^2)	Plant-type	Water requirement	Irrigation-type	Distribution uniformity	Water requirement (L/month)
600	Trees	Medium	Drip irrigation	90%	14,000
1000	Shrubs	Medium	Drip irrigation	90%	23,333
1400	Groundcover	Medium	Drip irrigation	90%	32,667
Landscape water requirement based on the site's peak watering month (liters/month)					70,000
Landscape water baseline					1,552,000
% reduction from the baseline					95%

12.6% reduction in actual water use and third was rainwater harvesting for flushing by a 0.01% reduction in actual water use. And in the case of combining between using efficient device and graywater reuse for flushing; the savings will be raised up to 47%. For the outdoor water use, it was found that graywater could cover all the irrigation needs. When using plants with low water demand, replacing turf grass with ground-cover and using drip irrigation water savings will reach 48%. Rainwater harvesting from roofs could save about 5% and stormwater harvesting could save 30% of the water needed for irrigation.

In Paraisópolis case study, when comparing condominiums, A, B, C, D and F with condominiums E and G; it was found that there is about 40% reduction in indoor water use in addition to efficient management of stormwater in condominiums E and G. From the previous assessment it was found that graywater could cover 100% of the water needed for flushing and could achieve a 30% reduction from the total indoor water use. While rainwater could cover one third of the water needed for flushing and 10% from the total indoor water use. Furthermore; using efficient devices resulted in a 31% reduction from the total water consumption in condominiums E and G compared with the other condominiums. Using rainwater harvesting was found to be more efficient when used for irrigation as it could cover 100% of the water needed for irrigation, while graywater could cover 86% of it.

When comparing the results of the two case studies; it was found that the water consumption is affected by many variables like the water strategies used, social behaviors, country policies and regulations regarding water and climate. The actual water consumption/person in New-Cairo is 67% higher compared with the actual water consumption/person in Paraisópolis social housing. When comparing the efficiency of each water conservation strategy in reducing water use in the two projects it was found that there are some variances.

2.6 Discussion

Social housing projects deal with very limited resources and it's important to consider water conservation when developing such projects. But when resources conservation isn't considered and in an attempt to reduce the upfront costs in social housing, the selection of strategies doesn't always go hand-in-hand with achieving water efficiency or with minimizing environmental impacts. When analyzing the comparison between the two projects an important point must be considered; which is the global domestic production (GDP) to the average of water consumption/capita in each country as it reflects how critical the water situation is in each country. The GDP of Brazil is four times higher in Brazil than in Egypt while the average water consumption/capita is 2.5 times higher in Egypt compared with Brazil.

The results show that water efficiency isn't only affected by the technical aspects; but also by environmental, social and economic aspects, it's influenced by social behaviors, by climate, by technical ways used in the operation, by urban context, site selection and by the overall sustainability of the project. Urban choices and selecting the site of the project in a location with sufficient infrastructure to handle the load of the project is important to ensure a good water management in social housing projects. In the case study of New-Cairo; selecting the site in a location with some problems in the wastewater and stormwater systems resulted in water leakage and stormwater management problems in the project. In Paraisópolis case study, no problems regarding the water infrastructure appeared, this could be due to selecting the location in a pre-developed area with sufficient infrastructure. Furthermore, the urban design and the design of buildings affects the water consumption as providing shade for the façade and outdoor spaces helps in achieving thermal comfort and in reducing heat gain, and consequently reduces the need for using more water in hot days. In addition, reducing the impervious areas and increasing the green areas is effective in handling stormwater.

Although the areas of the residential units are different in the two case studies; but both residential units have an average of four people living in it, in addition to one kitchen and one bathroom. Using water pressure regulators, tap aerators and dual flushing helped in reducing the direct water use; in addition to using water meters which made the residents care more about the amount of water they use; contrary to what happens in New-Cairo social housing. Those measures adopted in the case study of Paraisópolis combined with the country's regulations made the residents more aware of the water situation. Differences in the climatic conditions between New-Cairo and Paraisópolis might also lead to this variability in the water consumption. For example, in New-Cairo the weather is hotter and more arid, which indeed leads to more water use, combined with some social practices like using excessive amounts of water for cleaning and some design aspects like not considering shading for the open spaces and treatments of facades to reduce heat gain.

For indoors; rainwater harvesting was more effective for indoor water reduction in Paraisópolis than in New-Cairo due to the climatic conditions and the rainfall patterns in each city. While graywater recycling had the same ability in the two case studies to cover all the water needed for flushing with larger impact in Paraisópolis social housing, as the water used for flushing represents 29% of the total indoor water use in Paraisópolis and represents 12.6% in New-Cairo social housing. Water efficient devices had the highest rate of water savings in the two case studies due to the average of water consumption in each project and the residents' awareness; but the savings were higher in Paraisópolis social housing.

For the outdoor water use in New-Cairo case study, the average water use/m^2 is about 6.5 L/month, and for Paraisópolis case study is about 32.3 L/month; although in the first case the reduction from water baseline is -157% and in the second is 94% but this depends on the rainfall patterns and the evaporation rates in each climatic zone. It was also found that for the case study of New-Cairo, graywater could cover all the irrigation needs, while rainwater harvesting in Paraisópolis is more efficient than in New-Cairo and drip irrigation could have an average savings of 30% in the two projects. The efficiency of graywater recycling is higher in New-Cairo social housing, but this doesn't mean that it's better; but it reflects the high water consumption as the more water you use the more graywater you will have. Furthermore; the amount of stormwater, which could be collected is higher in New-Cairo social housing and could cover all the irrigation, this also doesn't mean higher efficacy but it reflects the effect of the large impervious areas which lead to more runoff.

For the case study of Paraisópolis in condominiums E and G, the average water consumption/person in indoors is considered optimal. Rainwater and stormwater management is achieved through green areas and a rainwater retention system, but using graywater for flushing and rainwater for irrigation will improve the efficiency and reduces the loads on the water infrastructure. Rainwater for irrigation will not require much fittings as the rainwater retention system already exists; while adopting a graywater recycling system for flushing will make the water consumption/person/day about 55 L.

In order to improve water efficiency in the case study of New-Cairo it's recommended to use graywater for irrigation in addition to integrating between using water efficient devices and reusing graywater for flushing in indoors, this can reduce the average water consumption to 113 L/person/day. In the case study of New-Cairo; harvesting rainwater and stormwater would not be very efficient due to the climatic aspects, so it's recommended to improve the quality of the open spaces and adopt green infrastructure solutions to manage rainwater and stormwater like green roofs and bioswales, which will also improve the environmental aspects and reduce heat gain in the open spaces. In addition to using water efficient technical strategies, there is a need for raising the residents' awareness about the importance of reducing water use. There is a need also for implementing some environmental solution for the building design to reduce the heat gain through facades and get benefit of the high solar radiance in the location by using solar energy for heating water. Furthermore, using water sub-metering is necessary as an incentive way to make people use less water; even though it doesn't have direct impact on the water consumption but it affects the people's behaviors. In addition to this, using leakage sensors will save water, time and energy as it reduces the effort needed to detect leakages (Figs. 2.8 and 2.9).

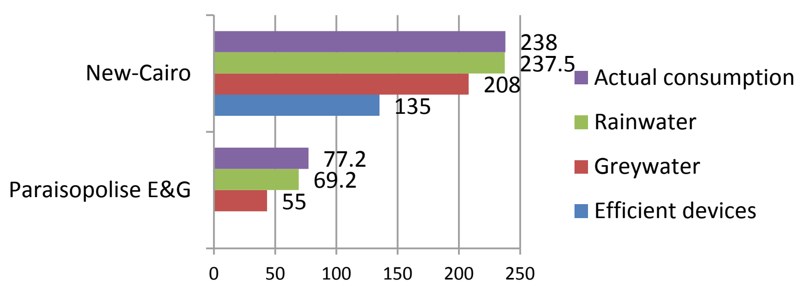

Fig. 2.8 Water consumption in liters/person when using conservation strategies (Author 2020)

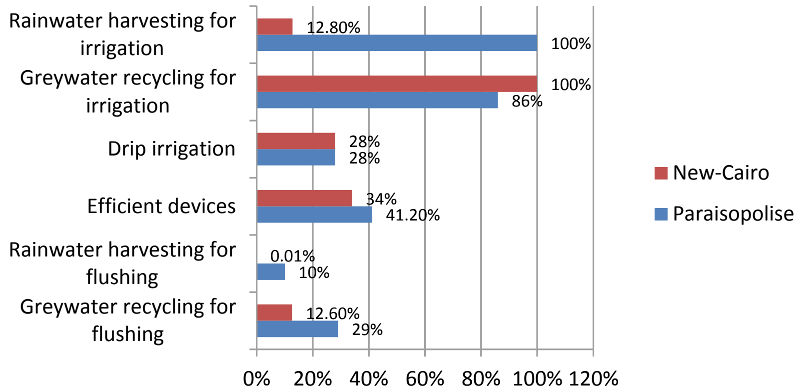

Fig. 2.9 % Water reduction when using conservation strategies (Author 2020)

2.7 Conclusion

The whole country's policies and regulations regarding water are reflected on the water consumption of people. In Egypt and Brazil, where water scarcity is threatening their future; adopting water efficient strategies are of main interest; while in Brazil there are some examples of water conservation in Egypt, the situation is still unsatisfactory. From the assessments of the two case studies, it was found that each project has its own opportunities and challenges depending on environmental, social and economic aspects.

Achieving water efficiency in social housing projects in developing countries; requires co-operation between people, architects and duty bearers. Generally, integration between more than one water efficient strategy and integrating green infrastructure enhances the sustainability of the project on the environmental, social and economic levels. Environmentally, the reduction in water use will lead to a reduction on the pollutants held to freshwater resources; also using green infrastructure will improve the efficiency of the indoor and outdoor spaces. Socially, water conservation strategies will help in raising awareness among people about the importance of rationalizing consumption and its effect on the project particularly and on water resources globally. Economically, adopting water conservation strategies will reduce the demand on freshwater resources and the load on the waste water system and consequently the load on energy; this will also reduce the maintenance costs.

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3 Sustainable Infrastructure and Water Strategies for a Resilient Addis Ababa (Ethiopia)

Ruben Garcia Rubio, Alec Paulson, and Sonsoles Vela Navarro

Abstract

The capital of Ethiopia, Addis Ababa, is one of the fastest-growing cities today, experiencing rapid urbanization over the past few decades. The city's population has almost doubled from 2.7 million in 2007 to around 4 million today. With such unprecedented growth, sustainable development in the city has been compromised as existing infrastructures struggle to keep up, leaving much of the urban population with a lack of access to basic public services. With that, the network of rivers that run through Addis Ababa has deteriorated as modernization has increased pollution and the overall degradation of river ecologies. Coupled with the rising threat of climate change, inhabitants who live along those rivers increasingly suffer from flooding and other issues related to worsening weather patterns. This paper details the outcomes of the "Addis Ababa River City" research project, which seeks to resolve some of the most urgent urban issues that the city currently faces due to rapid growth. Within it, urban issues are analyzed, and holistic solutions are proposed to create a more resilient city and to improve the relationship that Addis Ababa has with its rivers. The interventions introduced in this paper serve as examples of what can be done to improve infrastructures throughout the city, applying ecological engineering with hybrid infrastructures that work in tandem to enhance sociocultural programs and reinforce the natural dynamics of the city's rivers.

Keywords

Climate change · Resilient urbanism · River management · Sustainable infrastructure · Addis Ababa

3.1 Introduction

Throughout known history, rivers have provided civilizations around the world with the ability to flourish and expand to new heights. Cities have used nearby rivers to stimulate their economies through commerce while also providing them with a water supply for irrigation, sanitation, and industry.[1] Today, the relationship between cities

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[1] Yu Fang, et al., "Globally universal fractal pattern of human settlements in river networks," *Earth's Future* 6, (2018): 1134– 1145. Jordan, Jan M., "The Uses of River Water and Impacts," in *Fresh Surface Water*, vol III, ed. James C. I. Dooge (UNESCO-EOLSS: Paris, 2009). Adeloye, Adebayo, "Rivers and Human Development," in *Fresh Surface Water*, vol III, ed. James C. I. Dooge (UNESCO-EOLSS: Paris, 2009).

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and their rivers is changing as modernization allows for unprecedented growth, affecting the ecologies and dynamics of the rivers that support them.[2] With climate change becoming an ever-pressing situation, today's cities must adapt to the increasing severity of weather patterns and natural disasters, particularly river cities where flooding occurs more regularly.[3]

The capital of Ethiopia, Addis Ababa, has expanded significantly over the past decades, both in terms of population size and land coverage. It is estimated that the city has almost doubled its population, a range between 3.6 and 4.4 million inhabitants in this millennium.[4] Also, the capital city has seen its built area increase by more than 50 percent over the last few years.[5] However, the urban's supporting infrastructure has been unable to keep up with the city's explosive growth demand. As a result, residents of Addis Ababa suffer from a series of issues stemming from the city's growth coupled with the dynamics of its unique geography.

A particular feature in Addis Ababa is the network of small rivers that weave through it. Most of them are tributaries of the Akaki River, which itself branches off into both the eastern and western areas of the city. These rivers present their own challenges to the city as Addis Ababa continues to grow around them while failing to address the inevitabilities of expanding so closely to their banks.[6] With climate change becoming a more pressing issue, the relationship between the city and its rivers only continues to deteriorate.[7] If conditions in Addis Ababa are not improved, both the city and the ecology of its environment will continue to suffer.[8]

This paper unfolds part of the Addis Ababa River City research project.[9] The methodology used for the project began with researching and identifying the major problems the city currently faces due to its explosive growth and subsequent environmental impacts and infrastructural shortcomings. The city was then mapped out to understand better the current conditions, including public transportation, neighborhood characteristics and programs, and existing infrastructure. Once the dynamics of the city were analyzed, specific areas for intervention were identified. An iterative design process followed to create new hybrid infrastructures (by exploring precedent studies and analysis of the daily lives of Addis

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[3] Martin Richardson, and Mikhail Soloviev, "The Urban River Syndrome: Achieving Sustainability against a Backdrop of Accelerating Change," *International Journal of Environmental Research and Public Health* 18, no. 12 (2021): 6406.

[4] Central Statistical Agency, *Projected Population of Ethiopia—2011* (Addis Ababa: Central Statistical Agency, 2019), https://www.statsethiopia.gov.et/population-projection/; United Nations, Department of Economic and Social Affairs, Population Division, *The World's Cities in 2018: Data Booklet,* ST/ESA/SER.A/417 (New York: United Nations, 2018), 10, https://digitallibrary.un.org/record/3799524?ln=en; Elias Yitbarek Alemayehu, Imam Mahmoud Hassen, Yonas Alemayehu Soressa, and Laura Stark, "New Perspectives on Urban Transformation in Addis Ababa," in *The Transformation of Addis Ababa: A Multiform African City*, ed. Elias Yitbarek Aemayehu and Laura Stark (Newcastle upon Tyne, UK: Cambridge Scholars Publishing 2018), 2.

[5] UN-Habitat, *The State of Addis Ababa 2017: The Addis Ababa We Want* (Nairobi: UN-Habitat 2017), 73–74.

[6] Ruben Garcia Rubio and Taylor J. Scott, "Resilient Urban Ecologies: Adaptive Sustainable Infrastructures for Addis Ababa," *The Plan Journal*, vol. 5, no. 2 (December 2020): 473–94. Ruben Garcia Rubio, and Sonsoles Vela, "Rivers for Urban Regeneration. The Case of the Kebana River in Addis Ababa (Ethiopia)," in *Global Village, Shelter for Resilient Living, Conference Proceedings,* edited by Tatjana Mrđenović (Belgrade, Serbia: Faculty of Architecture in Belgrade), 144.

[7] Paolo Billi, Yonas Tadesse Alemu, and Rossano Ciampalini, "Increased frequency of Flash Floods in Dire Dawa, Ethiopia: Change in Rainfall Intensity or Human Impact?," *Natural Hazards* 76, no. 2 (March 2015): 1373–94; Bisrat Kifle Arsiso, Gizaw Mengistu Tsidu, Gerrit Hendrik Stoffberg, and Tsegaye Tadesse, "Influence of Urbanization-Driven Land Use/Cover Change on Climate: The Case of Addis Ababa, Ethiopia," *Physics and Chemistry of the Earth* 105 (2018): 212–23.

[8] UN-Habitat, *The State of Addis Ababa 2017*, 73.

[9] The "Addis Ababa River City" is an academic, independent, multidisciplinary, and long-term research project lead by the Assistant Professor Dr. Ruben Garcia-Rubio, which is part of the Saul A. Mintz Global Research Studios, within the Tulane School of Architecture (Tulane University—New Orleans LA, USA).

Ababa residents) to improve the city and promote its resiliency within the city.

The following text analyzes some of the critical urban issues that Addis Ababa is currently confronting while also proposing theoretical solutions for how they might be addressed. This paper aims to establish design ideas for specific interventions that can be applied in Addis Ababa through comprehensive, sustainable architecture, combating identified urban issues, and setting an example for other developing cities experiencing similar problems. Because of the range and complexity of challenges the city faces, a holistic solution is needed where conditions can be improved for both residents and their surrounding environment. The intervention described in detail later in this paper provides a solution in the form of hybrid infrastructures which address multiple of the UN's Sustainable Development Goals, overcoming issues related to a lack of mobility, flooding, pollution, and more. The resulting design sets an example of how multiple sustainability issues can be mediated as a whole to create a more resilient city.

3.2 Diagnosis and Urgent Urban Interventions for Addis Ababa

The first step in the research was a holistic analysis of the current situation in Addis Ababa.[10] This analysis unfolds several issues, five of which were determined to be the most urgent and able to be addressed through urban and architectural design.

3.2.1 Lack of Mobility

The Upper Kebena river suffers from connectivity issues due to insufficient infrastructure for a rapidly growing city.[11] Along the northern regions of the river, where most residents walk as their primary source of transportation, there is little access to public transportation services forcing residents to walk on roads unfit for pedestrian travel.[12] Public access to the river is waning as the city grows. Homes are built close to the river, creating barriers to water access for most of the city. Walls and fences are also being put in place along the river in addition to the already steep slopes that exist along much of it.

Bridges exist throughout the city that allow for access across the river. However, most exist downtown, where vehicle travel is predominant. Other city regions lack bridge connections, which limits the mobility of many residents to other communities across the region, particularly those on foot. Due to the overall lack of connection through the rivers, the Upper Kebena river misses opportunities for better connectivity and mobility across the city and sufficient public access to the river.

3.2.2 Flooding

Due to rapid urbanization and the unfortunate realities of climate change, Addis Ababa has been increasingly suffering from flooding issues in recent decades, which has interfered with the city’s continued development.[13] Being a city full of small rivers and tributaries, Addis Ababa's urbanization has negatively impacted the natural dynamics of its waterways and the permeability of much of the city's ground surfaces, both crucial aspects of natural water management.

[10] Ruben Garcia Rubio, and Taylor J. Scott. “Resilient Urban Ecologies: Adaptive Sustainable Infrastructures for Addis Ababa,” 477–83.

[11] Clelie Nallet, “The Challenge of Urban Mobility: A Case Study of Addis Ababa Light Rail, Ethiopia,” Institut Français des Relations Internationals—Notes de l’Ifri, February 2018, https://www.ifri.org/en/publications/notes-de-lifri/challenge-urban-mobility-case-study-addis-ababa-light-rail-ethiopia.

[12] The World Bank,*Transport Systems Improvement Project* (Washington, D.C.: World Bank Group), http://documents.worldbank.org/curated/en/490361467992052159/Ethiopia-Transport-Systems-Improvement-Project.

[13] UN-Habitat, *The State of Addis Ababa 2017: The Addis Ababa We Want* (Nairobi: UN-Habitat, 2017), 73. Ruben Garcia Rubio, and Taylor J. Scott. “Resilient Urban Ecologies: Adaptive Sustainable Infrastructures for Addis Ababa,” 473–76.

Many people in the city live in poorly constructed informal housing that is built close to the bank, mainly due to a lack of space from the rapidly growing population of the city.[14] This housing contributes to erosion along the banks and covers much of the necessary green space along the river needed for ground absorption and flood protection. Because of this, informal neighborhoods are particularly susceptible to fluvial flooding as the winding meanders of the river frequently overflow in the wet season.

3.2.3 Pollution

The natural geography and rivers flowing through Addis Ababa had historically spurred the development of settlements that eventually became the city we know as the capital of Ethiopia today. Despite this, the bodies of water responsible for the inception of civilization in the area have been neglected, becoming open trash dumps in many instances throughout the city.[15]

While the city has increased around these rivers, the waste management infrastructures have not kept pace. With an incomplete sewage network, an inadequate solid waste management system, domestic organic matter discharge, industrial leakage wastes, agricultural and washing outflow among the city's most common waste sources, rivers today have become unfit for necessary uses like cleaning, cooking, or washing.[16]

[14] Raffaele De Risi, et al., “From Flood Risk Mapping Toward Reducing Vulnerability: The Case of Addis Ababa,” *Natural Hazards* 100, no.1 (December 2019): 387–415.

[15] Ruben Garcia Rubio, Ryan Green, and Sonsoles Vela, “Nature-Based and Hybrid Infrastructures to Build Resilient Cities through the Rivers: Two Case Studies in Addis Ababa (Ethiopia),” in *Proceedings of the ARCC-EAAE 2022 International Conference—Resilient City: Physical, Social, and Economic Perspectives*, edited by Chris Jarrett, and Adil Sharag-Eldin (Architectural Research Centers Consortium), 82–83.

[16] Tamiru Alemayehu, “The Impact of Uncontrolled Waste Disposal on Surface Water Quality in Addis Ababa, Ethiopia,” *Ethiopian Journal of Science* 24, no. 1 (2001): 93–104.

3.2.4 Water Scarcity

Addis Ababa's existing water services are also under stress because of the city's rapid growth. While over 90% of the city has water coverage, certain areas on the outskirts have only occasional access to water due to the rising demand for housing in the city.[17] Some sub-cities have access to water for only 12 h, three days a week or less.[18] With that, wastewater management is lacking, with about half of the residents using a shared pit latrine, about 18.3 percent using private pit latrines, and 26.4 percent using flush toilets, including pour flushing.[19] Much of this waste is improperly transported and disposed of due to a lack of proper desludging services, leading to significant sanitation issues.

In addition to this, Addis Ababa's sewer system is more or less obsolete, only serving about 10 percent of the population.[20] Many neighborhoods have no access to water taps with little to no infrastructure in place to support the movement of sanitary water. Due to the lack of pipes, people sometimes utilize personal wells or water towers; however, these serve as their own private water supply and do not support surrounding neighbors. The little infrastructure that does exist in the city is old and in desperate need of renovation.

3.2.5 Lack of Facilities

With the lack of infrastructure throughout the city, there is also a general lack of public facilities for residents. This includes services like public restrooms, proper trash collection, etc. As these necessary facilities are rarely provided, the lack thereof contributes to other issues, such as the pollution of rivers and health problems because people have little means of properly

[17] International Development Association, *Ethiopia—Second Ethiopia Urban Water Supply and Sanitation Project* (Washington, D.C.: World Bank Group, 2017), 1–5.

[18] Ibid.

[19] Ibid.

[20] Ibid.

disposing of waste. Additionally, a sizable portion of Addis Ababa's occupation is comprised of informal trade; however, other than a few larger markets, there are few convenient places designated for people to sell goods and produce. Affordable housing is also scarce in the city, leading many to resort to building informal housing where they can. As discussed earlier in this paper, these informal settlements further contribute to the degradation of the river ecologies.

3.3 a Strategic Plan for the Upper Kebena River and Kazanchis Neighborhood

The research proposes a strategic plan for the Upper Kebena river, which starts in the northern part of Addis Ababa (Entoto Mountains), extending from the lower-density areas north, down southward to the higher-density areas around Peacock Park close to the city center.[21] The general plan uses the river to address the identified urban issues, improving the overall relationship between the city and its bodies of water, as it focuses on the ecology, mobility, and connectivity opportunities that a river regeneration could bring to the city. One neighborhood along the river that was selected as an appropriate example of how this strategic plan works is the downtown Kazanchis neighborhood. Here, there are opportunities to improve conditions concerning the UN's Sustainability Development Goals (SDGs). More specifically, the strategy addresses clean water and sanitation; innovation and infrastructure; sustainable cities and communities; responsible consumption and production; zero hunger; decent work and economic growth, and climate action (Fig. 3.1).

The Kazanchis neighborhood lies between Kenenisa Ave and the A2 highway and is bisected by the Kebena river. Located downtown, this neighborhood was chosen as a site for further investigation and intervention due to severe flooding problems caused by the Kebena's natural meander in an area filled with informal housing settlements. The poorly constructed homes are built too close to the river and are unable to cope with the natural flooding that occurs in the area. They also contribute to the erosion of the banks, which only furthers the flooding issues over time (Fig. 3.2).

As was mentioned, due to the general lack of infrastructure throughout the city, the river acts as a barrier that divides the neighborhood. The only two bridges that span the river, both over 50 m, are busy roads designed with only vehicles in mind, making them unsafe for pedestrians. In a city where walking is the predominant means of travel, access across the river that caters to pedestrians should be essential. Moreover, as the city continues to grow, access to the river itself decreases, with homes being built too close to the river in addition to walls and fences being constructed along the banks. If people cannot use the water from the river, what incentivizes them to keep it clean?

3.4 Revitalizing the Meander, a Holistic Urban and Architectural Design

The intervention proposes the use of hybrid infrastructures in the Kazanchis neighborhood that span the Kebena river to create multifunctional points of connection across, while soft-ecological interventions such as meander diversions, gabion walls, riparian restoration, and more are strategically implemented to mitigate flooding along the river's banks. The hybrid structures are intended to serve first as-needed bridges for pedestrians that work as an extension to a proposed "green and blue" street typology strategy, discussed later in detail, while also providing additional programming where it's needed, most importantly, housing for those living in the flood-prone settlements on the banks (Fig. 3.3).

[21] Ruben Garcia Rubio, and Taylor J. Scott, "Designing for Sustainable and Resilient Neighborhoods: The Case of Peacock Park in Addis Ababa (Ethiopia)," in *2020 AIA/ACSA Intersections Research Virtual Conference: Carbon*, edited by Corey T. Griffin and Erica Cochran Hameen (Washington: ACSA Press), 82–89.

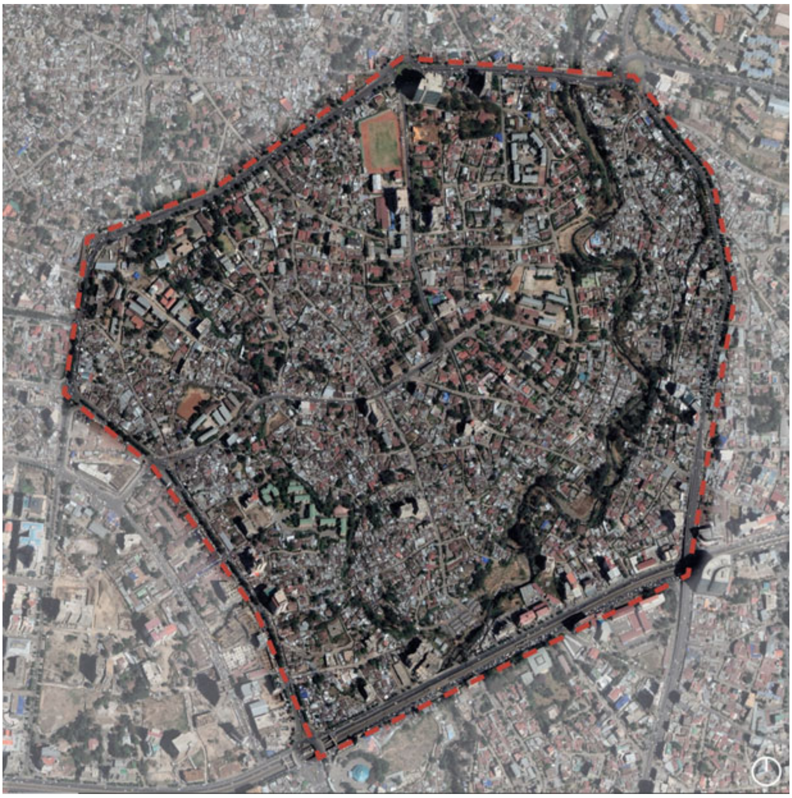

Fig. 3.1 Kazanchis neighborhood. Google Map (February 2022), edited by "Addis Ababa River City" (henceforth AARC)

Fig. 3.2 Strategic plan for Kazanchis neighborhood: Connection, Housing, and Flooding. Connection diagram (left): potential bridge connections across the river in red. Housing diagram (center): plans for new hybrid bridges in black, with proposed housing and other amenities. Flooding diagram (right): areas of predominate flooding along the river meander in blue. AARC

At a larger scale within the neighborhood, multiple structures are proposed at specific points along the river, determined to have the most opportunities considering the surrounding street layout and planned green street strategy. These nodes not only connect both sides of the river but also provide some form of amenities and/or utilities accessible to the public within the

Fig. 3.3 General axonometric, the extent of all interventions included within a hybrid bridge structure. AARC

structures. These include markets, public facilities, waste collection, compost, urban agriculture, and recreational green space to improve water-ground retention. By providing these needed programs at the connection points across the river, more significant interaction and access to both the connections and included programs are reinforced. Along with a slow mobility path that follows the river and strings them together, this network would enhance the walkability and usage for pedestrians who currently have limited access across the river.

At the building scale, one of these hybrid infrastructures was further designed as an example. The location was chosen where a large bend in the river creates about a five-meter disparity in elevations of each bank, causing significant flooding issues for the surrounding area. On the higher side, a steep drop to the river makes access to water challenging. On the lower side, poorly constructed homes frequently flood during the wet season due to a shallower bank and a lack of permeable ground. The proposed structure would become a multilevel bridge spanning the river, creating a seamless connection between selected streets on either side (Fig. 3.4).

The hybrid bridge is intended not only to function as a bridge but also as a neighborhood amenity, becoming a hub for pedestrian activity. On one side of the bridge, a marketplace is proposed as an entry point continuous with the existing street. While on the other, new housing relocates those prone to flooding. Additional arms extend off the bridge to further enhance connectivity along with the proposed mobility path, which stretches along the river. In addition, different ecological interventions are used throughout and around the site, including existing streets, to combat flooding in the area while cleaning the river.

The design of the regulated structural system allows for a variation in a form where multiple programs can be freely housed. Because informal trade is prevalent throughout the city, the market was chosen as the additional program to support the housing on the other side. According to a study conducted by the Ethiopia Microfinance Institution in 2002, about 50% of the active labor force in Addis Ababa was employed in the informal sector.[22] Coupled with the agricultural field proposed adjacent to the bridge, the marketplace creates an opportunity for those residents to sell locally grown produce, among other goods, at a central location. Together, the market

[22] Tekle Bekele Tekle, "Management of Informal Traders in Public Spaces: A Case Study of Megenagna Square, Addis Ababa, Ethiopia" (Research Project—Master of Urban Management, University of Nairobi, Nairobi, 2021), 12.

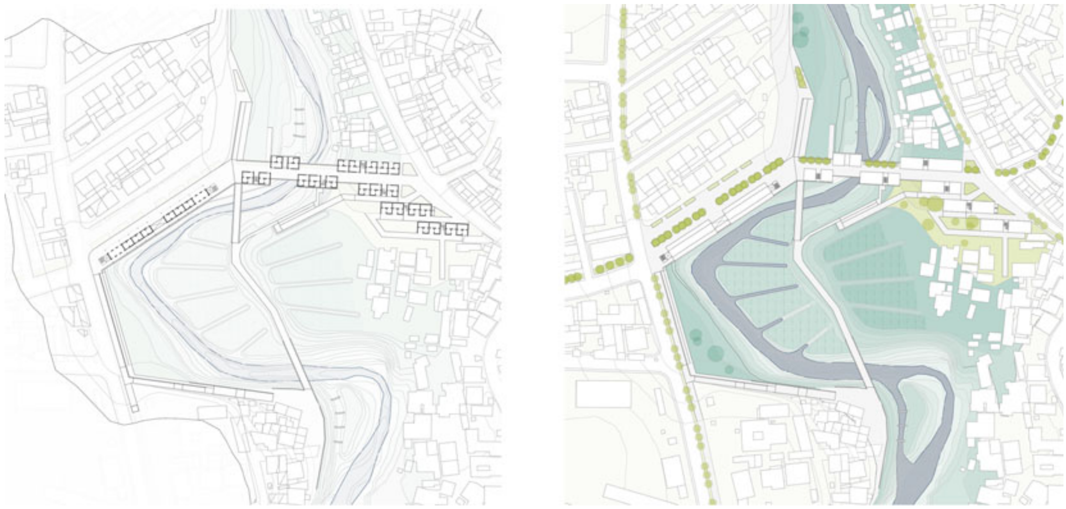

Fig. 3.4 General ground plan and flooding plan. Ground plan (left): the floor plan of housing and marketplace along with the river during normal conditions. Flooding plan (right): the site plan of the hybrid bridge structure and all included interventions shows the river during flooded conditions. AARC

and local agriculture work to enhance responsible consumption and production, zero hunger, a decent job, and economic growth.

The housing is intended to relocate those living in the informal settlements near the river, freeing up much-needed green space for water absorption and retention along the banks. These new homes would be more accessible to residents and of much greater construction quality, being built into the bridge's structure. Providing locals with proper housing that is safe from flooding and restoring the necessary green space for flood protection is an example of how the sustainability of the city and community can be reinforced throughout Addis Ababa.

The streets on either side that the bridge links are converted into “green and blue streets” that fit into the greater network of street typologies established at large throughout the strategic plan to improve clean water and sanitation and promote sustainable cities and communities. The blue street typology is proposed for larger main roads and focuses on wastewater management through above-ground sewer systems. Green streets are comprised of smaller streets that branch off the more significant blue streets. A portion of the street is allocated toward green space that takes the form of bioswales and other plantings, which are used for water filtration and managing runoff. The green streets are continuous over the bridge structure, providing ecological benefits while establishing a visual continuity across the river. The street connection across becomes the trunk of the bridge with secondary paths, then branching out into the surroundings. Certain routes connect to the lower levels of the structure where the slow mobility path intersects before continuing up the river. There is public access to the river on the lowest level, where locals can use the water (Fig. 3.5).

In the center of the river bend, a field of urban agriculture serves as the primary flood mitigation strategy at the river meander. When the river rises, water floods the trenches between the plantings, both retaining and filtering the water heading downstream while also irrigating the crops. A diverse range of crops would need to be used to create effective resiliency. After analyzing more than 150 experiments worldwide, the Union of Concerned Scientists determined that for the most outstanding efficiency, agricultural fields need to incorporate perennial crops in addition to

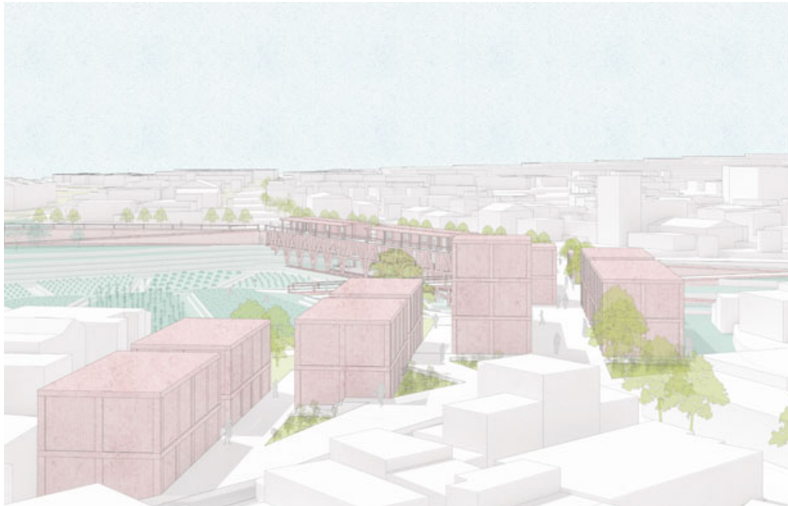

Fig. 3.5 Aerial general view, a perspective of the hybrid infrastructure from the housing. AARC

grasses and cover crops to ensure permanent land cover.[23] This increases crop water use efficiency by reducing runoff and contributing to soil improvements that create more water storage, in turn enhancing resilience to flooding.

River diversions are strategically placed at either end of the meander, bookending the agricultural field in the center. These diversions help to redirect water when the river rises to keep it from flooding the banks. While they only redirect the water when it reaches a certain level, the riparian buffer is restored within the diversions to enhance the deteriorating river ecosystem. According to the European Environment Agency's platform Climate-ADAPT, riparian vegetation alongside bodies of water reduces vulnerability to floods by protecting against sediment and pollutant runoff and increasing groundwater recharge.[24] This natural vegetation improves water quality and slows water flow during wet seasons. Additionally, gabion walls are employed at the meander diversions to filter the water further and prevent more significant pollutants from collecting. These walls are beneficial for erosion control and dissipating river energy during flooding (Fig. 3.6).

Using ecological interventions as simple as the examples above not only prevents flooding and erosion but also goes a long way toward promoting clean water and sanitation for residents in the city. Being a mostly "river city," Addis Ababa should look to its rivers not as obstacles to be built around but as opportunities to be integrated.

3.5 Conclusion

As urban issues are complex, multi-faceted solutions are necessary to address the problems emanating throughout our cities. Today, climate change has become one of the greatest threats to our future, impacting populations globally. Precisely, developing nations and those adjacent to bodies of water are predicted to see the most considerable negative impacts with weather patterns becoming more severe. As climate change worsens, further aggravating already existing urban issues, a rapidly growing city like Addis Ababa must become more resilient as it continues to expand. On top of that, with the unexpected COVID-19 pandemic that persists today, the need for well-designed public spaces is only

[23] "Turning Soils into Sponges. How Farmers Can Fight Floods and Droughts," *Union of Concerned Scientists*, August 7, 2017, https://www.ucsusa.org/resources/turning-soils-sponges.

[24] "Establishment and Restoration of Riparian Buffers," Climate ADAPT—European Environment Agency, September 3, 2016, https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/establishment-and-restoration-of-riparian-buffer-s.

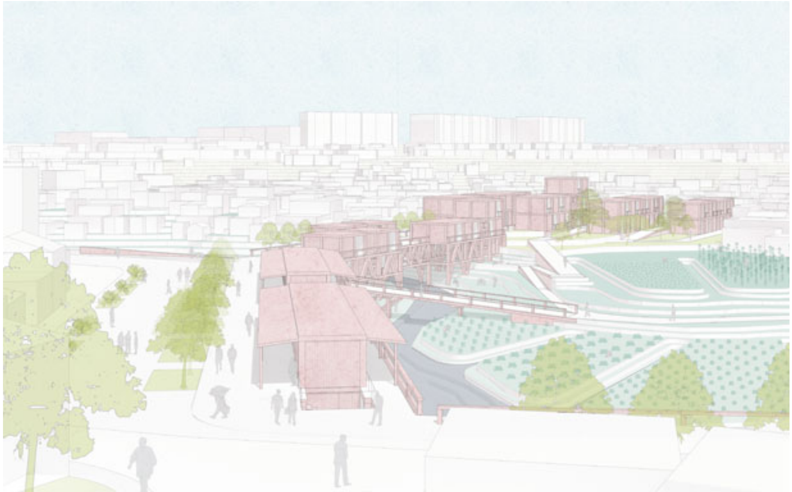

Fig. 3.6 Aerial general view, a perspective from the marketplace. AARC

becoming more apparent. Climate change or COVID-19 should not be seen as hindrances in future design but as opportunities to curb environmental and public health issues before they become emergencies. Efforts to create healthier cities for both their inhabitants and their environment should be prioritized as the new standard in design.

The objective of this paper is to outline proposed design measures resulting from the research done for the Addis Ababa River City research project. The specific intervention detailed in this paper for the Kazanchis neighborhood serves as an example of integrated designs that can create better-functioning, more sustainable cities while focusing on much-needed climate action. As existing systems fail to keep up with the demands of a growing city, Addis Ababa must look toward ecological infrastructures to remediate the pressures it has put on its environment and hinder the worsening effects of climate change. Specific measures, like the ones detailed in this paper, can be taken to curb issues relating to flooding, pollution, water scarcity, mobility, etc., while enhancing the public realm for city residents. Using hybrid-programing, multiple infrastructural and programmatic needs can be met where they are currently lacking and necessary, all within an active node that extends into its surroundings. Incorporating the rivers into design allows for passive strategies in cleaning polluted water bodies and enriching soils for farming, making them an essential part of urban living. Having these interventions work with the natural dynamics of Addis Ababa's landscape and waterways, rather than fighting against them, improves access throughout the city for those who need it, reduces the adverse effects that modernization and growth have had on the environment, and creates a more productive, resilient city for the future.

The ideas proposed in this paper are justifiable for progress in Addis Ababa. However, such comprehensive designs are primarily based on theory. For actual development to occur, greater political and economic strategies for implementation would be necessary. The residents of Addis Ababa would be unable to execute on their own so government involvement would be required. As land in the city is predominantly state-owned, a viable first step could include government action in terms of constructing new bridges spanning the river. Because hybrid infrastructures are at the center of this proposal, this would be the necessary catalyst for developing the sustainable strategies detailed in this paper. At worst, new bridges that enhance connectivity in Addis Ababa would be created, connecting neighborhoods across the river. At best, funding through the private sector could take the next step to improve these bridges, making them genuinely hybrid and allowing other programs that have been described above to be included, such as housing. Because the government presumably lacks adequate funds to conceive the entirety of this project, private institutions would likely be necessary. For example, affordable housing rent could generate income to continue the development of hybrid bridges and gradually include more interventions over time, such as the marketplace, agricultural fields, and other ecological infrastructures. Such inclusive involvement could bring the ideas of this project into fruition, steadily improving the resiliency, sustainability, and overall conditions of Addis Ababa and achieving progress toward the UN's Sustainability Development Goals in the city.

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4 New Water Village Planning Model: Preserving Ocean Biodiversity for Community's Health and Well-Being

Muhammad Adham Nor Efenday, Rahinah Ibrahim, Harhamsah Hairal, and Anna Kamelia Kamarudin

Abstract

Malaysia is one of the eleven countries in Southeast Asia. Long-term sewerage pollution is a source damaging 90% of coral reeves by 2050. Decades of untreated sewage pollution also exposes children living at water settlements to water-borne diseases. This paper proposes a new water village planning model for Malaysia which could empower the local community to pay for sanitation management through architectural provisions, hence could generate ecotourism revenue. This study combines results from three earlier studies on Lok Urai, a water village located in East Malaysia. From these studies, incorporation of ISTP wastewater treatment tanks must come with viable economic activities; the architectural solution must include related microarchitecture to support homestay activities; and the local community desires to develop a homestay program to improve their livelihood. The architectural aim is creating opportunities for water villagers to self-finance Lok Urai's sanitation provision and maintenance. This study posits that microarchitecture for small enterprises and combined with a well-planned homestay program are suitable amenities to attract tourists to stay with local families at Lok Urai. The proposed model consists of 98 housing units planned with twelve clusters of homestay units that will support the community to pay for their sanitation management and stop sewage pollution from spreading water-borne diseases. A viable water village model is replicable to 25,000 islands in Southeast Asia.

Keywords

Water security and health · Water village planning model · Sanitation management · Ecotourism · Ocean biodiversity

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4.1 Introduction

Malaysia is one of the eleven countries in Southeast Asia. It has a population of 31.4 M. The country is divided into two parts: Peninsula Malaysia and East Malaysia. Sabah and Sarawak are two Malaysian states located on Borneo Island, one of 25,000 islands in Southeast Asia

A. Hasan et al. (eds.), *Design for Health*, Sustainable Development Goals Series,
https://doi.org/10.1007/978-3-031-36316-0_4

(See Fig. 4.1). Based on the World Health Organization (WHO 2023) report, 494 million people still defecate in the open such as in open bodies of water. 90% of Southeast Asian coral reeves are expected to die by 2050 if the countries did not take any actions (Becatoros 2017). Unlike open defecation in rural villages that are causing infestation of intestinal worms (Lim-Leroy and Chua 2020), the same is affecting spread of diarrheal diseases such as cholera and dysentery at water villages (WHO 2023). With water pollution, the human heart and kidneys can be adversely affected if polluted water is consumed regularly (Afroz et al. (2014). In addition, raw sewage is discharged directly into the sea are mixing with household trash and plastic debris. The outbreak of water-borne diseases like skin disease, diarrhea, and dysentery is inevitable (Haque et al. 2010). A major cholera outbreak among the sea gypsies happened in Sabah in 2014 (Jikal et al. 2019) and as recent as in 2020 (Vanar 2020).

In a satellite study by Evers (2015) on water settlements on Borneo Island, he documented 10,000 water homes in Sabah. Nor Efenday (2022) reported there were more than 1100 houses located in Lok Urai village alone. Lok Urai has no beach frontage as seen in Fig. 4.2. It is located in the vicinity of Tunku Abdul Rahman National Park and the residents are active in coastal activities including diving, snorkeling, island hopping, and deep-sea fishing. Their houses are traditional wooden homes built on pillars erected on the ocean floor (See Fig. 4.3) and the water environment is where the children of Lok Urai play and grow up (See Fig. 4.4).

The whole of Lok Urai was gazetted by the Kota Kinabalu City Hall which saw the whole village bounded into one piece of marine land. The gazetted land made the head of village a person of authority who decides the location of new homes to be built within the gazetted land. Interviews with the locals found the water homes would be passed down from parents to children. The traditional wooden homes are built on pillars erected on the ocean floor. The houses seem unorganized because their foundations followed the topographical contours in the seabed below the homes. It is common for immediate and extended families to stay together in one house resulting in more than seven people living

Fig. 4.1 Location map of Malaysia within the Southeast Asia region. Malaysia is divided into Peninsular Malaysia and East Malaysia consisting of Sabah and Sarawak states. Lok Urai water village is located on the east coast of Sabah. *Source* Google Map

Fig. 4.2 Satellite image of informal settlement at Lok Urai village, Sabah, Malaysia. *Source* Google Map

Fig. 4.3 Homes and boat jetties are made of timber materials. *Source* ACT Malaysia

Fig. 4.4 Sabah, Malaysia. *Source* ACT Malaysia

together (Said 2011; Kraus et al. 2016; Mohd Zaini and Ibrahim 2021). The placement of residences with various docks in the South China Sea promotes fishing and travel to the mainland. The jetty and docks are the main gate to enter each block in the Lok Urai village. The arrangement of the jetty (called as bridge by the locals) varies as some are located at an axis and some are not.

Unstructured (informal) human settlements are usually defined as dense settlements comprising communities housed in self-constructed shelters under conditions of informal or traditional land tenure (Acqua et al. 2006). If informality is the characteristics of Lok Urai, it is merely the results of how the head of village would allow families to build their homes within the Lok Urai village boundary. Another criteria of informal settlement is higher density, but for water settlements such as Lok Urai, that high density is due to the number of persons per household which could range from an average of six to fourteen persons.

Lok Urai has water and electricity provided by the local utility companies to legal Malaysian residents. As families tend to live close together, many households are sharing the utility points with their neighbors. Unfortunately, the most critical utility service not available at Lok Urai is the sewerage treatment service (Mohd Zaini and Rahinah 2021). All the homes at Lok Urai village are currently disposing their feces directly into the ocean below their homes. Despite this dire need, majority of the water villagers cannot afford to purchase their own sewerage treatment system or the local authority could not provide a standard sewerage treatment system until today.

The purpose of this study is to present a creative architectural solution—the consequential response to findings from selected earlier studies conducted by the authors. The architectural aim is creating opportunities for water villagers to self-finance Lok Urai's sanitation provision and maintenance. This project supports a symbiotic collaboration between communities and local service providers to build a community on social capital as mooted by Mitlin and Bartlett (2018). This study is limited to proposing a feasible new water village planning model that would allow water villagers to pay for their own sanitation maintenance from a homestay program and home-based micro businesses.

4.2 Materials and Methods

4.2.1 Materials

Smart Sanitation for Water Settlements Program: The first project is called the Smart Sanitation for Water Settlements (SSWS) Program (Ref. UNEP/SSFA 3036). It was a small pilot project sponsored by the United Nations Environment Program (UNEP) in collaboration with a civil society organization, Action Caring Team (Malaysia) Berhad or ACT Malaysia. The pilot project was recognized by the United Nations as one of the SDG Good Practice Project (Department of Economic and Social Affairs, United Nations 2021). Visits to study the water settlements' architectural typology in Sabah in 2011–2013 had led to a shocking discovery that the homes were not connected to any kind of sewerage treatment plants. Similarly, too, the water village of Lok Urai has about 1100 homes with neither centralized nor independent sewerage treatment system. The water village households are too poor to purchase their own treatment tanks. The study reported unexpected benefits to the women and girls living at the water village. Interviews with the women and girls in the households revealed feeling unsafe when using their present toilets, and more so during their menstrual cycles.

The pilot project found no one to blame for, especially the local authorities, for not prioritizing sanitation for Lok Urai and other water settlements by the state of Sabah per se. In fact, various local governments in Sabah have made many attempts to provide sewerage treatment systems to water villages in their jurisdictions. Their installations failed to withstand the twice-daily water level changes between 1 and 1.5 m. Flushing from the toilets have little water to carry sewage water over long distances causing blockages that are difficult to detect in the long plumbing system. In addition, the timber pillars supporting the houses have limited capacity to structurally support a 2000 L sanitation system. In lieu of these geographical challenges, researchers at Universiti Putra Malaysia (UPM) had come up with a sewerage treatment solution that is modular, small in size, and effective with minimal piping connections. Most importantly, the local community could learn how to install and maintain the system on their own.

UPM's innovation has two detachable modular parts totaling 350 L working volume. The small size and detachable features allow easy handling when the water villagers are transporting and maneuvering the parts among timber columns beneath the homes. The technology eliminates long connecting pipes to the treatment tank. Once attached, the tank functions like a mini sewerage treatment plant that has three anaerobic–aerobic-anaerobic chambers and treats the sewage for a total of 7 h before being discharged as Standard A effluent into the ocean below. For 6 h aeration, the effluent data measure 11.60 mg/l for BOD_5 51.88 mg/l for COD, 12.50 mg/l for TSS, 2.48 mg/l for AN, and 7.03 pH (Mazandarani 2016). Figure 4.5 is the conceptual diagram showing treatment process for the technology, and Figure 4.6 shows how the

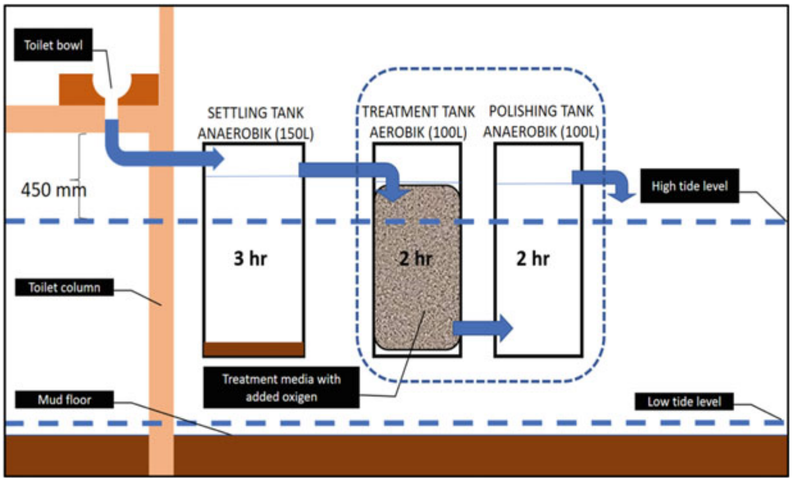

Fig. 4.5 Conceptual illustration of the IST sewerage treatment process. *Source* Rahinah Ibrahim, Universiti Putra Malaysia

Fig. 4.6 One ISTP tank after installation below a toilet at Lok Urai water village. *Source* ACT Malaysia

assembled ISTP tank below a toilet at a water home.

Results from the pilot project pointed to several urgent issues that must be addressed for the larger goals concerning the health and well-being of the water villagers and ocean biodiversity preservation in general. Firstly, the local and international standards for designing a five-member household sanitation system did not work at all at Lok Urai. It turned out that an average household could range from six to fourteen household members. Secondly, the villagers were not used to using water for cleansing since they could simply "drop" their feces directly into the ocean below their toilets. Thirdly, the water villagers were not keen on paying anything extra for a sanitation service from their hard-earned income. Upon cross-checking with the local authority, the authority realized that the Kota Kinabalu City needs a new guideline for sanitation management specifically for its water settlements along the coastal areas. Lessons gleaned from the initial pilot project are recommended to guide the development of a new guideline for sanitation management. In order to optimize any future guideline recommendations, this study proposes a design and planning feasibility study which would take into consideration the sociocultural behavior of the Lok Urai villagers, besides documenting the extent of their desire to maintain the new wastewater treatment technology in place.

Socio-economic Microarchitecture in Water Settlement: The second study from an architectural dissertation project (Nor Efenday 2022; Nor Efenday et al. 2022) on socioeconomic microarchitecture had recommended development of homestay activities for the water villagers. His dissertation attempts to understand the needs of water villagers and how microarchitecture could help in supporting revenue generating activities for them. The project proposes that "microarchitecture for small enterprises are suitable amenities to maximize customer access hence increase income to households at water villages." "Microarchitecture" refers to the way resources are structured in connection to design and development in a given setting such as a suburban region (Tazilan et al. 2008). Similarly, the presence of traditional street vendors at Lok Urai such as ice sellers, noodle sellers, local delicacies, and "nasi lemak" sellers could form microarchitectural typoscape. With street merchants are familiar scenes along Malaysian streets, this microarchitecture concept at Lok Urai village would allow family-owned small businesses to improve their incomes for their households.

Several types of enterprises were identified by the Lok Urai villagers in Nor Efenday et al. (2022) study. 90% of respondents strongly agree in developing fish and marine resources farming at Lok Urai village to provide food and income to their households. Another prospect is fish drying where wider walkways and public spaces could be used for the activities. 78% of respondents support turning Lok Urai into a tourist destination to boost the locals' standard of living. The homestay program is one of Malaysia's newest tourist attractions that is well-liked in many of the rural regions. Visitors can experience the host community's way of life and culture when they live with the adopted families (Ramele et al. (2017). Under the Ministry of Rural Development or the Ministry of Tourism, Culture and Environment of Sabah, the homestay programs can help rural communities flourish while preserving their cultural, historical, and environmental legacy. Being located adjacent to the Tunku Abdul Rahman National Park is an advantage for Lok Urai. 90% of respondents strongly agree that participating in an entrepreneurial training and coaching program could better prepare the community for participating in the tourism economy. 100% of respondents agreed that the women in Kampung Lok Urai could contribute to the household income by running a small business industry from home. Commercial operations such as selling snacks and soft drinks can be accessed by customers through a small grocery store near a house's main entrance. From there, one can earn a living and support the family.

Homestay Program and Community Participation at Lok Urai: The third study is a master's thesis (Hairal 2021) which specifically evaluated whether a homestay program is feasible at Lok Urai and how the villagers can work together to make it successful. The criteria for working together as a community is critical for a homestay program and so does the participation of every member of the community. The implementation of the homestay program is expected to elevate the state's economic income and also help in increasing the level of socio economy for those who participate in them (Ramele et al. 2017). Among the successful homestay programs in Malaysia are community-based tourism, rural tourism, cultural tourism, sustainable tourism, and special interest tourism (Ramele et al. 2017). All homestay programs in Malaysia welcome tourists to stay with families in the villages and participate in the rural community activities. In contrast with most sites, Lok Urai village is literally built over a water body.

Janjua et al. (2021) stated many researchers from developing countries are working on community-based rural homestays. Despite their efforts, their study found prior researchers lacking in homestay entrepreneurship and homestay development for sustainability. Another study by Mohamad and Nasir (2019) describes motivation competency is the main factor contributing to the sustainable entrepreneurship in Terengganu and Pahang while the opportunity competency is the main factor contributing sustainable entrepreneurship in Terengganu. Both studies found financial sustainability is critical to sustain the respective communities. Therefore, this current study is recommending that future planning of homestay program at water village shall include the need to preserve their natural environment against sewage pollution besides the global awareness on plastics waste as a motivation for water communities.

Hairal (2021) conducted a survey on 150 respondents involving the head of households or their representatives and further in-depth interviews of fifteen informants (or village stakeholders) to ascertain the water villagers' commitment. Results showed 67.33% or 101 villagers agreed to participate in a homestay program.

> …iya in shaa Allah ahli keluarga saya menyokong ini buat homestay sebab dia mendatangkan hasilkan, lagipun saya sendiri memang mau ada satu ini homestay…
> …yes, if Allah wills my family supports this homestay program because it will provide us income, I myself really want to have one homestay… (Hairal 2021)
> ...penduduk kampung bersedia membangunkan program homestay di mana pembukaan homestay tersebut akan membuka peluang pekarjaan dan daya tarikan kampung…
> "…the villagers are ready to develop this homestay program in view that the homestay is expected to open job opportunities and make it the village's attraction… (Hairal 2021)

The survey results indicated the threat of social cohesion (Tavakoli et al. 2017) is very low at Lok Urai, a good indicator since homestay programs will need to strengthen the social capital among certain groups of a host community. Additionally, a study by Janjua et al. (2022) highlighted the importance of sustainable tourism marketing and brand equity in rural community-based homestays in Malaysia. Their study supports the authors' observation in which, involvement by local political authorities would be most crucial for rural tourism promotions. In fact, they may need to become the key players in sustainable rural tourism transformation at Lok Urai village. Figure 4.7 is a SWOT analysis finding showing a higher support between strengths and opportunities aspects provided the water villages improve their architectural and structural aspects for such program to take place.

4.3 Methods

This planning feasibility study follows Yin's (2014) case study research methodology containing: (1) research question, (2) theoretical proposition, (3) unit of analysis, (4) linking theory to data, and (5) criteria for interpreting data. The research question is "how can state authority provide supporting architecture in creating a resilient water village?" The study proposes inclusion of supportive economics in view of the water village's indigenous socio-cultural aspects for improving their resilience. The study maintains Lok Urai water village in Sabah, Malaysia as the location of the study. The new planning was superimposed upon

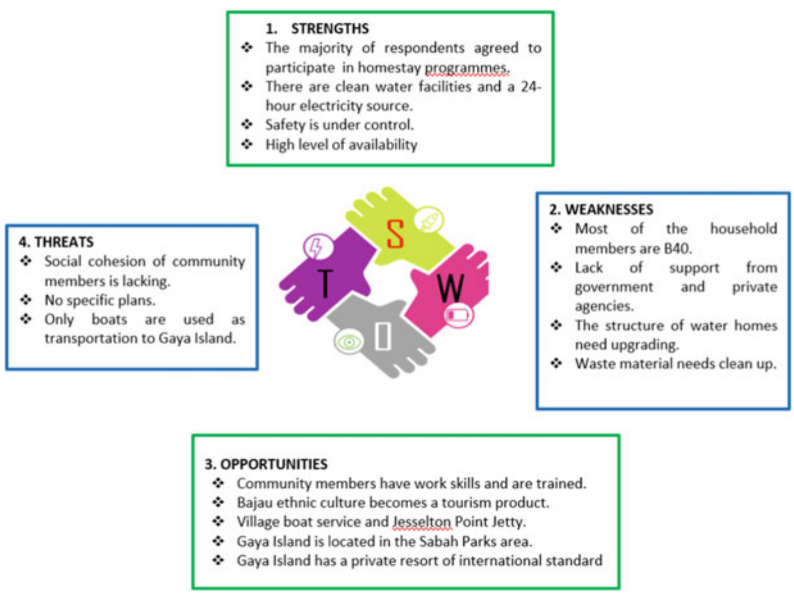

Fig. 4.7 SWOT analysis of community and built environment aspects at Gaya Island. *Source* Hairal (2021)

the home lots that were destroyed in the big fire in 2020. This study posits that to ensure the new water settlement planning would be sustainable, its new architectural planning must maintain the current indigenous lifestyle, include ecotourism and microeconomic activities and integrate sustainable features that preserve its natural environment. The proposed new water village plan consists of 98 housing units where an average eight members of a family live in one household. It incorporates 12 clusters of homes in a homestay program with supporting small business activities for the whole community. Additional infrastructure support is proposed for the sociocultural activities for the tourism economy. In determining the criteria for validating the theoretical proposition, the proposed new water village planning model must be able to incorporate all the above planning requirements into one water village planning prototype. This planning feasibility study is limited to the water village planning restructuring only and exclude any financial feasibility study.

4.4 Results

The resulting new water village planning model looks into integrating the new sewerage treatment system as well as water and power which are critical for the population of Lok Urai village. Herewith, this study reorganizes the water village planning to address the challenges mentioned above. Reducing cholera infection and returning dignity to women and girls when using the ISTP technology would meet SDG 3 Health and Well-Being for the community. Thereby, incorporating the ISTP wastewater treatment technology under the water homes would stop untreated sewage pollution being discharged directly into the ocean whereas installing rainwater harvesting system for hygiene care would meet SDG 6 Water and Sanitation. In fulfilling both SDG 3 and SDG 6, Lok Urai can meet the aims of SDG 11 Sustainable Cities and Communities when safe and better dwellings with decent utilities, services, and lifestyle upgrades are proposed in the new water village planning model. This study agrees with Dakhia and Berezowska (2010) that in creating today's natural living society, the "urban ecosystem" with functional space aspect of microarchitecture can be similar to the streets ambience and culture which had existed for more than 120 years at Lok Urai Village.

The overall proposed model applied clustering design concept consisting of eleven clusters of eight home units and one cluster of 10 home units. Lok Urai village planning prototype contains 98 homes with each home having separate bath and toilet rooms in consideration of larger household size of eight persons. Standardized modular homes are proposed to facilitate prefabricated assembly for marine installation. The proposed model also displays the similar traditional dwelling design in Southeast Asia that are suitable for hot-humid weather. Solar panels are proposed on rooftops in lieu of incoming tourists who may not be comfortable in tropical climate and to power the whole house. The whole planning layout employs open-space planning where as much as possible the front facades face the water body. Figures 4.8, 4.9, 4.10, 4.11, 4.12 and 4.13 are illustration for the proposed new water village planning model.

By manipulating the spatial planning layout, placing all living and sleeping areas elevated on stilts, creating permeable apertures and longer

Fig. 4.8 Perspective view of new water village planning model for Lok Urai village, Gaya Island (Illustration by: Nor Efenday)

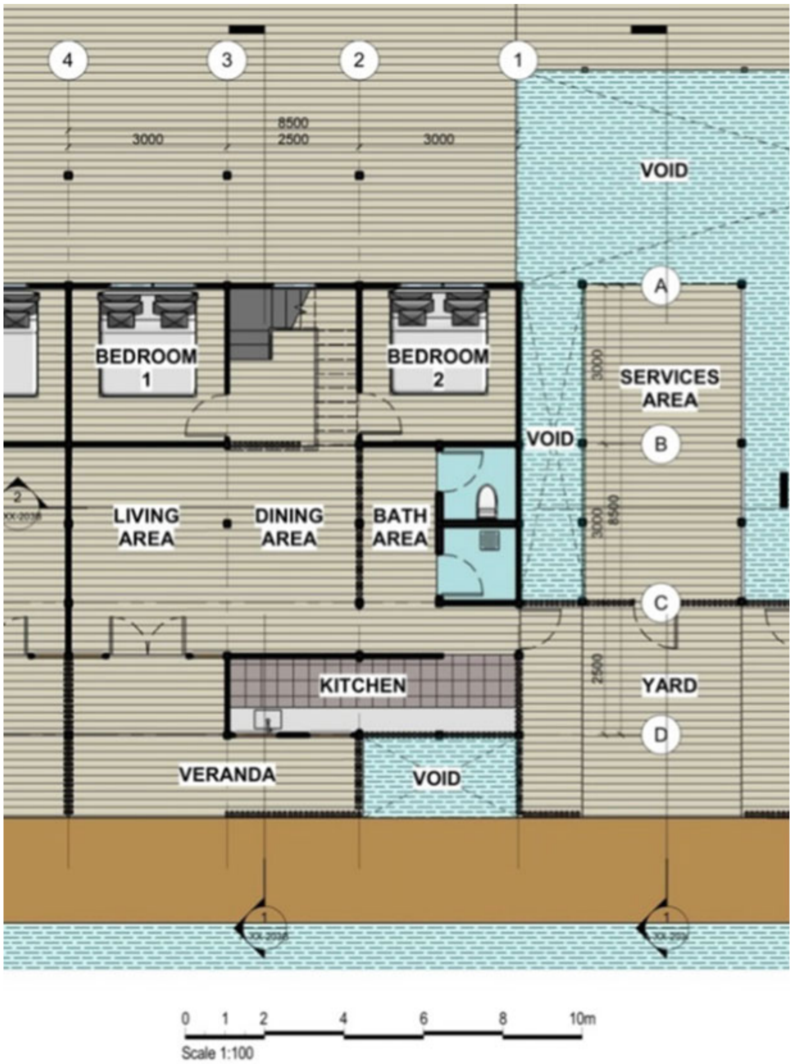

Fig. 4.9 House unit with public and private amenities to support homestay programs in new water village planning model. (Illustration by: Nor Efenday)

overhangs, the design team was able to maintain the interior thermal comfort in the home unit design. All windows will have insect netting protection to minimize insect's penetration. The proposed water village planning model added some distances to improve privacy between water homes. Moreover, the water residents prefer simple timber architecture. The 3 m by 3 m structural approach is employed in this house layout. The overall water village planning has successfully incorporated the recommended requirements for stopping sewage pollution, integrate passive design characteristics by exploiting the Lok Urai's natural resources, introducing homestay support facilities, and support home-based small business enterprises by families.

4.5 Discussion and Conclusions

This paper synthesized lessons from the UNEP program call for development of a new guideline regarding sanitation management. Hence, it proposes a planning feasibility study which takes into consideration the socio-cultural behavior of the villagers at Lok Urai. The key in proposing a new water village planning model is seeking how

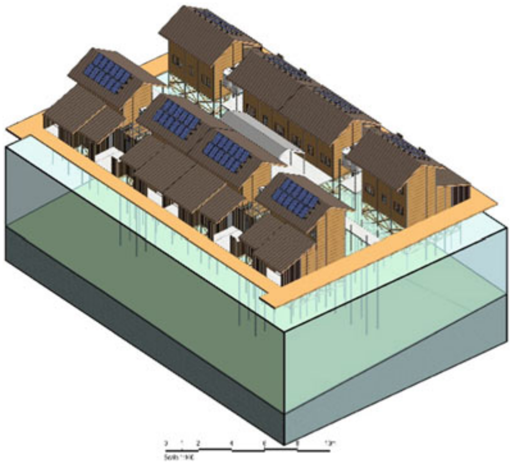

Fig. 4.10 Perspective view of homestay cluster planning in new water village planning model for Lok Urai village, Gaya Island (Illustration by: Nor Efenday)

the architectural approach can strike a balance between how local communities can preserve their natural environment, and the need to finance the purchase and maintenance of much needed sewerage treatment system. Without the sanitation system, the idea for creating a successful homestay program will be at risk due to the continuous sewage pollution condition. This proposed planning model also enforces lessons learnt from the other two research projects. Microarchitecture elements such as small nooks to sell candies and local delicacies have been incorporated into the individual home designs while the public spaces are available for cultural activities such as fish drying, fishing net repair services, local crafts making, and cultural shows. Twelve clusters of homes are supported by amenities such as extra water tanks, rainwater harvesting tanks, and solar power generation for each household and the operation of the sanitation system.

The Lok Urai project has started creating impacts after two years. Awareness is increasing among the local Sabahan how ocean conservation could protect the state’s RM25B tourism (Fong 2022), RM2B fishing (Daily Express Online 2022) and RM60M seaweed industries (Jistoh 2022) and Sabah's local coastal communities. It could also contribute toward the advancement of strategic plans for the island and coastal settlements in Sabah. The project could open doors for interagency collaboration between universities and policymakers. The Mayor of Kota Kinabalu has been actively involved in supporting the development of sanitation management guideline and in advocating more ISTP tanks installation at water settlements along the coastal areas of Kota Kinabalu in the advent of the Sabah Tourism 2022 event. However, this huge effort must start with the development of a proper sanitation management guideline, specifically for water settlements for Kota Kinabalu.

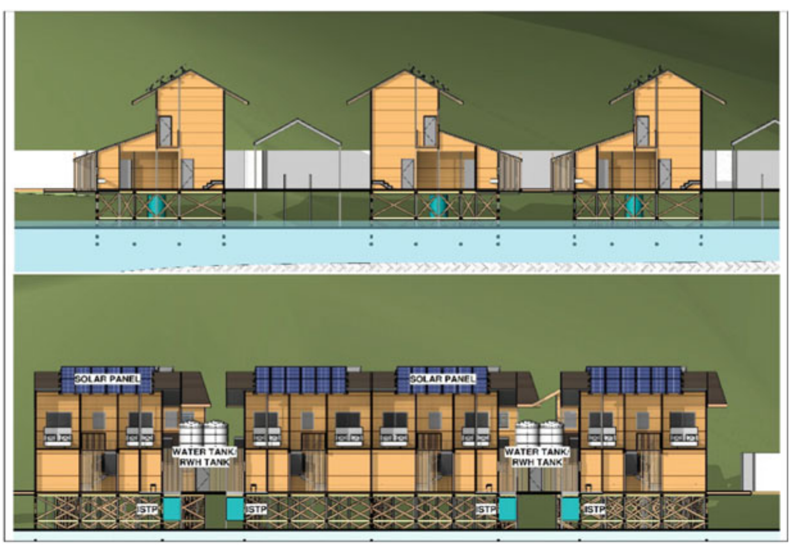

Fig. 4.11 Sectional view across new water village planning model for Lok Urai village, Gaya Island (Illustration by: Nor Efenday)

Fig. 4.12 Cluster planning at platform level with public and private amenities to support homestay programs in new water village planning model (Illustration by: Nor Efenday)

Through awareness campaigns on the importance of understanding biodiversity challenges and their consequences at the national level, the Malaysian Federal Government has approved RM4B for conserving the environment in the 2022 Budget (Government of Malaysia 2022). This provides further avenue for the project to contribute toward national policymaking. The corresponding author was appointed by ACT Malaysia as the lead researcher for the UNEP-ACT Malaysia demonstration project. She was later asked to become the focal lead for the Implementation Working Group of the Global Wastewater Initiatives Program under UNEP.

UPM had actively raised ocean pollution awareness by hosting eight (8) webinar series in the year 2021. The Webinar Series on SDG 6 Water and Sanitation was organized in conjunction with the 50th anniversary of UPM. Members from the Global Wastewater Initiatives Program partnered with Malaysian experts to speak about sanitation issues, wastewater pollution, microplastics, and other pollutants into the ocean. While the webinar series allowed the R&D project team to identify potential partners who can contribute further to the Lok Urai village demonstration project, the effort gave the limelight to Malaysia as a country having a potential technological breakthrough in providing sanitation to remote coastal settlements. The webinar series culminated in the organization of the Virtual Symposium on Wastewater and Sanitation that was held in conjunction with the UN's World Toilet Day 2021 on 19th November each year. Two (2) Malaysians were invited as expert panelists where one represented the Academy of Sciences, Malaysia and another represented ACT Malaysia.

The proposed water village planning model could improve health through better sanitation management for islanders and a viable planning model can be replicable to other 25,000 islands

Fig. 4.13 Cluster planning at platform level with public and private amenities to support homestay programs on upper floor in new water village planning model (Illustration by: Nor Efenday)

in the Southeast Asian region whose water villages do not have proper sewage treatment system. Asian Development Bank (2021) highlighted the plight of damaging impacts of polluted oceans to including and not limited to disappearance of seafood, disappearing of coastal habitats, rapidly rising sea levels, and increasing pollution. Hence, implementing the proposed water village planning model could give beneficial impacts as follows:

Stopping direct untreated sewage pollution by coastal settlements: Evers (2015) estimated the existence of 40,000 water homes Borneo Island. That would mean 40,000 homes are discharging untreated sewage into the water bodies surrounding Borneo Island. A five-person home is discharging 1125 L untreated sewage daily, hence discharging 45 M liters raw sewage daily or 16.4 T liters annually.

Prevention of dangerous infectious diseases: Integrating the ISTP tanks as architectural features in the new water village planning model can definitely help stop sewage pollution directly into the ocean below the water village. Over the long run, the water quality is expected to improve. Availability of clean energy and clean water from solar panels and rainwater harvesting in the proposed new water village planning model can reduce the numbers of cholera or diarrheal diseases when community members in the water village have access to clean water for washing. The improved environment is expected to lessen the exposure risk to children to the dangerous water-borne pathogens.

Self-empowering remote communities to pay for improving their ocean biodiversity preservation: The proposed new water village planning model has embedded functional features in its spatial planning that will support a homestay program such as at Lok Urai. Families could earn additional income by allowing tourists to stay in the family home and participate in social and cultural activities of the water residents. New microarchitecture feature as part of the home layout design can open opportunities for small businesses which are operated by women while the men go out to work. The additional incomes will help the water villagers to pay for the ISTP tanks implementation.

Financing Sanitation Management by Local Governments of Nations with Islands through Ocean Health Credit Trading Programs: The proposed new water village planning model can become the base for many monitoring measurements such as water quality measures, income per water household, number of tourists visiting, income from homestay program, number of disease cases, etc. Such mechanism can be used by local governments or the water villages in negotiating funding in preserving ocean biodiversity or stopping sewage pollution to avoid future economic or health disasters arising from polluted water bodies or decline of fish stock. Alternatively, international organizations could create ocean incentive schemes where marine food producers can earn blue ocean taxation for helping in ocean preservation by sponsoring installation of ISTP tanks in current or new integrated water village facilities. Microcredits is possible for the women-run businesses.

In conclusion, the inconsequential benefits of installing the ISTP tanks at water villages to stop untreated sewage pollution include reducing water-borne infectious diseases and improving the ocean water quality. By providing a potential new water village planning model, a water community can self-empower itself to finance the installation and management of its own sanitation system through its community homestay program and home-based small businesses. More so, the new water village planning model could return the dignity to the women and girls at Lok Urai when they feel safe to use the toilets in their homes.

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5 Age Distribution and Accessibility to Green Areas in the City of Copenhagen

Gustavo Ribeiro and Aleksander Nowak

Abstract

This paper presents an analysis of the distribution of urban spaces, parks, and other green areas in the City of Copenhagen in relation to demographic indicators, notably concerning population density and the spatial concentration of different age groups. The broad health benefits provided by urban greenery to urban dwellers are well documented in urban studies. The aim of this paper is to further contribute to this scholarship through the analysis of accessibility to green spaces by different age groups and in this way to shed light on their opportunities for health enhancing physical activity in the urban environment. The analysis is part of an ongoing study of urban density mapping based on a collaboration with the City of Copenhagen. The analysis of distribution of green spaces is based on several datasets, including location of major green spaces and parks, location, and radius of individual trees and NDVI index. The Copenhagen Municipal Plan 2019 proposes to increase social equity through physical and mental health-promoting urban planning and through provision of good quality green public spaces. The analysis shows that vulnerable groups such as the older population ($\geq$ 65-year-olds) are not particularly challenged in terms of accessibility to green spaces. Based on this analysis, the authors formulate urban policy recommendations for meeting the targets for healthy living set by the City of Copenhagen.

Keywords

Green spaces · Age distribution · Copenhagen

5.1 Introduction

This paper presents an analysis of accessibility to green spaces in Copenhagen in view of promoting inclusivity and social equity, which are policy goals formulated by the City of Copenhagen. The analysis focuses, in particular, on conditions of accessibility to green spaces by elderly and children, as spatial proximity is particularly relevant for these age groups (Sugiyama and Ward Thompson 2007). The discussion and findings presented in this paper are based on an ongoing study involving an analysis of population density, indicators of built density (floor area ratio, building height), socio-economic indicators (such as level of education and income), detailed demographic data on age distribution, and

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distribution of specific urban facilities, such as playgrounds.

The analysis presented in this paper is based on the City of Copenhagen's political ambition "that in the existing city there is no more than 300 m in walking distance from the city's housing to a recreational area." (City of Copenhagen 2019, p. 32).

A central argument presented in this article is that by combining several levels of data—namely data on population density at different scales (including number of dwellers per household, rooms per person in one household), data on distribution of the population by age groups, and data on built density (floor area ratio)—we can provide a nuanced analysis of distribution of green spaces in view of informing a discussion on accessibility to green spaces and the potential for promoting more equitable access to parks and other green spaces, notably to more vulnerable segments of the population (such as the elderly).

An analysis of race and ethnicity in relation to accessibility to green spaces is indirectly dealt with in this study, to the extent that the spatial analysis examines the distribution of social housing areas in neighborhoods such as Nørrebro which present greatest concentrations of first and second generation migrants—where Muslims are largely represented (Møller and Larsen 2015) and the conditions for accessibility to green spaces in those areas.

The spatial analysis involved production of data maps in GIS software representing each dataset with different levels of aggregation as well as production of combined layered datasets. The initial set of maps were produced by the Catalan urban planning agency 300.000 km/s in dialog with the authors. A further set of maps, particularly on the distribution of the population by age groups, was produced by the authors.

The focus of this article on urban density and densification is related to the fact that the City of Copenhagen is faced with a projected population growth of 62,000 inhabitants by 2032 (City of Copenhagen 2022, p. 18). In view of such population growth, the development of urban policy which promotes social equity in relation to accessibility to green spaces gains further urgency.

Following this introduction, this article presents a *background* section containing a discussion of state-of-the-art scholarship in urban green spaces studies, in relation to health benefits, accessibility, and social equity and age distribution. The *methodology* section presents a description and discussion of parameters and considerations concerning data gathering, data aggregation, and analysis. This is followed by a section presenting *results* of the study and sections covering *discussion* and *conclusion*.

5.2 Background

5.2.1 Benefits of Green Spaces

A number of health related as well as other benefits associated with green spaces are documented in several studies (Pauleit 2003), (James et al. 2009). Furthermore, a number of studies have pointed to specific physical and mental health benefits of exposure to nature (Hartig et al. 2014) and to green spaces (Zhang and Tan 2019), (Triguero-Mas et al. 2015), (Gascon et al. 2015), (Tamosiunas et al. 2014), while other studies have found that green spaces were associated with social, economic, and environmental benefits (Mensah et al. 2016, p. 142). Perceived health benefits associated with proximity to green spaces also constitute an important dimension of analysis of green spaces and are documented in a number of studies (van den Berg et al. 2015; Maas 2006). Recently, under the COVID-19 pandemic, the use of parks in Copenhagen has increased significantly (Google 2021) further highlighting the importance of accessibility to green spaces in urban policy-making.[1]

[1] COVID-19 Community Mobility Report, Capital Region of Denmark May 27, 2021.https://www.gstatic.com/covid19/mobility/2021-05-27_DK_Capital_Region_of_Denmark_Mobility_Report_en.pdf.

5.2.2 Densification

The detrimental impact of compact city development and urban densification on green areas has been documented in several studies (Pauleit et al. 2005, Haaland and van den Bosch 2015). Some studies found that the fact that green spaces may come under pressure through urban densification and does not necessarily lead to a deterioration in green space accessibility or people's perception thereof (Ståhle 2010).

5.2.3 Accessibility and Proximity

Studies investigating spatial distribution of green spaces and health (Dadvand et al. 2016) show that proximity to urban green parks (as well as factors such as maintenance and cleanliness) is associated with increased frequency in physical activity (Akpinar 2016), residential proximity to greenness, and perceived (subjective) proximity to green spaces which are associated with better subjective general health (Dadvand et al. 2016). A number of studies underline the importance of assessing subjective factors (Maas 2006), when investigating accessibility to parks and other green areas.

5.2.4 The Elderly and Green Spaces

The incidence of diseases associated with lack of physical activity, such as diabetes, high blood pressure, cardiovascular diseases, as well as depression and anxiety among others, is particularly high among the elderly, and research has shown that accessibility to green spaces plays a key role in promoting active, healthier living among the elderly. (Ali et al. 2022), (Copenhagen: WHO Regional Office for Europe 2017). Accessibility to greenness and to UGS has the potential of enhancing older people's physical and mental health by promoting physical activity and social contact, and studies have shown that accessibility to green spaces contributes to reduce stress, counters adverse mental health conditions, promotes enhanced sociability (reducing loneliness), and contributes to lower the impact of cardiovascular diseases and to lower mortality (James et al. 2015), (Sugiyama and Ward Thompson 2007), (Copenhagen: WHO Regional Office for Europe 2017). Studies on accessibility to green spaces in relation to age distribution highlight the disadvantage of vulnerable segments of the population, notably the elderly, and point to challenges concerning proximity of green spaces to residences (Stathi et al. 2012), (Liu et al. 2022, p. 1), urban design features of urban spaces (such as cleanliness and barrier-free routes) (Ward Thompson et al. 2014, p. 1), design and amenities of parks such as the presence of benches and "passive use areas" (Kabisch and Haase 2014, p. 137). On the other hand, some studies also show that improvement of recreational facilities does not necessarily lead to an increase in the number of users or the levels of physical activity (Cohen et al. 2009, p. 5) and that other factors such as programming and staffing also need to be considered (Cohen et al. 2009, p. 5).

Such condition of disadvantaged access to green spaces is further accentuated by the fact that the elderly are less likely to relocate to greener neighborhoods and in social contexts where there is an aging population (Liu et al. 2022, pp. 11–13), (Kabisch and Haase 2014, p. 137). In addition, it is important to consider that different segments of an elderly population may present different park use patterns, ranging from active health oriented users, to socially oriented users to passive users (Kemperman and Timmermans 2006).

5.2.5 Children and Green Spaces

The importance of accessibility to green spaces for the physical and mental well-being of children has been documented in several studies, and access to green spaces has been shown to be associated with enhanced mental health and cognitive development of children (McCormick 2017). Furthermore, accessibility to green spaces has been associated to other mental health such as moderation of stress, attention restoration, memory improvement, and improvement of behaviors and symptoms of ADHD; as well as sociability benefits, such as competence development, social groups support, and consolidation of self-discipline, among others (McCormick 2017).

Vanaken and Danckaerts' review of the literature on the impact of green space exposure on children's and adolescents' mental health point to consistent evidence suggesting "a beneficial association between green space exposure and children's emotional and behavioral difficulties, particularly with hyperactivity and inattention problems" (Vanaken and Danckaerts 2018, p. 1).

Further studies on children's health argue for the importance of playground facilities that promote physical activity not only in view of associated health benefits but also in view of benefits for social development and basic movement skills. (Quigg et al. 2012).

The importance of pedestrian connectivity in the urban environment is also highlighted as a factor that may lead to greater levels of physical activity (Fitzhugh et al. 2010, p. 259).

5.2.6 Copenhagen Demographic Development

According to projections by the City of Copenhagen, a sharp increase of 58% in the number of citizens over 80 is expected from 2022 to 2032. Notably, according to those projections, the number of 65 to 79-year-olds will begin to rise sharply at the end of the period. The increase in 0 to 17-year-olds and 18 to 64-year-olds is expected to be stable until 2032. Since there are relatively few elderly people, the average age will only increase by 0.8 years. (City of Copenhagen 2022, p. 23).

In addition, according to projections by the City of Copenhagen, there will be an increase in the coming seven to eight years in the number of Copenhageners of child-bearing age (City of Copenhagen 2022, p. 23) (Fig. 5.1).

5.2.7 Copenhagen Green Space Policy

Social equity is a key consideration in the Copenhagen Municipal Plan 2019, which underlines that "increase social equality in physical and mental health, health-promoting urban planning should start where it is most needed [in vulnerable areas]… [through] the establishment of urban spaces whose design motivates increased physical activity or green areas that promote mental health." (City of Copenhagen 2019, p. 22).

The enhancement of accessibility to green spaces is also formulated in the Copenhagen Municipal Plan 2019 in relation to the promotion of citizens' health and in view of their socio-economic background with the aim of achieving a more equitable urban development. (City of Copenhagen 2019, p. 28).

In order to further document accessibility to green spaces in view of fulfilling the above-mentioned ambitions, the City of Copenhagen has carried out an analysis of green spatial distribution in relation to these two parameters—that is, an ambition of a maximum distance of 300 m from residential addresses to a recreational area (with a minimum of 500 m^2) in the existing city and of a maximum distance of 500 m in urban development areas to green spaces larger than 2 ha. In this analysis, the City of Copenhagen introduces specific definitions of what qualifies as a green area[2] and a blue area.[3]

[2] According to the definition used by the City of Copenhagen in its 2022 "analysis of accessibility to green and blue areas", a "green" area in the existing city needs to fulfil certain criteria, including a minimum size of 500 m2, a minimum width of 10 m, and a minimum 25% green cover (including the extent of tree canopy), and public access is secured both physically and by law (The City of Copenhagen, Financial Administration, 2022, p. 6).

[3] According to the City of Copenhagen, no minimum size or extent has been used for the definition of "blue" areas (promenades, beaches, freshwater lakes, etc.). The criterion for designation as a blue area is whether the area "is laid out in a way that enables the user to dwell there and experience the water, and where the water body makes up a significant share of the experience without being part of the dwelling area itself." (The City of Copenhagen, Financial Administration, 2022, p. 6).

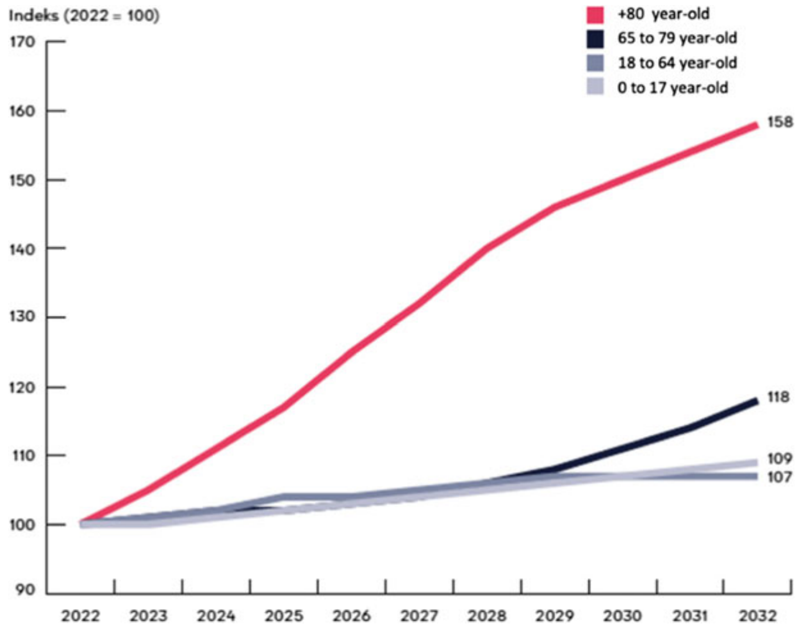

Fig. 5.1 Projection of population growth index according to age—2022–2023. *Source* City of Copenhagen

According to this analysis, 9.9% of housing (33,059 housing units) in the existing city is located at distance greater than 300 m from a green area—according to the definition by the City of Copenhagen (The City of Copenhagen, Financial Administration 2022), 34.4% of housing (114,889 housing units) in urban development areas is located at a distance greater than 500 m from a green area (incl. Amager Beach Park) larger than 2 ha. (The City of Copenhagen, Financial Administration 2022, p. 21).

5.3 Methodology

The present study is based on an analysis of spatial distribution of greenery in relation to population density and spatial distribution of different age groups (0–5, 6–17, 18–64, 65–79, and 80–99 years old). The study considers the green areas (as defined by the City of Copenhagen), trees, green courtyards/backyards, and NDVI values as well as aggregated values for amounts of people per age group in 100 × 100 m and 200 × 200 m grid cells in Copenhagen Municipality.

Publicly accessible registers consulted in this study include opendata.dk [https://www.opendata.dk/], Kortforsyningen [https://kortforsyningen.dk/], Municipal Plan 2019 map database [https://kp19.kk.dk/kortportal]. This was supplemented by more detailed and up-to-date datasets provided by the City of Copenhagen including datasets on trees, courtyard (location and presence of greenery), and location of green spaces (City of Copenhagen[4]). Data from the register listed above and from Airbnb were used to produce six types of maps:

1. Datapoint Maps—individual data points showing the location of trees
2. Heat Maps—showing intensity of concentration of data points
3. Mashup Maps—combining data from datapoint maps and heat maps
4. 200 m × 200 m Grid Maps—data aggregated on a 200 m × 200 m grid

[4] This dataset was revised by the City of Copenhagen in their 2022 “analysis of accessibility to green and blue areas” by using a new definition of publicly available green spaces (including minimum size and green cover criteria) and newly established or politically agreed green spaces.

5. 100 m × 100 m Grid Maps—data aggregated on a 100 m × 100 m grid
6. Urban Structure Maps—showing structure of road infrastructure, urban spaces, urban blocks, and courtyards.

The datasets were processed in QGIS and Python. Data from Copenhagen Municipal plan structure maps [green spaces, public spaces, streets, and blocks] [https://kp19.kk.dk/kortportal] were used not only as an underlay for the other maps in this study but were also aggregated into grid-equivalent densities and thus providing a basis for comparison between different urban areas and their public spaces. Sentinel-2 Satellite imagery was used to generate NDVI-based mappings of Copenhagen in addition to data on the spatial distribution of trees and greenery. Satellite imagery allowed for generating a consistent and uniform image of urban greenery and a detailed analysis of distribution of vegetation and its intensity. NDVI analysis further informed the level of present distribution, historical development of the green elements, or their relation to urban densification.

The household level data in the Municipality of Copenhagen were analyzed through four indicators defining housing attributes through perspectives of household size and number of rooms and cohabitation. The detailed datasets (BBR—Danish building register) were provided by the municipality. The location of publicly accessible green areas in municipalities adjacent to the City of Copenhagen as well as the location of "blue areas," though not central to this study, was both considered in the present analysis.[5]

5.4 Results

5.4.1 Distribution of Green Spaces

The analysis comprised the following datasets on green spaces and trees: (1) NDVI; (2) tree database; (3) parks and other green areas[6] (City of Copenhagen); and (4) green courtyards. Maps based on those datasets were used for analyzing the distribution of greenery in Copenhagen (both publicly and not publicly accessible, private, and semi-private). The results of this analysis were compared with those provided by the analysis carried out by the City of Copenhagen, which is limited to publicly accessible spaces (secured both physically and by law). A set comprising ten maps was analyzed through different combinations of these four levels of data and through different forms of aggregation/visualization (200 m x 200 m grid, datapoints, and urban structure maps). The maps (58, 67, 68, 69, 70, 71, 75, 76, 78, 79, 81, 90 and 91) listed on Table 5.1 show how greenery seen through the lenses of these four levels of data is very unevenly distributed throughout the city. Each dataset presents a different pattern of distribution. This uneven distribution of different types of green elements (whether they are trees, green courtyards, backyards, or green areas), as we will further elaborate upon below, is particularly relevant for an analysis of green spaces accessibility in relation to different housing typologies.

Housing areas in districts of the city, such as West Valby, Sundbyøster, Brønshøj-Husum, and Vanløse, present greater distances to green areas (map 67), but these areas consist of predominantly detached villas with green backyards. Inner Vesterbro presents housing with distances greater than 300 m to large green spaces in the city. On the other hand, Inner Vesterbro is located close to the Copenhagen Inner Harbor, one of the major blue recreational spaces in the city.

[5] This is consideration which is particularly relevant in relation to the Municipality of Frederiksberg, which is an enclave of Copenhagen, and which presents three major publicly accessible green spaces (Frederiksberg Park, Søndermark Park, and Solbjerg Cemetery Park) in close proximity to the boundaries of the City of Copenhagen.

[6] This dataset was revised by the City of Copenhagen in their 2022 "analysis of accessibility to green and blue areas" by using a new definition of publicly available green spaces (including minimum size and green cover criteria) and newly established or politically agreed green spaces.

Table 5.1 List of maps

#	Title	Data source	Description
65	Urban fabric – built density	Opendata.dk/CPH M	Representation of the built footprint and blocks hierarchy from the City of Copenhagen database
66	Public space – streets	Opendata.dk/CPH M	Street shape and public spaces as an intersection of the built footprint and blocks hierarchy
67	Major green spaces	Opendata.dk/CPH M	Major green spaces
68	Courtyards	CPH Municipality	Green courtyards
69	Vegetation NDVI	Sentinetl-2	Nature density vegetation index (Sentinel satellite network)
70	Trees	CPH Municipality	Location of trees from Copenhagen Municipality database
71	Green infrastructure	CPH Municipality	Superimposition of main public and green spaces, trees, and NDVI index
73	Built density	CPH Municipality	Built density in a 100 × 100 grid calculated from the building's footprint
74	Street density	CPH Municipality	Total surface of streets aggregated to a 100 × 100 grid
75	Density of green courtyards	CPH Municipality	Green courtyards aggregated (grid)
76	FAR vs courtyards	CPH Municipality	Superimposition of the sum of the built surface and the public spaces total surface - 100 × 100 grid
78	Trees	CPH Municipality	Total amount of trees aggregated to a 100 × 100 grid
79	Trees radius height NDVI	Sentinel-2	Average radius of trees (age indicator) & average height aggregated to a 100 × 100 grid
81	Trees + Veg. + Courtyards	CPH Municipality	Total m2 of public spaces, the total amount of trees, and the average index of vegetation - 100 × 100 grid
88	The surrounding built density	CPH Municipality	Total built surface (footprint) of the surroundings aggregated to the grid in public spaces
90	Green spaces – trees + NDVI	Multiple sources	3 levels of data combined NDVI, tree radius and tree height – 100 m x 100 m grid
91	Trees + NDVI	Multiple sources	2 levels of data – NDVI and spatial distribution of trees – 200 m × 200 m grid
92	Trees, NDVI, and yards	Multiple sources	3 levels of data combined NDVI, tree location, and green courtyards – 100 m x 100 m grid
98	Inhabited fabric	CPH Municipality	Populated areas in the city according to cadaster data
100	FAR (floor area ratio)	CPH Municipality	Plot occupation according to cadaster data
103	Pop. density / plot surface	CPH Municipality	Population per plot surface according to cadaster data
118	Demographic density/block	CPH Municipality	Demographic density aggregated at the scale of the city block

(continued)

Table 5.1 (continued)

#	Title	Data source	Description
120	Family size	CPH Municipality	Data on distribution of the population according to family size–district scale
121	Income distribution	CPH Municipality	Combined data of distribution of the population according to age and income–district scale
122	Age distribution	CPH Municipality	Age distribution aggregated on a 200 m × 200 m grid
131	Elderly population	CPH Municipality	Population density aged 65 and over ($\geq$ 65) aggregated by block
132	Young population	CPH Municipality	Population density aged 17 and under ($\leq$ 17) aggregated by block
133	Playgrounds	CPH Municipality	Distribution of playgrounds
134	Young population	CPH Municipality	Population density (0–5-year-olds and 6–17-year-olds) – 200 m × 200 m grid
135	Elderly population	CPH Municipality	Population density (65–79-year-olds and 80–89-year-olds) – 200 m × 200 m grid
136	Children	CPH Municipality	Distribution of families with 3 children or more – district scale

The distribution of green courtyards and green backyards (maps 68, 71, 75, 81) shows a pattern where the occurrence of private or semi-private green spaces is greater toward the periphery in proportion to the decrease in built density (map 73, map 100), demographic density (map 103), and density of road infrastructure and paved areas (map 66, 74). The relationship between built surface area and courtyards is shown in map 76. The analysis of NDVI maps (maps 69, 90, and 92) further illustrates the same pattern, where NDVI values (greenery) increase from the center to the periphery—where single family houses with backyard predominate. In addition, NDVI maps show the highest values where the green areas are located.

5.4.2 Green Spaces and Age Distribution

Building on the analysis presented in the article "Mapping Density and Distribution of Urban Spaces in the City of Copenhagen" (Ribeiro and Nowak 2022) and the analysis presented in the article "Green Spaces, Health, and Social Equity in the City of Copenhagen" (Ribeiro and Nowak 2022), this paper deals with the distribution of green areas in relation to indicators of population age distribution, density, socioeconomics, and individual household conditions. Based on this analysis, this study examines the distribution of the elderly population (65-year-olds or older), notably in lower-income areas, and examines conditions of accessibility to green spaces in relation to housing typology. The approach is also applied to the analysis of family with children, notably in lower-income neighborhoods. Data on children were analyzed according to two age segments, namely 0–5-year-olds and 6–17-year-olds.

The analysis of household conditions in the Copenhagen Municipality (which to some extent may be correlated with the socio-economic conditions) comprises four indicators of housing quality: (1) average household square meter size, (2) number of people per household, (3) average amount of rooms per household and, and (4) amount of people per room in one household. The GIS and statistical analyzes are performed through processing large datasets containing information on the number of inhabitants and their age (0–99) of each Copenhagen household (2020) mapped on a *school district* (skoledistrikt) level, based on the Danish Building Register (BBR) and inhabitants' age point data for all Copenhagen housing units.

The focus on lower-income groups reflects the consideration that those groups are the most reliant on public investment in green spaces. On the other hand, the medium and high-income elderly population is located in neighborhoods such as Østerbro, Christianshavn, and the Medieval City center, which do not present challenges in terms of proximity to green or blue areas (Figs. 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, and 5.9).

5.5 Discussion

The analysis shows that neighborhoods presenting the greatest concentrations of elderly people (Østerbro, the Medieval City, Christianshavn, Islands Brygge, and North Amager) are not particularly challenged in relation to accessibility to green areas, nor in socio-economic terms. Overall, residential areas with greater concentration of elderly people do not present distances greater than 300 m to green areas (as defined by the City of Copenhagen). The exception to that pattern is found in Amager South (Sundby Øster) and Amager West (Gyldenrigsvej).

Furthermore, the results of the analysis show that the areas with the greatest concentrations of children and young people ($\leq$ 17-year-olds) are not particularly challenged in relation to accessibility to green spaces—that is, areas showing higher concentrations of this age group are not located at distances greater than 300 m to green and blue spaces in the city.

An analysis of the distribution of playgrounds (map 133) shows a pattern of greater concentration of such facilities in central areas in the neighborhoods of Østerbro, Nørrebro, Vesterbro, and Amager, which are also the neighborhoods with the greater concentration of children (map 132).

The analysis of density of the elderly population ($\geq$ 65-year-olds) in relation to the overall distribution of green spaces shows that this age group is not particularly challenged in terms of accessibility (proximity to) green areas. Amager South (Sundby Øster) presents greater than average concentration of an elderly population ($\geq$ 65-year-olds) in medium to lower-income levels and is located at distances greater than 300 m to green areas. But it is important to highlight that the predominant housing typology found in this Sundby Øster is that of semi-detached houses with backyards. Thus, elderly residents living in that neighborhood have access to the green private space of their backyard. In this case urban space design, involving conditions that promote walkability for the elderly in the spaces of the neighborhood (streets, pathways, squares, among others), such as absence of barriers and maintenance of sidewalks and cleanliness (Ward Thompson et al. 2014, p. 1), come into focus and are likely to play a central role in the elderly's daily use of such spaces and the conditions for their access to green spaces. Amager West (Gyldenrigsvej) also presents greater than average concentration of an elderly population (65 + year-olds) in medium to lower-income levels. This neighborhood largely consists of social housing schemes from the late 1960s early 1970s following the principles of Le Corbusier's Athens Charter (Le Corbusier 1973, 1933). Even though it is located at a distance greater than 300 m to green areas following the classification by the City of Copenhagen, this neighborhood has generous large green spaces that have the potential of being further developed as high-quality green areas (as in the case of the urban renewal of Gellerupparken[7]) for the use of the local residents and residents from neighboring areas, notably the elderly. Investment in urban design, the provision of high-quality urban furniture, outdoors gym equipment designed for the use of the elderly and the development of nature-based solutions are of key importance in such neighborhood.

[7] https://www.landskabsarkitekter.dk/Aktuelt/gellerup-ny-naturpark-nomineret-til-green-cities-europe-award/.

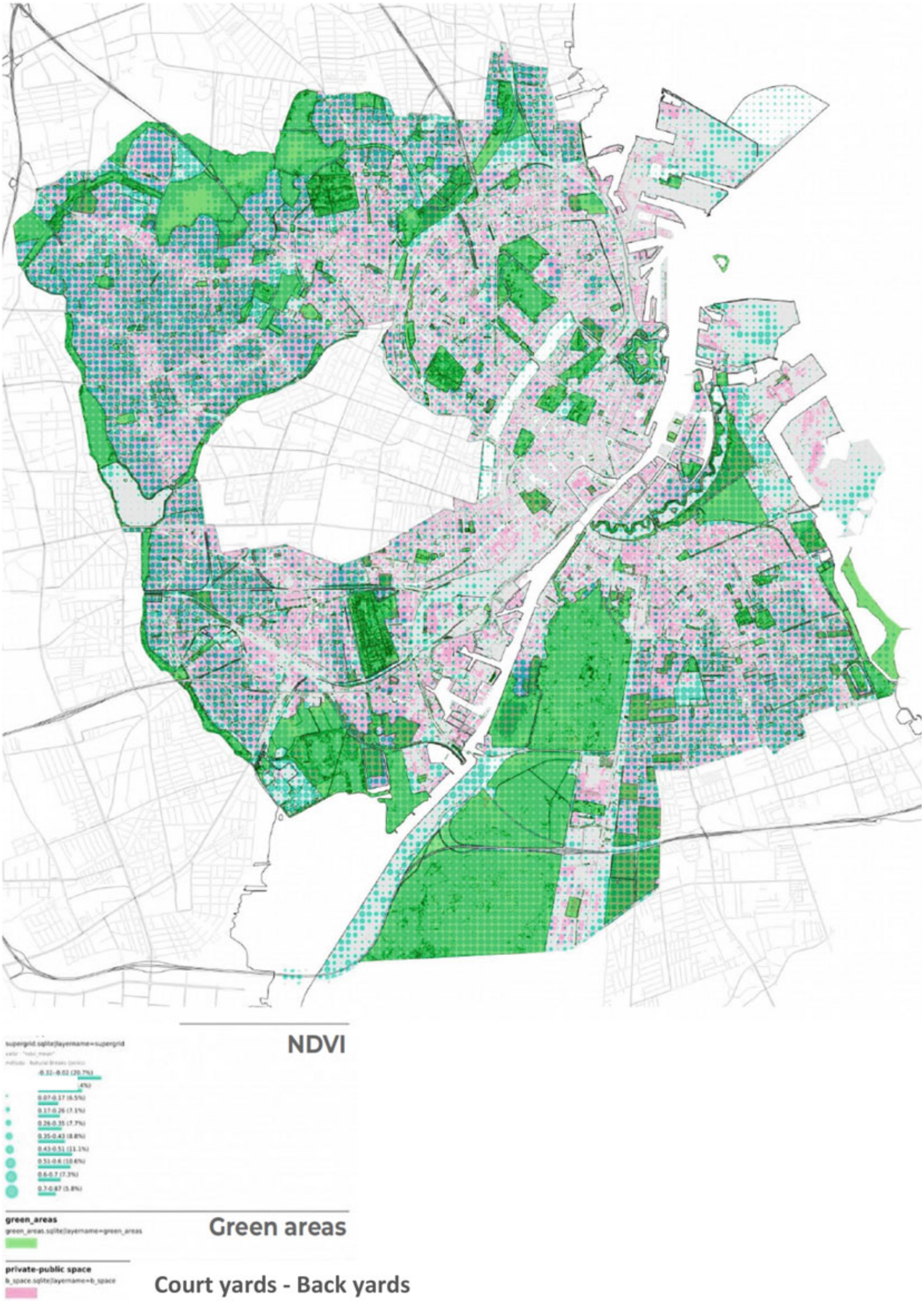

Fig. 5.2 Map 79 NDVI, green areas and green court yards/back yards. *Source* Copenhagen Municipality (300.000 km/s)

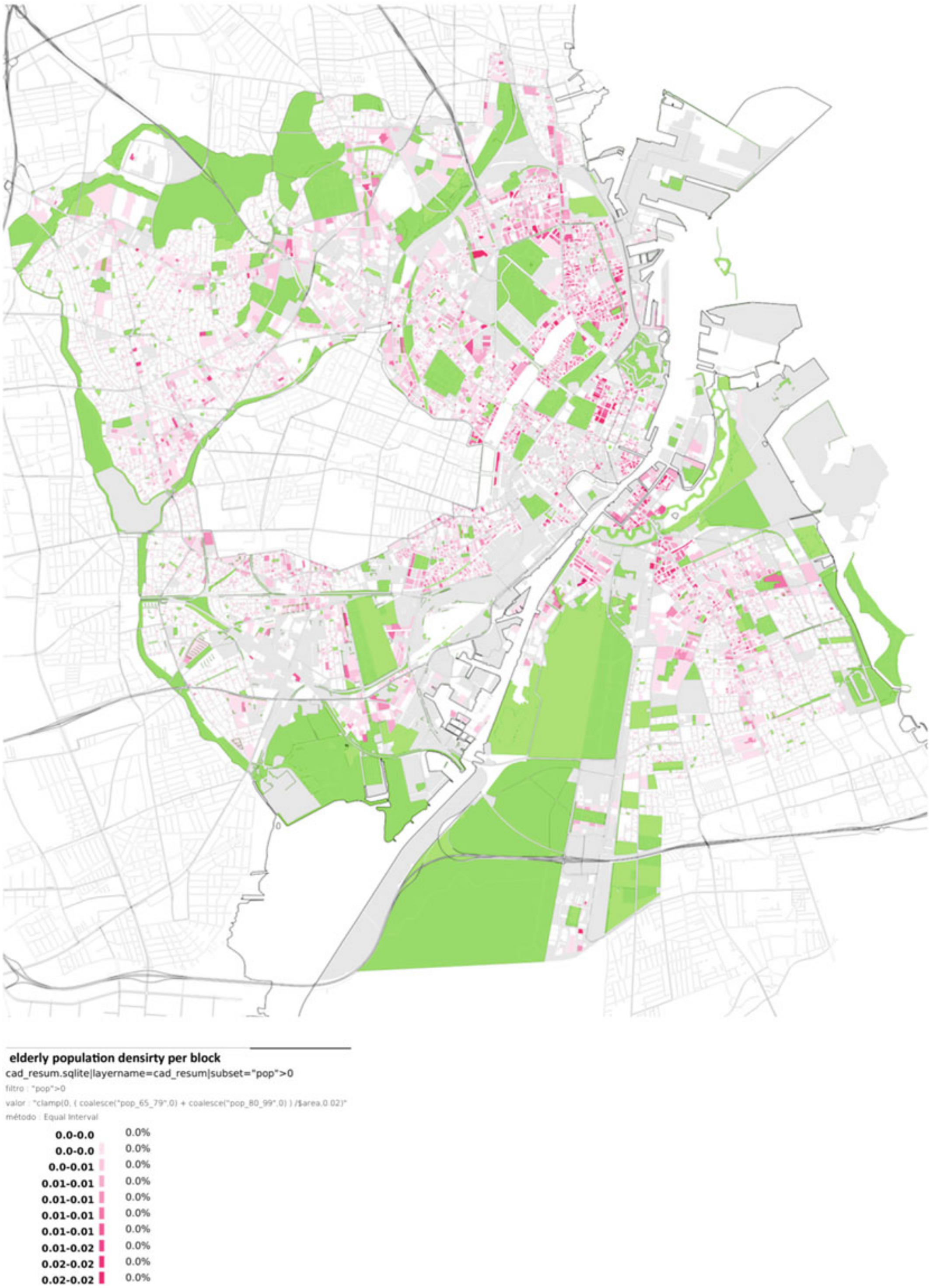

Fig. 5.3 Map 131 old population ($\geq$ 65-year-olds) density per block. *Source* Copenhagen Municipality (300.000 km/s)

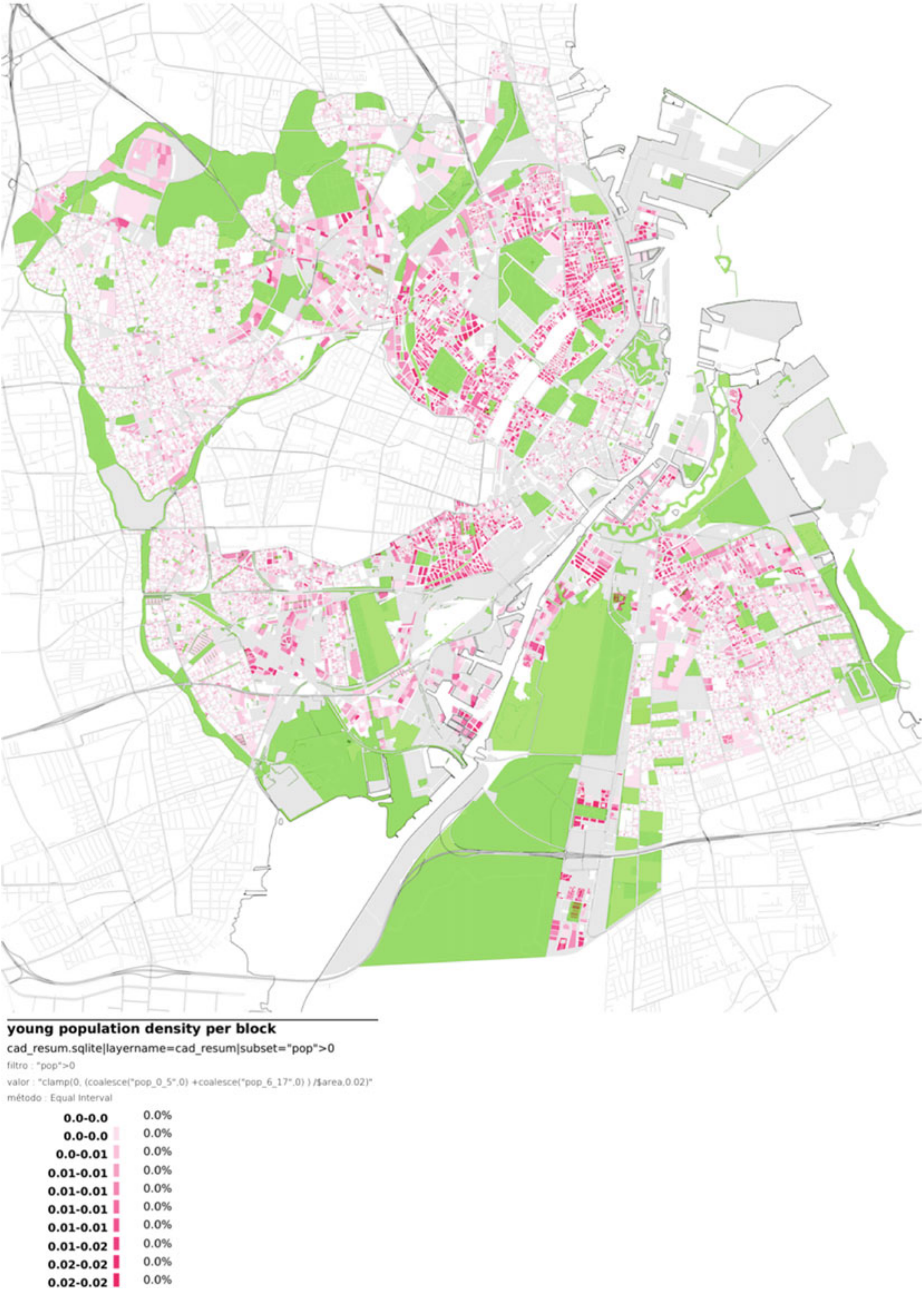

Fig. 5.4 Map 132 young population ($\leq$ 17-year-olds) density per block. *Source* Copenhagen Municipality (300.000 km/s)

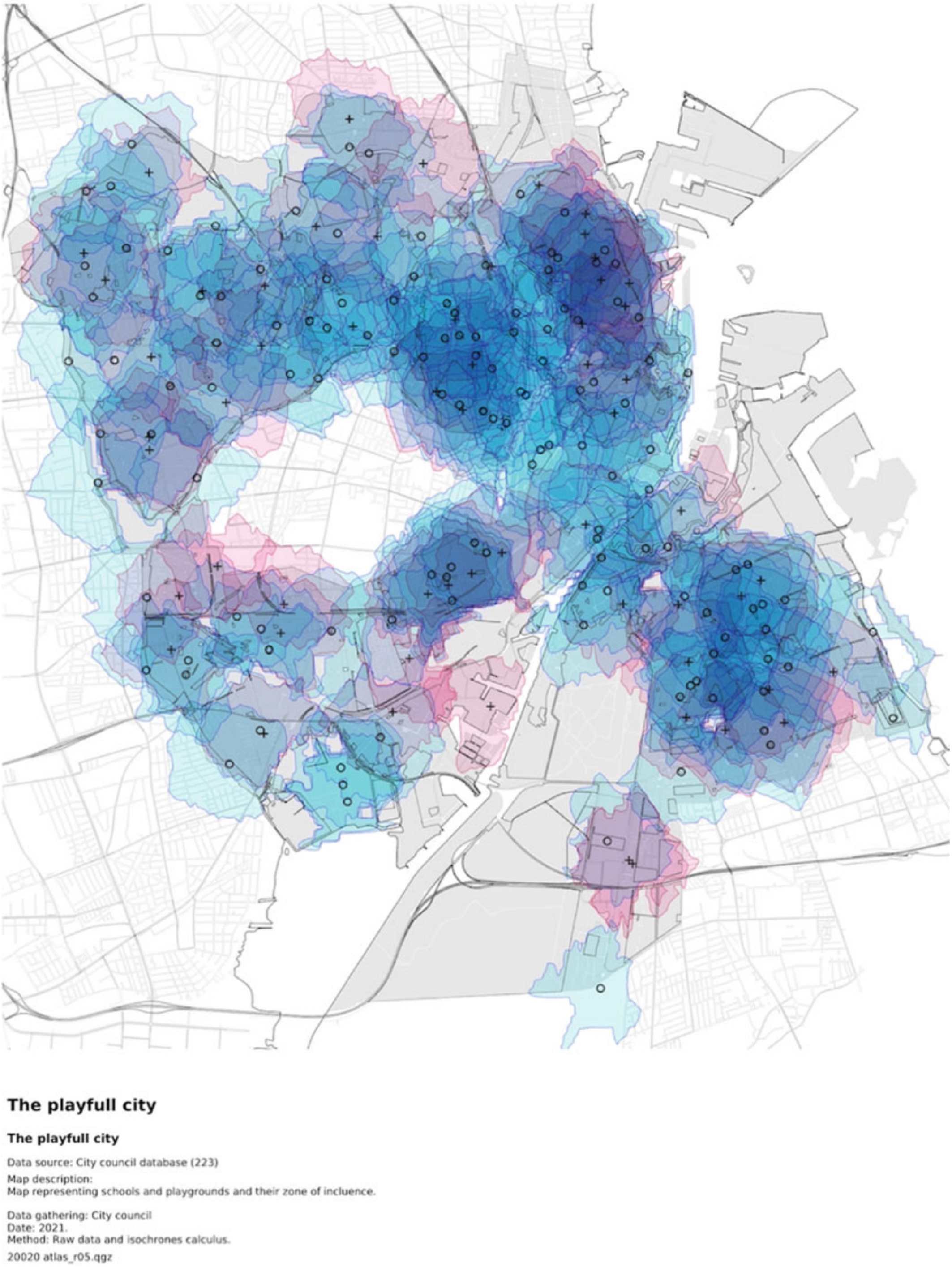

Fig. 5.5 Map 133 distribution of playgrounds—isochrone map. *Source* Copenhagen Municipality (300.000 km/s)

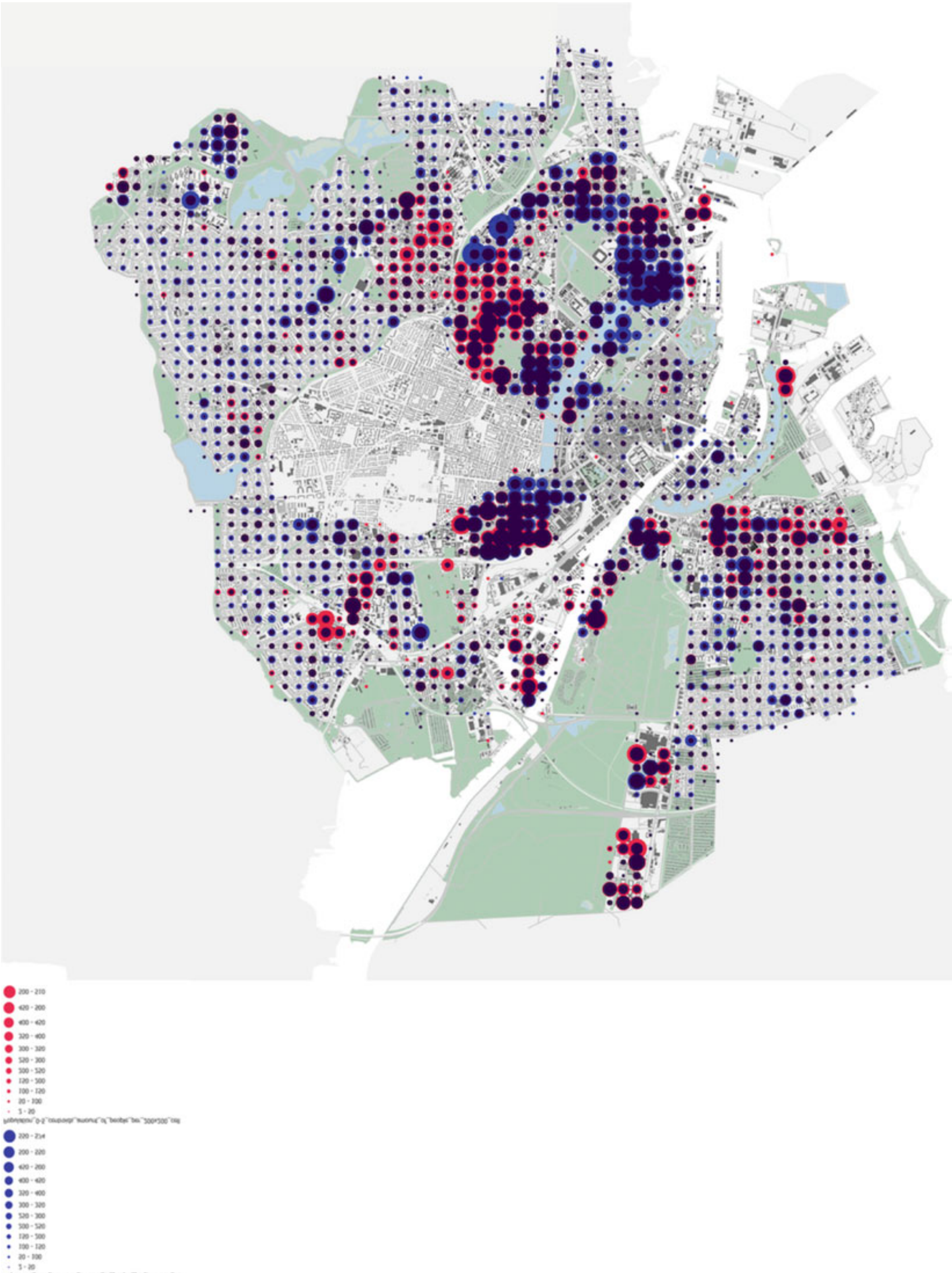

Fig. 5.6 Map 134 population density, children, and youth (age groups 0–5 and 6–17). *Source* Copenhagen Municipality

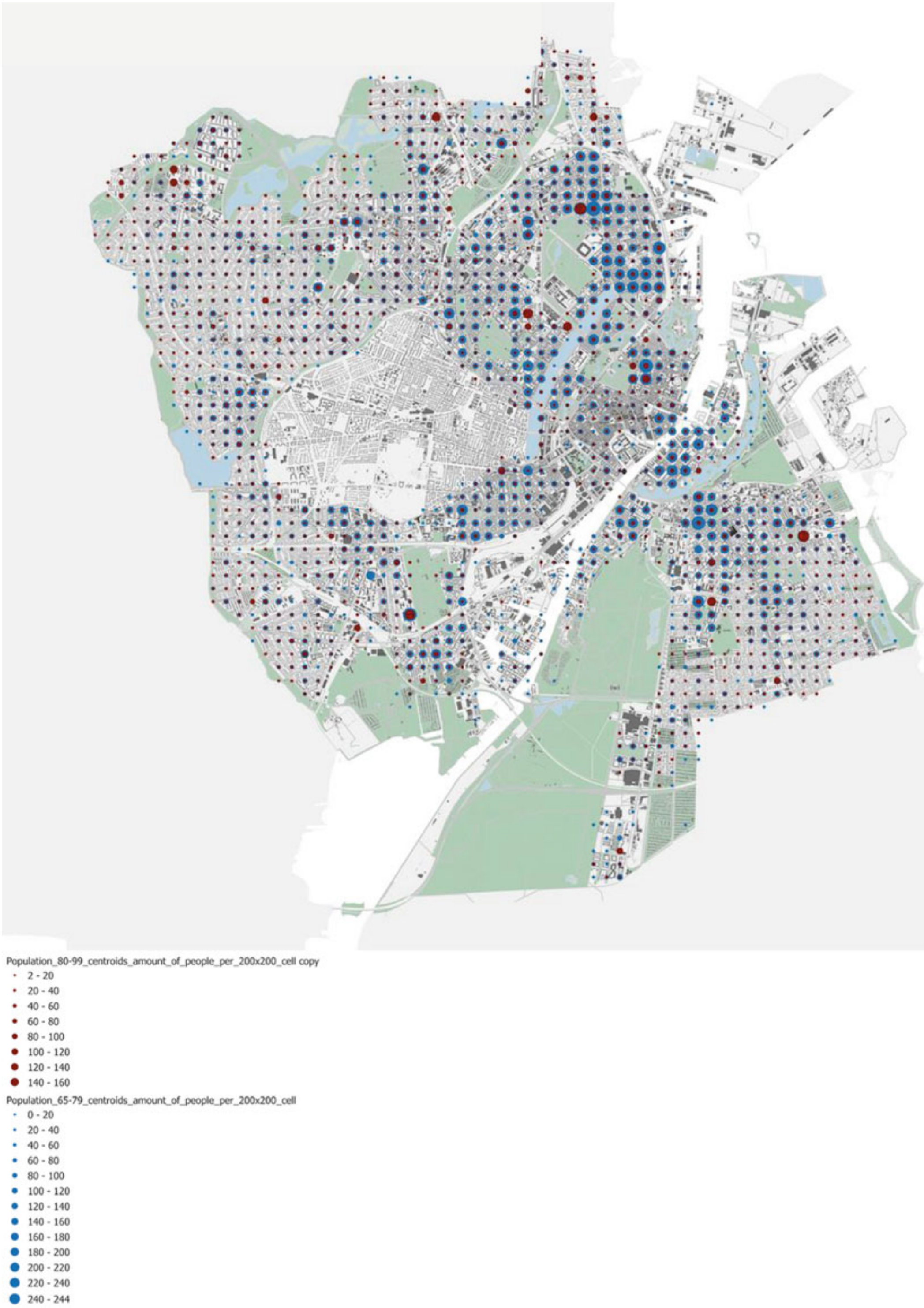

Fig. 5.7 Map 135 population density—elderly (age groups 65–79 and 80–99). *Source* Copenhagen Municipality

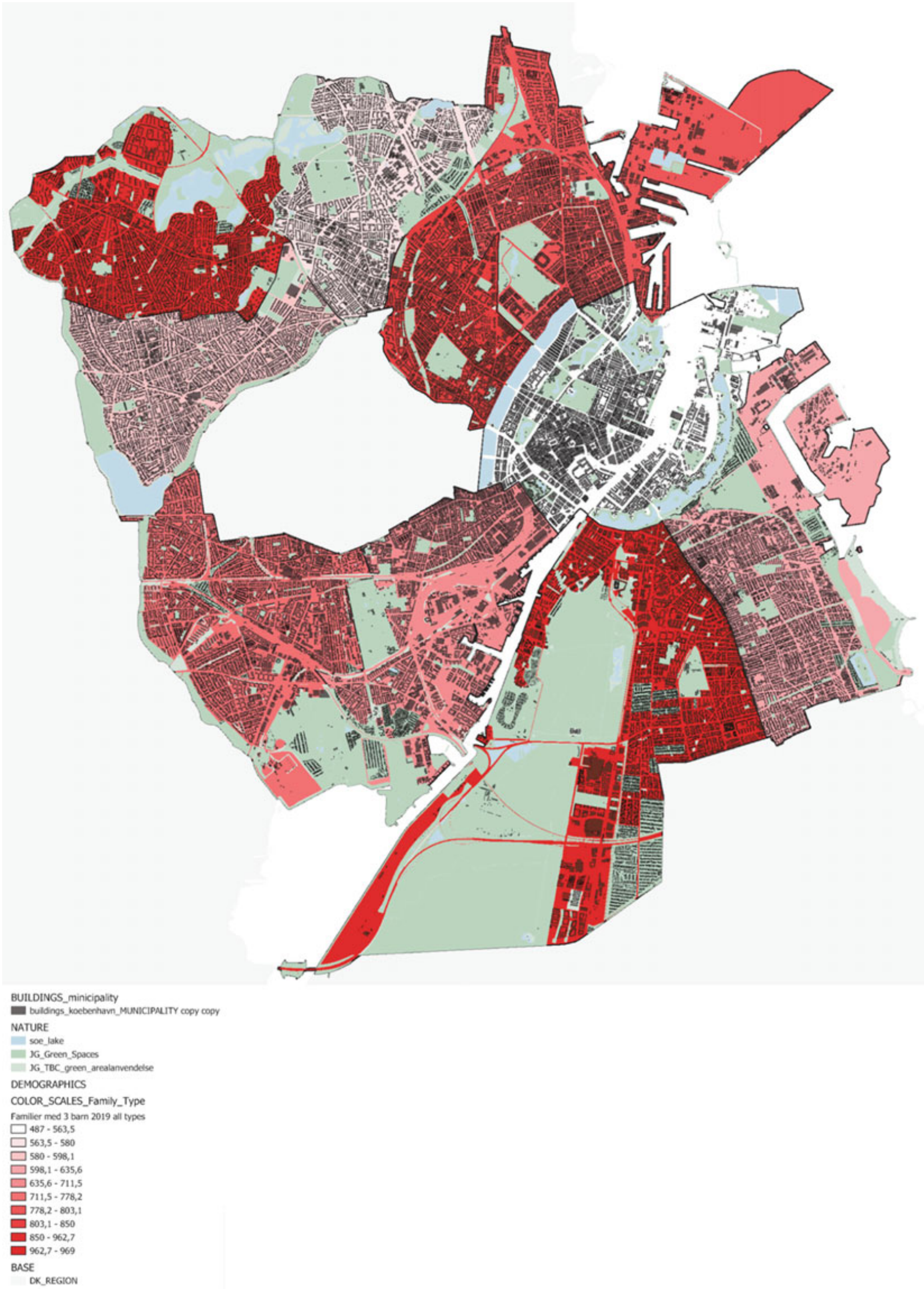

Fig. 5.8 Map 136 distribution of families with 3 children or more—district. *Source* Copenhagen Municipality

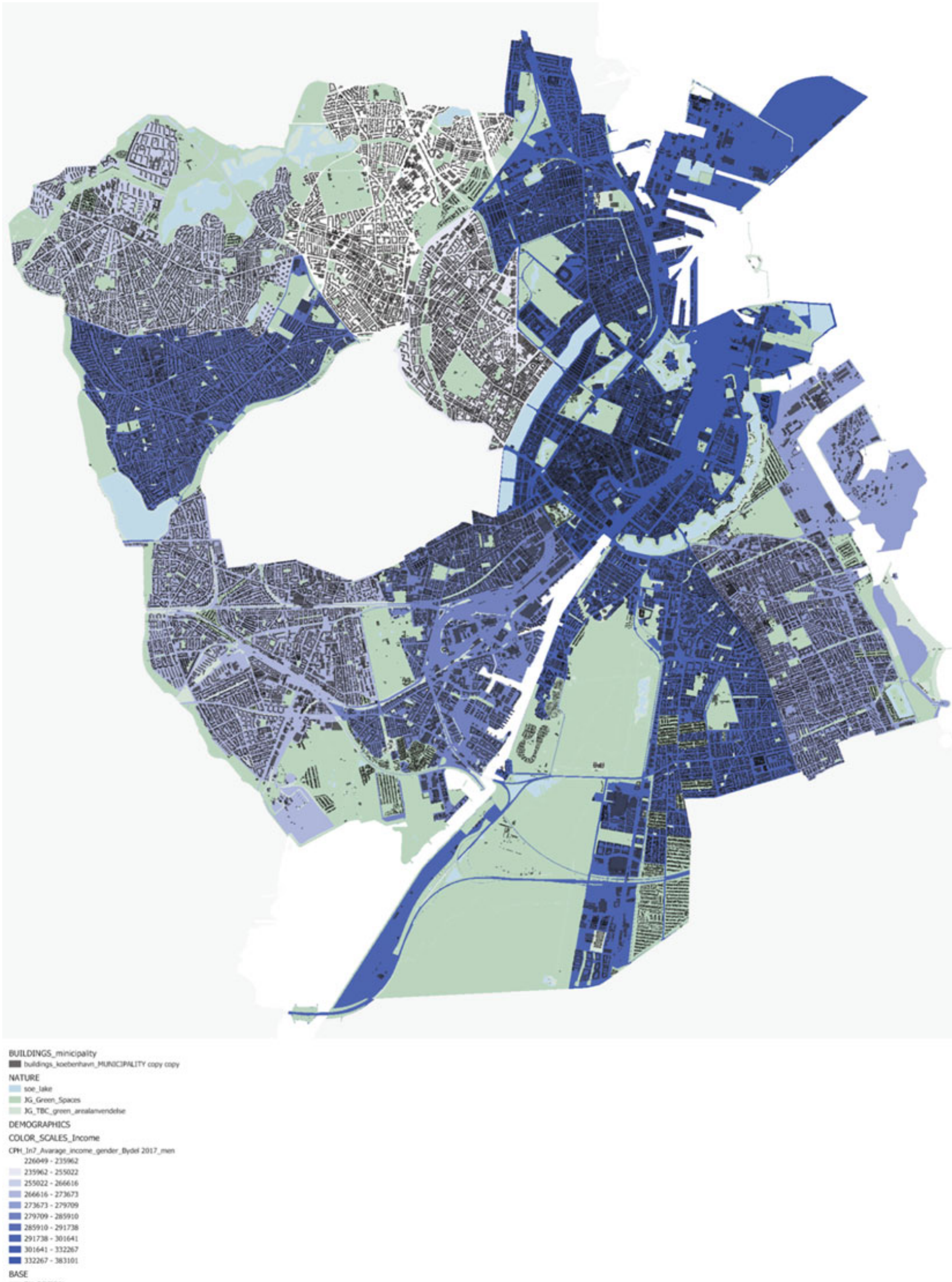

Fig. 5.9 Map 121 average income distribution—district. *Source* Copenhagen Municipality

5.6 Conclusion

The present analysis shows that the age groups primarily considered in this study, namely the elderly ($\geq$ 65-year-olds) and children ($\leq$ 5-year-olds), are not particularly challenged in relation to accessibility to green spaces, compared to other age groups. Neighborhoods with the greatest concentrations of those two age groups present green spaces and playgrounds with distances under 300 m from residential units.

This analysis also points to the importance of considering different urban typologies, whether they may be modernist housing schemes or individual houses with backyards, to investigate the potential of creating, improving, or expanding green spaces, notably in view of providing "inclusive" conditions that can accommodate the requirements of the elderly and families with children. The importance of including the elderly and children is brought further into focus given the prospect of an aging population on the one hand, and the population growth and densification which will put further pressure on use of green spaces and other public spaces on the other hand. This increased pressure on the use of public spaces is of key importance when planning for improving recreational facilities for families with children in the City of Copenhagen and accessibility to green spaces and playgrounds.

This study points to the potential of further expanding and qualifying analytical tools and methodologies used by municipalities to inform policy and decision-making on green infrastructure provision. Mappings made possible by the availability of large geolocated datasets indicating population spatial distribution according to age, and socio-economic and living conditions can enable more nuanced analysis of the actual relationships of accessibility to green and blue spaces by citizens in different neighborhoods. This may turn out to be particularly useful in face of crises such as the one experienced in connection with the recent COVID-19 pandemic and situations of lockdowns where accessibility to nearby green areas becomes even more critical in view of the promotion of mental and physical relief infrastructure.

As pointed out above, this study highlights the importance of analyzing distribution of green spaces in relation to different urban typologies (modernist housing slabs, courtyard blocks, detached houses with backyard, among others) as such typologies present different potential for green space development. Notably, large open areas laid out as car parks or grass lawns in modernist social housing complexes present a great potential for further development of city's green space infrastructure. In addition, this study underlines the need for further qualifying definitions of green spaces used in policy-making with a point of departure on specific requirements of different user groups, notably vulnerable user groups such as the elderly and children. As definitions and green spaces taxonomies based on an understanding of the needs of those groups can contribute to more impactful green space planning.

Furthermore, based on the analysis of household conditions, the study points to the importance for policy-making of taking into account overcrowding (measured in terms of square meters per inhabitant in individual households) as a an important socio-economic indicator, when analyzing accessibility to green spaces (as highlighted by the COVID-19 pandemic).

In view of the key role that green spaces play in promoting social inclusion (De Haas et al. 2021), an analysis of individual household conditions (and related socio-economic factors, such as income, ethnicity, unemployment, and education), as argued in this paper, is an important element in policy-making aimed at a more equitable provision of green areas.

One of the main limitations of the present study lies in that it does not provide a qualitative analysis of green spaces as well as playgrounds, in terms of their design, equipment, conditions (maintenance, among other factors), and additional relevant factors that are considered to play a key role in attracting users (Cohen et al. 2009, p. 5).

Further studies to qualify the use of green spaces by elderly should include an analysis of the design of equipment and amenities (Kabisch and Haase 2014, p. 137) based on different use patterns (Kemperman and Timmermans 2006). In addition, the design of urban spaces in general (streets and squares) can be analyzed in terms of conditions for elderly, focusing on urban design features such as cleanliness and barrier-free routes (Ward Thompson et al. 2014, p. 1).

Acknowledgements This study is based on dialog and collaboration between the Royal Danish Academy and the City of Copenhagen. Our collaborators in the City of Copenhagen have provided detailed built density and geospatial socio-economic data and have engaged in a constructive dialog about central issues connected to densification in the City of Copenhagen.The Catalan urban planning agency 300.000 km/s (https://300000kms.net), through the work of Mar Santamaria and Pablo Martinez, has contributed with data gathering, aggregation of data and production of most maps referred to in this paper as well as map analysis.

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Study on the Complexity of Urban Waterfront Interface from the Perspective of Restorative Experience

6

Chengzhe Lyu and Chunxia Yang

Abstract

Against the backdrop of rapid urbanization and pandemic, how to alleviate the increasing mental health problems of people in high-density cities has become an important challenge for urban sustainable development. This paper proposes new perspective and method to re-examine urban public space in order to explore the ability of built environment to support residents' restorative experience. Waterfront public space, a typical restorative environment in high-density cities, is selected as the research object to explore the impact of urban waterfront interface on peoples' restorative experience. It is pointed out that the restorative experience preference related to waterfront interface is likely to depend on the mixture of formal characteristics and content of waterfront interface, and this complexity can be defined from three dimensions, skyline silhouette complexity, and variance in building facades and interface color. On this basis, the quantitative analysis methods of each dimension are proposed, and the support capacity of different complexity dimensions to people's restorative experience is analyzed with the help of regression model. Based on the analysis results, the study finds that compared with the internal environment elements, urban waterfront urban interface is a more restorative element; ΔH and ΔH /ΔL of main landmark, first layer building facades visual proportion, diversity of building façades, and color diversity are the key factors affecting the level of waterfront restorative experience. The suggestions to develop a healthy urban waterfront environment are provided.

Keywords

Urban waterfront interface · Restorative experience · Skyline silhouette complexity · Variance in building facades · Color diversity · Healthy environment

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6.1 Introduction

Urbanization is an irreversible development trend in the current world. It is estimated that by 2030, more than 60.4% of the world's population will live in cities, and there will be 43 cities with a population of more than 10 million (United Nations 2018). In 1850s, Jarvis put forward the hypothesis that "the higher the level of urbanization, the more mental health problems", which was later confirmed (Plana-Ripoll et al. 2018). Studies have shown that people in high-density cities experience continuous pressure from

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information overload, tight pace, crowding, etc., which will cause harm to people's mental health and cause symptoms such as depression, anxiety, adjustment disorders, and even schizophrenia (Colodro-Conde et al. 2018; Wiens et al. 2017; Watanabe-Galloway et al. 2017). Due to the COVID-19 pandemic, the mental health problems of urban residents have been further exacerbated. The World Health Organization estimates that rates of already common mental health conditions, such as anxiety and depression, increased by more than 25 percent in the first year of the COVID-19 pandemic (WHO 2022).

The links between mental health and the sustainable development goals (SDGs) are complex and, in many cases, bidirectional, especially the good health and well-being (WHO 2022). Mental health is an integral part of general health and well-being but set against a backdrop of incredibly low investment in mental health care around the world. In addition to food security, positive parenting, quality education and employment (WHO 2022; Ford and Freund 2022), local built, and natural environments are also protective factors to restore mental health conditions (Lund et al. 2018). In the context of rapid urbanization and pandemic, it is an important issue for architects and planners to re-examine urban environment, tap the restorative potential of urban public space, and provide a healthy and sustainable living environment for urban residents.

6.1.1 Urban Waterfronts and Restorative Experiences

During the long-term design practices, people have found that natural or built environments with certain characteristics can make people feel physically and mentally happy, thereby reducing stress and relieving negative emotions. In 1980s, Kaplan proposed the concept of "restorative environment" and the attention restoration theory (ART). Kaplan pointed out that people do not need to focus intently when viewing attractive natural or artificial environments, thus repairing their declining attention and alleviating mental fatigue (Scopelliti and Giuliani 2004). Ulrich's stress reduction theory (SRT) has a similar exposition. Ulrich points out that a natural or artificial environment with appropriate depth and complexity, a certain overall structure, and a specific focus can attract attention and trigger positive emotions, which in turn have effect of reducing stress (Ulrich 1979, 1984). A series of studies have shown that the natural or built environment could become "restorative environment" for people to restore mental health when they have certain complex structural characteristics.

Among various urban environment types, waterfront public spaces have become important restorative environments in city due to its combination of natural and built environments. Among 43 cities with population over 10 million predicted by the United Nations, 31 (72%) are developed across river (United Nations 2018), which also makes the waterfront more representative in the restorative environment of high-density cities. The restorative characteristics of the urban waterfront environment are reflected in the ability to help people relax and relieve pressure by supporting various leisure activities, among which the most typical one is to view urban waterfront interface (Nasar and Terzano 2010). In the process of field survey, it is found that urban waterfront interfaces with different morphological structures have different attractiveness to viewing. Such phenomena can be explained by Berlyne's arousal theory (Berlyne 1960) and Wolhwill's adaptive level theory (Wolhwill and Kohn 1973). Individual attention preference will increase with the complexity of the object being observed, but environments that are too monotonous and too complex can also be uncomfortable. Combined with Kaplan's and Ulrich's elaboration on the restorative environment, the complexity of urban waterfront interface will affect viewing behavior to a certain extent and then affect people's restorative experience. So, it is of great value to explore the complexity description method of urban waterfront interface and its support capacity for people's restorative experience, to provide a healthy and sustainable living environment for citizens to cope with the difficulties caused by rapid urbanization and pandemic.

6.1.2 Description and Quantitative Assessment of Complexity of Urban Waterfront Cities

Although we have learned that the complexity of urban waterfront interface could affect people's restorative experience, complexity is still a relatively general concept which is difficult to effectively guide planning and design. We need to further find ways to describe and assess the complexity of urban waterfront interface from an architectural perspective.

The skyline is one of the earliest design concepts used to describe urban interfaces. Skylines were discussed early in an esthetic context (Delafons 1990). Later, people gradually realized its influence on environmental quality and behavioral preferences and brought it into the discussion of environment behavior. In past studies, some scholars (Heath et al. 2000; Stamps et al. 2005) found that visual preferences can be influenced by the amount and degree of twists and turns of the skyline and used them as indicators to describe the complexity of urban interfaces and guide design. In the discussion on the quantitative analysis method, the proportional relationship between buildings' height and buildings' spacing was often used to measure the curvature of the skyline (Im 1984; Stamps 1993). On this basis, Niu used mathematical algorithms to simplify the detail of building silhouette to extract the dominant trend of the twists and turns of the skyline (Niu and Li 2013). In addition, simplifying the buildings into a histogram to describe the curvature change of skyline (Qiu and Li 1997) and using the turns number of building roof to measure the curvature change of skyline (Stamps et al. 2005) are also relatively common methods to quantify skyline.

The subdivision and connectivity of urban interfaces are also important indicators affecting visual preference (Heath et al. 2000), which can be included in the discussion of complexity. The subdivision of urban interface refers to the diversity and clarity of building facade details, and the connectivity of urban interface refers to the hierarchical relationship formed by building facades at different distances (Stamps et al. 2005). In terms of quantitative analysis method, the subdivision of urban interface can be measured by evaluating the clarity and diversity of building facade details, and the connectivity of urban interface can be measured by the visual area proportion of building facades at different levels.

In addition, the possibility that interface color affects visual preference was retained in some researches (Nasar and Terzano 2010). However, due to the technical limitation, it could not be quantitatively analyzed and was only discussed as a control variable in the study.

6.2 Materials and Method

6.2.1 Samples

Shanghai is a typical high-density megacity developed across rivers. Since the completion of 45-km public space connection project along the Huangpu River in 2017, the urban central waterfront has been transformed from industrial production spaces to leisure public spaces for citizens. Eight typical sections among them and the interface on opposite bank were selected as primary samples. To meet the needs of flood control, waterfront public spaces often have a relatively complex three-stage spatial structure—hydrophilic space, flood control space, and adjacent hinterland space. Due to the shelter of plants and the height difference of site, the flood control space and the adjacent urban space cannot view the interface on the opposite bank freely. Therefore, in order to explore the relationship between urban waterfront interface and people's restorative experience more focused, the hydrophilic spaces in the above-mentioned primary samples were selected as final samples. According to the actual situation of site survey, the final samples are divided into 41space slices with 200 m as a basic activity range (Fig. 6.1).

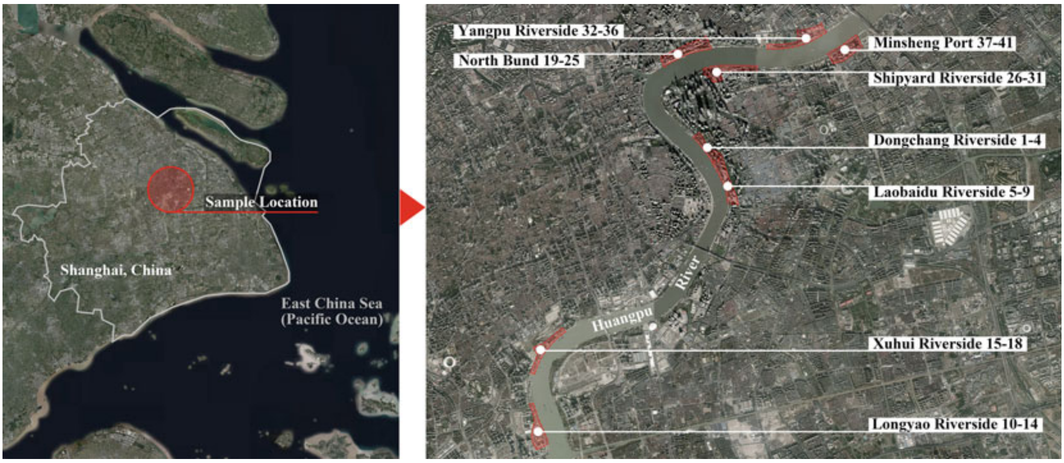

Fig. 6.1 Research samples

6.2.2 Data Collecting

Data collection includes site survey and Internet data acquisition. 1. The site surveys were carried out in the spring and autumn of 2021, when the weather was fine, and the temperature was suitable. There was a survey team consisting of 7 post graduates, mainly collecting behavior data in hydrophilic spaces and images of the interface on opposite bank. In terms of behavior data, the survey team conducted 12 field behavior sweeps (once every 30 min) in sample spaces during two periods of 14:00–17:00 and 19:00–22:00. With the help of mapping, the survey team recorded the number, types, and distribution of behaviors in sample spaces. During this process, the survey team focused on recording the viewing behaviors of subjects facing the opposite bank, such as overlooking and taking pictures. In terms of images of the interface on the opposite bank, the survey team recorded the waterfront urban interface at the fixed measuring points in 41 space slices during two periods of 15:00–16:00 and 20:00–21:00 and acquired high-resolution and consistent urban waterfront interface images with the help of digital cameras and tripods. 2. Internet data acquisition mainly included the building bases and height data of the waterfront and hinterland by means of open download and API access from Amap and OpenStreetMap.

6.2.3 Measure Complexity of Urban Waterfront Interface

6.2.3.1 Skyline Silhouette Complexity

Based on the mutual verification of the Internet data and site survey data, a 3D virtual environment reflecting real height and volume of the buildings along the Huangpu River were constructed in Rhinoceros7. Taking the height of 1.65 m relative to the surface of the location as the observation point (same with the photo shooting point in site survey), the interface view of waterfront that conforms to the real observation situation of human eyes was obtained. Then, the study imported the interface view into ArcMap 10.5 to draw the outline of buildings. In the planning and design of waterfront built environment, designers need to pay attention to the general trend of skyline silhouette rather than small turning changes of the roof. Therefore, the Polynomial Approximation of Exponential Kernel (PAEK) method in ArcMap 10.5 was used to generalize and simplify the drawn skyline (Niu and Li 2013). This method can extract the key points of the line direction on the premise of keeping the basic direction of complex lines unchanged, preserve the relationship between the key points, and smooth the complex lines into continuous curves. Based on the simplified skyline, the major and minor commanding high points and local low points on either side of the commanding high points can be extracted (Fig. 6.2). Based on the high and low points mentioned above, some indicators in the dimension of skyline silhouette complexity can be quantified, such as the relative vertical height (ΔH) and relative horizontal distance (ΔL) of main and secondary landmarks and local low points on their either side, the ratio between the relative vertical height (ΔH), and relative horizontal distance (ΔL) of main and secondary landmarks and local low points on their either side.

6.2.3.2 Variance in Building Facades

In the site survey, it was found that urban waterfront interface was mainly composed of the buildings in the first three-layer blocks close to river, so they were selected to calculate the variance in building facades. Based on the 3D virtual environment constructed in the previous step, different colors were assigned to the building facades (buildings of the same block layer are given the same color). Then, the study extracted the model view at the same observation points and calculate the visible area proportion of the building facade in each layer and used the Shannon entropy to calculate the diversity of building facades (Fig. 6.3). The calculation formula is as follows:

$$D = -\sum_{i} P_i \times \ln(P_i)$$

in which the "D" refers to the diversity, "P_i" refers to the visible area proportion of the building facade in each layer.

In order to reduce the calculation error caused by the difference in the development intensity—the interface in different area with different

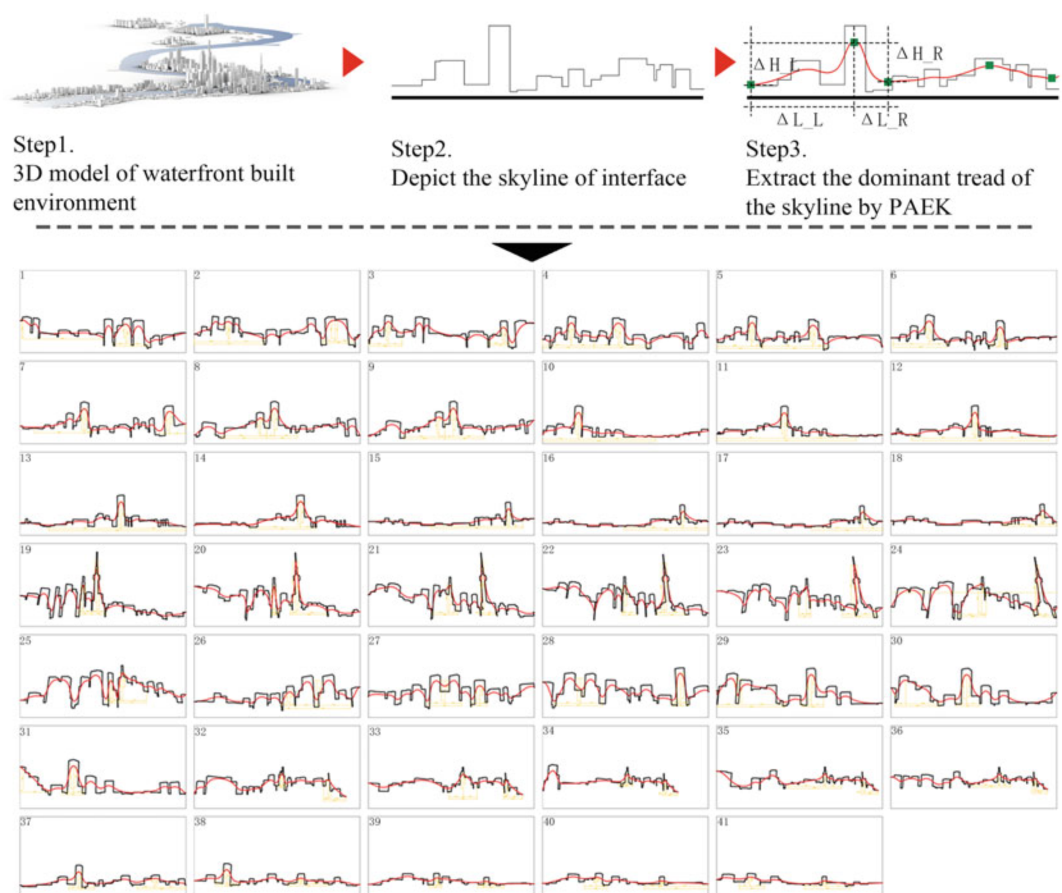

Fig. 6.2 Data processing of skyline silhouette complexity

Fig. 6.3 Data processing of variance in building facades

development intensity may lead to similar skyline silhouette complexity and variance in building facade, the sky visibility was taken into consideration. In the interface view obtained from the same viewing angle, the higher the sky visibility rate, the lower the development intensity of the area is.

Since the river width in samples ranges from 500 to 700 m, the details of the building façades are difficult to be recognized by viewers at such a scale. So, the subdivision of urban waterfront interface will not be discussed in this study (Fig. 6.3).

6.2.3.3 Interface Color

Urban waterfront interface presents different color effects during day and night. In daytime, the interface color is mainly affected by the material of building facade; in nighttime, the interface color is mainly affected by the lighting configuration of building facade. Therefore, different from the data processing method based on the 3D virtual environment, the interface color will be measured according to the real images. First, through the segmentation of the captured images of the interface on the opposite bank, building facades were extracted. Second, taking a single pixel as the calculation unit, the dominant colors of each image were extract by the K-means in Python platform. The visualization of data processing is shown in the figures (Fig. 6.4). All the data results are shown in Table 6.1.

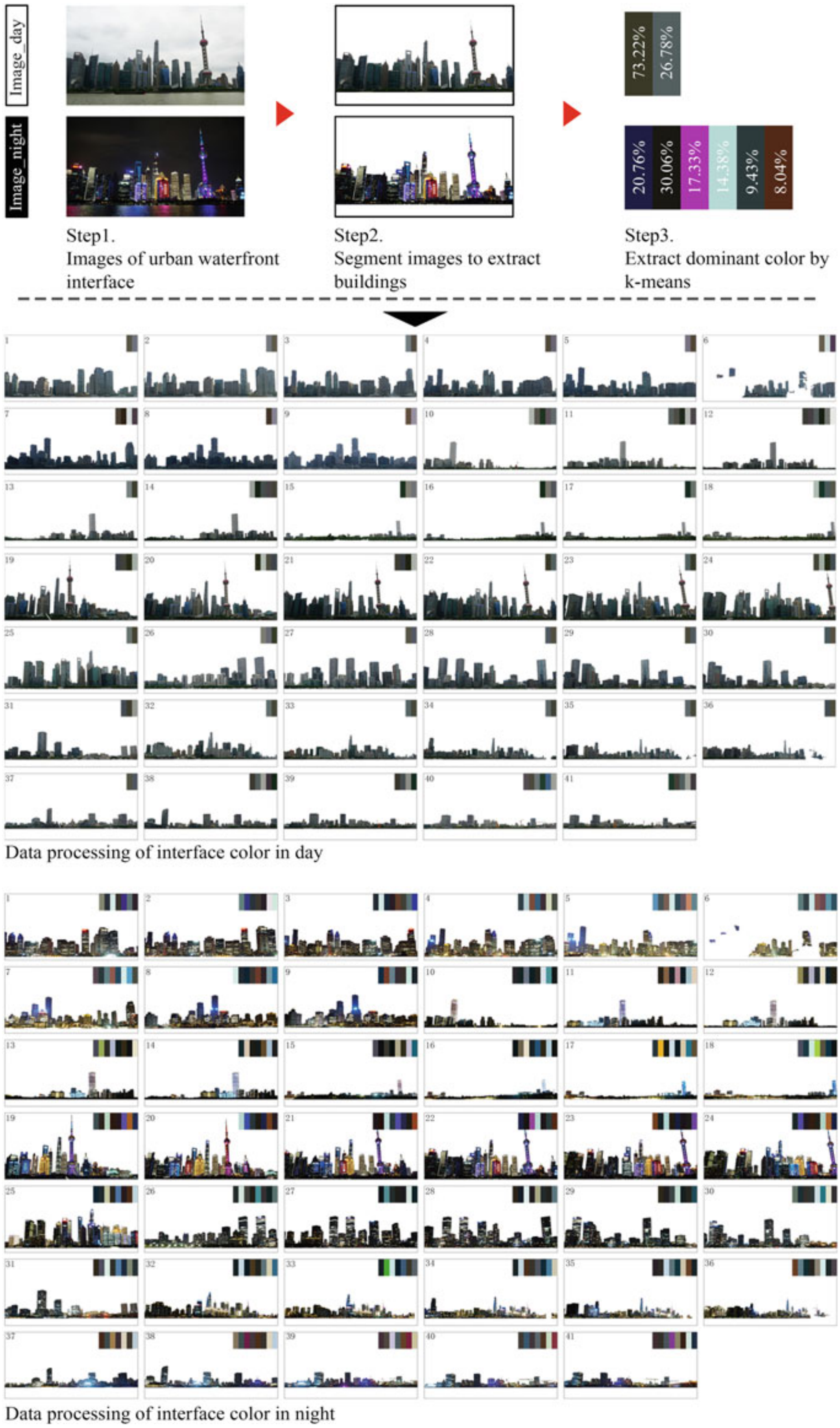

Fig. 6.4 Data processing of interface color

Table 6.1 Results of data processing

Complexity dimensions	Complexity factors	Descriptive statistics	S-W test	p-value
Silhouette complexity	Main landmark ΔH/ΔL	1.115(0.667–1.625)	0.773	0.000
	Secondary landmark ΔH/ΔL	0.627(0.194–1.321)	0.839	0.000
	Main landmark ΔL (W*)	0.182(0.142–0.274)	0.807	0.000
	Secondary landmark ΔL (W*)	0.135(0.083–0.262)	0.877	0.000
	Main landmark ΔH (H*)	0.214(0.141–0.262)	0.837	0.000
	Secondary landmark ΔH (H*)	**0.110 ± 0.077**	0.949	**0.067**
Variance in building facades	First layer building facades visual proportion	0.037(0.021–0.058)	0.881	0.000
	Second layer building facades visual proportion	0.118(0.038–0.234)	0.855	0.000
	Third layer building facades visual proportion	0.025(0.012–0.039)	0.902	0.002
	Sky visual proportion	0.777(0.686–0.910)	0.882	0.000
	Diversity of building facades	0.523(0.305–0.592)	0.844	0.000
Interface color	Color diversity (day)	0.646(0.583–0.806)	0.919	0.006
	Color diversity (night)	1.854(1.611–1.939)	0.898	0.001

Note W* and H* are the width and height of the observation field
The bold indicates that the P-value is less than 0.05, which means that the indicator is statistically significant in the analysis

6.2.4 Procedure

According to the data of site survey, the total number of activities and viewings in each hydrophilic space slice were counted, and the ratio of viewing was taken as an indicator to measure the level of restorative experience. All data were tested for normal distribution and standardized. Then, the study tested the correlation relationship between the level of restorative experience and the factors in three complexity dimensions of urban waterfront interface to explore and the key complexity factors. Taking the level of restorative experience as the dependent variable and the key complexity factors as the independent variable, the multiple linear regression analysis method was used to explore the effect of the key complexity factors. Based on the regression analysis results, the support capacity of the factors in three complexity dimensions of urban waterfront interface to the level of restorative experience was further analyzed. All statistical analyzes were performed in IBM SPSS Statistics24, and in all tests, p-values < 0.05 were considered to indicate statistical significance.

6.3 Results

6.3.1 The Level of Restorative Experience

Based on the statistics of survey data, 30,243 people came to the hydrophilic spaces to take leisure activities, and 4929 people stayed for viewing. Among them, 10,848 people came to the hydrophilic spaces to take leisure activities, and 1928 people stayed for viewing in daytime; 19,395 people came to the hydrophilic spaces to take leisure activities, and 3001 people stayed for viewing in nighttime. The viewing ratio of day and night was calculated as follows (Fig. 6.5).

6.3.2 Exploring the Key Complexity Factors of Urban Waterfront Interface

In the normal distribution test, 12 items of data do not conform to the normal distribution (Table 6.1), as the Shapiro–Wilk test was

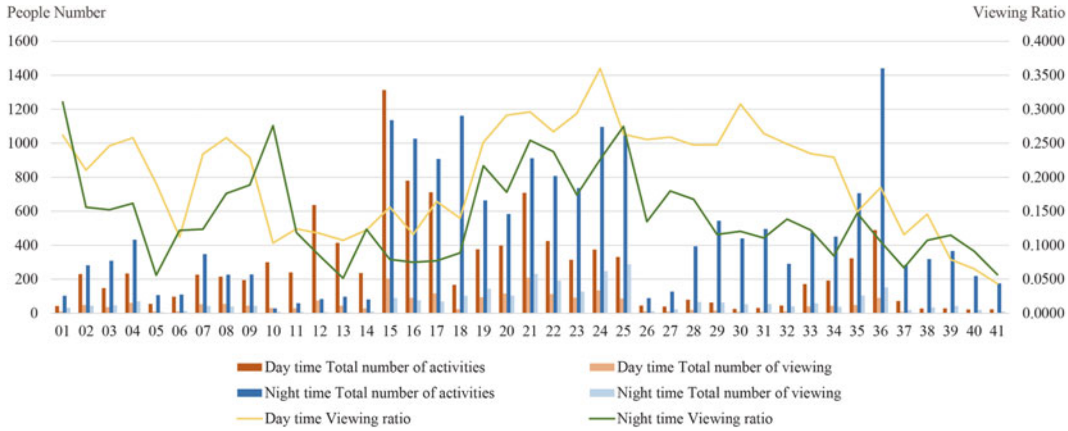

Fig. 6.5 Restorative experience level of each sample space

significant ($p < 0.01$). Therefore, Spearman's correlation coefficient was used to analyze the correlation between each complexity factor and the level of restorative experience.

In the dimension of skyline silhouette complexity, ΔH/ΔL of main landmark and secondary landmark shows strong significant positive correlation ($p < 0.01$) with the level of restorative experience in both day and night; ΔH of main landmark and secondary landmark shows strong significant positive correlation ($p < 0.01$) with the level of restorative experience in the day; ΔH of main landmark shows strong significant positive correlation ($p < 0.01$), while ΔL of main landmark shows weak significant negative correlation ($p = 0.024$) with the level of restorative experience in the night.

In the dimension of variance in building facades, second layer building facades visual proportion and the diversity of building facades show strong significant positive correlation ($p < 0.01$) with the level of restorative experience in both day and night; sky visual proportion shows strong significant negative correlation ($p < 0.01$) with the level of restorative experience in both day and night; first layer building facades visual proportion shows weak significant positive correlation ($p = 0.015$) with the level of restorative experience in the night; third layer building facades visual proportion shows weak significant positive correlation ($p = 0.023$) with the level of restorative experience in the day.

In the dimension of interface color, color diversity shows strong significant positive correlation ($p < 0.01$) with the level of restorative experience in the night. The correlation coefficients and significance levels of each complexity factor are shown in (Table 6.2). The complexity factors with significant correlation coefficients are considered as key factors in the subsequent analysis.

6.3.3 The Support Capacity of Key Complexity Factors to People's Restorative Experience

A linear regression model was used to further examine the association between the key complexity factors and the level of restorative experience. Prior to regression analysis, it is necessary to take a collinearity diagnosis of the data of key complexity factors. Collinearity existed among three variables—second and third layer building facades visual proportion and skyline visual proportion. The tolerances of these three variables were ≤ 0.1, and the variance inflation factor (VIF) was ≥ 10 (Table 6.3). After eliminating collinear variables, regression analysis was performed on the remaining key complexity factors (Table 6.4). The regression models of day and night showed a significant linear relationship by the F -test (F -test), which were valid models.

Table 6.2 Correlation coefficient and significance degree of waterfront city interface complexity factors

Complexity dimensions	Complexity factors	Viewing ratio (day)			Viewing ratio (night)		
		Correlation coefficient	*p*-value	N	Correlation coefficient	*p*-value	N
Silhouette complexity	Main landmark ΔH/ΔL	**0.757****	**0.000**	41	**0.784****	**0.000**	41
	Secondary landmark ΔH/ΔL	**0.640****	**0.000**	41	**0.555****	**0.000**	41
	Main landmark ΔL	– 0.128	0.425	41	**– 0.441****	**0.004**	41
	Secondary landmark ΔL	– 0.081	0.616	41	– 0.241	0.129	41
	Main landmark ΔH	**0.588****	**0.000**	41	**0.352***	0.024	41
	Secondary landmark ΔH	**0.656****	**0.000**	41	0.159	0.321	41
Variance in building facades	First layer building facades visual proportion	0.242	0.059	41	**0.432***	**0.015**	41
	Second layer building facades visual proportion	**0.856****	**0.000**	41	**0.580****	**0.000**	41
	Third layer building facades visual proportion	**0.354***	**0.023**	41	0.068	0.674	41
	Sky visual proportion	**– 0.856****	**0.000**	41	**– 0.600****	**0.000**	41
	Diversity of building facades	**0.868****	**0.000**	41	**0.594****	**0.000**	41
Interface color	Color diversity	0.091	0.573	41	**0.627****	**0.000**	41

The bold indicates that the P-value is less than 0.05, which means that the indicator is statistically significant in the analysis

Table 6.3 Partial results of collinearity diagnosis

Complexity factors	Collinearity statistics	
	Tolerance	Variance inflation factor
Second layer building facades visual proportion	0.019	51.322
Third layer building facades visual proportion	0.084	11.847
Sky visual proportion	0.009	109.772

The adjusted R-squares of these two models reach 0.736 and 0.518, respectively. In the regression model of day, ΔH of main landmark shows weak significance ($p = 0.039$), the diversity of building facades shows strong significance ($p < 0.01$), while the standardized regressive coefficients (beta) of these two factors are 0.206 and 0.792. In the regression model of night, ΔH/ΔL of main landmark shows weak significance ($p = 0.011$), first layer building facades visual proportion shows weak significance ($p = 0.035$), color diversity shows strong significance ($p < 0.01$), while the standardized regressive coefficients (Beta) of these three factors are 0.214, 0.239, and 0.371. The standardized regressive coefficients of the remaining factors did not show significance.

6.3.4 Supplementary Analysis Combined with Internal Environment Elements of Hydrophilic Space

In the researches on lingering behavior in waterfront public spaces, the internal environment

Table 6.4 Regression coefficient of key complexity factors in restorative experience level regression model

		Regression model (day)			Regression model (night)		
		Beta	*p*-value	Std. error	Beta	*p*-value	Std. error
Key complexity factors	Main landmark ΔH/ΔL	− 0.084	0.668	0.011	**0.214***	**0.011**	**0.006**
	Secondary landmark ΔH/ΔL	− 0.062	0.672	0.013	0.125	0.507	0.014
	Main landmark ΔL				− 0.184	0.182	0.001
	Main landmark ΔH	**0.206***	**0.039**	**0.001**	− 0.147	0.259	0.001
	Secondary landmark ΔH	0.137	0.363	0.001			
	First layer building facades visual proportion				**0.239***	**0.035**	**0.281**
	Diversity of building facades	**0.792****	**0.000**	**0.053**	0.044	0.821	0.091
	Color diversity				**0.371****	**0.006**	**0.051**
Model description	N	41			41		
	Adjusted R^2	0.736			0.518		
	F-test	$F = 19.622$, p-value < 0.01			$F = 6.121$, p-value < 0.01		

The bold indicates that the P-value is less than 0.05, which means that the indicator is statistically significant in the analysis

elements are always important factors affecting people's willingness to stay (Yang and Shao 2018). Thus, the study conducted supplementary regression analysis combined with the internal environment elements of hydrophilic space to further examine the support capacity of key complexity factors of urban waterfront interface to the level of restorative experience. The internal environmental elements of hydrophilic space include space design elements and facility elements. The former includes the depth of base surface of hydrophilic space and the form of shoreline, and the latter includes the area density of seats (Yang and Shao 2018, Yang et al. 2021). Among them, the shoreline form is defined by the tortuosity of shoreline (total length of the shoreline/straight line distance between the two ends of the shoreline*100%). The complementary regression models of day and night showed a significant linear relationship by the F-test (F-test), which were valid models. The adjusted R-squares of these two models reach 0.749 and 0.579, respectively. In the supplementary regression model of day, area density of seats shows weak significance ($p = 0.043$), while its standardized regressive coefficient (beta) is 0.126. In the supplementary regression model of night, shoreline form shows strong significance ($p < 0.01$), while its standardized regressive coefficient (beta) is 0.337. The standardized regressive coefficients of the remaining internal environmental elements did not show significance. The adjusted R-squares of the two supplementary regression models were improved by 0.013 and 0.061, respectively, compared with the previous models (Table 6.5).

6.4 Discussion

6.4.1 The Key Complexity Factors and Their Effect

In the dimension of skyline silhouette complexity, ΔH and ΔH/ΔL of main landmark are key complexity factors. In the dimension of variance in building facades, first layer building facades visual proportion and the diversity of building facades are key complexity factors. In the dimension of interface color, color diversity is the key complexity factor. Based on regression analysis, the key complexity factors of three dimensions can better predict the restorative experience level of high-density city waterfront areas.

The standardized regressive coefficient (beta) of the diversity of building facades is 0.792,

Table 6.5 Complementary regression analysis combined with internal environment elements of hydrophilic space

		Regression model (day)			Regression model (night)		
		Beta	*p*-value	Std. error	Beta	*p*-value	Std. error
Significant key complexity factors	Main landmark ΔH/ΔL				**0.349***	**0.036**	**0.007**
	Main landmark ΔH	**0.272***	**0.034**	**0.001**			
	First layer building facades visual proportion				**0.313***	**0.035**	**0.286**
	Diversity of building facades	**0.728****	**0.000**	**0.060**			
	Color diversity				**0.368****	**0.007**	**0.042**
Internal environment elements	Depth of space	− 0.056	0.619	0.001	0.109	0.501	0.001
	Shoreline form	0.045	0.362	0.038	**0.337****	**0.008**	**0.041**
	Area density of seats	**0.126***	**0.043**	**0.004**	0.020	0.884	0.006
Model description	N	41			41		
	Adjusted R^2	0.749			0.579		
	F-test	$F = 24.896$, *p*-value < 0.01			$F = 9.092$, *p*-value < 0.01		

The bold indicates that the P-value is less than 0.05, which means that the indicator is statistically significant in the analysis

which is the most influential key complexity factor in the daytime regression model. After the day-night switch, its impact utility drops to 0.044. This phenomenon may be related to the circadian change of individual's visual perception ability. In the evening, it is difficult for people to effectively distinguish distant buildings in different layers. They are more easily affected by the first layer building facades, which are closer to them, and the diversity of lighting colors on building facades. Therefore, in the nighttime regression model, the color diversity and first layer building facades visual proportion become the two most influential key complexity factors, with the standardized regressive coefficient (beta) reaching 0.371 and 0.239. However, in the daytime correlation analysis, the color diversity of building facades did not show a correlation with the level of restorative experience. During the day, the interface color is mainly affected by the material of building façade. According to site survey, the materials of building facades in waterfront are mostly glass curtain wall, stone, or paint with low color saturation. In the long-distance observation across the river, the color changes of the materials are difficult to distinguish, so there is no significant correlation with the level of daytime restoration experience. In addition, the standardized regressive coefficient (beta) of ΔH and ΔH/ΔL of main landmark reaches 0.206 (daytime regression model) and 0.214 (nighttime regression model). This suggests that people prefer highly prominent landmarks during the day, while they prefer the twists and turns of the skyline at night, which is consistent with Nasar's study (Nasar and Terzano 2010).

6.4.2 Quantitative Analysis Methods from the Human-Based Perspective

The skyline silhouette complexity and the variance of building façade have been discussed by different scholars from a morphology perspective (Heath et al. 2000; Xu et al. 2013), most of which start from a macro perspective such as urban landscape and image planning. Fully considering the behavior practices and visual perceptions of the crowd in waterfront when constructing the sample database makes the study closer to the human-based perspective.

In this study, the ratio of viewing in waterfront public space was selected to measure the level of restoration experience. Different from subjective evaluation data after viewing real pictures or virtual scenes, collecting behavior data from the actual environment is more intuitive and meaningful and can better reflect the real level of restorative experience in waterfront public spaces. Of course, doing so created more work. There is often an error caused by fluctuations in subjective consciousness between purposeful psychological assessment and subconscious behavior practice. On-site behavior research is more realistic, but it is also more susceptible to other environmental factors than laboratory data. To cope with these, the study explores the influence of internal environmental factors on the prediction degree of the key complexity factors by means of supplementary regression analysis. The results show that after supplementing the internal environmental elements, the prediction degree of the day and night regression model is slightly improved, but their effect is much lower than the key complexity factors of urban waterfront interface. This further confirms the importance of urban waterfront interface to people's restorative experience.

In the processing of viewing objects, urban waterfront interface data obtained at the points with the actual human eye height can better reflect the real visual experience of individuals than the ideal model. The data obtained by the method of simplifying skyline with the help of PAEK is closer to the visual experience when viewing from a distance, that is, paying more attention to the dominant trend of skyline, ignoring the subtle turns and undulations. This approach also helps architects and planners to use the analysis results in future designs. It should be noted that the utility of this approach in dealing with close urban waterfront interface (where the river width is narrow) has not been proven. When viewing the waterfront urban interface up close, subtle changes in the skyline and building facades are more easily captured by individual vision, which in turn may affect the restorative experience. In addition, the interface color diversity data obtained based on the k-means clustering algorithm effectively supplements the inadequacy of existing complexity studies of urban interface that cannot quantify color.

6.4.3 Guidance to Healthy Urban Waterfront Environment Development Based on Quantitative Analysis

From the perspective of urban design, among the three dimensions, skyline silhouette complexity and variance in building facades are more inclined to the study of urban form and need to be defined first. The interface color is more inclined to material and lighting design, which needs to be further defined on the basis of urban form.

In the dimension of skyline silhouette complexity, the skyline with obvious undulating changes can meet people’s visual preferences. This inspires us that the control range of skyline should be divided according to the development intensity of different riverside sections in waterfront urban design. By creating significant local commanding points within each control range, the restorative potential of urban waterfront interface will be improved, and more viewing will be triggered. In the dimension of variance in building facades, improving the diversity of building façades and increasing the first layer building facades visual proportion are the development guidance derived from the regression model. There is a certain contradiction between the two, which needs to be treated dialectically. In actual construction, affected by the blue and green line, most of buildings in the first block layer are limited to medium and low-rise buildings to control the development intensity of waterfront. In this way, it can enrich the variance in building façades without blocking the visible area of the buildings on the rear floors too much. It also provides more convenient and diverse functional services for the waterfront while controlling ecological threats. Of course, the guidance derived from the analysis needs to be combined with local urban planning laws and regulations to form a comprehensive urban design guideline that can be implemented to better guide the development of a healthy waterfront environment.

Pressure on living and work, climate change, and reduced opportunities for social and outdoor activities due to the pandemic are all driving a growing desire of people in high-density cities for restorative environments, especially after sunset. However, the difference in the adjusted R-square indicates that the complexity of urban waterfront interface is insufficient to explain the level of restorative experience at night. The difference in adjusted R-square shows that there may exist a more complex impact mechanism on restorative experience in waterfront at night. Internal environmental elements of the waterfront may play an important role besides urban waterfront interface. In addition to the shoreline form mentioned above, ambient lighting has also been confirmed to affect the waterfront lingering behavior (Yang et al. 2021), and its impact on viewing and other leisure behavior need to be studied in future.

6.5 Conclusion

Rapid urbanization and pandemic on a global scale pose challenges to the mental health of urban residents. Architects and planners need to re-examine our urban spaces to provide restorative environments for the physical and mental health of urban residents. Taking urban waterfront interface as the sample, the study expands the complexity definition of restorative environment in Kaplan's attention restoration theory and Ulrich's stress reduction theory, pointing out that the complexity of urban waterfront interface can be defined from three dimensions of skyline silhouette complexity, variance in building facades and interface color. The study shows that the key quantitative complexity factors of the three dimensions can better predict the restoration experience level of waterfront and can provide designers with the analysis results that can guide the design. There are some limitations in the scope of application and nocturnal interpretation. Future studies can be made up and optimized by expanding the sample range and quantity, collecting and analyzing physiological data during observation, analyzing environment lighting, etc.

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7 Health, the Circular Economy, and Our Built Environment

Tiago Da Costa Vasconcelos

Abstract

Covid-19 rapidly highlighted the significance of good public health, similarly, showing that our built environment is crucial in responding to global challenges. Through the lens of Building Back Better, and with a continued focus on health, this paper presents a literature and rapid scoping review examining the extent to which the relationship between our Health, the circular economy, and our Built Environment has recently been investigated. Building Back Better is a future risk mitigation strategy focused on establishing resilient communities. Circular economy has been explored as one such vehicle towards developing economic, social, and environmental resiliency. Circular economy is a systems' solution framework, aimed at breaking the linear 'extract, use, dispose' model. Circular economic advantages are largely emphasised from the perspective of effective and sustainable production and consumption: with the ramifications for health receiving comparatively little attention. Despite this, a circular transition may offer potentially considerable health benefits, while simultaneously contributing societal resiliency, and numerous UN Sustainable Development Goals. The study finds that the implications of the circular economy on health are largely under-explored and highlights significant gaps in the literature regarding the health outcomes of a transition to a circular economy in the built environment. It concludes that while the circular economy presents a viable option for building resilience, it also calls for more systematic investigation to fully understand the potential health and social impacts of circular transition in the built environment. The paper also notes that the uptake of the circular economy remains relatively slow and further research is required to understand its social and health impacts.

Keywords

Circular economy · Built environment · Health · Resilience · Social impacts

7.1 Introduction

7.1.1 Lifting the Veil: Covid-19

Human health and well-being have been at the forefront of discussion since the world awoke to the terrifying reality of the Covid-19 pandemic. The novel coronavirus—first reported on the 31st

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of December 2019 (WHO 2020a), and later declared by the World Health Organization (WHO) as a pandemic on the 11th of March 2020(WHO 2020b)—has impacted virtually every facet of life. Originating in Wuhan, China, the virus spread rapidly to neighbouring Japan and South Korea, quickly reaching Europe, Oceania, Africa, and the Americas soon after. Experts across the globe had long-purported that a global event of this nature would spark a cross-border economic disaster due to the globalised, interconnected world of today. Morse et al. (2012), Daszak (2012), Wu et al. (2017), Pinter-Wollman et al. (2018) Undoubtedly, these anticipated dangers have not only materialised, but in many instances far surpassed the anticipated impacts.

First and foremost, the pandemic represents a tremendous human tragedy which swept across the globe, with 6,518,749 confirmed Covid-19-related deaths worldwide as of September 28, 2022. WHO (2022) While global vaccination rates have increased to curb transmission, social disorder and great economic losses have been suffered. UN DESA (2020), IMF and World Bank (2021) Certainly, the pandemic devastated the world over, placing immense strain on global health services, infrastructure, supply chains, and individual well-being. This has lifted the veil on our operating assumptions, exposing the fragility of the current, dominant economic model. Pinner et al. (2020) The struggle to respond to an unplanned crisis and unforeseen shocks has triggered a renewal in calls to investigate ways in which future shocks can be better absorbed, and crises best dealt with—or indeed avoided altogether.

This paper presents the potential to leverage circular economy (CE) as a vehicle for this call to action. It reviews literary evidence for its connection to resilience and subsequent potential implications for human health and well-being. An argument is made for its implementation in the context of the built environment (BE) as a means of responding to UN SDGs '3. Good Health and Well-being', '9. Industry, Innovation and Infrastructure', and '11. Sustainable Cities and Communities'. For the purposes of this study, the BE is to be considered as the man-made structures and spaces that make up the places where we live, work, and play. This includes things like buildings, roads, bridges, infrastructure, and other physical structures that are created by human activity. It encompasses everything from residential homes and commercial buildings to parks and public spaces, to transportation systems and power grids." (Roof and Oleru 2008).

Finally, this paper presents a rapid scoping review on research related to human health and well-being as an outcome of CE implementation in the BE. The results of this review highlight substantial gaps in the literature, representing an opportunity for further investigation of CE implications on human health and well-being in the BE.

7.2 Literature Review

7.2.1 Resilience by Way of Industrial Innovation

The concept of 'Building Back Better' was first described in the UN Sendai Framework for Disaster Risk Reduction 2015. Nations Office for Disaster Risk Reduction (2015) Building Back Better is a future risk mitigation strategy focused on establishing resilient communities through the BE: via strategic management, effective planning, and policy enactment. Its resiliency is established in relation to other long-term concepts such as robustness, continuity, sustainability, stability, durability, and duration. Hassler and Kohler (2014) The greater the capacity to absorb shocks, while maintaining essential socio-cultural and economic functions in society, the more resilient the BE. Our BE is directly influenced by the underpinning economic models that drive development. Thus, the ability for essential socio-cultural and economic functions to endure and adapt over sustained periods is key when considering the development of resilience in the BE. Bäunker and Haigh (2020) articulated this point:

> If we muddle through each new crisis with the same economic model that got us here, albeit with short-term fixes to abate the impact, future shocks will continue to exceed capacities.

The Covid-19 pandemic's crippling of systems worldwide has exemplified how a profits and growth driven economy's resulting capacities fall short on the longer-term, risk reducing, sustainable approaches required to deliver true resilience. To identify innovative solutions which looked to build resilience and promote well-being —reacting to Covid-19—a recent study from Mossin et al. (2022) mapped and documented responses to the Covid-19 pandemic in the BE. This study underlined the significant impact that our physical surroundings have on our health and well-being through the documentation of thirty-five cases around the globe. Successfully responding to challenges arising from the pandemic, cases demonstrated how creativity can turn mitigatory tactics into innovative ways for Building Back Better. While each case exhibited intrinsic value, collectively, the researchers identified a set of trends across cases. Four trends emerged through this process: (i) reconfiguring of interiors, (ii) moving activities outdoors, (iii) consideration of space and its organisation, and finally (iv) industrial innovation.

Here, we focus on (iv) industrial innovation, as this trend looked to the implementation of novel technologies, solutions, systems, and frameworks to streamline processes towards net improved outcomes. Their implementation in response to the pandemic resulted in contributions to the overall health and well-being of users, while minimising the negative impact on their environments. Several cases covered in the study highlight how the Covid-19 pandemic accelerated developments which were already underway in some countries, while the need for swift responses prompted novel approaches elsewhere. For example, in Kenya a newly built care facility was completed in rapid succession to increasing demand for quarantine and isolation facilities. The use of prefabricated building elements (a novel technology within the context at the time) resulted in a timely response to challenges of the pandemic and a reduction of construction waste. Elsewhere, industrialised construction is well-established, with deeper questions regarding its implementation concerned with how it may improve the well-being of those who inhabit its spaces (and further diminish negative impacts on our natural environment). The leveraging of Modular Integrated Construction technologies in Hong Kong, for instance, resulted in record speed building, minimal waste production, and greater occupant safety in the construction of four separate quarantine facilities, and an 800-bed hospital—built in just four months.

These responses to the Covid-19 pandemic in the BE demonstrate that industrial innovation in the BE can contribute to well-being of building users and overall resilience, taking the form of novel technologies, solutions, systems, and frameworks. One such framework, which has the potential to contribute to societal resilience, UN SDGs three, nine, and eleven, and offer potentially considerable health benefits, is the circular economy (CE).

7.2.2 Circular Economy

A circular economy is an economic system in which resources are used, reused, and recycled in a continuous loop, rather than the traditional linear economy of 'extract, use, and dispose'. The goal of a circular economy is to reduce waste and minimise the use of new resources, while also promoting sustainable growth and development. In contrast to our current linear economic model, CE relies on three principles: (i) design out waste and pollution, (ii) keep products, components, and materials at their highest value and in use, and (iii) renew natural systems. Arup et al. (2017) By design, the system is regenerative and restorative, aiming to decouple economic growth from finite resource consumption. Ellen Macarthur Foundation (2017) The Stockholm Resilience Centre (2016) reported that a lasting, positive impact on resilience through sustainability can be achieved by:

> Resilient systems that promote radical innovation in economic policy, corporate strategy, and in social systems and public governance.

As such, CE has been explored and discussed as both a vehicle for establishing more resilient economies and a facilitator of inclusive—and socially just—societies. Ibn-Mohammed et al. (2021).

In the context of resilience, long-term mitigation of risk through CE relates mostly to the optimisation of cycles. For instance, (ii) keeping products, components, and materials at their highest value and in use, designed for disassembly and reuse, making them more easily handled and transformed (virtually a 'non-entity' within the current linear model). Such cycles allow for localised production and consumption loops, with the potential to minimise reliance on global supply channels for—example—essential goods, such as food items. Covid-19 exposed how globalisation has created vulnerabilities in supply chains around the world, consequently limiting access to and increasing costs of a multitude of goods and services once disaster struck. Megahed and Ghoneim (2020).

As a facilitator of inclusive societies, CE presents the potential to minimise resource distribution imbalances through management initiatives—taking the form of participatory governance. Through local stakeholder engagement, strategies such as closed-loop value chains which transform waste into resources—reducing pollution and offering economic opportunities—can contribute to the reduction of inequality in developing and underdeveloped economies lacking certain production capabilities. Lacy and Rutqvist (2016), Stahel (2016) posited that a benefit of CE as such a facilitator is that it is often more labour-intensive than traditional linear modalities, offering a potential for '*reindustrialisation of regions*' where local jobs are created through the substitution of manpower for energy, of materials for labour, and workshops for centralised factories (while boosting local microindustries and the subsequent 'repair economy').

These explorations of CE demonstrate its potential as a means of contributing to societal resilience, but they also highlight clearly that a focus is maintained on sustainable growth: emphasised from the perspective of 'effective and sustainable production and consumption'. Maximising material and resource usage efficiency and negating harmful environmental impacts are central tenets to a circular transition, with co-beneficiary or 'knock-on' positive effects receiving comparatively little attention. Thus, CE as applied in the BE is chiefly aimed at responding to UN SDGs '9. Industry, Innovation and Infrastructure' and '11. Sustainable Cities and Communities'.

This focus is echoed in literature related to CE in the BE, as was demonstrated by Mhatre et al. (2021). Their paper reviewing the evolution of the literature and theory development on CE in the BE demonstrated that research is chiefly concerned with the (i) interpretation of CE-built environment, (ii) CE business models, (iii) CE enablers [and barriers], (iv) end-of-life (EoL) management, (v) circular building materials, (vi) material stocks, and (vii) environmental impact. The top five journals, for instance (by number of publications on CE in the BE), were the Journal of Cleaner Production (68), Sustainability (Switzerland) (25), Resources, Conservation, and Recycling (24), Waste Management (10), and Science of the Total Environment (9).

In a separate paper from Osobajo et al. (2022), published CE research—as it was related specifically to the construction industry between 1990 and 2019—was systematically reviewed. Here, the findings established that CE research shows extensive focus on resource use and waste management, with a lesser focus in areas of supply chain integration, building designs, policy, energy efficiency, land use, off-site manufacturing, cost reduction and cost management, whole-life costing and risk, and health and safety. And in a review by Ghisellini et al. (2018), the environmental and economic costs and benefits of CE as applied in the BE were explored, with the core aim of providing evidence to the '*environmental and economic sustainability*' of different cases of application of CE approaches through its principles.

While the body of literature continues to grow, in practice, the implementation of CE and adoption of its principles in industry face unique challenges. In contrast to consumable goods for example, which typically have a higher turnover rate, the BE is characterised by greater durations, lifespans, a complex-web of stakeholders, and components and materials which over time interact dynamically. This characterisation contributes to various challenges in implementing CE in the BE. To better understand these challenges, barriers and drivers towards CE in the BE have been largely explored and identified.

Araujo Galvão et al. (2018) provided an overview of barriers extracted from the review of 195 academic papers related to CE barriers published between 2005 and 2017. Their study identified seven initial categories: technological, policy and regulatory, financial/economic, managerial, performance indicators, customer, and social. In their discussion, they note that a lack of societal pressure, associated with the lack of public knowledge on the benefits of CE, is a barrier to the implementation of novel policies and strategies by business and government. Additionally, one of the great challenges facing CE adoption is the pursuit of viable strategies and initiatives which are capable of decoupling economic growth from environmental resource exhaustion, while—crucially—benefiting peoples' well-being.

Later, Hart et al. (2019) delved further into these categories and assessed more specifically the barriers and drivers in CE and the BE. Their work pointed towards the emergence of a consensus that despite many technical and regulatory challenges, the greater obstacles towards a CE transition in the BE are cultural, social, and market-related issues. Cultural and social barriers here largely concern the behavioural and social aspects which relate to long-entrenched perspectives linked to a linear economy: on ownership and status—and particularly in the BE—silo mentality, and short-term blinkers.

As an example, the difficulty in demonstrating strong business cases for circular models greatly contributes to slowed adoption. Additionally, nonfiscal benefits such as long-term environmental advantages and influence on health and well-being tend to be difficult to measure precisely and therefore complicated to communicate—contributing further to disillusionment of transitioning towards CE in the BE. As such, there is a call to further analyse and define what is needed to put '*enablers into practice and accelerate the uptake of CE in the BE*'. (ibid.)

Barriers and drivers towards a CE transition in the BE underline that additional dimensions beyond consumption and production must be interrogated. A more holistic approach in promoting CE transition would benefit not only those who are proponents and champions of its implementation, but also those affected by its outcomes—as broader considerations will have taken place from early stages of planning. Here, the perspective of human health and well-being offers a considerably significant argument for such promotion; given the value of good health, exploring avenues through which CE promotes '3. Good Health and Well-being' in the BE may become a key driver in the BE.

7.2.2.1 Circular Economy and Benefits for Human Health

While recent literature has continued to emphasise that the most crucial barriers and enablers for furthering a circular transition in the BE are socio-cultural, the focus of these studies remains predominantly on the social preconditions and predispositions for the transition. Kirchherr et al. (2018), Ranta et al. (2018) In the 2018 report '*Circular economy and health: opportunities and risks',* WHO explored the implications for human health of a CE transition from a policy perspective. WHO (2018) The report acknowledges that the concept of CE has gained increasing prominence in policy development at various levels, but that the coverage of health impacts has been limited. The report frames CE and its implementation in the context of health by outlining current evidence on human health, towards furthering policy development. Interestingly, this report highlights substantial knowledge gaps in the understanding of the nature of CE impacts on human health and well-being, while noting that:

> Available estimates of health impacts from specific policies or packages of policies for the circular economy suggest very significant potential benefits across a number of sectors and for the general population. (ibid, p. 32)

In a follow-up report, WHO (2019) looked to assess these potential health impacts of CE. The aim was to begin addressing the gap identified previously by developing a framework which categorises pathways through which human health and well-being could be impacted. The report utilises this framework to identify real, potential positive (and negative) health implications of CE models, processes, and technologies—as they apply to various economic sectors. The report briefly covers case studies of how to integrate health into CE. With respect to the BE, the following is discussed as far as the implications for human health and well-being (WHO 2019, p. 30):

- Minimising construction and demolition waste—in the EU this currently accounts for ~ 1/3 of all waste generated. This has '*implications for reducing associated health impacts at waste disposal/landfill and treatment sites*'.
- The phasing out and avoidance of toxic materials in buildings—paints, adhesives, insulation materials, etc.—are often contaminants. This '*will have eventual health benefits since much construction waste is hard to separate and contains toxic elements*'.

The points above are then linked in a third which indicates that a reduction in harmful waste will lead to the reduction in negative externalities—such as GHG emissions, water, soil, noise and air pollution, and their associated human health exposures.

- Circular design at an urban and building scale may bring wider health benefits. The report lists improved air quality as an example which may result from reduced traffic/congestion in cities. Additionally, it points to increased well-being which may result from improvements in '*quality of public, work and residential areas and their buildings, and expanding green infrastructure*".

While the report seeks to begin to integrate human health as a key consideration in CE transition planning and policy, it ultimately highlights obvious gaps in this area, stating:

> [This report] leads to the conclusion that there is a lack of current integration of health issues into CE strategies and visions, as well as policy, plans, programmes and projects through which a CE is implemented.

In their paper '*Sex, drugs and circular economy. What are the social impacts of the circular economy and how to measure them?*', Pitkänen et al. (2020) investigate the promises of the CE in the context of social impacts. With a focus on the European Union (EU), they assess the anticipated benefits of the CE by summarising key statements issued by the EU on CE and discuss the relationship between expected impacts with currently recognised social effects resulting from CE.

Numerous claims on the benefits to human health and well-being because of CE were found by the study from several sources: such as the avoidance to risks of exposure to hazardous waste materials and pollution, the redesigning of raw materials used in production processes, decreasing litter and volumes of problematic waste—like that from construction and demolition, and the public health benefits gained from avoiding emissions and pollution by adopting circular strategies in product and service deployment.

Generally, the researchers found that CE was connected more broadly to '*generally physical, mental and social health of humans'* such as a reference to The Ellen MacArthur Foundation's claim that the CE seeks to address natural capital challenges that respond to mental well-being and health, such as the negative impacts felt by people because of urbanisation, limited green space and biodiversity, high temperatures, material and noise pollution, and congestion. Ellen MacArthur Foundation and McKinsey Center for Business and Environment (2015, p. 51). The paper concludes that to assess the social impacts of transition, relevant social aspects need to be determined, and reliable indicators are developed for their monitoring.

Currently, this monitoring is limited to economic indicators and covering a broader spectrum of impacts would contribute greatly to a CE transition by providing relevant data for decision-making at various levels.

7.3 Rapid Review Methods

Based on findings from reports (WHO 2018, 2019), and previously limited monitoring of indicators related to health and well-being in CE transitions in the BE (Pitkänen et al. 2020), a rapid review has been carried out (Morris and Rogerson 2011), informed further by the methodological framework for scoping reviews set out by Arksey and O'Malley (2007).

Having become an increasingly popular approach, the scoping review aims to rapidly synthesise existing research evidence by mapping key concepts, sources, and types of evidence within existing literature in a field. It evaluates the volume, nature, and characteristics of primary research, seeking to present an overview of a potentially larger body of literature. Pham et al. (2014) while sharing many similarities with systematic reviews, scoping reviews differ in that they address broader topics, are less likely to assess the quality of studies included, and can be carried out with fewer resources and within shorter timeframes. Thus, the scoping review is a viable and practical methodology for a rapid scan of literature on a particular topic.

7.3.1 Rapid Review

Morris and Rogerson's (2011) rapid review approach draws from scoping review methodologies and formulates a framework which can be applied by smaller teams under time or resource constrictions. While applied typically within the health sciences, the seven-step rapid review approach provides an appropriate framework for this investigation given the themes being investigated and time constraints.

7.3.1.1 Research Question

This rapid review was guided by the question, '*Has new research emerged, since the publication of World Health Organisation reports, investigating the impacts of a circular economic transition in the built environment on human health and well-being?*' (WHO 2018, 2019).

7.3.1.2 Search Parameter Definition

Search resources: This review was carried out using the popular academic literature database ScienceDirect (ScienceDirect 2022).

Search parameters (Table 7.1)

7.3.1.3 Bias Identification

See Table 7.2.

7.4 Results

7.4.1 Search Execution

A ScienceDirect advanced search on was carried out by locating articles using the search string and further refined according to the search parameters. This search returned 382 results.

All results per search page were then exported as a BibTeX library citation object and imported into Mendeley Reference Manager. Once all records were collated, they were collectively exported as a Microsoft Word '.xml' file. This data file was then imported into Microsoft Excel and tabulated to facilitate initial screening and selection.

7.4.1.1 Search Screening and Selection

An initial screening of results was carried out by evaluating the titles of each entry, followed by a secondary abstract screening.

Title analysis: Article titles were assessed according to the inclusion of keywords and study topic. Conditional formatting and cell counts were applied to the data to determine the entries whose titles included the following search terms: *'circular'*, *'economy'*, *'health'*, *'well-being'*, *'wellbeing'*, *'built'*, *'environment'*, *'impact'*, *'effect'*, and *'influence'*.

Table 7.1 Study database of search parameters

Time period	2020–2022
Language	English
Search string	Circular economy, built environment, health
Article type	Review articles, research articles

Table 7.2 Identification of potential biases in conducting the review

Rapid review processes	Potential bias
Only 1 reviewer performing study selection	Lesser transparency and reproducibility
Only 1 reviewer performing results appraisal	Increased errors
Use of only 1 database	May exclude studies listed in other databases
Exclusion of grey literature	Excludes unpublished data
Exclusion of non-English articles	May exclude significant studies not published in English
Two-month study period	Limited scope in conducting search

Table 7.3 Number of total and unique entries whose titles contain search terms

Search term	No.
Circular	26
Economy	31
Health	50
Well-being	3
Well-being	3
Built	3
Environment	53
Impact	24
Effect	13
Influence	4
Unique entries	144

The number of entries containing each of the terms, together with the total number of unique entries (as some titles contain more than one of the terms), were recorded (Table 7.3).

Abstract screening: Screening was conducting by applying eligibility criteria through a simple decision tree. The abstracts of the 144 unique entries were then scanned and evaluated for relevance in three separate passes. Figure 7.1 describes criteria applied through this decision tree which was used to determine eligibility entries.

Pass 1 resulted in 67 relevant abstracts and an additional 13 abstracts whose themes fit the aims of CE. Pass 2 further refined the search, resulting in 28 abstracts and an additional 7 which considered environmental impacts. Finally, the abstracts which were included totalled 30 entries. The number of entries published each year, respectively, were: 2020 (5), 2021 (12), and 2022 (13). The most popular journals (by number of publications, where more than one entry was found) are: Journal of Cleaner Production (5), Sustainable Cities and Society (3), and Environment International (2).

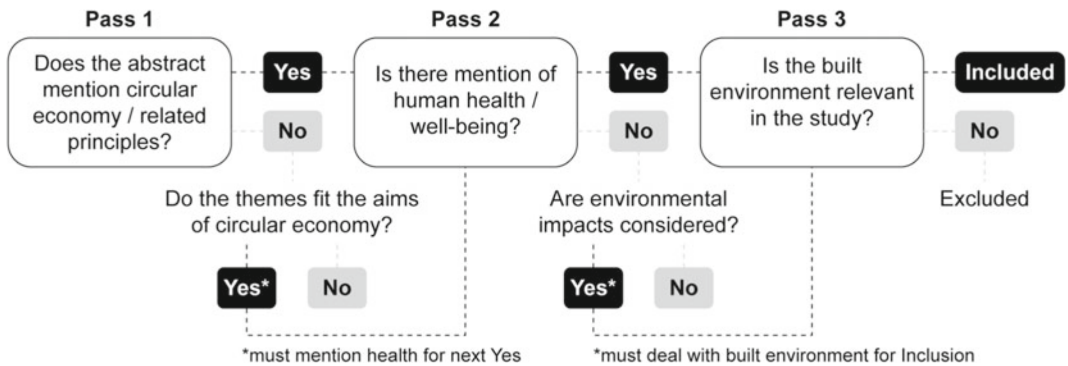

Fig. 7.1 Basic decision tree for determining article eligibility

7.4.2 Results Appraisal

The full texts for resulting entries (30) were then located on ScienceDirect and through Google Scholar search. A total of 23 papers were successfully retrieved. Prior to a full-text review, papers were scanned with a focus placed on introduction and conclusions. Papers which did not deal specifically with the exploration of CE as it relates to the BE, and where human health was not mentioned as part of the investigation outcomes/considerations, were excluded from the full review. A final 15 papers were selected for full review.

7.4.3 Synthesis of Evidence

A brief synthesis is presented here, unpacking some of the findings from notable studies. Crane et al. (2021) looked to the transformation of cities for sustainability through the perspective of human health. Their work mapped various urban health challenges into a cross-sectoral matrix which looked to delineate the relationships between goals contributing to transformation (such as reduction in consumption and climate change adaptation and resilience) with sectors and urban form. While reference is made to policy and reports regarding public health outcomes, the study discusses health more broadly as a goal of transformation.

Perchinunno et al. (2020) applied multivariate statistical methods together with territorial classification to identify and analyse relationships between environmental quality and health outcomes of the population in Italian provinces. The study demonstrated that the level of infrastructure and service provision in a given locale promotes environmental well-being and human health. The availability of urban green areas, use of renewable sources, minimised transfer of waste to landfill, and differentiated collections of urban waste (goals of CE) are discussed as indicators of effective infrastructure—and consequently good regional health.

Vanhuyse et al. (2021) conducted a detailed scoping review to determine the level of social impact considerations in the transition to CE of urban zones. Various categories of social impact were defined, such as 'People's way of life', 'People's culture', 'People's community', 'Political systems', and the like. Category 6 defined 'People's health and wellbeing': the state of complete physical, mental, social, and spiritual well-being and not merely the absence of disease or infirmity. Of the 178 articles which were fully screened, only 14 '*explicitly discussed social impacts of circular cities*'. Remarkably, it was found that none of the 14 articles addressed health impacts explicitly.

Kucukvar et al. (2021) investigated the impacts of circular design on social sustainability and human health by analysing the case of an innovative shipping container stadium proposed for the FIFA World Cup Qatar 2022. The investigation applied a Social Life Cycle Assessment (S-LCA) model to evaluate the potential impacts for all phases of the construction cycle. The study identified impacts of utilising materials, energy, water, and waste on human health under a CE model using the cradle-to-cradle approach. From a health perspective, mid-point impacts for the use of a variety of materials and construction processes have contributed towards climate change, human toxicity, ionising radiation, ozone depletion, particulate matter formation, and photochemical oxidant formation. Each of these poses a threat to human health in various dimensions. The article demonstrates that considered circular construction could significantly lower damage risks to human health in relation to these mid-point impacts.

Çimen (2021) performed a comprehensive literature review of current construction and BE in the CE, aiming to demonstrate trends in development and highlight understudied fields. Based on a full review of 238 papers, the paper determined that the most studied subjects in the field are waste valorisation and CE promotion and transition, and crucially, that the construction industry is battling to adopt CE principles. The study notes that flexible buildings, adaptive reuse, and modularity help to promote efficiency and health benefits together with circular principles; however, the specific mechanisms through which this is achieved are not detailed.

7.5 Discussion

Both the literature and rapid review conducted in this study highlight how considerations of human health and its impacts and outcomes because of CE in the BE are largely understudied and often under-considered. There is a solid case to be made in championing CE beyond its obvious contributions to sustainable consumption and production. Mhatre et al. (2021) However, without fully understanding health impacts, negative consequences resulting from CE adoption may arise. As Pitkänen et al. (2020) highlight in their study, not all outcomes are positive, with negative impacts largely affecting disadvantaged or underprivileged regions where recycling and material recuperation may take place—exposing those who undertake the work to potentially harmful chemicals and toxins in the process.

Since the release of WHO (2019) follow-up report, limited exploration of the health impacts of CE as it relates to the BE has been conducted, pointing to a gap which when filled may offer valuable avenues for CE policy and planning promotion. The core tenets of CE contribute directly to the UN's SDGs in Industry, Innovation and Infrastructure, and Sustainable Cities and Communities, and while progressively more businesses' cases are being made to promote CE, uptake remains relatively slow Hart et al. (2019).

As with many studies, this was subjected to limitations which impact results. Literature and rapid review synthesis was conducted primarily based on the author's interpretation, and within a narrow scope—the domain of health outcomes in humans as a direct consequence of CE is being applied in the BE. Additional time and resource constraints are also a major factor. However, I believe that this paper demonstrates an apparent gap and great opportunity to further study the topic. Vanhuyse et al. (2021) review of materials spanning across ten years of study resulted in just 14 out of 178 papers discussing social impacts of circular cities. In their concluding remarks under discussion, they note that:

> Overall, we can confirm that the social dimension of CE is under-represented…Where social impacts have been considered, a narrow interpretation has been followed: discussions have tended to centre around employment opportunities

And with reference to the WHO follow-up report assessing health impacts of CE in the BE WHO (2019).

> In its report, the WHO noted a lack of studies on the impacts of a CE on health. We confirm that finding and call for more research insights to be generated in this field.

7.6 Conclusion

Given recent calls to action as a direct result of the Covid-19 pandemic, CE presents a viable option as a vehicle for establishing resilience in the BE, simultaneously contributing to sustainable production/consumption and human health/well-being. This study provided a literature review and argument for exploring CE as such and sought to determine to what extent this has been investigated.

With the opportunity to enact radical transformation, CE offers a framework to decouple growth from resource consumption, simultaneously promoting positive outcomes in softer aspects of society. It may contribute to Building Back Better towards a more resilient economic and social system through localised production loops and as a facilitator of inclusive societies. While CE explorations are predominantly focused on sustainable growth: emphasised from the perspective of 'effective and sustainable production and consumption', questions surrounding its implications on socio-cultural impacts are growing. Numerous claims on the benefits to human health and well-being because of CE have been made by several sources and attempts to quantify such benefits are infrequent (in-part due to the difficulty in measuring precisely such outcomes).

However, this difficulty results in an opportunity to generate new ways of measuring, tracking, and tracing the impacts of CE which have on human health when applied in the context of the BE. Likewise, our BE is complex and complicated, and tracing its effect on human health is challenging. Despite this, recent study discussed in this paper which documented responses to the Covid-19 pandemic demonstrated that our physical surroundings have a direct and lasting impact on our health and well-being.

The rapid review in the second part of this paper was driven by the question: '*Has new research emerged, since the publication of World Health Organisation reports, investigating the impacts of a circular economic transition in the built environment on human health and well-being?*'. Review results illustrate clearly that further study will benefit our understanding of this area given its complex and multi-faceted nature. It is vital that further contributions towards developing these new methods for measuring, frameworks for tracing, and indicators for determining impacts of CE in the BE can be taken on by the research community. Ensuring that negative impacts are mitigated and positive social outcomes are proliferated in a circular transition in our BE is of utmost value. In acknowledgment of the limitations of this study, further systematic investigations into the health impacts of CE applications in the BE have on humans, and crucially, those where disadvantaged or underprivileged regions are subjected to investigation are encouraged.

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Part II

Health as Consequence of Design

8 Analysis of Spatial Elements Affecting Human Thermal Perception and Thermal Landscape Design

Zhuoyu Yu and Dexuan Song

Abstract

The energy consumption and carbon emissions for indoor heating and cooling in the building field are getting higher and higher. At the same time, the steady thermal environment regulated by equipment for a long time is not only harmful to the health of users but also reduces the energy utilization rate. Therefore, from the perspective of space combination and detail design, the paper analyzes the six spatial elements of human body heat perception, including space material, color, scale, shape, natural proportion, and human flow density. Breaks through the traditional design method of thermal environment, but from the perspective of space thermal perception analysis puts forward landscape design method, respectively, attraction, for the space diversity, energy saving and guides the architect in the thermal environment design and energy-saving building design, coordination of thermal environment, space combination, the relationship between the thermal perception, make buildings more energy efficient, make people healthier.

Keywords

Thermal perception · Thermal landscape · Energy-saving design

8.1 Introduction

The global sustainable development goals mention making cities and human settlements inclusive, safe, resilient and sustainable, promoting sustainable construction industry activities. The world's cities account for only 2% of the Earth's land area, yet they consume 60–80% of energy and produce 75% of carbon emissions. Building energy usage cannot be disregarded. It is vital to examine how building energy is utilized from a new perspective and decrease energy consumption waste in order to reduce resource and energy consumption. A number of physical and mental health issues, including "sick building syndrome" and "inadequate air-conditioning adaptation," are on the rise as a result of "constant temperature and humidity" environments. The main objective of environmental control shouldn't be to maintain a constant interior thermal environment. It is easier to meet human demands in a dynamic thermal environment, and this makes people more thermally adaptable (Zhu et al. 2016). There are currently few thermal environment creation techniques and environmental energy-saving design guiding methods in

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building environmental control design, despite the extensive study of active and passive energy-saving measures of building space from the standpoint of energy consumption. The idea of soundscape in architecture was first put forth with a lot of research findings (Mengqi and Kangjian 2018). The idea of a light landscape was developed later, but it has now found widespread use in both landscape architecture and urban planning. Architectural thermal landscape is a little-discussed physical aspect of architecture. Few relevant studies have considered the architectural spatial scale of the architecture itself; the majority have concentrated on the urban thermal environment (Wenrui et al. 2014), climatic map (Chao et al. 2012), and block scale. This work reexamines the energy-saving building space design methods and advances the idea of spatial thermal landscape development in this setting. Building science and technology stimulate creative thought and architectural design while creating a more comfortable thermal environment for people and reducing energy consumption in buildings. The goal of this study is to promote the achievement of the global sustainable development goals' building energy-savings goal.

A thermal environment that one or more people perceive, comprehend, and feel in space is referred to as a thermal landscape. The thermal expression of architectural design, the thermal form of architectural space, and the new architectural language all revolve around creating a dynamic, healthy, and enjoyable thermal environment. Thermal landscape refers to a pleasant thermal environment as sensed by the body rather than a visual landscape. People experience space as well as use it, and it is this type of experience that gives space its unique qualities. The thermal environment, heat source, space materials, openness, color, natural qualities, etc., as well as elements like people's psyche and expectations, are some of the spatial characteristics that influence how people perceive heat. More and more research has shown that people's perception of heat can be influenced by spatial contexts besides the physical surroundings and indications. As a result, this study proposes the idea of a thermal landscape in an effort to develop a healthy thermal environment in a more systematic, sophisticated, and rational manner.

A thermal environment that one or more persons perceive and experience in space is referred to as a thermal landscape. A type of thermal environment is a thermal landscape, however this type of thermal environment isn't just a static physical thing; it's also a dynamic, healthy thermal environment that people can sense. The properties of heat conduction are connected to the thermal landscape's conductivity. The skin system, which determines that people are more sensitive to the thermal environment, is the primary organ through which people perceive the thermal environment. The application of thermal landscape spatial orientation in space design can efficiently direct the flow of people. Heat transmission modes, which can be categorized into three categories: conduction, convection, and radiation, determine the variety of the thermal landscape. As a result, the "thermal landscape" can be customized to fit various settings, e.g., a centralized heat source, sun radiation to produce a thermal landscape, or improved air convection. The diversity of heat conduction determines the diversity of an architectural space, and under the influence of a vibrant "thermal landscape," the space can have a particularly rich spatial effect.

Heat perception can be influenced by vision, spatial proportions and openness, a building's material composition, and more. The spatial arrangement, distribution, openness, and features of the building all have an impact on how heat is perceived. People will feel more depressed in a room with a narrow floor height at the same temperature, for instance, yet in a room with a relatively open floor plan, they will feel more comfortable even in a room with a greater temperature. When designing a space, keep in mind that hot air rises and cold air falls. Often, a hierarchical analysis is used to place the requirements for high temperature space at the top and conveniently chilly area at the bottom. Because we frequently cannot alter some aspects of the local environment, such as the local climate, but we can influence other aspects of it within a certain range, the openness of space offers great potential and possibility for architectural design. Through the creative use of space, space combination, and environmental control, designers can push the boundaries of climate design. Different spatial arrangements and intricate designs result in various thermal field distributions, as seen in Fig. 8.1.

Similar to how the air-conditioning system is positioned above the room, the thermal distribution of the room exhibits obvious changes due to the qualities of hot air ascending and cold air falling. The spatial heat distribution will undoubtedly be impacted by the specific architectural elements, such as vents, outdoor spaces, skylights, and the interaction between people and

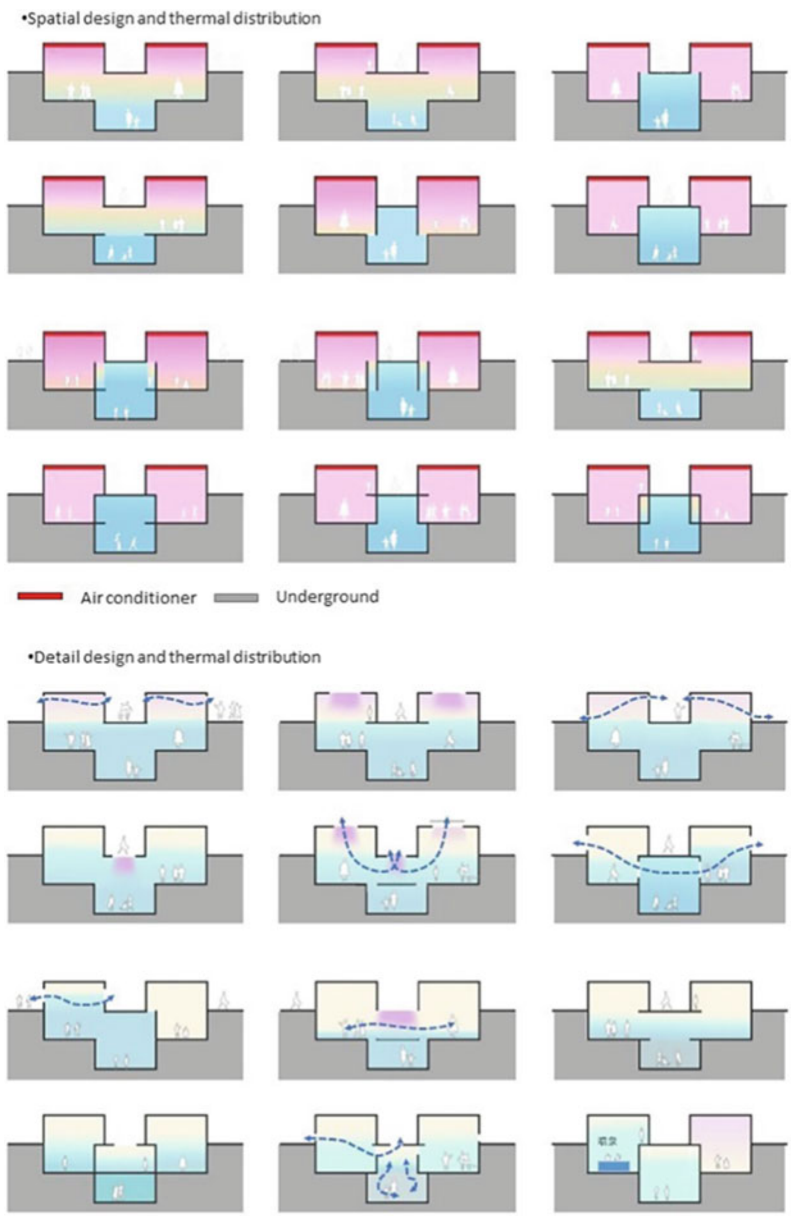

Fig. 8.1 Effect of spatial composition and detail design on thermal distribution. *Created by* authors

the space. The quality of the thermal landscape will be impacted by how heat, space, and people interact. As a result, other factors that we frequently overlook, such as the characteristics of the space and the people and objects carried in the space, also have an impact on the thermal environment of a building. These other factors include the outdoor environment, air-conditioning, fans, and other equipment. Heat perception in people is complicated, involving psychological, physiological, and emotional factors. So that energy may be used successfully, the thermal landscape can be more precisely designed using a thorough examination of the components of heat perception.

8.2 Design and Thermal Perception

8.2.1 Materials, Color, and Thermal Perception

There are few studies on how objects in space affect how hot individuals feel. However, because they have varying thermal conductivities and heat transfer coefficients, concrete, wood, stone, and even the present will change how hot people perceive it to be. Additionally, the color of the materials in space will also have an impact on how hot people perceive it to be. Relevant research by Professor Fanger demonstrates that: people in the extreme red environment can stay inside comfortably at a temperature that is 0.4 °C lower than in the extreme blue environment. Thermal sensation, thermal comfort, and environmental comfort are known to be influenced by both temperature and environmental color. Warm colors can ease cold-weather discomfort, while cool colors can ease hot-weather discomfort. Human physiological indicators such as blood pressure and heart rate will be impacted by color. Blood pressure and heart rate will rise in a red or yellow environment while falling in a green or blue one. Additionally, there are some differences in the human body's comfort zone below cool and warm color tones. The wavelength of different colors affects the human thermal comfort. The findings demonstrate that the thermal sensory voting value of the human body is highest in the red environment and lowest in the purple environment according to the shortest wavelength. In warm color environments, the thermal sensory voting value is higher, but in cold color environments, it is lower. Attention should be given to the combination of building materials and colors in space design, particularly in public places and open areas, to create a thermal landscape (Fig. 8.2).

8.2.2 Shape, Scale, and Thermal Perception

The quality of the indoor environment is also influenced by the size and shape of the room. In a room that is big and well-ventilated, people are more likely to feel satisfied. A space will feel chilly and serious if it has too many right angles and acute angles, while a space with more smooth curves would feel pleasant to the touch. There are few studies on this type of space shape's effects on thermal sensation, which may primarily affect people's psychological well-being. In contrast, spatial scale has a greater impact on people's experience of heat. A variety of psychological discomfort will be produced in a small area, and this discomfort will be transmitted to the demanding thermal environment. Numerous related research on the impact of spatial scale on temperature perception are currently available. Researchers who looked at the thermal comfort in five different types of spaces in the summertime east of the Netherlands discovered that the spatial shape and type has an effect on the comfort of the thermal environment (Taleghani et al. 2015). Space form, which encompasses the shape, size, aspect ratio, height, and aspect ratio of the space plane, is the most intuitive feeling provided by space. People's psychological and spiritual states will be influenced by the volume, scale, shape, proportion, and other aspects of an architectural space. To some extent, the size of an architectural space can affect how individuals feel psychologically and spiritually. People's psychological and spiritual states will alter their breathing rate, pulse,

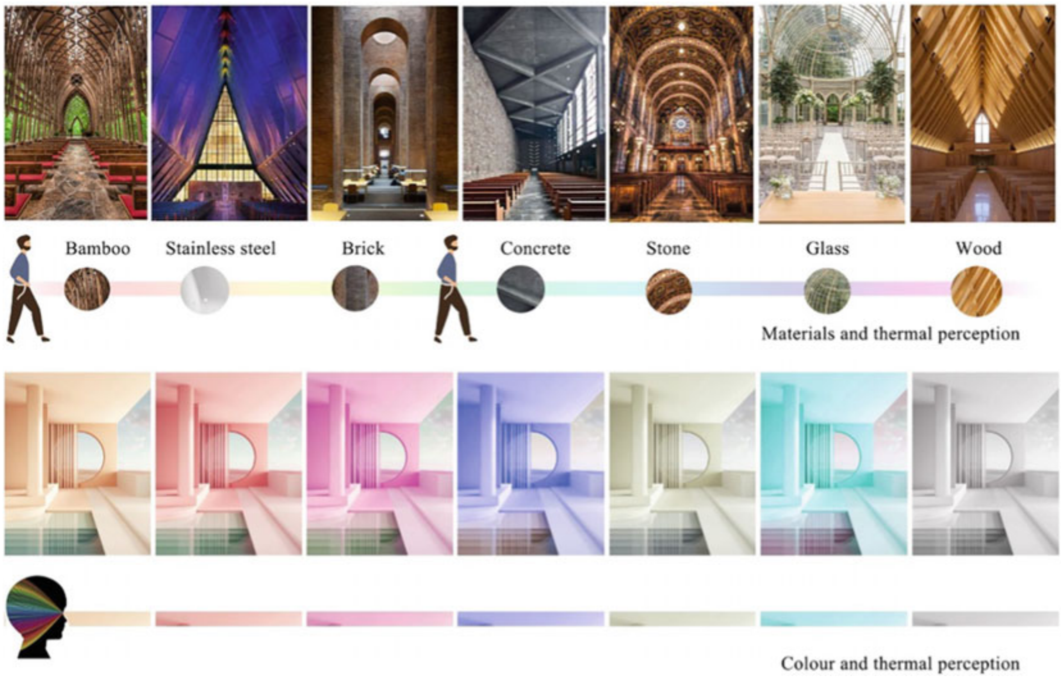

Fig. 8.2 Materials, color and thermal perception. *Created by* authors

blood pressure, and other physiological aspects, and these aspects directly affect how comfortable they feel with their body temperature. As a result, while designing an interior thermal landscape, care should be taken to evaluate the size and layout of the area, with an early emphasis on the need for comfort and energy efficiency (Fig. 8.3).

8.2.3 Nature, Human Flow, and Thermal Perception

It makes a lot of sense how natural components interact with objects and spaces. The genuine construction materials and integral components of the building and urban system, water, air, land, and water all have a significant impact on the design. From an ecological standpoint, the city was built by a system of people, space, and natural and cultural landscapes, as well as building integration for the integration of a metabolic system, human material production and consumption, and participation in social and cultural activities. The quality of the building space will improve as the natural environment is expanded. The University of Michigan professors Rachel Kaplan and Stephen Kaplan developed the idea of restorative environments, which emphasizes the resilience of people who frequently interact with the outdoors and defines restorative environments as "environments that better enable people to recover from psychological fatigue and stress-related negative emotions." However, because so much of the technology and materials used in architecture are manufactured, people frequently feel unhappy and exhausted. Therefore, the amount of natural environment, including indoor plants, water features, fountains, areas exposed to sunshine, and the degree of connectivity to the outdoors, is a crucial aspect. The natural landscape of demand with the seasons are different than quantity, is influential, and in a very hot summer, if there is too much sun exposure area, will lead to people not feeling comfortable. Therefore, from the perspective of space, about the rationality of the natural elements of mainly comes from two aspects, it is a quantitative indicator that is

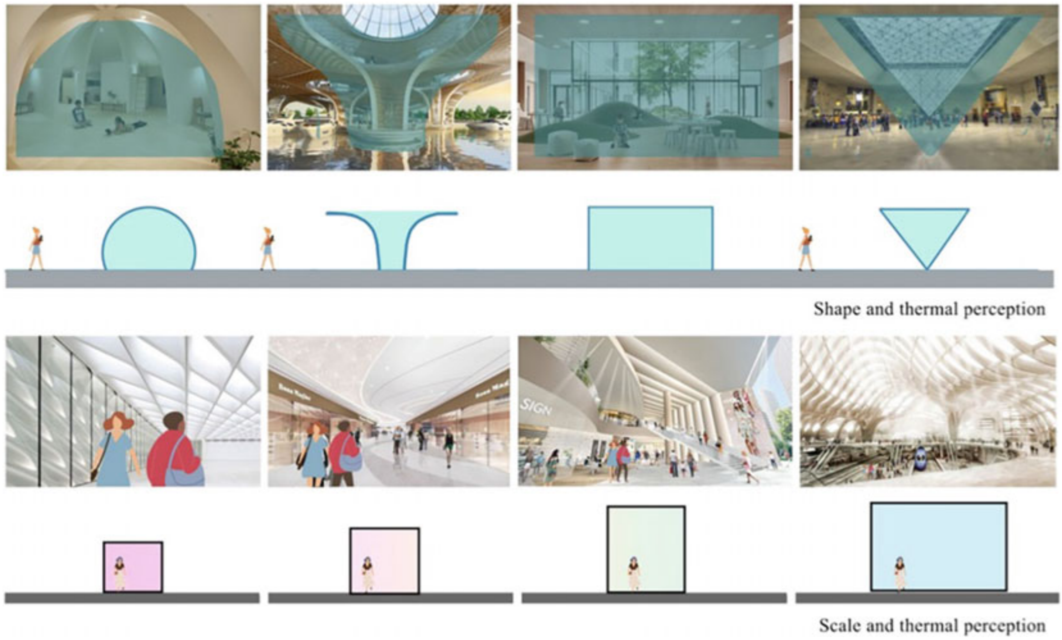

Fig. 8.3 Shape, scale, and thermal perception. *Created by* authors

primarily based on the research of associated fields. Historical experience is derived from the analysis and summation of architectural spatial form under particular climatic circumstances. According to research, people are better able to withstand thermal comfort variations and are more likely to feel content and joyful in an area that is close to a window. The potential cause is that windows can draw attention away from thermal discomfort and toward the more varied sensory inputs outside, so enhancing thermal comfort. It's also likely that people's expectations of indoor thermal settings are influenced by their visual acceptance of sunlight and warmth in nature. The building's ability to create green space is favorably connected with its users' happiness and satisfaction scores. People will instinctively seek out green spaces since they subjectively associate them with love of greenery, thus it's important to take that into account when designing a space's environment (Klemm et al. 2015). Since people generally give the natural environment high marks for thermal comfort, architects can raise people's contentment with the thermal environment by designing spaces with a natural feel. In addition, the function of space will affect the number of people. The more people, the larger the radiation generated, traffic density is too high in areas of the body of radiant heat accumulation, the heat accumulation, if not promptly dissipated, also produces thermal discomfort, and the entertainment value of a strong space can also affect a person's metabolic rate. The function of the space and the human flow density in the space will affect the thermal perception , and these effects can not be ignored (Fig. 8.4).

8.3 Construction Method of Thermal Landscape

While engineers are more accustomed to employing equipment to solve issues in the building environment control process, thermal landscape places a greater emphasis on maximizing the environment and improving energy utilization through design strategies. Thermal landscape research takes into account not just precise numerical figures but also the well-being

Fig. 8.4 Nature, human flow, and thermal perception. *Created by* authors

and good moods of the participants. Additionally, they focus on the application of heat transfer concepts in conjunction with findings from the fields of architecture, anthropology, and environmental psychology in order to actively create a more hospitable and environment that is better suited for human life. Thermal landscapes are built using techniques including space combination, place gathering, varied composition, and energy-saving adaptation. Following that, four perspectives—space design, site attraction, zoning design, and energy-saving scheme—are used to introduce the situations and techniques of thermal landscape design.

8.3.1 Space Combination

The properties of heat conduction are connected to the thermal landscape's directivity. When compared with heat transmission, light and sound transmission are more susceptible to environmental obstructions such as noise and other debris. There are two benefits to the thermal landscape. One is that heat transfer has clear anti-interference properties and is significantly less influenced by the outside environment. The other is that people primarily use their skin system to sense heat, rather than specialized organs. The flow of people and the functional zoning of building space can therefore be efficiently guided by the characteristics of thermal landscape space orientation in space design. For instance, the German convection apartment depicted in Fig. 8.5 employs the idea of warm air rising and cold air falling to produce a thermal landscape together with space functions. The highest temperature differential in this apartment between the floor and the ceiling is 10 °C. Each room in the residence has a varied temperature because of the variations in clothing thermal resistance and the activity of the people in those rooms. If a person is covered with a quilt in the bedroom, the temperature is 18 °C, thus the bedroom is designed in the lowest location, and the bathroom is setup in the area with the highest temperature. Temperatures and relative humidity fluctuate depending on height. People are free to

Fig. 8.5 Analysis diagram of convection apartment in Germany (https://www.philipperahm.com/)

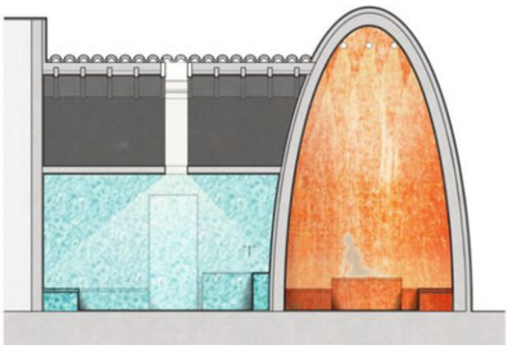

Fig. 8.6 Section of Hamam Hot Spring (https://www.archdaily.com/946020/hammam-spa-ressano-garcia)

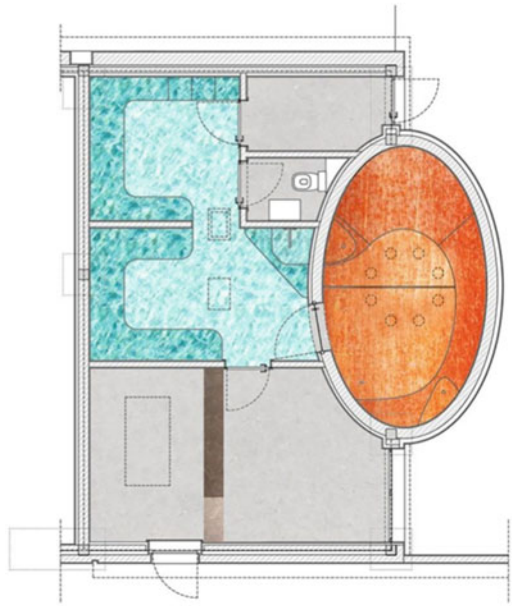

Fig. 8.7 Plan of Hamam Hot Spring (https://www.archdaily.com/946020/hammam-spa-ressano-garcia)

go around in search of a particular, comfortable thermal environment. Buildings have the potential to save a lot of energy. Figures 8.6 and 8.7's depiction of Hamam Hot Spring serves as another illustration. The geometry of the space is directly influenced by the temperature there. The shape of a room in a warm environment is a flowing curve, as if the room were melting; in a cold environment, the shape is straight lines and incisions, as if everything had solidified. To increase the level of stimulation that users experience, each room stresses temperature in a distinctive way.

8.3.2 Site Gathering

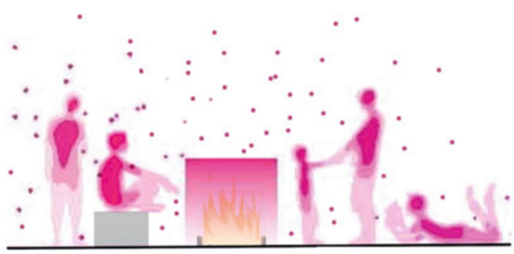

Fig. 8.8 Gathering of fireplace. *Created by* authors

The perfect thermal environment will inevitably develop into a gathering place for people. As an illustration, European and American families once gathered around the hearth. A basic dwelling feels more cozy with the dancing lights, the scent of smoke, and the crackling sound of burning (as shown in Fig. 8.8). In Northeast China, the heated kang also serves as a place for sleeping, eating, communicating, and relaxing (as shown in Fig. 8.9). However, excessive air-conditioning use maintains a constant temperature throughout the entire structure,

Fig. 8.9 Gathering of Chinese heated kang. *Created by* authors

homogenizing the area. Family members' ability to communicate and feel connected to one another has been hampered by the activities that were earlier concentrated in one area of the building due to a heat requirement. Warm kang and fireplaces, as opposed to air conditioners, cause our impression of the thermal environment to be influenced by a range of thermal elements, such as temperature, humidity, and airflow. People's perceptions of the thermal landscape will vary if one or more influencing elements change. As a result, thermal landscape contains a greater amount of scene information. People will have a strong feeling of connection to the architectural space once they become accustomed to a particular and rich thermal environment. People will depend on the space and exhibit the features of the location once they have a positive impression of the thermal landscape, which will increase the building's appeal. This method can improve the quality of the space while saving energy.

8.3.3 Diversified Composition

Diversity depends on the amount of heat being transmitted by the thermal landscape design. Since there are three different ways that heat is transmitted—through conduction, convection, and radiation—the thermal landscape can be modified to fit various design scenarios, including centralized heat sources, solar radiation, strengthened air convection, and plant control. As an illustration, consider Qingcui Garden in Taichung City. The weather in Taichung is often tropical. People prefer to stay in air-conditioned indoor spaces and are cut off from nature due to the area's severe air pollution and hot, humid weather. Therefore, lowering pollution, temperature, and humidity is the main goal of the design. To start, the architects calculated the site using fluid mechanics to identify its coldest, driest, and cleanest regions (Fig. 8.10). Then, the cool, dry, and clean regions were built based on these places. In order to improve the natural qualities of these locations and create thermal landscapes, a range of climatic devices including sprays, bladeless fans, concrete panel radiant tubes, dew collectors, ultrasonic insect repellents, and trees with thermal conditioning functions were devised. Tourists can select their own climate zone based on their individual preferences and activities; each zone offers a distinctive thermal environment experience. In the cool zone, people can engage in quiet activities like reading and chit-chatting; in the dry zone, people can exercise; and in the scene area, the entire family can get together and have a picnic. In spite of the humid and hot weather outside, people can still find a comfortable spot in the park, and the thermal landscape building increases park enjoyment and usage.

8.3.4 Potential for Energy Savings

Vernacular architecture all over the world has complex ways of dealing with temperature, and the shapes and materials used in the original architecture work well to make up for climate problems. In deserts, for example, materials like sand and soil have a high specific heat capacity, which means they absorb solar radiation during the day and slowly release it at night. In the tropics, houses are made of lightweight materials like bamboo and reeds to block thermal radiation and improve ventilation. Folk houses can only be built by people who know how to do construction. Only by following their laws can they shape them, which is why the culture of traditional folk

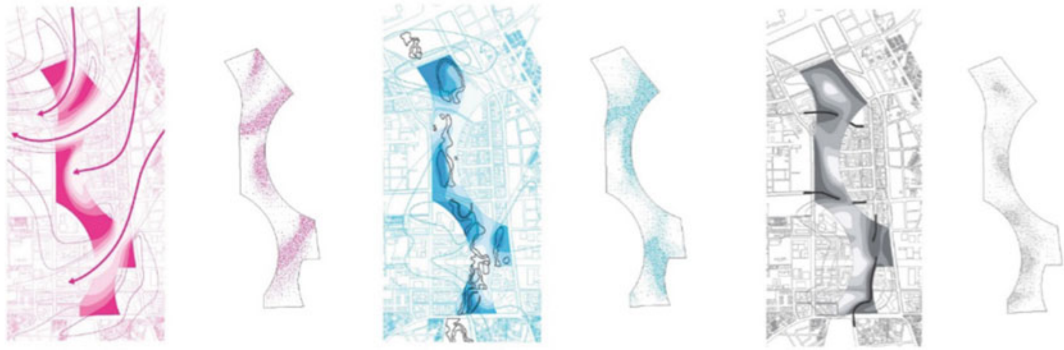

Fig. 8.10 Site calculation, analysis, and planning of Qingcuiyuan (www.Philipperahm.com)

houses has been passed down for so long (Qun et al. 2020). But because people use air-conditioning too much, architects can't show off their original thermal environment design skills, and the wisdom of traditional residential building is slowly going away. If you use your air conditioner too much, you will forget things about your region and culture. Traditional building methods are respected in thermal landscape construction, which focuses on bringing people into and back to nature while saving energy, e.g., in the Austrian National Pavilion at Expo Milano 2015 (Fig. 8.11), there are a lot of plants, and high-pressure spray devices are put in place to help the leaves evaporate water. Even without air conditioners, the temperature inside is still 5–7 °C lower than the temperature outside.

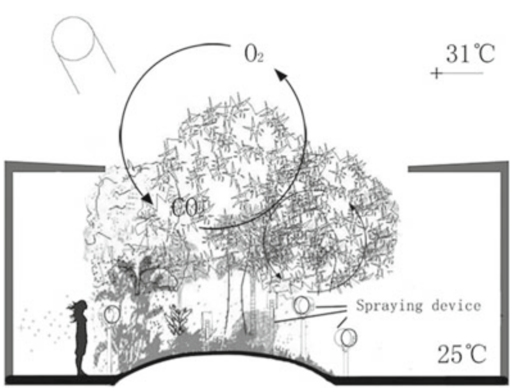

Fig. 8.11 Energy conservation analysis of Austrian National Pavilion (https://www.metalocus.es/en/news/austrias-pavilion-expo-milano-2015)

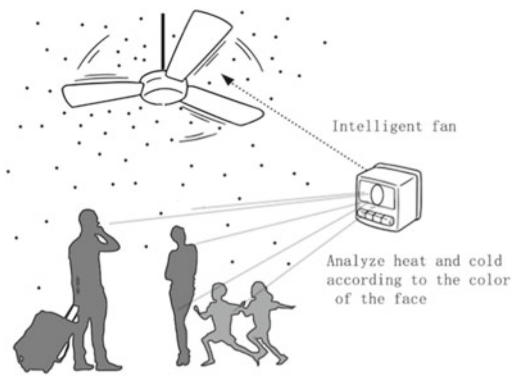

Fig. 8.12 Schematic diagram of intelligent on-demand ventilation. *Created by* authors

This saves a lot of energy. Also, the intelligent communication system of risk control technology can achieve on-demand ventilation (as shown in Fig. 8.12). Some scholars have designed a system of feature extraction and analysis of thermal sensation (Wang et al. 2021), which can adjust the ventilation rate based on the user's facial color and how hot or cold they look. It can also tell how many people are in the room.

8.4 Conclusion

The world's current energy and climate crises serve as a reminder to architects to be mindful of their usage of energy. The only way to maintain the thermal comfort of the space while lowering building energy consumption is to use energy consumption in a more precise and refined way.

A thermal landscape concept is a brand-new area of study and way that architectural environment control science is being used. When designing spaces in the past, designers typically focused on functional aspects and organizational simplicity rather than environmental control and energy-efficient building design. This article suggests the following five techniques for designing thermal landscapes:

(1) The idea of a thermal landscape broadens the scope of the initial design. The thermal landscape approach stresses eliminating reliance on air conditioners while the standard environmental control method promotes neutral space, which uses more energy to maintain a lukewarm atmosphere. Pay attention to how well people adapt to heat and the need for a dynamic thermal environment at the same time, use architectural design strategies to create a cozy thermal environment, follow the rule that warm air rises and cold air descends, and make the most of windows, sunshades, and building materials. The relationship of space and thermal environment, space requirements, human behavior, and physiological factors should all be taken into consideration by architects when designing the thermal environment of a building to save energy.

(2) Warm colors can make people feel warm, while cold colors can make people feel cool, depending on the material and hue used. Therefore, it is important to understand that people's perception of heat can be influenced by the color of lighting and décor while designing an architectural structure. To change how people perceive heat, you can use warm lighting in the winter and cold lighting in the summer in conjunction with interior design. The choice of materials should be made in accordance with the thermal environment requirements of the building and acceptable materials should be selected for the design of spaces with diverse needs. Concrete and steel will make people feel cool, while wood and brick will make people feel warm.

(3) The scale of the space should not be pursued excessively during the design process because the larger the scale, the more obvious the sense of emptiness will be, the colder the people in the space will feel, and more energy consumption is required to maintain comfort. On the other hand, the more private the space, the more it can increase people's sense of security. To prevent energy waste, the relationship between human thermal perception and scale should be taken into account for visual effects with a big scale. Using human thermal experience features can reduce building energy usage. When designing small spaces, curves can make people feel comfortable, but too many edges and corners can make people feel chilly and serious.

(4) The presence of more natural features, such as indoor plants, ponds, and fountains, as well as windows that open to the outdoors, will increase customer happiness in the area, regardless of whether the temperature is high or low. People are better able to handle temperature variations because of the architecture. To increase people's enjoyment with the environment and lessen the energy use of air-conditioning, it is therefore important to pay attention to how nature interacts with architecture and to employ more flowers, trees, water features, skylights, and windows in public spaces of buildings.

(5) Smart devices can be used to intelligently adjust the temperature and wind speed in the space, as well as adjust the indoor temperature at different times of the day in accordance with people's physiological habits, in order to control the energy consumption of buildings in conjunction with the needs of human behavior. Thermal environment, for instance, after employees arrive at the office following a commute, the demand for temperature is not great within 30–60 min after arriving at the office because the metabolic rate during commuting is relatively high. The temperature might be reduced during this time. Then gradually raise the air conditioner's temperature. When there are few individuals present in a broad area, it is sufficient to employ heaters

or fans to locally warm up or cool down the area. Energy can be saved by switching to the proper temperature adjustment equipment. Additionally, workers should turn off air conditioners and lights in buildings promptly after leaving work as part of the energy management process for buildings. Attention should also be made to energy consumption regulation at night.

The study of thermal landscapes is based on an examination of the components of thermal perception and human body adjustment. It entails a thorough planning and designing of the thermal landscape of an architectural space from the viewpoints of scale, color, material, location, and the positioning of natural elements, among other things. Design the space's thermal environment from one perspective, use fewer air conditioners, increase user comfort and thermal adaptability, and realize synchronous improvement from equipment thermal environment control to human body thermal adaptability and comfort based on thermal landscape, all while lowering building energy consumption, usage, and preventing energy waste.

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9 Design as Loom: Interweaving Health with Nurturing Care. A Visual Essay on Two Early Childhood Development Centres in Eastern Zambia as Architectures of Health

Tomà Berlanda and Sunniva Berlanda Viking

Abstract

Through a visual essay, the authors argue that health needs to be understood not simply as a medical result, but should instead be the evidence of a holistic attention to care for all, where the physical and conceptual framework of any infrastructure plays a pivotal role in creating the conditions for a planetary well-being. This is evidenced in the narrative of their experience in enabling a collective and participatory design and build process for two pilot early childhood development (ECD) hubs in remote villages in Eastern Zambia. Initiated by a programme launched by UNICEF Zambia in support of the country's Government Seventh National Development Plan, the architectural response proposes the construction of social landscapes of care, benefitting existing cultural practices, bringing new spatial perspectives, and augmenting educational and agricultural capacities. Conceived of as a ribbon of meandering structures, interweaving health with nurturing care, each centre becomes the anchoring point for societal change. Here services are delivered, promoting resilience and social transformation, using a language of scarce material resources, planting the seeds for an evolving, living ecosystem. One marker of the success of the scheme presented has been its replication in eight other sites since 2020, as a lead up to developing national guidelines for ECD centres in the country.

Keywords

Design · Community · Participation · ECD · Africa · Zambia · Architecture · Health

9.1 Introduction and Position

Health is widely understood as a universal right, value, and goal. However, different material, social, cultural and political conditions offer diverse interpretations of health. Importantly, the idea of health is no longer identified simply with the absence of illness. Similarly, what is understood as being an architecture for health is no longer limited to a hospital, or a medical centre, but stands as the result of a holistic interplay between primary developmental functions, and their relationship with their surrounding. To demonstrate our point, and as a contribution to the panel, this visual essay documents a design

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and construction project we have been involved with in Eastern Zambia since late 2018, guiding the construction of integrated community hub prototypes, aptly called "Insaka" centres, a Bemba word for "place to gather".

Operating at the nexus of socially engaged and transcultural design, our studio's commitment is to experiment and cross pollinate with a multiplicity of forms of architecture and urbanism, balancing economic and political forces. Through spatial negotiations and interrogations, our collaborative platform seeks innovative architectural thoughts and processes, bridging cultural, social, and ethical distances between local and foreign building techniques.

Globally, an estimated 43% (or 250 million) children under 5 years of age are not achieving their developmental potential. Children who do not receive adequate health, nutrition, early stimulation, learning opportunities and services, care and protection,—all identified by the WHO in a 2018 document as foundational elements of "nurturing care"—tend to have lowered cognitive, language and psychosocial outcomes, translating to lowered academic achievement in future.

To contrast such risks, UNICEF's Early Childhood Development (ECD) Programme Guidance Note (2017) indicates how young children, from birth to school entry, require access to essential quality health, nutrition, protection, and early learning services to address their developmental needs. To achieve this, parents and caregivers should be supported and engaged in nurturing care with their young children. Evolving skills in early childhood are acquired through interaction with the environment and therefore the parents and caregivers are critical as they are the architects of this environment.

The methodology and approach used here build upon two strands of literature. The first points to elements presented in Ager and Metzer's (2012) structured review of existing approaches and operational frameworks to developing ECD centres. The second is exemplified in Amorós Elorduy's (2021) theoretical framing of the role architecture and design have in providing a nurturing environment for young children (Fig. 9.1).

This is particularly important in a context such as that of rural Zambia, with one of the world's fastest growing populations, projected to almost triple by 2050. Combined with the harsh reality of the country having one of the highest levels of poverty and inequality globally, this requires innovative imagination in terms of securing health for all.

As a response to the programmatic perspective and challenging background, in 2018 UNICEF Zambia conceptualised an integrated approach to ECD delivery. This addresses children (aged 0–6 years) as direct beneficiaries to critical services, whilst at the same time aiming to equip parents and caregivers, who create the primary enriched environments for young children. The result is the creation of "Insaka" hubs within vulnerable communities in two rural villages of the Katete District, to contribute to the Human Development national objective under the Government of Zambia's Seventh National Development Plan (2017–21) and SDG Target 4.2, to ensure that by 2030 all children have access to quality ECD (Fig. 9.2).

The entire life cycle approach underpinning the project, leads to our argument that health needs to be understood not simply as a medical result, but should instead be the evidence of a holistic attention to care for all, where the physical and conceptual framework of the infrastructure plays a pivotal role in creating the conditions for everybody's well-being. As will be further elaborated in the essay, this holistically speaks to four different SDG goals, integrating goal 3. Good Health and Well-being, with goal 4. Quality Education, as well as finding overlaps with goal 2. Zero Hunger, and goal 6. Quality Water and Sanitation (Fig. 9.3).

Operating as designers between a multiplicity of stakeholders, ranging from international donors, UN agencies, NGOs as implementing partners, local and national authorities, and communities, we engaged in creating ensembles where the complex articulation of flexible and evolving spaces between buildings and site is influenced by the layout of traditional compounds.

This was done to establish a clear ownership of the design, and its replicability, and developed

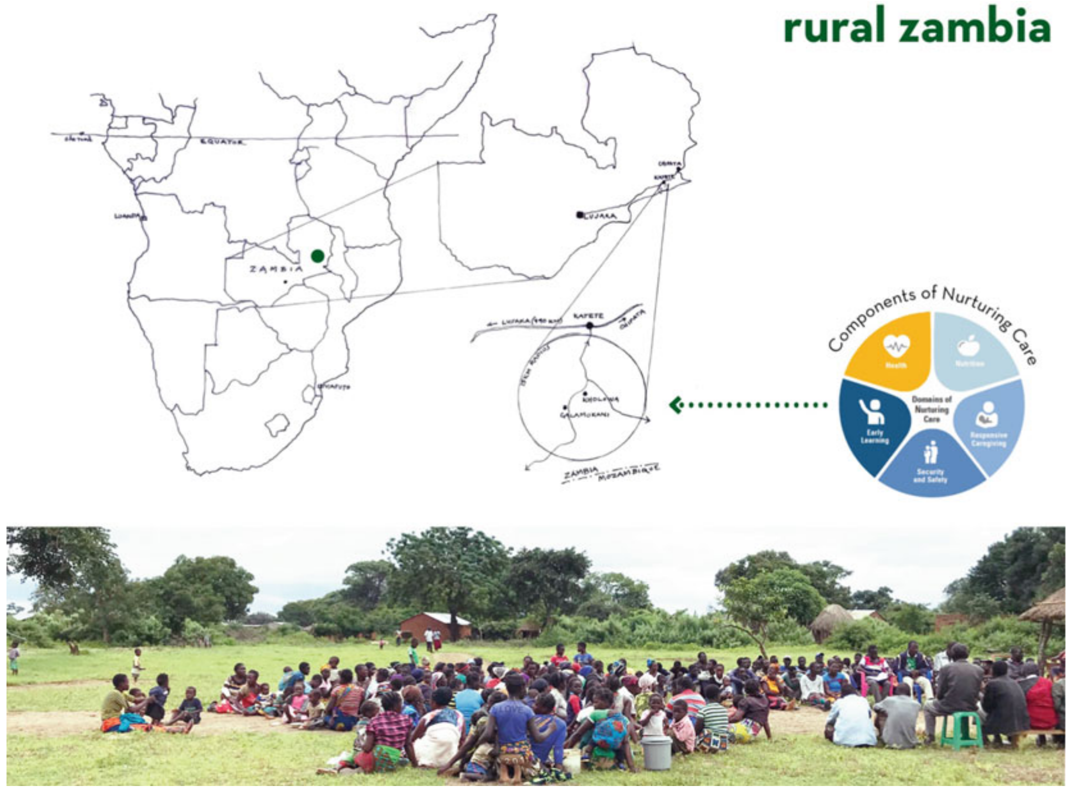

Fig. 9.1 Nurturing care framework and the rural Zambian context

on site as an extensive participatory process to guide the construction of integrated community hub prototypes. The schemes are conceived of as social landscapes of care, benefitting existing cultural practices, bringing new spatial perspectives, and augmenting educational and agricultural capacities (Fig. 9.4).

Kholowa and Galamukani, the two villages we worked in, are located approximately 15 km to the southeast of Katete, the district capital. The two communities, although similar in size, and close to each other, feature differences that can be traced back to their relative proximity to, or distance from, a main road. The Galamukani site is a large flat field that abuts the road, and lies in a relatively barren land, with scarce vegetation surrounding it. By contrast, the Kholowa site is in the heart of a dense village structure, embedded in rich vegetation and agricultural fields, and connected to a busy pedestrian movement network.

To facilitate the provision of services, the Insaka hubs are linked to the nearest health and education facilities and will benefit from the existing community outreach programmes under the various sectors (Fig. 9.5).

UN agencies, NGOs and foreign consultants like us, operate along fraught lines in seeking a balance between imported technical solutions and the ability to involve local inhabitants. By deliberately avoiding an initial design phase, the project allowed for co-production and knowledge exchange, engaging the social fabric of the end users. This meant that we did not arrive with a predetermined design, and “offered” it to the community, but rather initiated a hands-on stakeholder consultation. Whilst living on site, through a set of questionnaires and data gathering, we proceeded to build trust in the process, as well as documenting the availability and financial viability of technical and material solutions. The construction of a 1:1 mock-up made of

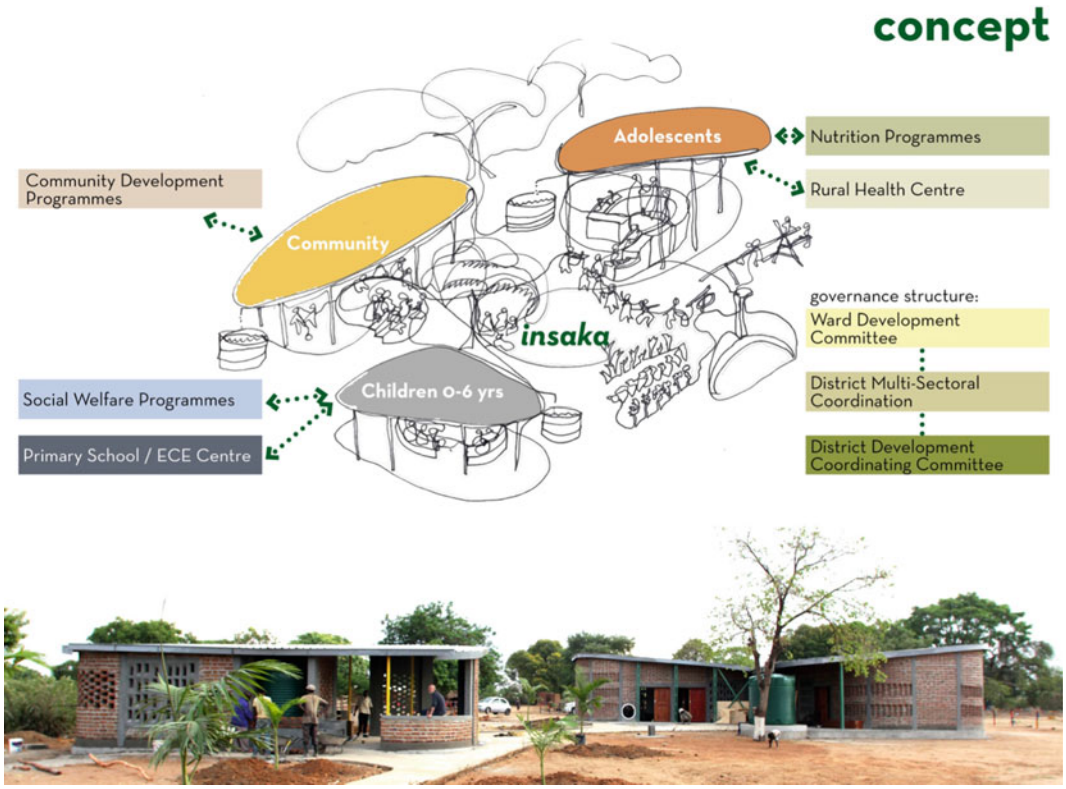

Fig. 9.2 UNICEF and the Insaka concept

primary load bearing elements, as well as cladding and finishing experiments, allowed us to define a grammar of architectural elements that we could then start developing further through the design.

To limit the impact of transport and energy consumption in a period of drought and prolonged electrical blackouts, the design adopted a support-and-infill approach. The structural framework operates as a loom, providing a stable and durable envelope, where perforated brick walls are assembled to provide climatic comfort, absorbing heat, and allowing for airflow, interweaving health with nurturing care (Fig. 9.6).

The different programmatic elements of the Insaka centre are organised around a central courtyard space. This coincides with the belief that education, nutrition, health, and agriculture are all interrelated, and that at their nexus the most significant and thoughtful improvements to daily life can be made. The landscaping, boundary walls, shading trees, kitchen garden, playground, all work with the architecture to create an integrated educational landscape which is born off the ground in response to the climate.

Thus conceived, each hub becomes the anchoring point for societal change, where services can be delivered, promoting resilience and social transformation, using a language of scarce material resources, and planting the seeds for an evolving, living ecosystem (Fig. 9.7).

The lesson we learnt whilst working on this project is that the relationship between architects and community concerns should be further developed and institutionalised, securing the promotion of health. It is an ecosystem made of interconnecting and interacting parts. As such, the design of the ECD centres purposefully integrates the different programmatic components at various scales with the desire that the site be both a hub, and a catalyst for the development of surrounding villages. The result allows waste

Fig. 9.3 Stakeholders: UNICEF/Childfund/communities/designers

products to be shared and recycled, land use to be multifaceted, and the implementation of a kitchen garden and energy generation at a meaningful scale. In addition to environmental benefits the different spaces can be configured to promote cross-pedagogical and community programmes within a productive landscape. The use of locally available resources such as clay and stone make it possible to shorten the supply chain and to spend the construction budget within the local community (Fig. 9.8).

The formal and material choices of the design act as an added educator, and provider of care. Stimulated, healthy, well-nourished children are poised to become the next generation leaders of societal change. As such, the design and architecture exist as a crossroad between educational centre, agricultural hub, community farm, water source, children's playground, biogas plant processor, and health post. Whilst so varied a programme might be problematic in some situations, the multivalent and ever-evolving functions of the Insaka buildings allow them to become a critical part of village life, attracting interest from neighbouring communities (Fig. 9.9).

Care in education is closely connected to health and hygiene. For this reason, thermal and acoustic comfort, as well as protection from rain and wind are critical elements in defining the appropriate nurturing environment. This allows to showcase also for adults in the community, the possibilities of using limited resources in improving the spaces in which children grow, facilitating nurturing care at household level, to maximise the impact of the intervention. The end result is directly linked to achieving SDG target 4. Quality Education (Fig. 9.10).

The infrastructure operates as an integrated provider of multiple services. From rainwater

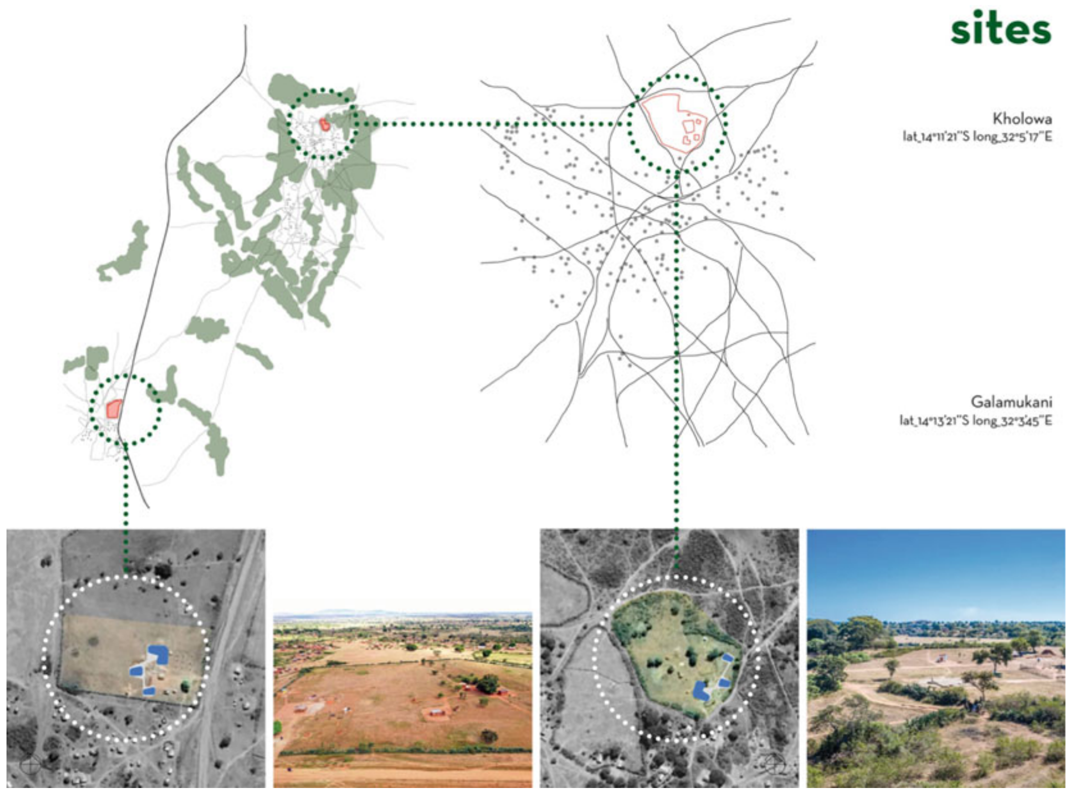

Fig. 9.4 Villages and sites

harvesting, to biogas production, provision of artificial lighting through solar energy panels, the adaptability of the spaces, and their flexibility, facilitates social, cultural, and economic development. The technical decisions taken contribute to achieving SDG target 3. Good Health and Well-being. The storage of rainwater in large tanks creates a viable source for the kitchen garden during the dry season. A bio-digester supplies fertiliser and gas that allows to cook meals without consuming precious wood. The solar panels help charge mobile phones, and power the only artificial lights in the village (Fig. 9.11).

The Insaka also serves as a health outreach post providing community outreach services to children, expectant mothers, and adolescents. Health facility workers perform growth monitoring, immunisation services, basic health screening and referrals, as well as facilitating nutritious cooking classes and hosting Child Health Week activities. Achieving SDG target 2. Zero Hunger, and target 6. Quality Water and Sanitation, were integral to the decision-making process (Fig. 9.12).

The choice of materials and techniques was a balancing act as the community initially asked to employ CO_2 emissions intense ones, seen as a paradigm of progress. Our approach follows two principles: preferencing the innovative use of locally available material and where cement and steel were used and maximising the production of building components on site, to avoid transport and favour low-tech assembly. The use of regionally scarce wood and glass was avoided. The walls are in exposed locally produced kiln fired bricks from glycoprotein intense termite stack grounds, simplifying maintenance efforts and limiting the use of plaster. The intuition behind this stems from, amongst others, Pereira (2008), who suggested how termite mound soil/clay has better qualities than ordinary clay

Fig. 9.5 Assemblages

for brick moulding in terms of strength and elasticity, being more resistant to weather, abrasion, and penetration of liquids and antibacterial and antifungal properties (Fig. 9.13).

One marker of the success of the scheme presented has been its replication in eight other sites since 2020, as a lead up to developing national guidelines for ECD centres in the country. Questioning binary distinctions—urban and rural, non-indigenous and local, rich, and poor—we maintain that understanding the ecosystemic role ECD centres have in, and for, communities, is a critical component of their capacity to operate as catalyst for urban growth of surrounding villages and landscapes.

Particularly in the global south and the postcolony we believe it is architecture's responsibility to imagine spatial infrastructures where healthcare-related services to be delivered play an integral role to redress environmental, economic, and racial injustices. Ultimately, we posit one should translate the notion of "dispersion" across social and cultural barriers, to achieve the spatial, and social, contract that will be necessary to mitigate inequality, and envision better, inherently healthier, futures.

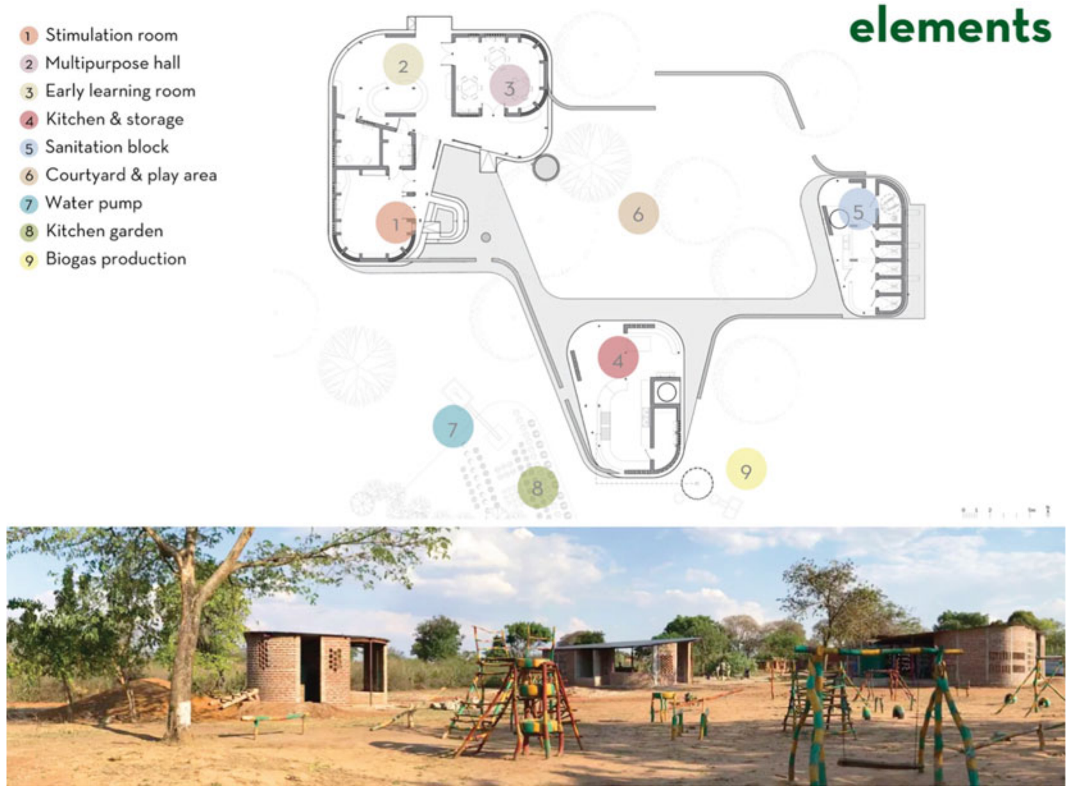

Fig. 9.6 Elements

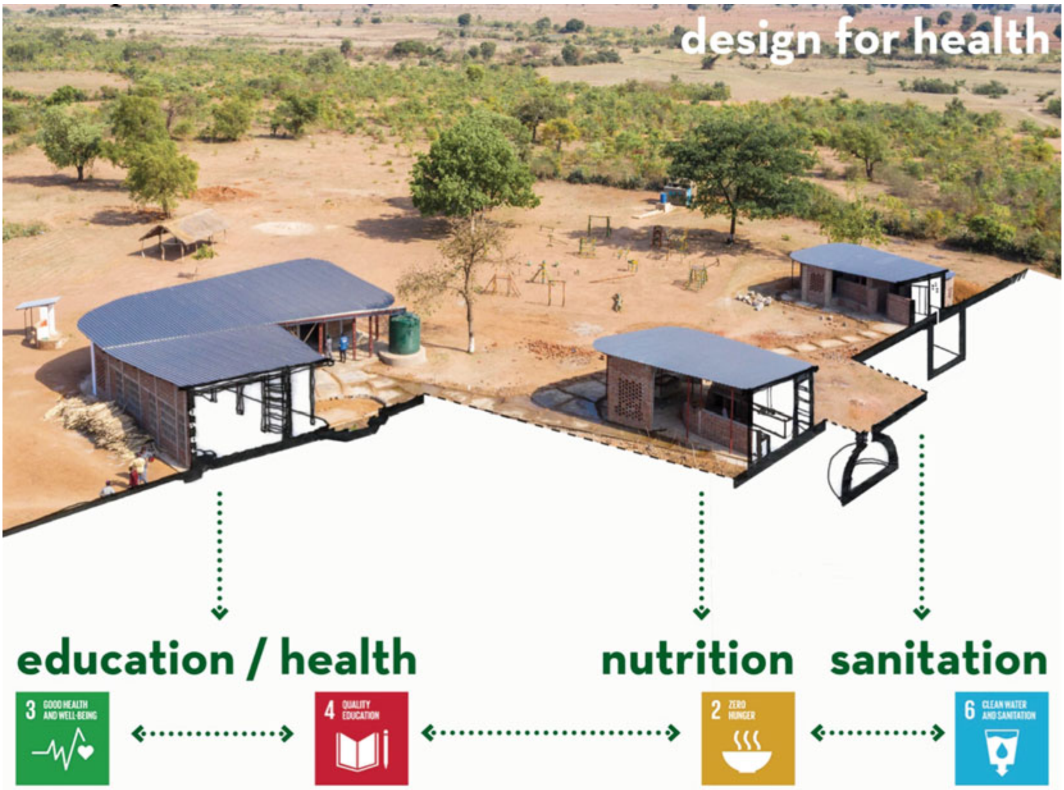

Fig. 9.7 Design for health

Fig. 9.8 Environment

Fig. 9.9 Stimulation

Fig. 9.10 Framework

Fig. 9.11 Nutrition

Fig. 9.12 Systems

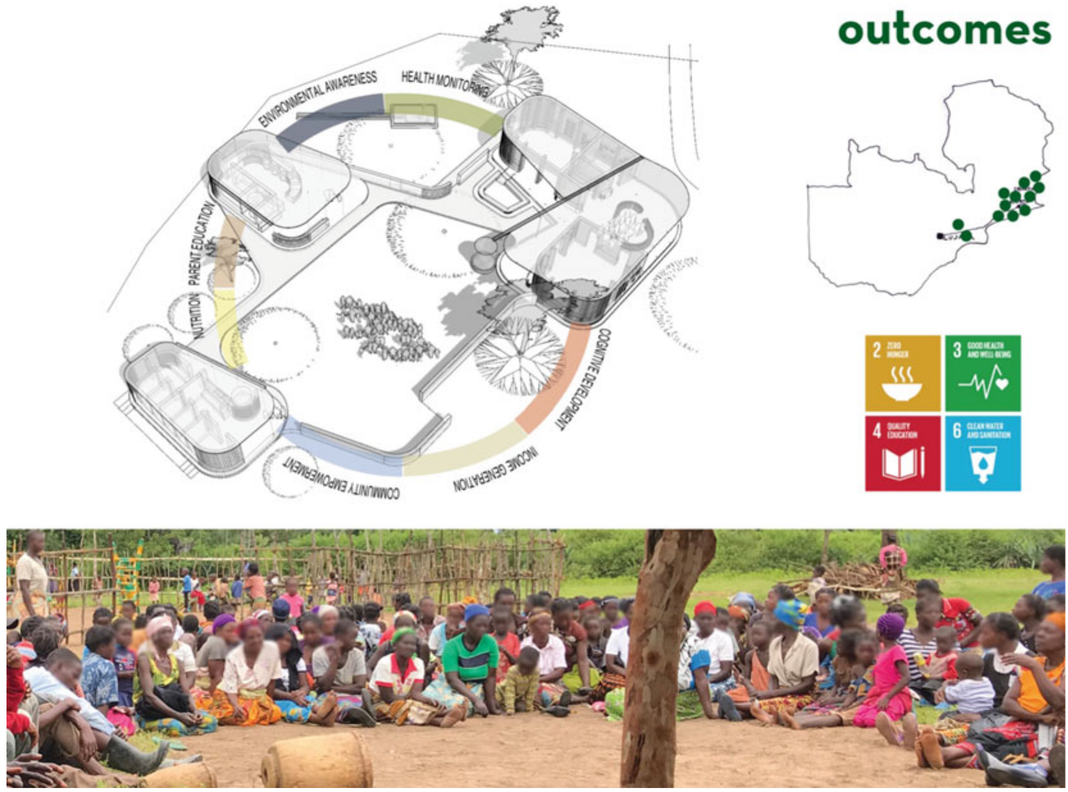

Fig. 9.13 Outcomes

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10 The Effect of the Front Porch and Loft on Natural Ventilation of the Main House in Beijing Courtyard

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Abstract

Since urban development began, Beijing courtyard homes have struggled with issues like population growth, renewal and renovation, and a lack of available housing. While the population is growing, the size of the original house remains intact for the occupants. In light of this incremental growth, the primary methods of remodeling the main house involve advancing the exterior wall, making use of the front porch to expand the living space, and adding a loft at height of approximately 6–7 m on the hard roof of the room, with stairs or climbing ladders connecting the upper and lower levels. However, despite the fact that ventilation is crucial to the home's indoor environmental condition, the designers did not give it enough consideration before the restoration. The goal of this essay is to investigate the effects—both good and bad—of two variations on the quadrangle's front porch and loft designs on the patterns of indoor ventilation. The comparative analysis approach is employed as the primary method in the study, with the front porch and loft serving as two variables to examine the internal ventilation of four distinct building models using computational fluid dynamics (CFD) techniques. The sectional airflow study and the 1.5 m height cloud in plane results show that the loft isolates the indoor airflow organization to some extent and makes the high interior windows less effective. Although the effect of occupying the front porch on ventilation is not significant, other effects on aspects other than ventilation need further study.

Keywords

Beijing courtyard · CFD · Indoor environment · Ventilation analysis

10.1 Introduction

As the primary area of urban renewal in Beijing, the courtyards face issues including hazardous homes, subpar living conditions, and tensions between new and old structures, according to SDG 11 “sustainable cities and communities”, these issues need to be addressed urgently. The main house of the courtyard serves as the primary residence for its inhabitants, and in the context of incremental development, the rise in the population has resulted in a growing need to expand the main house's living space. This need can now be met by occupying the front porch and expanding the interior with a loft. The problem is

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that the increasing demand for living space has led designers to overlook the effect of adding and modifying the main house on indoor and outdoor natural ventilation, and relevant studies have not paid enough attention to the natural ventilation of courtyard houses, so this paper explains how the two building configurations, the front porch and the loft, act on the indoor and outdoor natural ventilation of the main house through a comparative study.

10.2 Methods

This study uses a quantitative research method to build four architectural models of a courtyard with or without a front porch and with or without an additional loft, from which we can learn how the two variables above affect the indoor ventilation of a room, while also allowing designers and residents to better understand the indoor ventilation of a courtyard. This study's steps are as follows: (1) Arrange the architectural data and building measurements of the courtyard, and then use sketch up to create four distinct models. (2) Simplify and fix the models, as well as create the boundary conditions. (3) Open the ANSYS 2021 program, load the models, and configure the simulation's settings. The results acquired by ANSYS have been shown to be trustworthy in the developed theoretical framework and research methodology. (4) Compare and assess indoor airflow patterns, wind speed, and other factors, including any modifications brought on by various models.

10.2.1 Comparative Case Study Through Simulation

Beijing courtyard has been extensively studied and mapped as a representative example of traditional residential structures. Although there are many other buildings techniques and main house forms in use today, the modeling in this study is based on the most typical main house sizes and shapes. The main house has inside windows that are 1.16 m above the ground, a depth of 5.1 m, a width of 9.3 m, and a height of 6.3 m (Bingjian 1999).

The effect of roof shape, height, and ventilation methods on the indoor thermal environment performance of buildings were summarized as a result of a comparative study on the ventilation performance of multi-story roofs of traditional buildings in Myanmar carried out by CFD (Zune et al. 2020). The scholar Aydin made two comparative case studies on the effect of the "Cumba" structure of traditional Turkish houses on indoor ventilation, and proposed a plan typology to promote wind-driven indoor houses (Aydin and Mirzaei 2017). Therefore, this paper analyzes the influence of two classical structures of the main house on indoor ventilation by means of a simulated comparative case study method.

10.2.2 Simulation Methods

Adopting the same software and methods used in similar studies can ensure the authenticity of the results. CFD turbulence model can predict three-dimensional airflow and pressure distribution in indoor and built environment (Singh and Sharston 2021), in CFD research, 62% of scholars use ANSYS software, and 66% use RANS basic turbulence model (Toja-Silva et al. 2018). So the numerical simulation approach was selected using the same solution equations and techniques as in related research findings, and ANSYS series Fluent commercial software was employed. The second-order difference equation and the RNG k-ε in RANS turbulence model are used to calculate the diffusion term since it is necessary to take into account both inside and outdoor wind settings (Jing-yu et al. 2022). At 10 heights above the ground in Beijing, the boundary conditions are chosen as the predominant wind direction and the average wind speed with 5.5 m/s. The building facade is non-slip in the model, and the entering and exiting flows are represented by the conditions "violet-inlet" and "pressure-outlet", respectively (Wei et al. 2022).The calculation area is shown in Fig. 10.1. The boundary conditions of

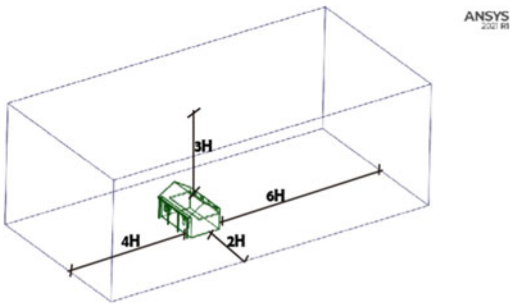


Fig. 10.1 Calculation area schematic

the indoor natural ventilation simulation refer to the average wind velocity of the window openings in the main room obtained by CFD simulation in the case of case 1 building with a front porch, with 1.8 m/s at the window inlet and 1.8 m/s at the back wall window as the outlet.

10.2.3 Simulated Cases

The case 1 is main house was separated into two examples of outside wind environment simulation with and without a front porch after the research to build a typical model, as illustrated in Fig. 10.2. The case 2 by adding a 3.4 m high floor slab, the interior was separated into two examples of indoor wind environment simulation with and without a loft, and the model developed by disregarding the extraneous features is illustrated in Fig. 10.3.

Fig. 10.2 Comparison of two models of the main house outdoor

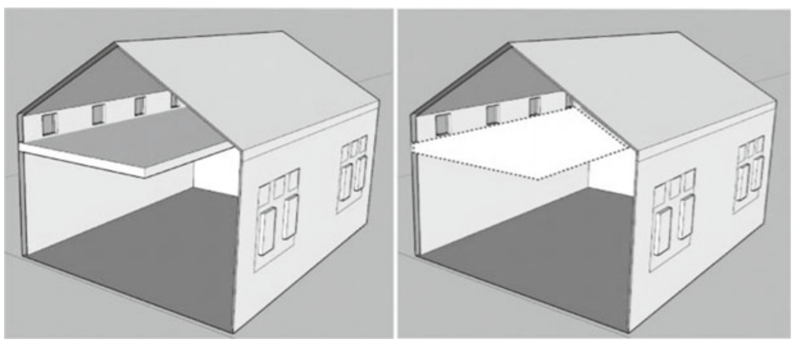
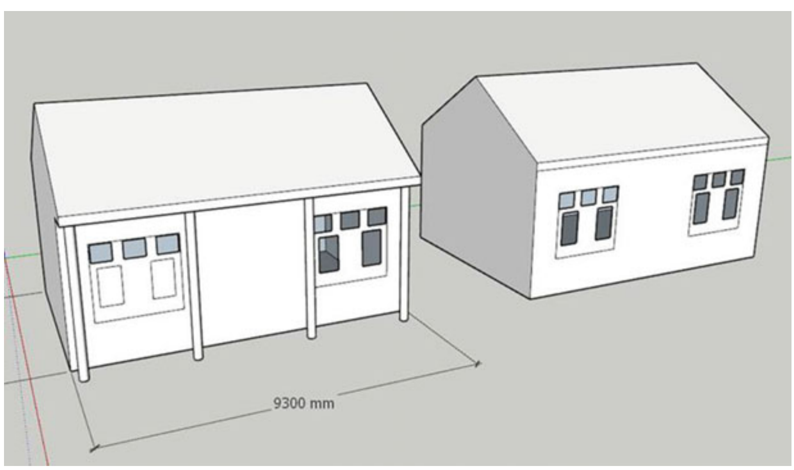


Fig. 10.3 Comparison of two models of the main house indoor



10.3 Results

10.3.1 Effect of the Front Porch

Figure 10.4 depicts a model of the main house with a front porch on the left and a model of the inhabited main house's front porch on the right. The region of the static wind zone with wind speed less than 0.5 m/s is bigger near the front porch than in the other instance, with an average wind speed of 1.9 m/s and 0.9 m/s in the case without a front porch. The reason for this is because the airflow beneath the roof is sluggish and the pressure is high, causing the airflow to ascend quickly and cause more vortex and disturbance on the leeward side of the roof.

10.3.2 Effect of the Loft

Figure 10.5 depicts the inside ventilation effect, with the wind speed cloud and airflow traces superimposed. The airflow enters from the window and travels upward in the room without the loft construction, resulting in greater indoor ventilation throughout the space. The room has a bigger vortex at the ground level in the case of the loft structure, which results to a loss in local ventilation effectiveness, mostly because the floor slab blocks the updraft and diminishes the ventilation impact of the windows on the rear wall of the main house.

10.4 Discussion

As the primary residence of the courtyard's residents, it is important to examine the natural ventilation of the main house. The presence of the main house's architectural front porch is necessary, and the loft structure has an impact on the original ventilation path of the interior, it can be deduced from the outdoor examination of the wind environment. According to certain studies, traditional residential research offers a distinctive viewpoint that can be used to combine socially-based solutions to economic and environmental issues (Lezcano and Burgos 2021). For this study, the small size of the quadrangle rooms becomes less in living space as the population increases means that residents face the dual challenges of living environment and economic pressure. Then the significance of the study on natural ventilation is to provide the residents of Beijing courtyard with the positive or negative impact of the renovation addition on the existing wind environment in an incremental context, which will later be continuously supplemented and improved in synergy with different disciplines. What is insufficient is that the effect of more morphological types of houses of Beijing courtyards on natural ventilation should be further discussed in the follow-up study.

10.5 Conclusion

The original architectural design in the courtyard building should not be modified as much as possible; only the inappropriate sections or structures need to be replaced, according to the numerical simulation study of indoor and outdoor natural ventilation of the main house building. In order to provide warmth and wind shelter in the winter, the building's front porch might weaken incoming airflow. In the summer, however, the porch can encourage local ventilation by raising the average wind speed in the area, which will improve internal ventilation.

In actuality, the loft serves as a living space, but due to poor loft ventilation, the building may need to use air-conditioning more frequently in the summer, which increases the energy use of the building. In order to accurately simulate ventilation in a courtyard, more complicated factors like the nearby structures, the surrounding vegetation, and the envelope structure must be taken into account. The role of the front porch of the building is not only reflected in indoor ventilation, the front porch is a kind of building indoor–outdoor transition space, which has the role of shading, rain, rest, and so on. In short, in the analysis of natural ventilation should focus on interdisciplinary, multiangle and multilevel research problems in the subsequent research.

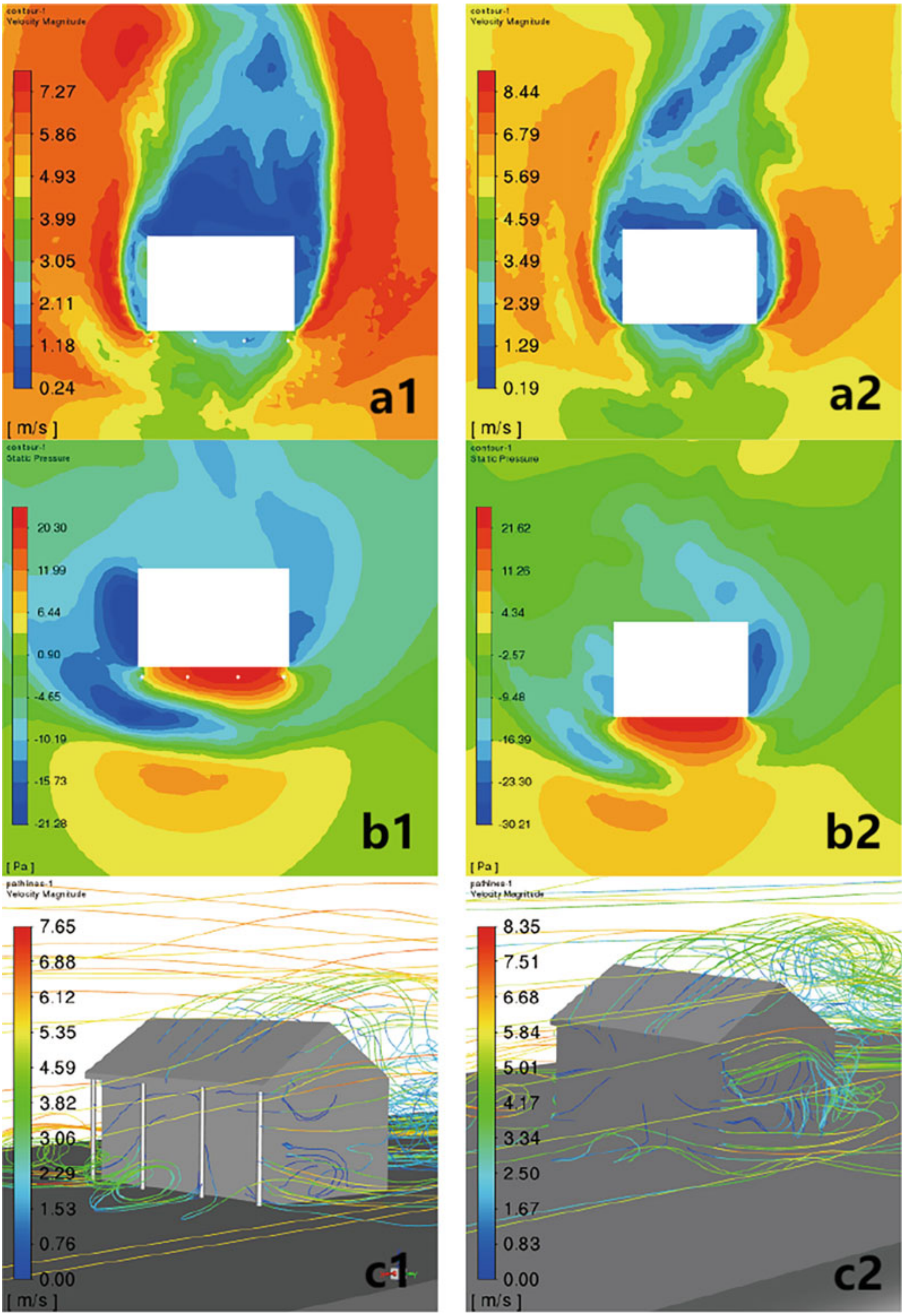


Fig. 10.4 Comparison of outdoor wind environment simulation results (the left picture is the model of the main house with front porch, the right picture is the model of the main house without front porch)

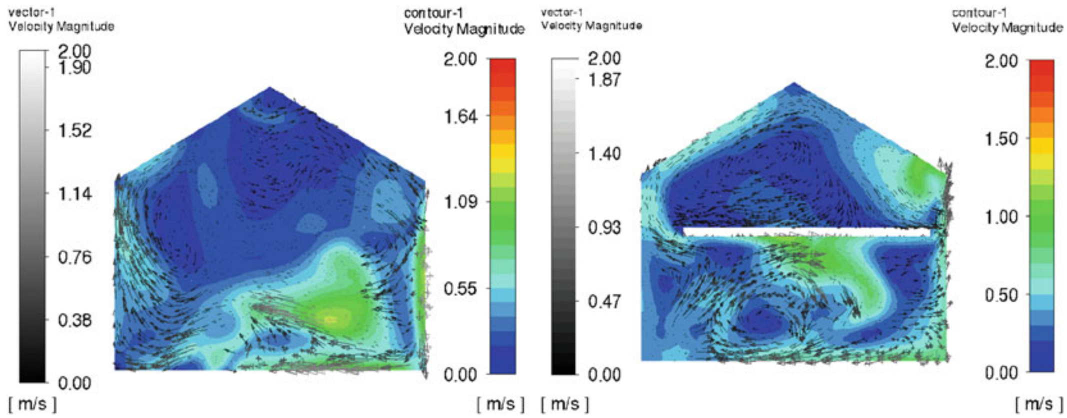


Fig. 10.5 Indoor ventilation analysis diagram (left diagram without loft ventilation, right diagram with loft ventilation)

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11 Cities Designed in Human Scale Make Healthier and Happier Societies: A Visual Essay

Shreya Das

Abstract

Cities are built for humans. Yet most modern cities fail to keep it human centric. With challenges of constant population growth, limited land availability, most cities are now adopting the high-rise model. Vertical cities may resolve the above challenges to some extent; however, they do not represent human scale. Most often these forms of development have led to social exclusion, fewer interaction opportunities with neighbors which increased feelings of loneliness among residents. Research states that loneliness can affect mental health and overall well-being of humans. Along with other social factors, architecture and urban design play a huge role in achieving the much needed social sustainability, which is one of the main pillars of 'sustainable cities & communities' (the 11th SDG of the UN Agenda 2030). On the one hand, researchers are talking about place making for humans, the importance of public spaces and happier cities. On the other hand, modern urban design is creating concrete giants with a total disregard for human connections. In India, most cities present a combination of urban environments with low to mid-rise residential developments in older neighborhoods and high-rise high-density developments in newer planned parts. This visual essay attempts to compare the human scale attained through the built environment between 'high-rise' and 'low to mid-rise' neighborhoods in Kolkata and analyze their impact on social sustainability.

Keywords

High-rise condominiums · Mid-rise neighborhoods · Urban lifestyle · Social sustainability · Human scale

11.1 Introduction

Over the last few decades, Indian cities have witnessed a gradual transformation in their urban landscape. The urban skylines of many Indian cities today are dominated by a blend of low-medium rise traditional neighborhoods and high-rise condominiums as shown in Fig. 11.1 (Bharat et al. 2018).

Like all traditional cultures, the ancient Indian social structure was designed for human co-existence that emphasized collaborative work, spending time with family, community participation, gatherings for festivals, religious congregations etc. (ClearIAS 2022). This was disrupted only after invasion and colonization of the land by foreign invaders and the introduction

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Fig. 11.1 Modern Skyline of Kolkata which shows a contrast of high-rise and mid-rise developments. © *Sketch by* Dr. Shreya Das (Author)

of the caste system (ClearIAS 2022). These political changes influenced the social structure of the communities inhabiting the region which in turn had new spatial requirements that were accommodated in the built environment. Traditional neighborhoods were dominated by low to mid-rise independent family houses, with courtyards, terraces, balconies and windows used for interactions between women within family and with neighbors (Malviya 2021; Bhagat 2021). Pre-colonial Indian settlements were clustered around forts and palaces ruled by kings. In those periods, public spaces were mostly in the form of a large tree (usually a Banyan tree which had a large canopy providing shade underneath) used for council meetings, along with markets and temple courtyards used for celebration of festivals and religious congregations (Jangir 2022) (Figs. 11.2, 11.3, 11.4 and 11.5). Thus, traditional Indian neighborhoods grew around strong socio-cultural life. Yet, the temple authorities and the monarchs had a strong influence and control on their lives (Kanaka Durga and Sudhakar Reddy 1992). Such communities co-existed with nature, in harmony, respecting her boundaries. Often various forms of nature were worshipped as gods (Pandey 2021).

Modern Indian society has a strong foreign influence and mirrors the transition from a supportive society to one driven and controlled by money. After colonization, Indian human settlements got a new character identified as urban or rural. Urban settlements are formed by industry-driven economy which further encouraged human migration and agglomeration. This pattern influenced the entire world, creating numerous urban centers with high population density which put pressure on the civic infrastructure. This further impacted local cultures, creating more of self-centered or introvert individuals and nuclear families. Such a socio-economic structure has little space for human 'co-existence'. United Nations identifies social sustainability of the Anthropocene (humans) as one of the pillars of sustainable earth. Furthermore, co-existence with humans and nature plays a key role toward sustainable human societies (The United Nations Brundtland Commission 1987). All traditional societies were structured around physical social interactions as opposed to modern societies, where social interactions are primarily carried out virtually through various social media platforms. Physical gatherings are rare today. For a modern urban Indian,

Fig. 11.2 Community gathering under the Banyan tree. In indigenous Indian communities, trees with large canopies have a significant role in the socio-cultural system. Because of the local climate, these trees offered the needed shade, especially during the hot summers. Thus, these were hot spots for community gatherings. Village heads also used these spots to hear cases and pronounce their judgment. © *Sketch by* Dr. Shreya Das (Author)

Fig. 11.3 Festival celebrations at temple premises. In ancient India, the temple and priests had a huge control and influence on the locals and also on the king. © *Sketch by* Dr. Shreya Das (Author)

Fig. 11.4 Social interactions between women on terraces. © *Sketch by* Dr. Shreya Das (Author)

Fig. 11.5 Traditional Indian neighborhoods with roofs and terraces in close proximity that offered opportunity for community interactions. © *Sketch by* Dr. Shreya Das (Author)

'happiness' is associated with a good job and salary, access to good infrastructure and amenities, materialistic possessions and showcase of luxury. Yet, numerous research conducted on the lifestyle of residents in skyscraper cities like New York highlight the increase in urban loneliness, depression and anxiety (Krishnan 2019; Puliyel 2020). In such cities, as opposed to Indian cities, the race for gigantism is far greater and is of concern (Fig. 11.6).

Figure 11.7 is a picture of the New York skyline shared by an Indian living in the USA for a long time. When asked about her experience with the city, the respondent described her feelings as mixed. On the one hand, she said she enjoyed such views, looking down toward the ground, from a high-rise balcony. On the other hand, she said that such an urban skyline also came with a feeling of disconnect with neighbors and that of loneliness.

Fig. 11.6 Modern skyline of New York city. © *Sketch by* Dr. Shreya Das (Author)

Fig. 11.7 New York city view. © *Photo Credit*: Ms. Kangabam Sanjana Priyadarshini Devi, a young female respondent of Indian origin, who has been living in New York for the last 10 years

Fig. 11.8 Women interacting over balcony in old Kolkata, the balcony from where the photo was taken is the author's own residence. The building faces a traditional courtyard house with projected balcony, as shown here. © *Photo Credit*: Dr. Shreya Das (Author)

11.2 Comparative Analysis of Daily Life in Traditional Neighborhoods Versus High-Rise Gated Communities of Kolkata

The following figures depict the scenario in an old city neighborhood of Kolkata where the author lives. Figure 11.8 shows two women talking to each other from their balconies on a regular day. This picture was taken by the author from the balcony of one of these houses. The position of the two houses is such that their balconies, facing each other, enjoy visual and acoustical proximity. Figure 11.9 was taken of the above two houses from ground level. Figure 11.10 represents an indicative section of the right of way of the road, demonstrating the approximate height of the houses that ensures physical proximity with the street.

Figure 11.11 demonstrates how mid-rise (here G + 2) of the houses provides a connection with the activities on the road. One person is also seen lazing on the sitting area, attached to the buildings at ground level. Such sitting joints are typical to traditional neighborhoods in Kolkata and are commonly known as 'rok' in Bengali. These 'roks' offer spaces for casual interactions on a daily basis and are primarily used by men. The locals have named such gatherings as the 'roker adda', where 'adda' in Bengali refers to casual chit chat between a group of people as shown in Figs. 11.12 and 11.13. These 'roks' are usually part of the buildings premises. However, these are usually used by the locals as public spaces, without the need to take permissions from the owner. Thus, the architecture of these traditional neighborhoods has been silently promoting co-existence, for years, by increasing 'chanced interactions'.

Women in these parts, however, primarily interact over balconies, courtyards or terraces. Another popular human activity that gives identity to an Indian urban neighborhood is the 'gully cricket'. Cricket is a game, popular among Indians along with football. The low rise of the building abutting these by-lanes of Kolkata also enables women to watch-over their kids playing on the street (Fig. 11.14). On the other hand,

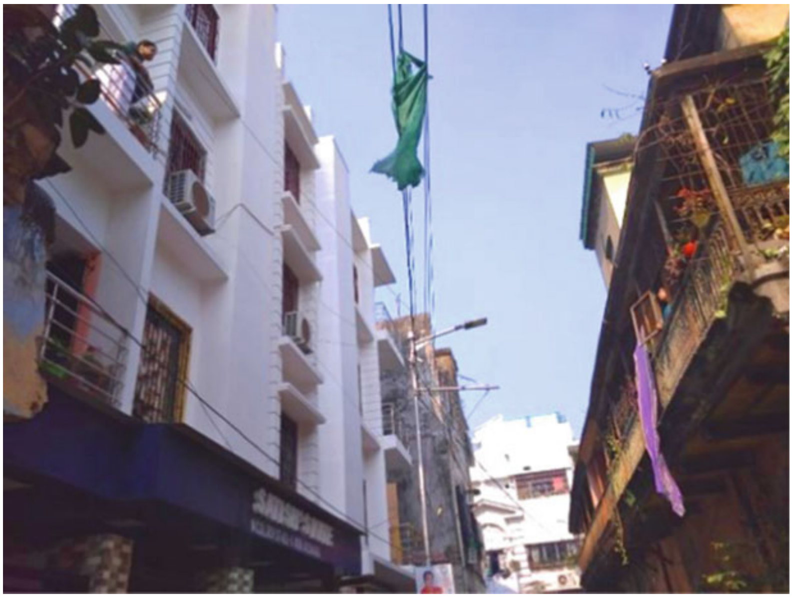

Fig. 11.9 View of above neighboring residences, taken from street level. © *Photo Credit*: Dr. Shreya Das (Author)

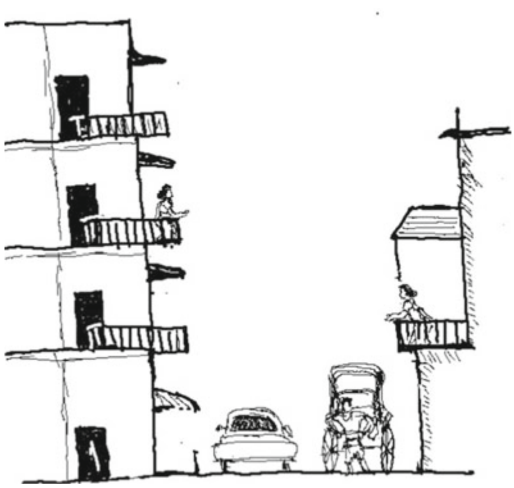

Fig. 11.10 Visual representation of a typical road section in old Kolkata neighborhood. © *Sketch by* Dr. Shreya Das (Author)

such sitting joints ensure that there are enough people on the streets all the time, especially during evening hours, making them safer roads (Fig. 11.12).

Except for some stray incidents, Kolkata is still considered safer compared to other cities of India. This is due to a large population size and a traditional neighborhood architecture having sitting joints and mixed use development which ensures presence of human beings on roads, all the time. However, there are some demerits to this urban form, including issue with privacy. This, however, is often addressed by covering windows and balconies with curtains and screens (Fig. 11.15). On the other hand, mid rises allow residents to be more visually connected with nature, with tree canopies being at eye level. Even a person who is not much interested in biophilia has more daily visual communication with birds, bees and butterflies moving around (Fig. 11.16), which is absent in high-rise living.

Life within high-rise gated communities is more luxurious, private but with higher maintenance cost. Although these gated communities come with a lot of amenities like gym, spa, community hall along with beautifully landscaped gardens, yet, busy urban lifestyles prevent the residents from using these on a regular basis. People spend more time indoors than outdoors. Moreover, vertical height often discourages the elderly to travel to the ground level to access the garden hangout spots. A typical gated high-rise condominium in Kolkata accommodates around

Fig. 11.11 Mid-rise houses in residential neighborhood have higher proximity with street. © *Photo Credit*: Dr. Shreya Das (Author)

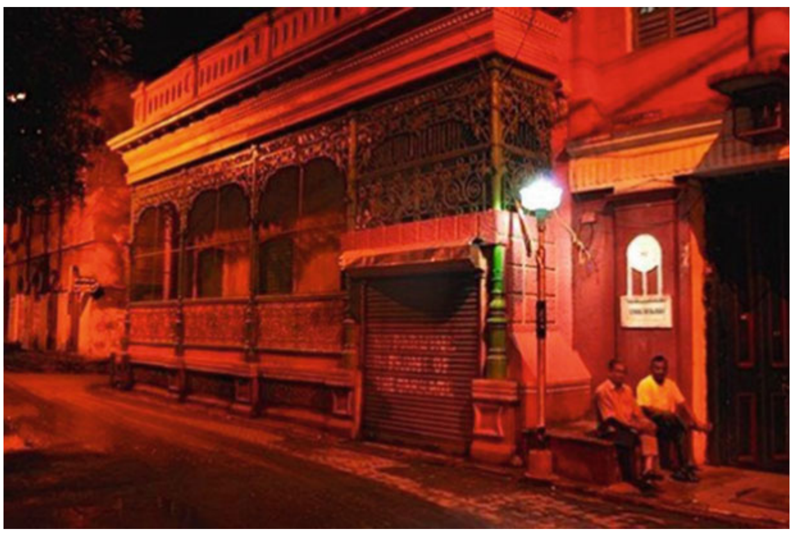

Fig. 11.12 Typical evening scene with 'Rok-Adda' in old Kolkata. This characteristic ensures safety on roads as night. © *Photo Credit*: Dr. Shreya Das (Author)

1500–2000 families. Research says that too much crowd can limit one's feeling of belongingness with the place (Krishnan 2019; Puliyel 2020). Figures 11.17 and 11.18 are pictures of views from a high-rise balcony, which were shared by a single lady (in her late 30's) living on the 14th floor of a standalone high-rise apartment complex in Kolkata. The pictures show that the surrounding neighborhood is low to mid rise. The resident said that she enjoyed the unobstructed view of the vastness ahead and a glimpse of the river flowing in the vicinity. The picture shows that the balcony does not face any other neighbors' façade, thus enjoying full privacy and good views.

However, the experience may be different for those living in high-rise apartments, placed in building clusters. Figures 11.19 and 11.20 represent pictures of a high-rise condominium in Kolkata, where the buildings are

Fig. 11.13 Another scene of evening 'adda'/gathering in old Kolkata. © *Photo Credit*: Dr. Shreya Das (Author)

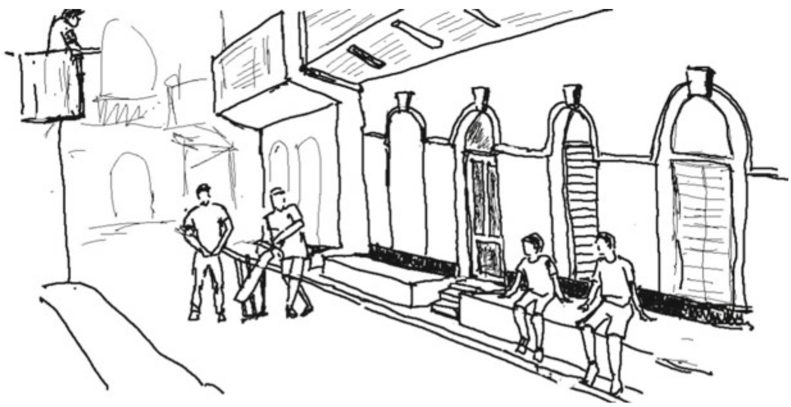

Fig. 11.14 Gully cricket in old neighborhoods of Kolkata. The low to mid-rise built environment provides visual proximity with the street and the activities happening there. © *Sketch by* Dr. Shreya Das (Author)

arranged in clusters. These pics demonstrate that buildings placed in close clusters may generate feelings of crowdedness and lack of privacy. However, the perception may vary according to the space maintained between the clusters, which is further explained through Figs. 11.21 and 11.23.

Figure 11.21 portrays the view from a high-rise balcony from one of the premium housing condominiums in Kolkata. It shows that the neighbors' balconies can be seen from the balcony from where it was photographed. This is due to the orientation and proximity of the neighboring towers, as designed by the architect. While this may be perceived as an opportunity to interact with neighbors, some may consider this as a privacy issue. In such cases, visual screening may be incorporated in the balconies for better privacy as demonstrated in Fig. 11.22.

Figure 11.23 depicts the view from the balcony on 24th level from another high-rise condominium in Kolkata, which also depicts that neighbors' balcony can be seen from there. However, the distance between the towers is such that it will not significantly affect the privacy of the balcony. Hence, placing visual screens in such cases may not be necessary.

Figure 11.24 shows how the amenities and gardens, despite being well designed, remain underutilized in a high-rise condominium in Kolkata. On the other hand, Fig. 11.25, shared by an elderly lady living on the tenth floor in a high-rise condominium in Delhi, India, depicts how building clusters can prove to be

Fig. 11.15 Use of curtains to improve privacy from neighboring balconies, old Kolkata. Taken from the residence where the author lives. © *Photo Credit*: Dr. Shreya Das (Author)

Fig. 11.16 Low-rise neighborhoods provide better visual contact with surrounding nature. Photo taken from Author's balcony. © *Photo Credit*: Dr. Shreya Das (Author)

advantageous. The picture shows the view from the lady's kitchen that overlooks her neighbor's kitchen. The elderly lady lives with only her husband, with her children settled in other cities. For her, loneliness can be an issue and thus it is important for her to socialize. According to her, the kitchen facing each other helps her interact with her neighbor on a daily basis over kitchen chores.

11.3 Discussion and Conclusion

The above visual essay indicates that high-rise structures may give a feeling of awe and grandeur to the observers because of their gigantic scale, but they do not enable human connection for the residents. Low to mid-rise neighborhoods, on the other hand, offer a relatable scale. This

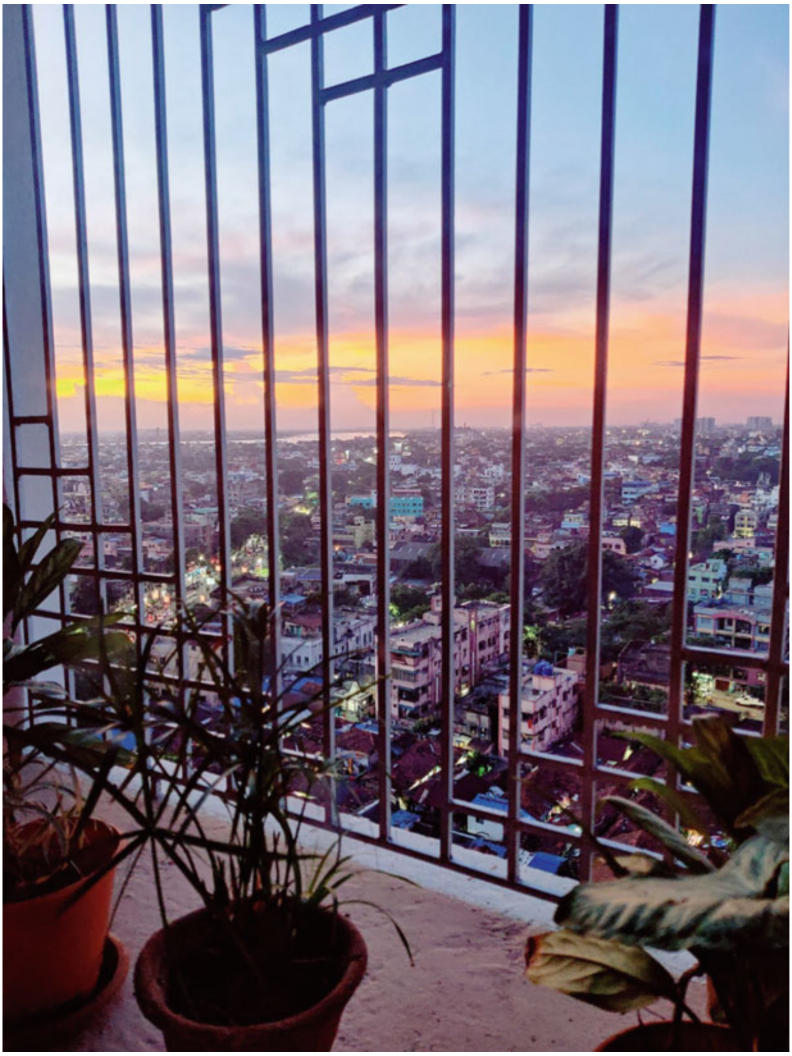

Fig. 11.17 View from a high-rise balcony, Kolkata, surrounded by mid to low-rise developments. © *Photo Credit*: Ms. Kabita Choudhury, survey participant for this paper

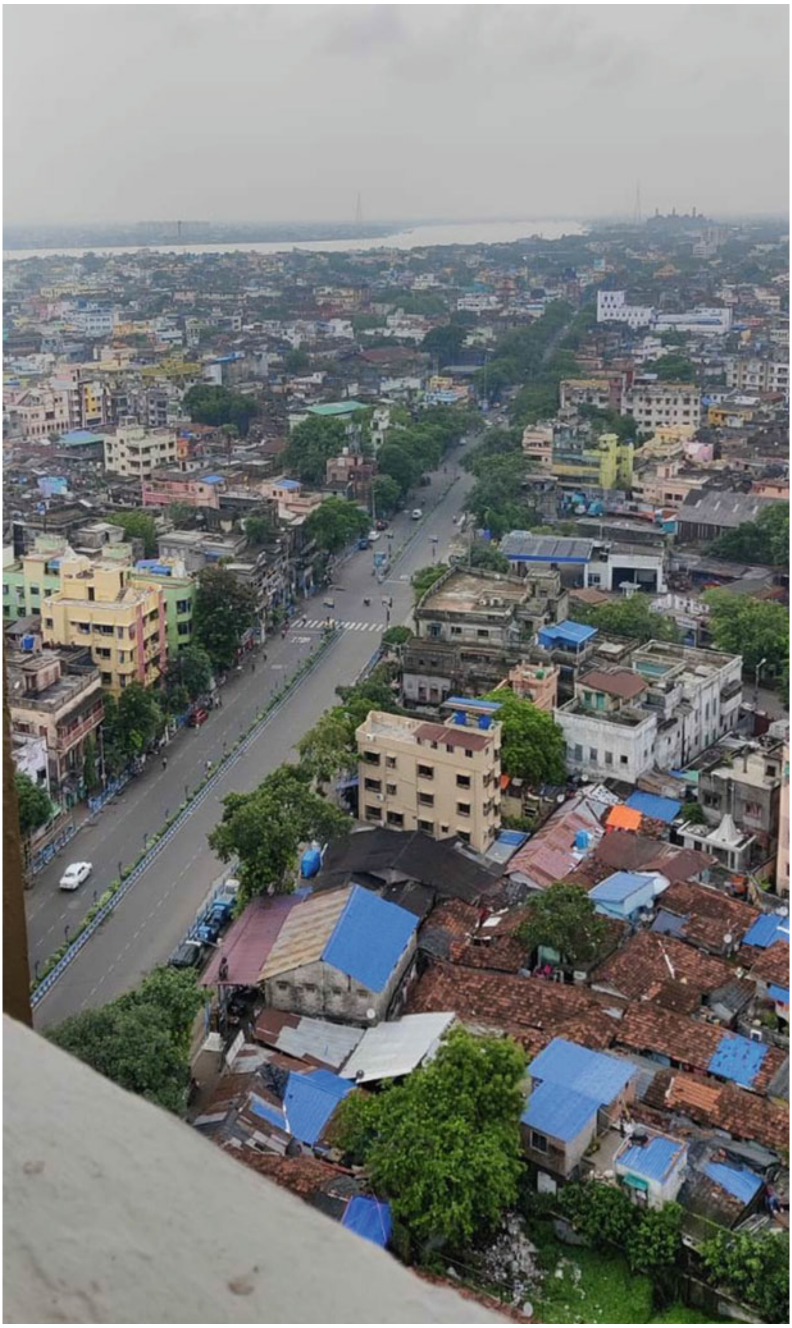

Fig. 11.18 Unobstructed view from the same balcony as shown in Fig. 11.17. © *Photo Credit*: Ms. Kabita Choudhury

Fig. 11.19 Views of high-rise clusters in a condominium in Kolkata, observed from street level. © *Photo Credit*: Dr. Shreya Das (Author)

Fig. 11.20 Views of the same high-rise condominium observed from terrace. © *Photo Credit*: Dr. Shreya Das (Author)

Fig. 11.21 View of neighbor's balcony from a high rise in Kolkata, where proximity of neighboring tower hampers privacy. © *Photo Credit*: Dr. Shreya Das (Author)

Fig. 11.22 Illustration how balcony privacy can be improved by using screens. © *Illustration by* Author

increases chanced/casual interactions and enhances the probability of knowing more neighbors. Traditional neighborhoods have their own limitations, including poor privacy and lack of space, but the human scale adopted in its urban design compels more social interactions. Residents feel safe on street and connected with neighbors due to visual, acoustical and psychological proximity offered by the built environment. This further encourages more social interactions. Urban areas designed in human scale empathize with the human psychological needs. This promotes co-existence, happier societies and a sustainable earth.

Fig. 11.23 View from the balcony in a high rise, located on 24th floor. This is an example that shows that correct spacing between towers in cluster may not affect privacy. © *Photo Credit*: Dr. Shreya Das (Author)

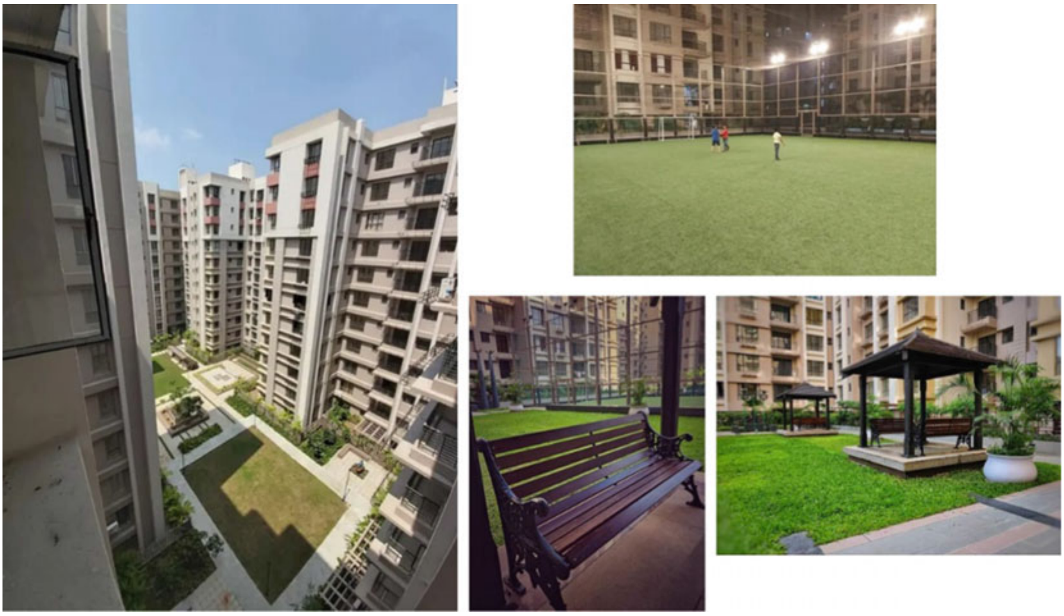

Fig. 11.24 High-rise condominium in Kolkata where its well-designed gardens and amenities remain underutilized. © *Photo Credit*: Mr. Sandip Das, resident of the condominium in picture, Photo Collage by Author

Fig. 11.25 Neighbor's kitchen overlooking each other, in a high-rise condominium, can improve social life for some residents. Here, adjacent towers are in good proximity, yet the kitchens in the opposite apartments face each other, contrary to balconies or bedrooms. © *Photo Credit*: Mrs. Richa Mittal, an elderly resident in the condominium shown here

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12 Designing a Rehabilitation Center for People with Physical Disabilities: Social Sustainability-Climatic Approach Interaction in Tehran

Mona Sadeghian,
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and Mehrnoosh Sherafat

Abstract

Human society is a combination of diverse strata and people with physical disabilities are also an integral part of society. In the past, this group and their needs and challenges they are faced with have been neglected due to lack of knowledge, lack of facilities as well as technology that has led to their low presence in society. One of the most important components of social sustainability is improving life quality, removing discrimination and ensuring individual independence and social identity. Therefore, the society should provide equal opportunities to everyone in the first step, and in the next step, there should be the right of individual choice for everyone independently. Health, efficiency and satisfaction in work and the feeling of human comfort are largely dependent on environmental physical criteria. The stable physical environment, which is the result of complex factors such as ventilation, temperature, lighting, acoustics and installation systems, directly affects people's work ability. Despite the many researches that have been done in the field of providing indoor thermal comfort for the general public, still few researches have focused on special people such as the elderly, the sick and people with physical disabilities. Accordingly, the aim of this study is to achieve a model of design using the definition of architecture and social sustainability and its application to meet the needs of these people, such a center that can be designed in one of the crowded areas of Tehran city to address the challenges these marginal groups are faced with.

Keywords

Social sustainability · Sustainable architecture · Rehabilitation center · People with disabilities · Tehran climate

12.1 Introduction

We are ecologically interdependent with the whole natural environment; we are socially, culturally and economically interdependent with all of humanity; a sustainability, in the context of this interdependence, requires partnership, equity and balance among all parties. A diverse and healthy environment is intrinsically valuable and

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essential to a healthy society (U.I.A. Chicago 1993: 1). In fact, physically disabled people are doubly harmed by the physical problems of the environment. They feel dissatisfied physiologically and their health is impaired, and at the same time, they will depend on the help of other people to provide minimum comfort. This requirement (whether to reach a destination or to reach the appropriate temperature of the environment) is in contradiction with the independence and right of free choice of people in activities and work. Physical movements are an important factor in regulating the body's metabolism and the ability to adapt to the environment, which people with disabilities are limited in using. So, in line with the goal of social sustainability, providing thermal comfort to these people seems to be an important component.

Yet, most research in this area focuses on the urban built environment and design aspect of a city (Bramley and Power 2009; Ali et al. 2019). Other significant researches such as (Karji et al. 2019; Qtaishat et al. 2020) regarded the social sustainability assessment of building and construction. In this framework, a few recent studies have demonstrated the sustainable principles inherent in the conception and design of health architecture (Bonnet 2014; Boys 2017; Goldsmith 2018; Liebergesell et al. 2018).

In the present study, in addition to meeting the criteria effective in the design of a standard rehabilitation center including ease of access and creating all-round comfort to provide various services to people with physical-motor disabilities, the deep effect of climate is reviewed in designing and solving the previous challenges that the target group are faced with, in order to help in empowering them. Based on the intended approach in this research, it has been attempted to distinguish between different aspects of social sustainability, including the user's constructive relationship with the built environment and the individual's relationship with other members of the society, in order to meet the physical and psychological needs of a person who is mentally and physically vulnerable to create an effective communication and examine different factors in climate design and social sustainability. Since the goal of sustainable development was in the past to create a safe and comfortable environment and meet the needs of users, it is highly necessary to focus more on this concept today due to the existence of basic problems in societies.

In fact, as an architect with some physical disabilities who suffers from poor design of public buildings in society and as one of three writers of this paper, this study aims to achieve a model of design using the definition of architecture and social sustainability and its application to meet the needs of people with physical disabilities by means of qualitative research method. The first step is designing a rehabilitation center with observing worldwide standards located in one of the crowded areas of Tehran city to address the challenges these marginal groups are faced with.

12.2 Literature Review

12.2.1 What Is Disability?

Although a disabled vehicle may be considered useless, people with disabilities are not. Putting people first is the right way to describe someone with a disability. Over the past thirty years, activists for the accessibility movement have campaigned to replace words like “handicapped” and “disabled” with the phrase “people with disabilities”. This politically correct terminology was chosen to reduce the stigma associated with obvious disabilities.

People with physical disabilities are part of the tapestry of any urban fabric. Most of them lead normal lives. Persons with chronic disease learn to cope with progressive limitations. A person with any type of disability may enlist the support of family, friends and neighborhood organizations. Very few people are completely dependent upon others. From the perspective of universal design, the job of the architect is to design enabling environments that prolong and enhance independence (Heckel 2003, p. 14–22).

There are two origins of disabilities: congenital and acquired. Congenital disabilities exist at birth. In most cases, these disabilities are permanent. Acquired disabilities are the result of events which happen after birth. Age-related disabilities such as hearing loss affect everyone who lives long enough. Accidents can happen to anyone. Disabilities acquired during life may be permanent or temporary, e.g., spinal cord injuries are usually permanent but not always fatal.

12.2.2 Sustainable Architecture

"Our Common Future", a report presented in 1987 by the World Commission on Environment and Development, defined development as sustainable just when it meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED 1987). Despite the almost universal acceptance of this definition among various sciences, sustainable design is subject to a wide variety of ideas and attitudes (Guy and Moore 2007; Sanya 2012; Khademi et al. 2019). Similar to the definition of sustainable development, sustainable architecture addresses specific issues of architecture in terms of the concept of sustainability (Roaf et al. 2004; Akadiri et al. 2012; Esmaeili and Litkouhi 2013; Grover et al. 2019).

At the UIA World Congress of Architects in Chicago, 18–21 June 1993, the following document was adopted. The Declaration of Interdependence for a Sustainable Future recognizes that buildings and the built environment play a major role in the human impact on the natural environment and on the quality of life; sustainable design integrates consideration of resource and energy efficiency, healthy buildings and materials, ecologically and socially sensitive land-use, and an aesthetic sensitivity that inspires, affirms and ennobles; a sustainable design can significantly reduce adverse human impacts on the natural environment while simultaneously improving quality of life and economic well-being.

Today, in order to reduce environmental pollution and optimize energy consumption, sustainable architecture has received more attention from designers and architects. Sustainable architecture is actually a response to the crises in today's industrial and modern world. This type of architecture, which is also known as green architecture, reduces the damage caused by the design of buildings on energy resources and the environment. Therefore, a building based on sustainable design principles has the least incompatibility with the environment.

12.2.3 Social Sustainability

Everyday life and collective action of people encompasses social sustainability (Søholt et al. 2012). 'It concerns how individuals, communities and societies live with each other and set out to achieve the objectives of development models which they have chosen for themselves, also taking into account the physical boundaries of their places and planet Earth as a whole. At a more operational level, social sustainability stems from actions in key thematic areas, encompassing the social realm of individuals and societies, which ranges from capacity building and skills development to environmental and spatial inequalities. In this sense, social sustainability blends traditional social policy areas and principles, such as equity and health, with emerging issues concerning participation, needs, social capital, the economy, the environment, and more recently, with the notions of happiness, well-being and quality of life' (Colantonio and Dixon 2009, p. 5).

12.2.4 Social Sustainability in Architecture

Social stability deals with current events inside the space and it cannot be guaranteed by physical stability alone as it is dependent on human behavior. In other words, the time span that social stability deals with in theory is shorter than its physical type. Therefore, social sustainability focuses more on matching the space with the behavioral patterns in the present time and increasing the quality of life instead of dealing with the stabilization of events for long years. But in order to make this life flow as long as possible, the space should be given the ability to adapt itself to changes in the course of life; in other words, indicators should be considered in the design that make the space flexible. In this research, social sustainability indicators effective on architectural design are considered as follows:

- *Social Interaction*
  The human need for social interaction at different levels is generally accepted and the architects are responsible to design physical space to increase social interaction (Zoghi Hosseini et al. 2020). Architectural spaces are physical phenomena that reflect many cultural and geographical characteristics of a region (Norouzi and Khademi 2021). The sociability of human-made space can reduce or increase the amount of social interaction between people. However, creating a platform for social interactions requires creating physical platforms as well as social platforms and creating spaces that suit the needs of users, especially citizens with specific physical limitations.
- *Social Security*
  Creating a sense of security in the space is another indicator of increasing social sustainability in the quality of the built environment and satisfaction with it (Norouzi et al. 2019). The proper design of urban borders and the design of a defensible space can increase the sense of controllability in users. The sense of security is a psycho-social process that is not only imposed on people, but the individuals in a society fundamentally contribute to its creation or destruction based on their needs, interests, desires and personal abilities; therefore, it seems necessary to pay attention to the issue of security in architecture to develop social sustainability.
- *Livability*
  Livability is a concept defined on the two macro and micro levels. At the macro level, it includes concepts such as justice, efficiency, compatibility and environmental quality as well as the vitality of urban spaces. Livability is a general concept related to a number of other concepts and terms such as sustainability, quality of life, quality of place and healthy communities (Norris and Pittman 2000). Finally, the dynamism and livability in the city lead to increased social stability, since the level of vitality and the citizens' presence in the public spaces of that city is an indicator that distinguishes a city from other cities more than any other criteria.
- *Flexibility*
  'Flexibility is dependent on socio-psychological and economic performance; and the physical spatial organization of the building must be in harmony with the natural and cultural environment, manmade environment, economic and political environment and the livelihood of the community' (Kefayati and Moztarzadeh 2015). In line with this definition, it can be defined as an emphasis on compatibility. To brief, the concept of flexibility is the ability of building to change physically and adapt regarding changes of situation (Habraken 2008).

12.2.5 Sustainability and Designing Based on Climate

As mentioned previously, economic sustainability is among the three basic principles in the sustainable development of buildings (Akadiri et al. 2012). In this regard, climate design is a way to comprehensively reduce the energy costs of a building (Esmaeili and Litkouhi 2013). Building design is the primary frontier against external climatic factors. Buildings that are built according to the principles of climate design reduce the need for mechanical heating and cooling to a minimum in all climates and use the natural energy available around the buildings instead which in turn reduce energy consumption (Hoseinzadeh et al. 2021). Given that the desired rehabilitation center will be built in Tehran climate, it is necessary to study that climate to achieve a design based on the climate of the design site with the aim of increasing sustainability in architecture.

12.2.6 Tehran Climate

Tehran has a hot summer, especially in the south and center of the city, and moderate weather in the north part of the city. The center of the city is mild in winter, but the northern parts are cold. In the cold seasons of the year, Tehran is affected by the high-pressure systems of northern Siberia with a cold, dry and generally polluted winter, while it is affected by the low-pressure thermal systems of the central desert in the hot months of the year indicating hot and dry summers. The maximum air temperature in Tehran reaches + 43°, while the minimum is -15 °C. In the climate zoning map of Iran with housing and residential environments presented by Varmaghani and Kasmaei (2021), Iran is divided into eight climatic groups, and each of these groups has separate subgroups. In this map, Tehran is placed in climate group 5 and subgroup 2, indicating that it has relatively cold winters and semi-hot and dry summers.

12.2.6.1 Temperature

According to the latest official data provided by Mehrabad Meteorological Station of Tehran in 2010 and the analysis by Climate Consultant software, as can be seen in Fig. 12.1, the average annual temperature of Tehran is about 17 °C, which is lower the range of human comfort. That is, the weather is cold in most months in Tehran which proves the necessity of using active heating systems in this city. The minimum temperature recorded in Tehran is about − 5 °C in Dey (approx. January) and the maximum temperature is about + 40 °C in Tir (approx. July). It can also be pointed out that the average temperature of Tehran is observed to be in the comfort zone only in the two months of Ordibehesht and Mehr (approx. May and October).

12.2.6.2 Relative Humidity

Humidity reduces the temperature of dry air. This decreased air temperature is due to the evaporation of the added air humidity, which causes the expansion of the comfort zone. Air cooling may be done mechanically or naturally by increasing humidity using different plants or fountains (Kasmaei 2016).

Given that the city is far from the sea and they are separated by Alborz mountains, the relative humidity level in Tehran is not too much high. According to the diagram and Fig. 12.2, the relative humidity in Tehran is above 60% only in the five coldest months of the year, which decreases to below 20% from June to September. The highest rate of relative humidity in Tehran is recorded in December, January and February at almost 70%; while its lowest amount belongs to June at around 15%, July and August at around 19%. A careful examining of the graph indicates that the difference in relative humidity and temperature increases especially in the morning and at night and moves away from the comfort zone as the dry temperature decreases in the cold months of the year. This difference tends to decrease between 12:00 and 16:00, it is still not in the comfort zone. With the beginning of the spring season, on the other hand, we see that the relative humidity and temperature are in the comfort range only once during the day around 4 pm, and again they distance from each other with the cooling of the air and the increase of the relative humidity. In the most ideal possible situation, these two indicators are within the comfort range in May from 12 noon to 8 pm. In next months, this trend will eventually experience two confluences between 8:00 and 12:00 p.m., until it becomes a little more stable in the month of Mehr that both indices are in the comfort zone from 12:00 p.m. to 4:00 p.m. In general, it can be concluded that if the temperature of Tehran is in the comfort range of 20–27 °C, the relative humidity tends to be in the comfort range, but the amount of relative humidity also increases significantly and it becomes more difficult for the user to bear the conditions as the temperature decreases.

12.2.6.3 Wind

Air flow speed affects the human body in two ways. On the one hand, it determines the amount of heat exchange through convection, and on the other hand, it determines the amount of body cooling through sweating based on the air evaporation capacity (Kasmaei 2016). By examining the wind rose graph of Tehran city in Climate Consultant software, as can be viewed in Fig. 12.3, it can be concluded that the prevailing wind in

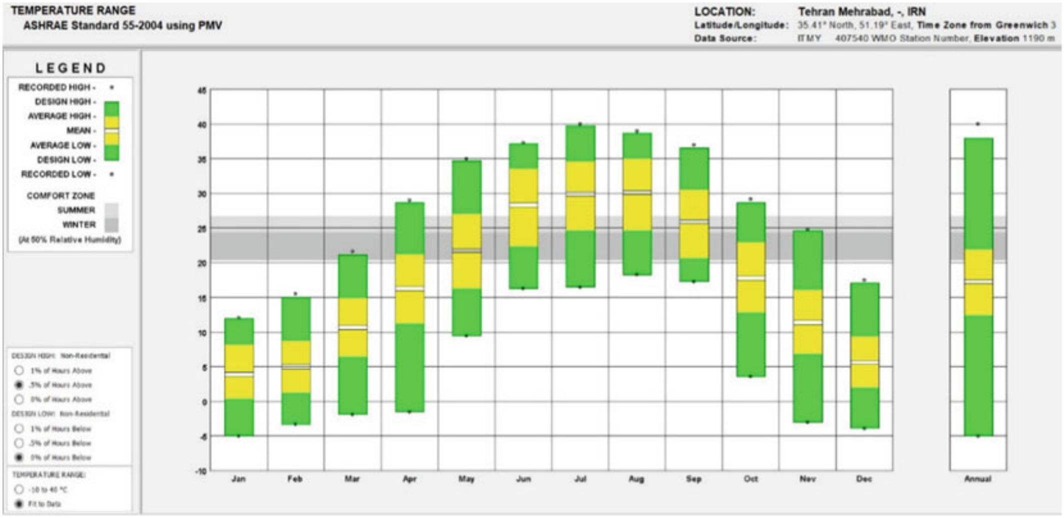


Fig. 12.1 Monthly temperature range of Tehran (Climate Consultant)

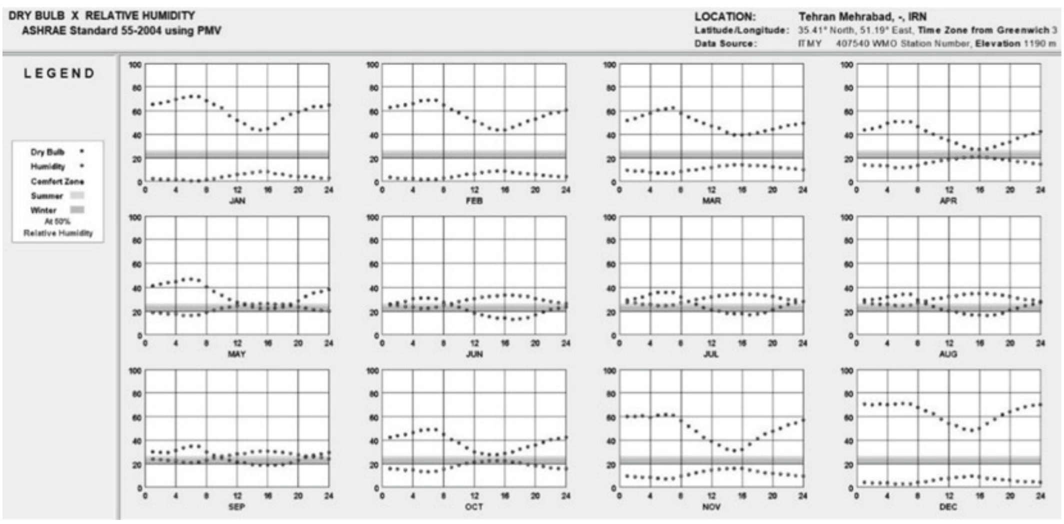


Fig. 12.2 Hourly relative humidity and temperature in Tehran (Climate Consultant)

Tehran city is the west wind with a speed of about 10 m per second. However, a more accurate approach should be taken in providing appropriate design measures to deal with unfavorable wind and to make more use of favorable wind.

According to the temperature chart, the lowest temperature recorded in Tehran in January is − 5 °C, with an average temperature of about 4 °C, which is much lower than the comfort level. Therefore, we found that most of the winds that blow in Tehran in January are cold and humid by checking the wind rose chart in January, but the dominant wind is the westerly disturbing winds with a speed of 8–14 m per second and a temperature between 0° and 21° that are blowing in 8–12% of the hours of the month. Of course, these winds have a relative humidity of 30–70%, which reduces their unpleasantness because they cause less itching and burning on the skin. In the following, the best design

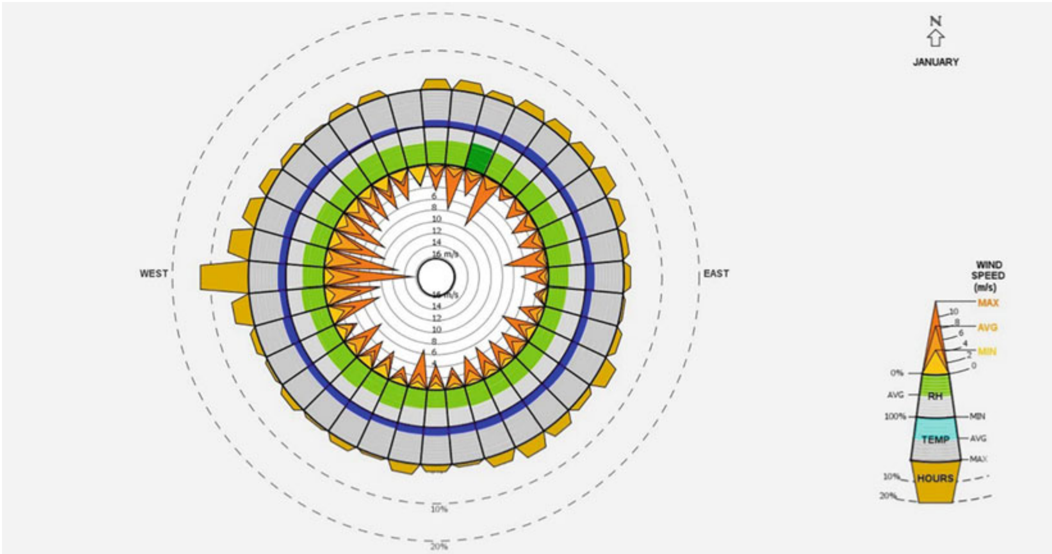


Fig. 12.3 Direction and characteristics of different winds in January in Tehran (Climate Consultant)

approach to deal with cold winter winds is to use a wind breaker on the west side of the building and to use minimum openings on this side.

In contrast, according to Fig. 12.4, the wind rose chart of July in Tehran as the hottest month of the year with the maximum recorded temperature of + 40 °C and the average monthly temperature of + 30 °C indicates that the July winds from different geographical directions are hot with a speed of 4–10 m per second. But the important point is the blowing of cool northeast winds in July. These winds have a temperature equivalent to 21–27 °C and blow at a speed of 4–10 m per second. Although these favorable winds blow in less than 10% of the hours of the month, it is reasonable to consider more openings in the northeast front to take advantage of these winds.

12.2.6.4 Comfort Zone

It is said to be an area where a person feels comfortable in terms of air temperature and humidity without feeling cold or hot or humid. Several climatic factors, such as sunlight, wind and air humidity are effective in determining the comfort zone. Since users in rehabilitation centers are always working and moving, environmental design that is according to comfort zone criteria has an impact not only on their physical performance, but also on their mental performance and mental peace.

12.2.6.5 Psychrometric Chart in Tehran

According to the psychrometric chart of Tehran city which is based on the latest official data provided by Tehran Mehrabad weather station in 2010, we can conclude:

The temperature in Tehran varies between − 5 °C in the cold seasons and + 40 °C in the hot seasons. In addition, the number of days with a relative humidity below 30% at a temperature above 25 °C is more in the hot months of the year, which strongly indicates the use of evaporative cooling sources. Meanwhile, it is recommended to use heating sources in the cold months of the year, due to the high number of days with temperatures from − 5 to + 15 °C and relative humidity above 50%.

As a dry city with a relatively low absolute humidity index throughout the year, according to Fig. 12.5, Tehran is in the comfort zone in 19.6% of the time of the year, i.e., 1720 h out of a total of 8760 h. In other words, a person can feel comfortable in a building with a normal cover without using special equipment only 19.6% of

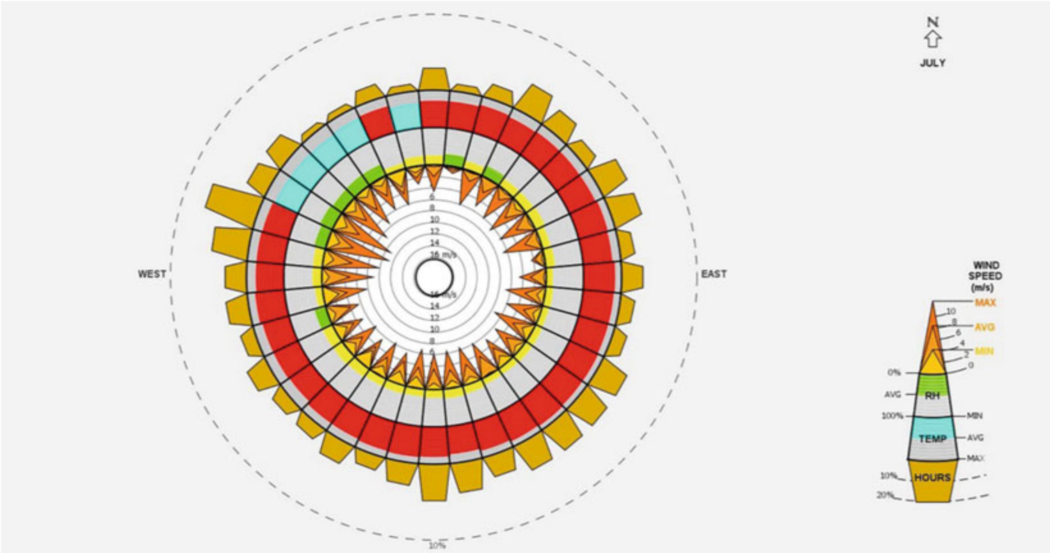


Fig. 12.4 Direction and characteristics of different winds in June in Tehran (Climate Consultant)

the whole year in Tehran. But it is possible to expand the comfort zone using measures such as awnings on the openings, materials with high thermal mass, evaporative ventilation, natural ventilation for the hot season and maintaining the internal air temperature by sealing the openings, passive solar energy, the protection of the building against disturbing winds and the use of internal heating systems.

12.2.6.6 Analysis of Tehran Psychrometric Chart in the Cold Months of the Year

According to the proposed solutions and the range on the left side of the diagram related to the cold months of the year based on Fig. 12.6, it is possible to create thermal comfort from December to March in Tehran by creating heating and humidification as necessary, as the most effective solution in 73.6% of the time (2668 h). In addition, using the internal heat created in the space with proper sealing and insulation 17% of the time (617 h) and using passive solar energy can contribute 7.13% of the time in expanding the comfort zone in Tehran in autumn and winter.

12.2.6.7 Analysis of Psychrometric Chart of Tehran in Hot Months of the Year

According to the proposed solutions and the right-side range on the diagram related to the hot months of the year in Fig. 12.7, the best solution is the use of two-stage direct evaporative coolers that expands the comfort zone by 9.36 and 36.8% in Tehran from April to October. In the next step, thermal comfort conditions can be provided in 25.7% (1318 h) of the time using solar shade for the windows exposed to sunlight. In these months, not only the use of materials with high thermal mass in the building can cause thermal comfort in 11.5% of the time (592 h), but also in the door can achieve the same effect in 16.2%. Finally, 10% effect of natural ventilation and 7.8% effect of unnatural and mechanical ventilation (using a fan) cannot be ignored in increasing the comfort range of people in the hot months of the year in Tehran.

12.2.6.8 Adopting Appropriate Design Strategies in Tehran

The seven efficient and appropriate design strategies to expand the comfort zone in Tehran are shown in Fig. 12.8 according to the

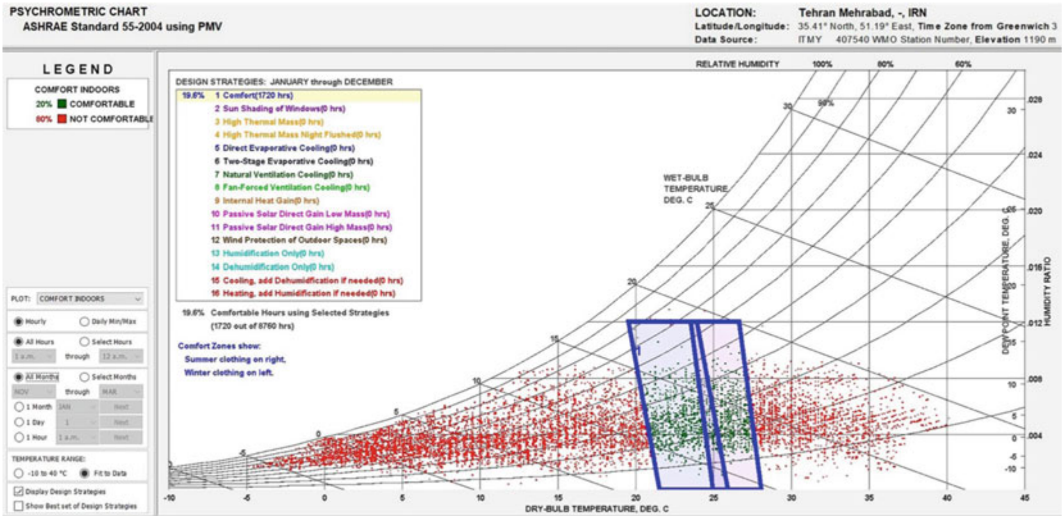


Fig. 12.5 Psychrometric chart in Tehran (Climate Consultant)

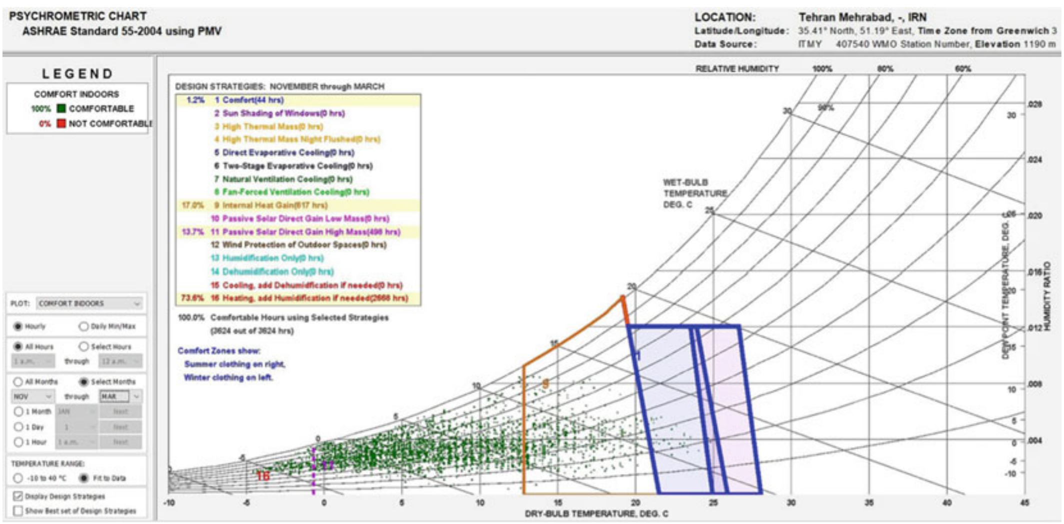


Fig. 12.6 Tehran psychrometric chart in the cold months of the year (Climate Consultant)

psychrometric diagram of Tehran city in the Climate Consultant software.

In the following, the best design solutions are suggested in order to realize the above strategies:

12.2.6.9 Active Heating and Passive Solar Energy

According to the psychrometric chart of city of Tehran and the noticeable decrease in dry temperature in the second half of the year, the comfort zone can be expanded in 33 and 21.3% of the time, respectively, using a suitable heating system by maintaining the internal heat produced by the activity of people and various devices.

The effect of sunlight on the comfort zone is determined by two factors: temperature and air humidity. In areas where the air temperature is less than 21 °C, sunlight may cause the expansion of the comfort zone. In such a way that if the body compensates its lost temperature with the

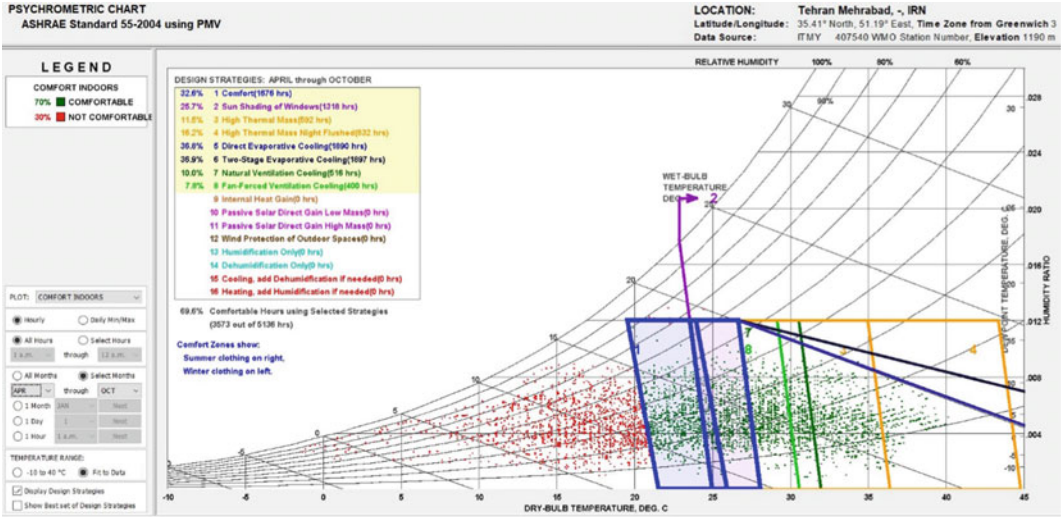


Fig. 12.7 Tehran psychrometric chart in the hot months of the year (Climate Consultant)

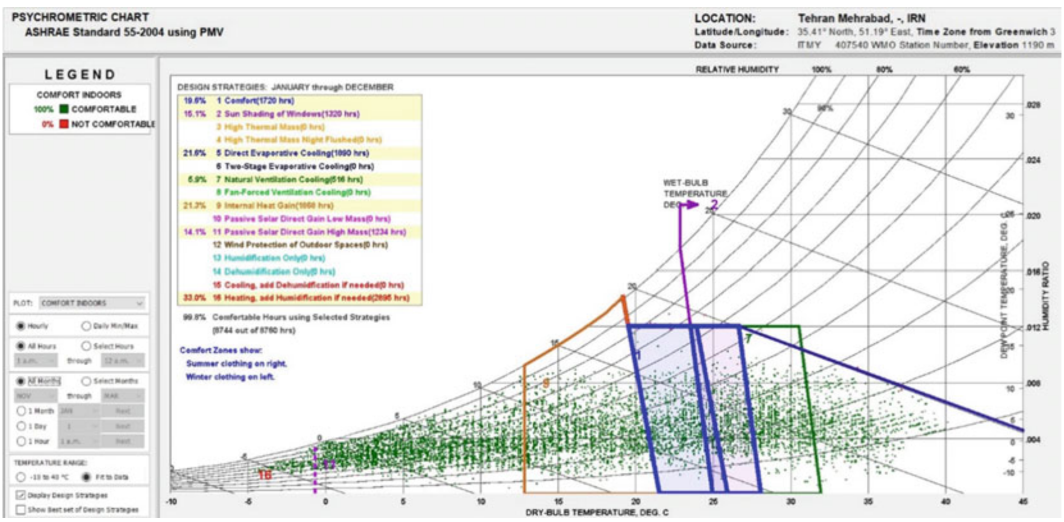


Fig. 12.8 Adopting appropriate design strategies in Tehran (Climate Consultant)

heat of the sun in low temperature, the conditions are provided for human comfort (Kasmaei 2016). As a result, this comfort zone will expand up to 14.1% using passive solar energy. As can be seen in Fig. 12.9, it is recommended to design an elongated form with east–west orientation and create more openings in the south face of the building in order to achieve the maximum amount of passive solar energy. It should be noted that these openings should be protected by horizontal movable shades, so that the glazed surfaces have proper shading during the summer and hot seasons of the year, and the proper sunlight should be used on the south side of the building to heat the interior space in the cold months of the year.

According to the Fig. 12.10, it is recommended to use low-emissivity double-glazed windows on the west, east and north sides in order to make the most of the southern light; but

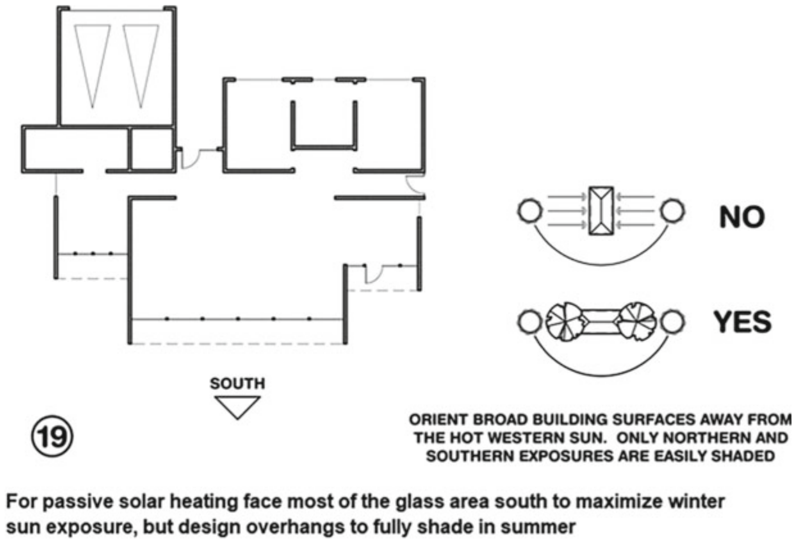


Fig. 12.9 Appropriate design suggestions (Climate Consultant)

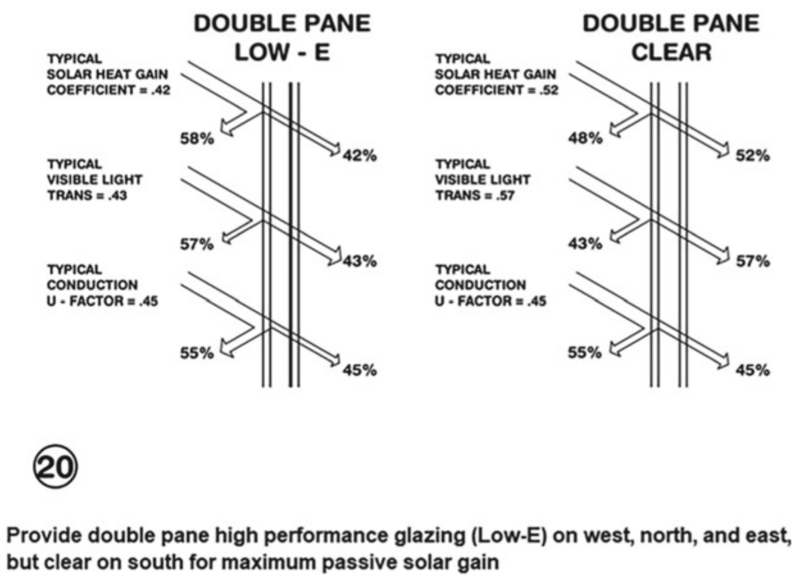


Fig. 12.10 Appropriate design suggestions (Climate Consultant)

transparent glass can be used on the south side (Varmaghani and Kasmaei 2021).

12.2.6.10 Ventilation

Water coolers can be used as a source of ventilation to expand the comfort zone in Tehran in 21.6% of the time in the hot seasons. But natural ventilation can be effective in increasing the comfort zone only 5.9% of the time in a year, if the openings are built along with suitable barriers in the natural wind path in order to direct the wind path and create positive and negative pressure to be embedded. You can perceive the role of natural ventilation in expanding comfort zone in Fig. 12.11.

12.2.6.11 Shading

In Tehran's climate, using skylights or external movable shadings are methods to create shading to prevent direct sunlight in hot seasons, which

Fig. 12.11 Appropriate design suggestions (Climate Consultant)

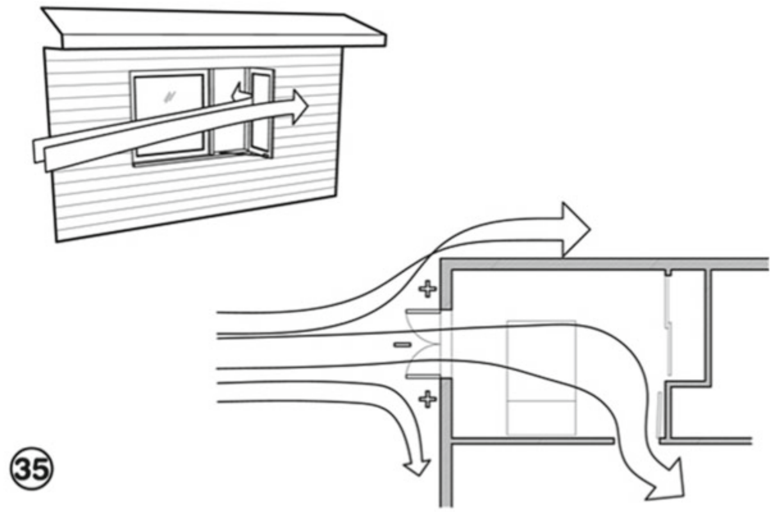
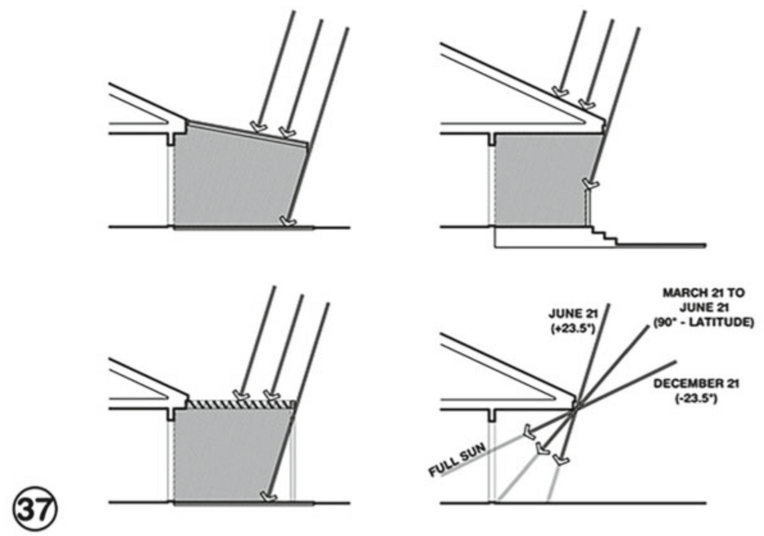


Fig. 12.12 Appropriate design suggestions (Climate Consultant)



expands the comfort zone by 15.1%. This particular method is simply described in Fig. 12.12.

Direct sunlight can also be prevented to some extent in the hot seasons of the year using shading vegetation against the skylights. However, it should be noted that this shading vegetation, including coniferous trees and deciduous trees, should not prevent the entry of favorable southern light in the cold seasons of the year. For this purpose, like Fig. 12.13, it is recommended to plant these trees further from the 45° radius from each corner of the building's southern wall.

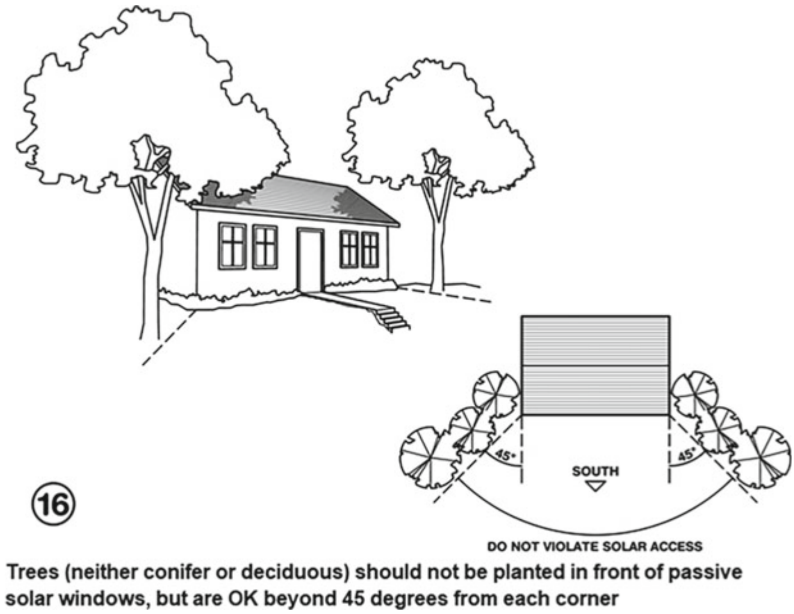


Fig. 12.13 Appropriate design suggestions (Climate Consultant)

12.2.6.12 4-Cold and Thermal Ground

Cold and thermal ground is a passive solution for cooling and heating in buildings. The benefits of direct contact of the building with the ground can be taken advantage of by placing the building completely or a part of it under the ground or raising the soil level and embankment on it. By going down in the depth of the Earth (more than 6 m), the temperature of the soil becomes closer to the annual temperature of the region, which in turn makes this constant temperature become cooler in summer and warmer in winter than average temperature outside.

12.3 Conclusion

When vitality, social interaction and social security are felt in the society at the micro and macro level, we are undoubtedly facing a more stable society. Another influential factor in social sustainability is flexibility and harmony with the surrounding natural and cultural environment. Due to the advancement of technology and the expansion of megacities, today, the way people interact with each other has undergone changes. Also, the increase in average life expectancy, population growth and changing needs have caused the need to change the planning and construction. As a result, in order to achieve sustainability in the field of architecture, we must examine social aspects among different aspects in design.

The design and construction of a rehabilitation center in Tehran with the approach of increasing social sustainability along with a climate perspective by adopting appropriate design strategies creates a favorable environment based on sustainable architectural patterns. According to the results of this research, an effective step can be taken with the design of this center to improve the physical and mental health of people with physical-motor disabilities.

A number of solutions and suggestions in designing buildings based on climatic approach can be provided to increase social sustainability. For example, related to accessibility designers can design an attractive path and create visual mobility, create flexible spaces to develop a sense of control and security and focus on the separation of space for visitors and companions. In addition, they should consider facilitating the access of people with physical-motor disabilities on the same floor, if possible, in case of separation of spaces in different floors, it is necessary to design sloping surfaces with a suitable percentage of slope and to install an elevator. In terms of designing buildings for people with physical disabilities, no interruption in service delivery and legibility and recognition of spaces are extremely important.

There is no doubt that placing openings along with appropriate buffers in the natural wind path in order to direct the wind path and create positive and negative pressure is an effective way to develop natural ventilation. Moreover, in terms of building form and shading, designing an elongated form with east–west orientation and creating more openings on the south front in order to achieve the maximum amount of passive solar energy, covering the openings with horizontal movable shadings and using appropriate scale and fit of the interior spaces and their compatibility with the physical conditions of the users are strongly recommended.

Cooling and heating by placing the building completely or taking a part of it under the ground or raising the level of the soil and embankment can be achieved. About utilizing color and light to design buildings which people with physical disabilities are main users, avoid using colors of the same spectrum next to each other, using contrasting colors to create visual appeal, controlling distribution of light in space steadily and avoiding to make the reflective surfaces of sunlight must be considered.

Additionally, to use materials and furniture some subjects, such as using non-slip and resistant materials on the floor, focusing on the scale and standards in the design of all spaces and furniture, using color and light as a guide to the target spaces (the flooring used should not be shiny and light-reflective) and using interior design elements such as appropriate furniture require special consideration.

Furthermore, designers should use suitable flooring to absorb sounds, design external shell for building, install silencer for the ceiling to prevent sound reflection and use sound insulation for walls. In terms of designing green space, not only should architects design a rest area next to the green space and designing a shallow pond in the open air to make the space pleasant, but also, they can increase social interaction and make outdoor spaces fun by shading trees.

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13

Using Co-benefits of Sustainable Building to Drive Net Zero Emissions in Southeast Asia: Findings of Two Evidence-Informed Stakeholder Dialogues

Nita Lauren, Paul Kellner, Alyse Lennox, Peter Graham, and Peter Bragge

Abstract

Co-benefits of sustainable building are rarely used to promote policy reform. Two stakeholder dialogues were convened by Monash University, Australia in collaboration with the Global Building Performance Network (GBPN) to deliberate upon strategies to support the progression towards net zero emissions in the building sector in Southeast Asia. The dialogues were informed by a rapid literature review which reported sufficient evidence of health benefits of sustainable building. The first dialogue (July 2021) between Monash University academics identified that narratives are a powerful tool for communicating value propositions of sustainable building—for example through demonstration projects, first-person accounts, creative arts and media strategies. The importance of tailoring strategies to the differing roles of multiple actors across government, civil society, and the building sector, and across countries and settings was emphasised. Consideration of 'top-down' and 'bottom-up' influences on sustainable building was also discussed. Formation of a community of practice and careful consideration of a long-term strategy were also highlighted. The second dialogue (December 2021), with participants from New Zealand and Indonesia, moved beyond the broad idea of health benefits of sustainable building to more specific priority areas for potential collaboration. These included the relationship between thermal comfort and health; air pollution and other risks associated with overcrowding; placing importance on indigenous knowledge; setting emissions reporting requirements for government-backed projects; and exploring the nexus between public facilities & housing, transport, urban planning, and health. The dialogues provide a platform for more formal projects or initiatives in this critical area.

Keywords

Sustainable building · Co-benefits · Multiple benefits · Sustainable development goals · Low carbon building

13.1 Introduction

The Net Zero by 2050 report published by the International Energy Agency in May 2021 highlights the need for rapid transformation of the whole energy system to achieve the Paris Agreement (1). To keep global warming to 1.5 °C, the

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building sector—which contributes to almost 40% of global energy use and global energy-related carbon dioxide emissions—must halve its emissions by 2030 and reach net zero emissions by 2050. Within the Asia–Pacific region, Southeast Asian economies are collectively the fourth largest emitters of greenhouse gases (GHG) from buildings. Furthermore, large economies in the region, such as Indonesia, are experiencing the fastest growth in energy demand for thermal comfort in the world. This presents a great opportunity for influencing the building developments in Southeast Asia.

The Global Buildings Performance Network (*GBPN*) is a not-for-profit organisation that works with governments and industry across Southeast Asia and India to decarbonise the buildings sector and advance sustainable development through policy reform. GBPN achieves this through forming local coalitions and equipping them with best practice, technical support, and education to deliver maximum impact. In 2021, GBPN collaborated with Monash University to reposition the role of sustainable buildings as drivers of social and economic benefits, with the aim of strategising and prioritising actions, aligning current funding opportunities, and identifying new collaborative opportunities that support the Asia–Pacific's progression towards net zero emissions in the building sector.

A rapid evidence and practice review was conducted to explore existing knowledge on the co-benefits of sustainable building (that is, benefits beyond reducing carbon emissions). The review identified 37 review-level studies that collectively assembled evidence that sustainable building can positively impact general and mental health and health equity, principally through improved air quality, thermal comfort, and light. A parallel videography project articulated lived experience stories reinforcing this published evidence. Interviews with six practitioners in the region revealed that demand-side factors, specifically health and other benefits to building occupants, do not appear to be prominent drivers of sustainable building in Southeast Asia, despite practitioners acknowledging that "customer appeal should drive the market".

The conclusion of the review was that enhancing knowledge and awareness of the non-climate change benefits of sustainable building could create a 'virtuous cycle where consumer demand for sustainable building is accelerated, government and private sector respond with policy and products to meet the demand, and with consideration and quantification of sustainable building co-benefits, stimulation of further interest and investment in sustainable building. Detailed review findings, as well as the videography, are published elsewhere (https://www.gbpn.org/healthy-buildings-healthy-lives/).

The review findings highlighted opportunities to build awareness of non-climate-related benefits of sustainable building in Southeast Asia and foster better connection between on-the-ground (micro and meso, community-level) benefits of sustainable buildings and the building policy (macro level). However, to realise these opportunities, greater connection between sectors with a shared interest in optimising building design, construction and renovation—e.g. health, business/real-estate and consumer groups—is required. Given the rapid growth and urbanisation of the Asia–Pacific, focussing on alleviating the climate impacts on communities in this region is key. Also, given the potential for leveraging the health and well-being benefits of sustainable buildings, there is great opportunity to influence the building sector in the Asia–Pacific so that it achieves net zero emissions in the building sector, while also supporting communities who are vulnerable to climate impacts.

To support development of a net zero strategy in the Asia–Pacific building sector, GBPN hosted stakeholder dialogues with sustainable building professionals and Asia–Pacific building sector representatives to deliberate on the potential for leveraging the health benefits of sustainable buildings to drive developments that address climate change and shared social challenges in Southeast Asia. The aim of the dialogues was to build a coalition of like-minded experts to develop a strategy for how the building sector in the Asia–Pacific region could achieve net zero by 2050.

13.2 Method

The stakeholder dialogues were conducted using the 'forum method' pioneered in Canada and successfully used across a range of projects and settings by the research team (Bragge) in Australia for over a decade. The method is characterised by: preparation of an evidence brief that is pre-circulated to dialogue participants to ensure that the dialogue is geared towards evidence-based action; carefully selecting dialogue participants based upon their tacit knowledge of the topic and/or the associated policy and practice environment; facilitation of the discussion against explicitly specified aims/discussion points; enabling of frank, off-the-record deliberations and protection of identity of participants using the Chatham House Rule; and emphasising that the deliberations are not designed to reach a consensus, but to surface a range of perspectives and ideas that may be progressed in different ways. Research has shown that these features result in both high participant satisfaction and strong intentions of participants to act on what they have learnt from the evidence brief and discussion (2).

Two stakeholder dialogue sessions were conducted with a total of 27 participants. The first dialogue was conducted on the 26th of July 2021 and was attended by 15 sustainable building stakeholders within Monash University. The briefing document for this dialogue included an infographic summary of the evidence and practice review and focussed on the following deliberation questions: what strategies to promote the health benefits of sustainable buildings are best suited to Southeast Asia? What known opportunities and/or networks relevant to Southeast Asia (including but not limited to COP26) can be reached to help advance identified strategies? Which groups and individuals across Monash University can participate in building a community of practice to create impact based on this work?

The second dialogue was conducted on the 8th of December 2021 and was attended by 12 Asia–Pacific stakeholders including representatives from New Zealand and Indonesia. The briefing document for the second dialogue included the same infographic summary of the review and an executive summary of the first dialogue. This was supplemented by two opening presentations—one outlining GBPN's mission and activities (presented by Peter Graham) and another outlining links between sustainable housing and health in research and policy (presented by an invited expert in this field who also participated in the dialogue). The deliberation questions for the second dialogue were: Based on project work to date, key trends and enablers and the need to think at a systems level, what are immediate (2022) and longer-term (2022–2030) shared priorities for public health & building sector collaboration? What is the starting programme of activities for public health and building sector collaboration and who are the key players (organisations and individuals)? What are the next steps?

Both dialogues were held under the Chatham House Rule, in which "participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed" (3). To further promote frank discussion and exchange, the dialogues were not audio-recorded and participants were allowed to identify specific comments as 'off the record'. Notes were taken by the research team of key discussion points and used to render summaries of each dialogue which were sent to all participants.

13.3 Results

The stakeholder dialogues resulted in rich discussions where the following key themes were identified.

13.3.1 Summary: First Stakeholder Dialogue

13.3.1.1 The Role of Narratives

Narratives can be powerful in creating a value proposition for sustainable buildings, and different narratives can appeal to different audiences. Potentially powerful narratives for promoting sustainable building are health benefits, decarbonisation, and financial benefits. However, these are not mutually exclusive. Narratives could draw on demonstration projects (or 'living labs') and are ideally promoted through creative arts and media strategies that help to bring sustainable building transitions into the future.

13.3.1.2 Understanding the Context and Systems

Sustainable building is context-specific and system-dependent. While incentives may be powerful drivers in some areas, they do not work for others. Therefore, strategies to promote sustainable building need to be tailored to and account for the differing roles of multiple actors, such as government (policy, regulation, incentives), civil society (advocacy, awareness, labour), and the building sector (suppliers, developers, architects, building owners) across countries and settings. The *Race to Zero Built Environment System Map* may be a useful resource with systems mapping and stakeholder discussion.

13.3.1.3 A Multi-pronged and Multi-scale Approach Is Required

Given the complexity of sustainable building systems, top-down (i.e. incentives, standards, regulations) and bottom-up (i.e. local champions, partners on the ground including community and NGOs, demonstration projects) influences on sustainable building need to be carefully considered.

13.3.1.4 Opportunities in the Asia–Pacific Region

Given the potential growth in emissions and the increasing vulnerability of people to climate change impacts in the region, several countries are beginning to focus on economic and buildings sector reforms, e.g. Indonesia recently committed to achieving net zero emissions by 2060 and is developing a zero-emissions roadmap for its buildings sector. Vietnam and Cambodia have also recently developed net zero roadmaps for their buildings sectors. A number of countries also include buildings sector actions in their climate change adaptation strategies. The increasing political will for encouraging sustainable building provides an opportunity for developing sustainable building demonstration projects or other initiatives in the Asia–Pacific region. Monash University's newly established Indonesia campus, a stated net zero ambition, and strong research capacity across multiple institutes and faculties, could allow it to support the Asia–Pacific's ability to achieve net zero in the building sector. Furthermore, a number of existing individual and organisational connections have already been established through Monash, and the university has a strong reputation in Southeast Asia.

13.3.1.5 Knowledge Gaps

A community of practice for sustainable building could connect and strengthen capacity, identify and address evidence gaps, and collaborate on demonstration or other projects.

13.3.2 Summary: Second Stakeholder Dialogue

The stakeholder group was highly engaged in responding to the questions; however, they did not coalesce around near-term priorities. The following themes were identified from the dialogue.

13.3.2.1 Priorities for Developing the Stakeholder Group's Shared Agenda

Stakeholders identified a need for determining a key health risk on which the stakeholder group could focus. Opportunities that were identified included health risks associated with thermal comfort, injuries, or overcrowding (such as air pollution, health risks of climate extremes, and policies required to address these and other climate-related health risks), as well as exploring how low-income communities could be involved in housing and urban regeneration, and connecting sustainable design principles (such as those from the *Global Alliance for Disaster Risk*

Reduction and Resilience in the Education Sector) to existing *World Health Organisation healthy housing guidelines*. Stakeholders also identified the importance of indigenous knowledge in developing solutions, e.g. two colleagues shared the example of traditional building practices in Malaysia that resulted in effective ventilation for the local climate, as well as being in close proximity to community and food production.

13.3.2.2 Ideas and Opportunities

Stakeholders identified several ideas and opportunities that would be beneficial for progressing net zero ambitions in the Southeast Asian building sector.

Set Emissions Reporting Requirements for Government-backed Projects: Setting emissions reporting requirements for government-backed projects could be an approach that works in multiple jurisdictions. For instance, basic efficiency requirements could be applied to government-backed public housing developments. Monash University and the Global Building Performance Network is currently supporting such a process in India. Multiple colleagues felt that a focus on public housing, supported by a narrative related to the 'right to adequate housing' could be an area of shared interest.

Developing a Fundraising Strategy Focussed on Public Health-Related Philanthropies: Currently, the link between sustainable building and health is not evident within debates around climate change. There is an opportunity to create an agenda around what sustainable building means for health. Participants observed that there are many philanthropic organisations that are looking for projects related to broad issues of health and well-being.

Explore the Nexus between Public Facilities and Housing, Transport, Urban Planning, and Health: Transport contributes substantial CO_2 emissions and so there is an opportunity to ensure that urban planning and transport are also considered as part of this discussion. There was the acknowledgement among some participants that the issues discussed during the dialogue often sit across the remits of multiple departments or ministries, including health, transport, and building (encompassing residential and commercial). A key metric mentioned in discussion was the indoor/outdoor temperature differential.

Consider Processes that Bring All the Relevant Stakeholders to the Table: The Urban Green Council in New York was highlighted as an exemplar, since it involved not only developers and government, but also unions, universities, and other stakeholders. The alignment of state and city government facilitated the establishment and functioning of the council.

Develop a Bi-Lateral Collaboration between Australia and New Zealand: Given the relative comparability of Australia and New Zealand, there is an opportunity to develop a bi-lateral collaboration. Specifically, developing a harmonised research agenda that allows for comparisons where possible.

Consider Other Stakeholders Who Should be Involved: It was raised that stakeholders relevant to economics should be involved to ensure that value propositions are rooted in plausible cost–benefit analyses.

The facilitator (Bragge) shared five key ingredients for systems transformation that may be relevant to this work. They were: public awareness (there is a need to find a way to get it on the public agenda); finances (there is a need to make sure that there is clearly sustainable resourcing for the work); a 'killer' statistic (finding a single fact that can capture a range of audiences' attention, communicate the importance of the issue, and point towards a trajectory of future work); political will (this involves meeting government ministries/departments where they are and developing universal consensus where possible); and monitoring and evaluation (ensure that the data systems are robust and ongoing is key to knowing progress is being made and sustaining the effort).

13.3.2.3 Insights for Developing Shared Work Specific to Indonesia

A meaningful portion of the dialogue focussed on how to collaborate across several issues.

Including the Right Ministries and Stakeholders in National-level Engagements: Multiple participants indicated that BAPPENAS (the Indonesian Ministry of Development Planning) is a key ministry to include because they are often able to have a substantial impact on how planning and budgeting decisions are made. Involving the media may also be advisable to ensure public awareness about the linkage between sustainable building and health. The project should involve the communities impacted by the proposed project or strategy and could build on GBPN's existing work in this area.

Rapid Policy Analysis to Target Key Stakeholders: Undertaking a desktop review of ministries' key indicators, targets, and goals would help align the group's value propositions with ministries' priorities. Such a desktop review could include relevant legislation, ministerial plans and decrees, grey literature, and possibly research produced in Bahasa Indonesia. A potential starting point might be working backwards from the current focus of the Ministry of Health and then mapping where this stakeholder group might most effectively contribute.

Demonstration Projects: Given the low rate of compliance with permitting and certification of buildings, (4) focussing on demonstration projects may be wise. One participant suggested that hospitals are an area of focus for such a project due to rapid expansion in the number of hospitals across Indonesia. It should be noted these hospitals may be both private and public facilities. The *Green and Healthy Hospitals Network* could be worth engaging in this context. They are also connected to the Australian-based *Climate and Health Alliance*. Another participant suggested that schools could be another opportunity for demonstration projects. Public–private partnerships, community-private partnerships and/or 'green bonds' (well-being bonds in New Zealand may be an equivalent) may be ideal for the proposed demonstration projects.

Consider Poverty Alleviation Goals: Serious consideration needs to be given to the poverty alleviation goals that Indonesia and other countries may have front of mind. GBPN has focussed on urban housing and landed housing. From a climate perspective, we need to focus on vertical housing (e.g. apartment buildings) as there are currently few standards for this form of housing.

13.4 Discussion

These two stakeholder dialogues, informed by a rapid systematic review of co-benefits of sustainable building in Southeast Asia, identified a range of short and long-term initiatives to progress evidence-based action in this critical area. The first dialogue brought together researchers representing multiple disciplines at Monash University and discussed ways to promote powerful narratives through top-down and bottom-up sustainable building initiatives. The second dialogue, with participants beyond the university in the Australasian and Southeast Asia region, focussed on more specific areas of potential research and advocacy focus including thermal comfort, a focus on low-income housing and connection of sustainable design principles to existing health housing guidelines.

Longer-term ideas included mapping a 10-year vision of sustainable buildings in the Asia–Pacific region, by undertaking stakeholder analysis of partnerships that intersect health and sustainable building sectors. Key government, academic, and other entities could be identified, and then engaged, in this way. Stakeholders identified a need for exploring the demand-side factors in Indonesia, as well as leveraging nationally determined contributions (NDCs) in global meetings to encourage sustainable developments. Other opportunities to foster interest and support in sustainable buildings included undertaking baseline studies to build investor confidence, developing position papers that focus on strategic opportunities and recommended actions for achieving adaptation and resilience in the Asia–Pacific building sector, running a series of webinars with relevant stakeholders to bring in additional collaborators and further share ideas and work, and finally, undertaking a co-design process to develop an Indonesia-based community of practice.

Collectively, the review and dialogues make an important contribution in this area. The review systematically identified, evaluated and synthesised a large volume of review-level studies of co-benefits of sustainable building, and highlighted important gaps in research evidence. The dialogues used this knowledge to strategise on relevant opportunities in the region. This work builds upon an established method of fostering evidence-informed deliberations on action which ensures that such action builds upon existing knowledge and addresses knowledge gaps. Previous studies have not conducted multiple dialogues based on the same evidence review. Doing so enabled an opportunity to connect relevant disciplines within Monash University, many of which had not engaged on this topic. This initial connection was useful in refining discussion points for a wider audience in the region. The collaboration of Asia–Pacific representatives deliberating on the evidence base meant that local knowledge about networks and regional strategies could be included into the discussion prior to it being published in the broader literature. The benefit of these dialogues is the mobilisation of a small community that has the potential to lead to great impacts for the Asia–Pacific region.

The need to progress these ideas cannot be overstated. Since COP26 and the IPCC's sixth assessment report, there has been widespread recognition that the building sector faces a complex, wicked problem that requires multi-disciplinary and multi-stakeholder collaboration. In drawing together the evidence base on the relationship between sustainable buildings and health, and creating a coalition of like-minded experts, GBPN are building bridges between sectors that have a common interest in addressing climate impacts of and the vulnerability and resilience of cities. There is growing global debate that mitigation should not be the only focus of the building sector, and that there is a great need to implement strategies that enable adaptation and resilience to climate impacts. The conclusions of these dialogues support the need for focussing on enablers that accelerate climate action in the building sector, as well as bringing stakeholders together from across disciplines and sectors, to address shared challenges of the built environment.

The impact and opportunity for decarbonising buildings in Asia–Pacific are increasingly being recognised as a core to achieving national climate action commitments and policy goals, e.g. the ASEAN APAEC Energy Efficiency & Conservation Committee Phase 2 (2021–2025) now includes a specific action for developing a sustainable building roadmap and capacity development "on sustainable EE in building towards net zero energy consumption buildings, building energy codes, and building envelopes systems" (5). Indonesia, who takes over the presidency of ASEAN in 2023 has also committed to achieving net zero emissions by 2060 in their recently updated Nationally Determined Contribution. While these commitments are an important starting point, ambition and speed of implementation need to increase. Providing better access to the health and co-benefits evidence base may help.

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14 The Thermal Indoor Environment of Danish Detached Houses—Past, Present and Future

Mette Lyhne

Abstract

Danish detached houses have shown a new tendency in terms of the thermal indoor environment. On 13.4% of houses built after 2000, problems regarding overheating have been reported by the owners. In addition to this, we stand before climate changes resulting in rising temperatures, which will increase the problem of overheating in the indoor environment even further. Since 1979, the energy requirements of the Danish Building Regulations (BR) have been tightened regularly, causing increased focus on re-insulation and sealed constructions. But as we are now experiencing the consequences of the tightened requirements regarding problems of overheating in new and energy-retrofitted houses, it is urgent to assess the Danish Building Regulations' influence on the thermal environments of Danish houses. This paper investigates the consequences of rising outdoor temperatures on the indoor temperatures of Danish detached houses providing state-of-the-art on the subject. Through studies of the Danish Building Regulations, the paper examines how we ended up with overheated houses in the first place. Furthermore, it discusses the influence of the Danish 'Design Reference Year' (DRY 2013) on indoor temperatures in the future. Finally, the paper points towards different solutions, which could decrease the risk of indoor overheating and improve the thermal indoor environment.

Keywords

Thermal indoor environment · Indoor temperatures · Detached houses · Overheating · Danish building regulations · Design reference year · DRY 2013

14.1 Introduction

Research has recently revealed a shift in challenges regarding thermal comfort in Danish detached houses. A survey among Danish house owners carried out by the foundation Realdania shows that houses built before 2000 typically deal with problems of draught and cold, whereas houses built after 2000 are more inclined to deal with problems of overheating (Danskerne i det byggede miljø 2022, p. 73).

Likewise, overheating is a problem in energy-retrofitted houses. According to the Danish Energy Agency, overheating is a consequence in 22% of energy-retrofitted detached houses (Pedersen et al. 2015, p. 26). It is often seen in cases of re-insulation due to highly sealed, insulated facades with a lack of ventilation (Marsh et al. 2013). This gives rise to the question: how

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do we design and retrofit our houses in a way that does not only focus on energy consumption but also considers the indoor environment?

If the way we build today does not fit the current climate, we are in for a serious challenge with an expected temperature rise of approximately 3.4 °C within this century (*Temperature and climate change* no date; *Data i Klimaatlas* no date). Today we see a tendency to the demolition of older houses in favour of new builds simply because it can be more affordable to start from scratch rather than renovate an existing house. In 2016, around 1000 houses were replaced by new standard houses (Nørgaard no date). Houses from the 1960s and 1970s are at stake because they typically do not meet the current energy requirements and may be too cold in winter. However, in the future, the tendency could shift to the demolition of houses that are too hot in summer. Increased demolition and construction activity could fuel climate change and accelerate rising temperatures—a vicious circle.

This paper assesses the relationship between Danish Building Regulations and thermal indoor environmental challenges in Danish detached houses. Through studies of the Danish Building Regulations and the so-called Design Reference Year (DRY 2013), it is investigated how we ended up with houses that overheat.

Furthermore, the paper discusses the consequences of rising outdoor temperatures on indoor temperatures by providing a state-of-the-art based on a literature review of texts and papers that deal with climate change and its influence on indoor environmental conditions. The literature review is combined with the preliminary results from an ongoing research project concerning the thermal indoor environment of Danish detached houses taking place at Aarhus School of Architecture.

14.1.1 Where Did We Go Wrong? Danish Building Regulations of the Past 60 Years

To understand how we in Denmark went from houses that are too cold to houses that are too hot, we could for one, look at the Danish Building Regulations of the past 60 years.

The first national Building Regulations were launched in 1961 and held modest requirements for a minimum amount of 50 mm of thermal insulation in the outer walls and roof. Furthermore, windows should have two layers of glass with a gap of at least 12 mm (Ventzel Riis et al. 2021, p. 35). Until the 1960s, the building legislation did not focus on energy use or the indoor environment but solely dealt with matters of craftsmanship, building construction and materials (Ventzel Riis et al. 2021, p. 35).

The majority of the Danish building stock does not live up to current standards of energy use, simply because it was built before energy requirements were implemented in the Danish Building Regulations (Ventzel Riis et al. 2021, p. 35). In 1979 (BR77) the requirements for thermal insulation were tightened as a result of the oil crisis, which caused increasing energy prices and, with it, an economic motivation for thermal insulation. At the same time, a limit was introduced to the percentage of glass in the facade to a max. of 15% of the building's floor area (Ventzel Riis et al. 2021, p. 36).

This shift most likely had an impact on the thermal environment in Danish houses built after that time. This can be observed in a survey made by Realdania, in which 7132 house owners were asked about their indoor environment. 24.9% of owners of houses built between 1930 and 1959 reported problems regarding cold and draught, whereas only 14.6% of owners of houses built between 1980 and 1999 reported these problems (Fig. 14.1) (Danskerne i det byggede miljø 2022, p. 73).

The 10 percentage point drop between 1959 and 1980 shows that problems with cold and draught evidently have decreased significantly during these 20 years, which could be explained by the emerging focus on thermal insulation and smaller windows in the 1970s and 1980s.

It should be noted that the results of the survey depict the situation in the houses today and not at the time when the houses were built. Furthermore, it should be added that the Realdania survey neither reveals information on the

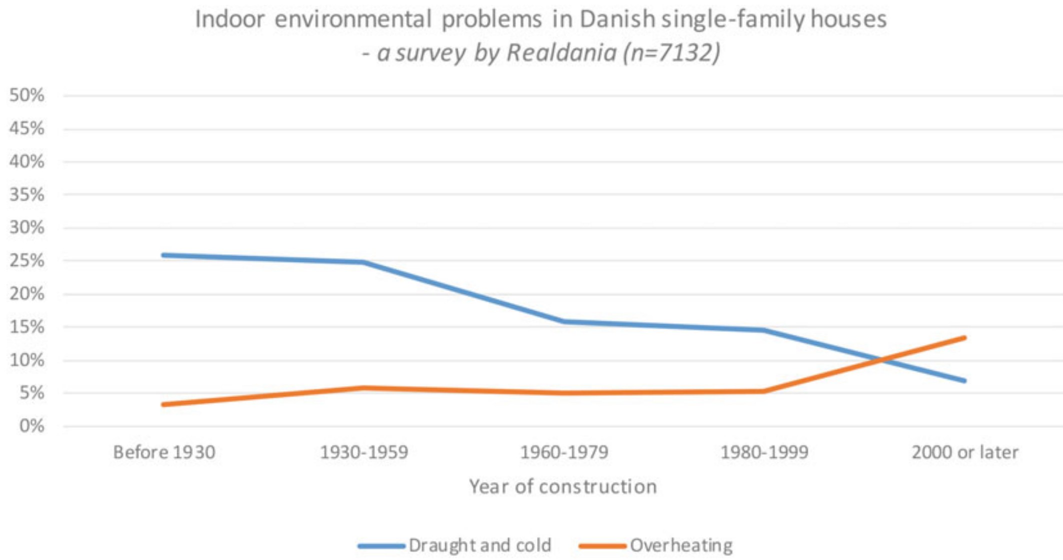

Fig. 14.1 Percentage of Danish houses with problems of either draught and cold or overheating based on the Realdania survey. (Danskerne i det byggede miljø 2022, p. 73)

condition of the houses nor the age of the owners, both of which have an enormous impact on responses in a survey about the indoor environments, which will be discussed further in this paper.

14.1.2 From One Indoor Environmental Challenge to Another

A lack of insulation requirements in the Danish Building Regulations could be one of the explanations why houses in Denmark built up until the 1970s are remarkably colder than houses built in the years hereafter. Even though many of the houses have been retrofitted since then, the current situation still reflects this picture (Danskerne i det byggede miljø 2022). The cold houses can partly be explained by a lack of thermal insulation, but also parameters such as airtightness and the quality of the construction are important factors when it comes to the thermal indoor environment. Houses built 100 years ago are likely to be less airtight and leaking facades and windows create a natural airflow through the house, also known as infiltration. Moreover, constructions of poor quality enable the transfer of heated indoor air to the outside (Lovell 2010).

The oil crisis in the 1970s demanded controlled building envelopes to optimize the energy for heating the building stock, which simultaneously resulted in a warmer indoor environment in general. Since 1979 the energy requirements of the Danish Building Regulations have been tightened regularly causing increased demands for thermal insulation and sealed constructions. This means that even houses built after the energy crisis in the 1970s can be far from today's standards in terms of energy use.

In 1995, the requirements for window sizes were changed from the previous maximum of 15% of the floor area to 22% (Ventzel Riis et al. 2021, p. 36). The enlarged allowed window sizes combined with the increasing focus on sealed and insulated facades have likely caused an increase in indoor temperatures of Danish detached houses.

When looking at the aforementioned Realdania survey we see that 14.6% of houses built between 1980 and 1999 experience problems in terms of cold and draught, whereas only 6.9% of houses built after 2000 show these problems. On the other hand, for houses built after 2000, another problem seems to be at stake as the survey shows that 13.4% of these houses have problems with temperatures that are too high. As this is only a problem in 5.2% of the houses built between 1980 and 1999, there is an indication that the requirements introduced in the Building Regulations during the 1990s have had an impact on the indoor environment. From a comparison of the development in the Building Regulations and the indoor environmental challenges of Danish detached houses, it seems that the thermal conditions have shifted from problems of cold and draught to problems related to overheating, which partially relates to the changed requirements of the Building Regulations.

14.1.3 Indoor Overheating and Health Effects

The Danish Meteorological Institute predicts the future weather in Denmark to become "warmer, wetter and wilder" (*Vejret i Danmark bliver varmere, vådere og vildere* no date). For example, they foresee an increase in summer nights with temperatures above 20 °C as well as more and longer heatwaves defined as three coherent days with temperatures above 28 °C (*Vejret i Danmark bliver varmere, vådere og vildere* no date).

More frequent heatwaves can create health risks in the future as a clear connection between higher outdoor temperatures and mortality has been detected (Vardoulakis et al. 2015). In 2003 the most severe heatwave since 1500 occurred and was estimated to cause 70.000 excess deaths in Europe. If emissions continue unaffected, heat waves as intense as the European one in 2003 are expected every other year by the 2040s (Vardoulakis et al. 2015).

Though a connection between high outdoor temperatures and excess deaths has been observed, this link cannot be directly transferred to indoor temperatures. Indoor temperatures depend on the construction type, the indoor climate devices and the residents of each dwelling and can vary significantly from the outdoor temperature. Thus, conclusions on the health effects brought on by indoor temperatures are harder to determine (Vardoulakis et al. 2015). However, additional research indicates that indoor overheating can cause dehydration, heart problems and increased mortality—particularly among elderly people and other vulnerable populations (Ortiz et al. 2020).

As for Danish detached houses, the majority of which are only ventilated naturally (Videncenter for Energibesparelser i Bygninger 2017), frequent heatwaves with temperatures above 28 °C will most likely result in difficulties meeting the requirements of the Danish Building Regulations in terms of indoor overheating. They set a yearly maximum of 25 hours above 28°C in housing (*BR18* no date), and since the number of heatwaves is expected to rise from 2 to 9 days per year in Denmark (*Vejret i Danmark bliver varmere, vådere og vildere* no date), keeping down the indoor temperatures by ventilating with outdoor air only could become a challenge (Petersen et al. 2014).

When looking at the dwelling not only as a shelter from cold but also from warm weather, higher indoor temperatures as a result of elevated outdoor temperatures can cause problems for Danish residents. Escaping a heatwave can become harder in the future if indoor temperatures are affected by outdoor temperatures, which will be the case for many Danish detached houses not equipped with air-conditioning or mechanical ventilation with integrated cooling.

Although it cannot be stated directly how indoor overheating affects the residents' health, rising outdoor temperatures and future heatwaves will undoubtedly affect indoor temperatures with a high risk of overheating houses, which could potentially lead to some of the health risks mentioned above. Improvements in the thermal indoor environment of detached houses could thus lead to a decrease in incidents of overheating, which might contribute directly or indirectly to sustainable development goal 3.4 "By 2030, reduce by one-third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being" (Martin no date).

14.1.4 Overheating of Danish Houses

Being a Nordic country, one might think that Denmark was outside the risk zone of overheated houses, but paradoxically, even Danish dwellings experience overheating. The Realdania survey showed that this problem appears in 13.4% of houses built after 2000 (Danskerne i det byggede miljø 2022, p. 73). It is, however, important to remember that the investigation by Realdania is based on a survey in which house owners responded to a questionnaire about their indoor environment. This means that the results of the survey are somewhat subjective and do not necessarily match the actual number of houses experiencing overheating if measures were compared to the requirements of the building regulations.

The current Danish Building Regulations (BR18) define overheating in housing as the number of hours the temperature exceeds, respectively, 27 °C and 28 °C. Under the circumstances that the dwelling can be vented, the indoor temperature is allowed to exceed 27 °C up to 100 hours per year and 28 °C up to 25 hours per year (*BR18* no date). The limit has been increased since the former Building Regulations (BR15), which had a limit of, respectively, 100 and 25 hours exceeding 26 °C and 27 °C.

A change of the allowed temperatures was suggested in an analysis of the requirements for the thermal environment in BR15 for the Danish Energy Agency, as the requirements were difficult to meet in dwellings ventilated naturally (Petersen et al. 2014, p. 9).

The thermal indoor environment for new buildings is calculated from the so-called 'Design Reference Year' (DRY 2013), which is based on weather data for the years 2001–2010 (*BR18* no date). As DRY 2013 has outside temperatures of 28 hours above 26 °C and 11 h above 27 °C, the analysis concludes that it would cause difficulties not to exceed these temperatures in dwellings ventilated by outside air (Petersen et al. 2014, p. 9). Consequently, the allowed limit to maximum indoor temperatures has been raised in the current building regulation (BR18). It can seem strange that the temperatures defining overheating in the Building Regulations are changed as a consequence of difficulties meeting the requirements. Though, if new houses were to stay below the allowed maximum temperatures they would require mechanical cooling or air-conditioning, as natural ventilation would not be sufficient to cool down the houses in the warmest periods. However, as we are experiencing rising temperatures it is not a sustainable solution to continually raise the limit values of allowed indoor temperatures.

14.1.5 Climate Change and Thermal Indoor Environment

One should bear in mind that the DRY 2013 is based on 12 years old weather data and as we are in the midst of climate changes, which will probably cause a severe temperature rise, we are facing even higher temperatures in the future.

Comparing the temperatures of DRY 2013 to the temperatures of the past ten years (2013–2022), it becomes clear that the data used for DRY 2013 is not up to date. The average temperature of DRY 2013 is 8 °C, whereas the average temperature of today (the mean temperature of the years 2013–2022) is 9.3 °C (*Vejrarkiv* no date).

That is a temperature difference of + 1.3 °C in 12 years alone. In comparison, the average temperature in Denmark has increased by 1.5 °C since the 1870s (*Temperature and climate change* no date; *Data i Klimaatlas* no date). In other words, the temperature difference between the DRY 2013 data and the current temperatures is almost as big as the temperature rise of the past 150 years.

The Design Reference Year is constructed from more years meaning that months of representative average temperatures are taken from the period 2001–2010 and gathered into one year. The Design Reference Year has been constructed from the following months (Fig. 14.2).

In DRY 2013 months of extreme weather have been excepted as the reference year functions as a standard value that can be used for simulations of future buildings, e.g. However, it might not be a bad idea to integrate weather

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Year	2009	2009	2006	2010	2006	2005	2009	2009	2009	2008	2010	2009

Fig. 14.2 Design reference year (DRY 2013) is constructed from months chosen from the period 2001–2010 as shown in the figure above. (*Danish Design Reference Year—PDF Free Download* no date)

extremes into the calculations of future design reference years as the climate change will cause more extreme weather (*Temperature and climate change* no date; *Data i Klimaatlas* no date).

The indoor environment of buildings built at the moment is thus calculated from weather data, which neither matches the climatic conditions today nor reflects the climate change and temperature rise we are facing in the future. The consequence could be houses that get warmer in reality than expected from the calculations, which means that the residents will experience a significantly higher amount of hours of overheating than expected. In other words, a gap between the calculated and observed indoor environment is likely to occur not only in houses that are being built now but also in houses that are to be built in the years to come.

14.1.6 The Gap Between Measured and Perceived Indoor Environment

Besides a gap between the calculated and the observed indoor environment, it can be argued that a gap between the *measured* and *perceived* indoor environment is also evident and plays a role in recognizing cases of overheating.

The scientific paper by K. J. Lomas et al. '*Dwelling and household characteristics' influence on reported and measured summertime overheating: A glimpse of a mild climate in the 2050's*' concludes that questionnaires concerning the indoor environment on one hand "are a useful tool for identifying thermal discomfort or the prevalence of overheating", but on the other hand, they are likely to underestimate the general prevalence of overheating in homes (Lomas et al. 2021, p. 11). The paper explains further, how older people are less inclined to report overheating than younger people, and therefore questionnaires answered by people older than 75 can be misleading when compared to the measured thermal indoor environment.

As the measured and the perceived thermal indoor environment can be two very different things, both can be correct even if they do not match each other. The perceived thermal indoor environment or thermal comfort is completely dependent on the person perceiving it. The same measured temperature can be too warm for one person and too cold for another. The perception of temperatures is closely related to age, gender, physics, clothing and activity level, but also the heat sensitivity of a person and the previously experienced temperature play an important role in the perception of a given temperature (Lomas et al. 2021, p. 4).

When the prevalence of overheating reported by people older than 75 can be misleading it has to do with the fact that people over 75 generally tend to have a higher comfort temperature than younger people due to their lower metabolic rates. Thus, they simply feel comfortable with high indoor temperatures, which could otherwise be classified as 'overheating' (Lomas et al. 2021, p. 11). Based on the questionnaires and monitored indoor climatic conditions, the article states that the monitored overheating was far higher than reported by the residents. In cases with residents older than 75, overheating was monitored in one-third of the dwellings, while the reported prevalence was only 8% (Lomas et al. 2021, p. 10).

This suggests that high age and heat sensitivity are closely linked to each other and that the residents' age is of great influence on the responses given in a questionnaire. If these conclusions are compared to the aforementioned Realdania survey, showing that 13.4% of houses built after 2000 suffer from overheating, it leads to the speculation of how the age factor comes into play here. As the survey is not backed by monitoring of the indoor environment, the responses of the residents stand alone and given that some of the houses built after 2000 have residents over 75 of age, the number of houses experiencing overheating could potentially be even higher than the stated 13.4%.

14.1.7 Renovation or Demolition

In Denmark, houses with low energy efficiency tend to be replaced by new houses with a higher level of energy efficiency, (Nørgaard no date) but according to the Realdania survey, more than every eighth of these houses suffer from overheating. Hence, in the future, it is very likely that we will experience fewer problems related to cold and draught but instead will have an increase in overheating-related problems in Danish houses.

During this century, the average annual temperature in Denmark is expected to rise by 3.4 °C (with an uncertainty range from 2.9 to 4.3 °C) from 8.4 °C (the average temperature over the years 1981–2010) (*Temperature and climate change* no date; *Data i Klimaatlas* no date) (Fig. 14.3).

With rising temperatures due to climate changes, it is most likely a question of time before overheating of Danish houses becomes a severe problem. As heating a house is known to be easier than cooling a house (Heschong 1979, p. 15), the houses built today could become targets for demolition in the future.

As the percentage of new buildings in Denmark each year adds up to 1%, it only constitutes a small part of the total building stock (Bech-Danielsen et al. 2018, p. 14). Around 70–80% of existing buildings are expected to still stand in the year 2050 ('Bygherreforeningen bidrager til regeringens klimahandlingsplan' 2020). In addition, a report by the Danish engineering company Rambøll published in 2020 shows that it is more advantageous to renovate than to demolish and build new—both in terms of economics and environmental impact (Sørensen and Mattson 2020, p. 6). Thus, demolition and new builds are hardly the most efficient way to reduce emissions

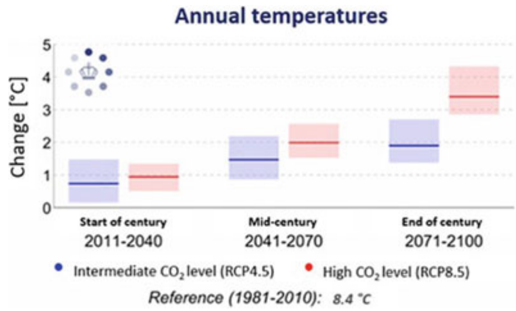

Fig. 14.3 Denmark's expected temperature rise during this century for two different scenarios (RCP4.5 and RCP8.5). (*Temperature and climate change* no date)

and solve the climate crisis. Instead, we should look for solutions for the retrofit of houses which have high energy use and with it a large potential for energy saving.

As the first actual energy requirements were implemented in the Danish building regulations in 1979 (BR77), the majority of buildings built before 1980 do not meet these energy requirements (Dansk Byggeri 2019, p. 15). Housing built before 1980 accounts for 35% of the total building stock and especially the housing stock contains a large potential in terms of energy savings through retrofit. Detached houses from the 1960s and 1970s play an important role in this matter as they account for a great part of the total amount of detached houses in Denmark. Between the years 1960 and 1979, 450,000 new detached houses were built, which corresponds to the same amount built within the 100 years before that (Lind and Møller 1996, pp. 136–137). Today detached houses constitute around 40% of the total amount of single-family houses in Denmark and adds up to 1 million in total (Sode and Jensen 2018; *Typehuse fra 60'erne og 70'erne renoveres efter ny metode* no date). Therefore, it would be obvious to look towards detached houses from the period 1960–1979 as a target for retrofit.

14.1.8 Indoor Environmental Retrofit

For a building to be sustainable, it is not enough that it meets certain requirements for energy consumption, it should also be healthy and comfortable to live in. Thus, instead of speaking exclusively about energy retrofit, to a greater extent, we should operate with the term 'indoor environmental retrofit'.

According to the Danish Energy Agency, overheating is a consequence in 22% of energy-retrofitted detached houses (Pedersen et al. 2015, p. 26). The problem is often seen in cases of re-insulation due to highly sealed, insulated facades with a lack of ventilation (Marsh et al. 2013).

However, recent research indicates that twentieth century Danish houses possess architectural features, which enable the regulation of the indoor environment. The regulation can even happen passively that is by means of non-electrical devices only (Lyhne 2021). Utilizing these passive architectural features as an integrated strategy could potentially serve as a solution to indoor environmental challenges (Kongebro 2012). Moreover, passive architectural solutions would simultaneously bring down the energy use spent on the regulation of the indoor environment. Therefore, the starting point for a sustainable renovation should be an analysis of the existing house including architectural features that impact the thermal conditions.

When renovating detached houses built between 1960 and 1979, one should be aware of their thermal advantages as well as thermal disadvantages. The houses from this period are characterized by relatively big windows, which are a primary reason for energy loss on one hand, and on the other, a source for optimal daylight conditions. Additionally, the big windows could cause overheating, but an overhanging roof, which is also typical for this house type prevents direct sunlight from entering the house in summer when the sun angle is at its highest.

14.1.9 Research Methods

As part of an ongoing research project at Aarhus School of Architecture focusing on the indoor environmental conditions of Danish detached houses, case studies and semi-structured interviews have been carried out together with owners of nine houses that have undergone retrofits spanning from minor renovation works to complete house renovation projects (Rysz 2022). The houses are located in the mid and southern regions of Jutland and the owners are a mix of younger couples with children, senior couples and seniors living alone. In more cases, the respondees point towards architectural elements in their homes which influence the indoor temperatures and their thermal comfort.

Three of the cases show similar organization and orientation of functions: the living room and one or more bedrooms facing the garden to the west of the house (Fig. 14.4).

In one of the cases, a detached house from 1965, half of the house, the part containing the kitchen, eating area and living room, was renovated. In this case, it is not the newly renovated part but the non-renovated part of the house that experiences overheating in summer.

On the question of whether or not direct sunlight can be inconvenient during the day, the husband answers: "Yes, when I'm working from home. After four o'clock, especially in the sun during the summer months, I have to shut down. (…) It both gets too hot and it is bothering".[1]

The problem of overheating in this case occurs in specific west-orientated rooms at certain times during the day. The fact that only the non-renovated part overheats indicates that other factors than energy-retrofit can lead to temperatures higher than desired and that in this case, the experienced overheating is closer related to the orientation of the room.

A respondee from one of the other cases told that she and her husband had the house built in 1968 and at that time they did not think much about the orientation of the house. "I actually don't think we gave it much thought, because the architect turned the house the way he found best (…) I don't really think we thought about that. To us, I think it was more a question of interior decoration and things like that".[2]

[1] Translated from Danish into English by the author.

[2] Translated from Danish into English by the author.

Fig. 14.4 Three cases of detached houses from, respectively, 1965, 1968 and 1973. The three houses have a similar orientation of living rooms and bedrooms facing the garden to the west

The resident later told that the architect mentioned should be understood as a representative from a standard house company as no architect was involved in the building process of the house. As is the case for many detached houses in Denmark built in the 1960s and 1970s, the house in question here is a standard house, which can be defined as a house built from a set of drawings that have formed the basis for many houses in different locations. One of the consequences of the standard house, which is not designed for a specific plot, is that the orientation of the house can be more or less coincidental.

A third case, an architect-designed detached house from 1973, had a similar layout and orientation of functions with the living room and bedroom facing west, but here the residents did not experience problems in terms of overheating in summer. "Yes well, as for the thermal indoor environment, we are very happy with the big trees over there, they provide shading in summer. (…) The afternoon sun moves all the way around here, and in summer, when the sun is at its highest, the tree crowns ensure shading, and in winter, when the sun angle is a bit lower, they allow for daylight to enter. It actually works very well".[3]

The owners themselves enhance the tall trees in front of the living room and bedroom as a natural kind of sun shading and explain how they contribute to regulating their indoor temperatures. This case shows an example of how external objects can affect the indoor environment thermally. Besides the trees to the west, the house is equipped with an overhanging roof, which similarly serves as sun shading in summer when the sun angle is high. The house is designed with a displaced facade, which means that the size of the overhanging roof varies from room to room creating more or less shade inside. In this way, the roof has been used as a means to ensure larger eaves above the bedroom, and thus secure it from overheating in summer (Fig. 14.5).

From this research, it is not possible to conclude a relationship between the tendency of overheating and the level of retrofit that the houses have undergone. This is due to the number of houses and house owners included in the project as well as the format of the research. The semi-structured interview allows the interviewees to go in depth explaining the indoor environmental situation of their dwellings accompanied by their own experience of the thermal conditions, but the answers given will be strongly influenced by the thermal comfort criteria of each respondee and so the interviews do not form a solid base for general conclusions regarding indoor temperatures and overheating (Brinkmann and Tanggaard 2020).

The research project concerned collects data for measured temperatures and relative humidity in each case, which eventually will be paired with data from the interviews, but as the quantitative data is not accessible until the fall of 2023, this paper deals with the preliminary conclusions of the project, which for now, are based on the interviews alone.

[3] Translated from Danish into English by the author.

Fig. 14.5 Big trees and the overhanging roof of the detached house from 1973 provide sun shading in summer. The displaced facade creates an enlarged overhang above the bedroom preventing it from overheating

14.2 Discussion

As we already experience problems of overheating in Danish detached houses, the increase in outside temperatures as a result of climate changes will undoubtedly worsen this situation. Additionally, our current building regulation is based on weather data, which is neither up-to-date nor reflects the future climate with its foreseen temperatures. As the weather data behind the Design Reference Year (DRY 2013) is 12 years old, it creates a baseline for the calculation of the indoor environment of future houses that is too low compared to today's outdoor temperatures.

The average temperature at the end of this century is expected to be around 11.8 °C (*Temperature and climate change* no date; *Data i Klimaatlas* no date). In comparison, the average temperature of DRY 2013 is 8 °C. That is a temperature difference of + 3.8 °C, which corresponds to nearly 50%.

Research within the field of indoor environmental health calls attention to potential health risks of indoor overheating, such as dehydration, heart problems and increased mortality (Ortiz, Itard and Bluyssen 2020). As the majority of Danish houses are ventilated naturally (Videncenter for Energibesparelser i Bygninger 2017), a significant rise in outside temperatures will most likely affect the indoor temperatures, too. Furthermore, the future Danish weather is likely to entail frequent heatwaves, which will probably bring the indoor temperatures above the maximum values outlined by the Building Regulations and lead to difficulties in meeting their requirements.

Imagining that houses built in Denmark today will last for at least 80 years, they should thus be suited for temperatures remarkably higher than the temperatures we build for today (DRY 2013). However, the houses built today will not be able to manage such temperatures, as they already experience challenges in terms of overheating as it is. The Realdania survey shows that 13.4% of houses built after 2000 tend to overheat (Danskerne i det byggede miljø 2022). The worst-case scenario could be a need for demolishing these houses before the end of the century due to overheating. As demolition and new builds will cause increased energy consumption and carbon dioxide emissions, such a situation will only enhance the climate crisis.

A report by the Danish engineering company Rambøll shows that it is more advantageous to renovate than to demolish and build new—both in terms of economics and environmental impact (Sørensen and Mattson 2020, p. 6). Therefore, it would be beneficial to look for possibilities for the renovation of the existing housing stock in Denmark.

It is important to notice that overheating is also seen in cases of energy-retrofit, however, a case study carried out by the author shows cases of houses experiencing overheating in parts that have not been renovated. This finding indicates that just the orientation of the rooms influences the indoor temperatures significantly and that rooms oriented to the west are likely to overheat —a finding supported by other research studies

(Kolarik et al. 2019). Furthermore, the case study points towards existing architectural elements as contributors to the regulation of indoor temperatures. Hence, when renovating houses from the 1960s and 1970s it is of utmost importance that not only the energy efficiency but also the thermal indoor environment of the house is taken into consideration. This can be done through interviews with the residents and mappings of architectural elements that influence the thermal indoor environment and can prevent overheating. However, these means must be taken into consideration before the retrofit takes place for them to become tools in facilitating an optimal indoor environment from the beginning, rather than mending a poor indoor environment as a result of energy retrofit.

14.3 Conclusions

The research paper intended to investigate the consequences of rising outdoor temperatures on the indoor environments in Danish detached houses. Studies of the Danish Building Regulations and Design Reference Year (DRY 2013) combined with a literature review have shown that the foreseen temperature rise due to climate change can cause severe challenges regarding the indoor environments of Danish detached houses.

The research addresses an urgent need for an update on today's Danish Building Regulations as the Danish Design Reference Year (DRY 2013), is constructed from weather data, which does not match the temperatures we see today. DRY 2013 is used as a baseline for calculations of the indoor environment for new builds, but relying on temperatures significantly lower than the ones of today can consequently lead to higher indoor temperatures than calculated. This could be the case for the houses built after 2000 that suffer from overheating, but it could also be the case for future houses.

New houses have the benefit that the functions of the house can be orientated optimally in terms of the sun's path, which in itself can minimize overheating, but that is not the case for existing houses. For existing houses standing before renovation or energy retrofit, it is instead crucial that architectural elements, which influence the indoor temperatures are mapped and preserved or even developed as part of the retrofit. In these cases, the orientation of the house and its functions can rarely be changed, but elements providing sun shading, such as trees or an overhanging roof, can contribute to the avoidance of indoor overheating.

This paper focuses on Danish detached houses specifically, however, it is often easier to regulate the indoor environment of detached houses than apartments or terraced houses, simply because they consist of one single unit, whereas the other types mentioned are surrounded by other units. Thus, research concerning the indoor environment and overheating of other building types, such as apartments and terraced houses is encouraged as the thermal challenges could be even bigger here.

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Part III

COVID-19

15 Place Attachment and Community Impacts of 24-H Convenience Stores: A Case Study in the Central City of Nanjing, China

Jin Xu and Yuzi Da

Abstract

During the lockdown of COVID-19, there was a lack of community support for residents. The 24-h convenience stores thus played an essential role as the commercial facility in ensuring the smooth running of community life. This study investigated the impact of the 24-h convenience stores on communities with reference to theories of place attachment. It also discussed the factors determining the effectiveness of the support given by convenience stores during the lockdown period, especially the spatial design factors, and how these factors facilitate the design of a resilience community. A comparative study was carried out based on empirical evidence of the convenience stores in the central city of Nanjing, China. Data were collected and analyzed through a longitudinal survey of the community residents affected by the epidemic (2019 before the outbreak and 2022 after the normalization of the epidemic). The findings highlighted the significance of the community support system represented by the 24-h convenience stores during the lockdown and showed the variability and possibilities of the convenience stores in different communities. Suggestions are provided in the end to improve community resilience and community attachment by redesigning convenience stores.

Keywords

Place attachment · Convenience stores · Community · Commercial facility · COVID-19

15.1 Introduction

24-h convenience stores are a typical type of retail facilities in the community, with the provision of food, daily necessities, and multiple services. The stores are usually characterized by compact space and long opening hours (24 h a day, 365 days a year), with a variety of products that meet or even exceed consumers' expectations. In the 1980s, convenience stores played an important role in densely populated communities in Japan, South Korea, and China, combined with multiple functions such as fast food, coffee, postal services, and laundry services (Terasaka 1998). They not only met the basic needs of people's everyday life, but also helped establish connections between residents and the community.

In face of the COVID-19 epidemic, most Chinese communities lacked preparations and plans. There was a lack of community support to

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ensure the normal lives for residents, with inadequate provisions of daily necessities and psychological intervention, especially during the lockdown period. In this context, the proximity of convenience stores to residents and their various functions served the purpose of guaranteeing the safety and health of residents, both physically and emotionally. Previous research on community illustrated that a resilient community would foresee, adapt to and recover from risks. The resilience or the ability of recovery and adaptation would be confined to the community relationships and the emotional support for the residents. However, we would further assume that the convenience stores, an element of community support, would also play an important role in ensuring the safety and resilience of the community.

This study investigated the impact of the 24-h convenience stores on the community with reference to theories of place attachment. Based on the questionnaire survey and on-site observation in the central city of Nanjing, we studied the factors affecting place attachment in the community, especially the spatial design factors, before and during the COVID-19 lockdown period. Finally, the study suggested how to optimize the design of the 24-h convenience stores, in order to enhance the resilience of a community.

15.2 Methods

15.2.1 Theoretical Analyzing Framework

Relevant research on convenience stores has mainly focused on the location and consumer behavior from business perspective (Hashimoto 1996; Yu 2005; Li and Gu 2019). But there is a shortage of research on the possible impact of convenience stores on residents and their community. Environmental psychology provides a perspective in the analysis of the relationships among the external environment, human behavior, and psychological feelings (Heimstra and McFarling 1974). Place attachment is one of the core concepts in environmental psychology, which means an emotional attachment based on the process of spatial experience in a certain place.

It has been proved that place attachment would be enhanced by improving the physical environment and facilities in the community (Audirac 1999; von Wirth et al. 2016). As a kind of public service facility, convenience stores supply daily products to meet residents' demands, provide space for social interaction, and in this way, enhance residents' sense of belonging to the community. With reference to the theory of place attachment, a theoretical analyzing framework was constructed in order to understand the relationships between the place (convenience stores) and people in the community (Fig. 15.1).

15.2.2 Research Area and Data Collection

The convenience store industry in Nanjing has developed rapidly in recent years. The planning of a 15-min community life circle means residents can easily get access to daily necessities by walking within 15 min. There are many local chain brands such as Suguo, Haodi, and Hualian. From 2017 to 2018, some foreign brands have also successfully settled in Nanjing, including Lawson, 7–11, and FamilyMart (Table 15.1).

This study is based on the empirical evidence of convenience stores in the central city of Nanjing, China. A web-randomized sampling method was employed to conduct cross-sectional surveys of community residents affected by the COVID-19 outbreak, with basic investigation into residents, convenience store usage, and place attachment to the community, which was a reference to previous studies (Tester et al. 2011; Reitzes 1986). First-hand data were collected by questionnaire surveys and on-site investigations in 27 sample convenience stores from 2021 to 2022 (Fig. 15.2). This paper presents the results so far, with more research and case study still continuing.

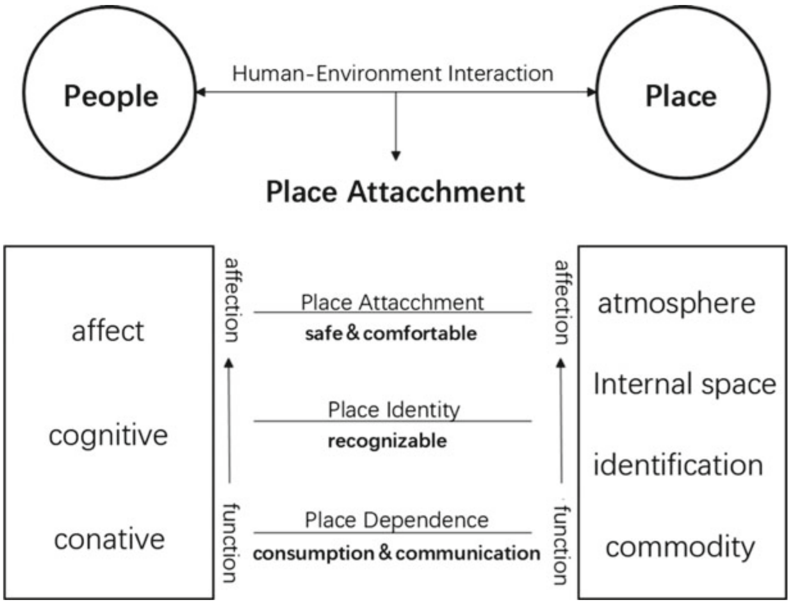

Fig. 15.1 Analyzing framework of place attachment between place and people

Table 15.1 Brands of the convenience stores in Nanjing

Brand	**Suguo**	**Lawson**	**7–11**	**Quanshi**	**Suning**
Number of stores	12	4	2	2	2
Ratio (%)	44.4	14.8	7.4	7.4	7.4
Brand	**Bianlifeng**	**Linli**	**Gouhao**	**Jingdong**	**Feiniu**
Number of stores	1	1	1	1	1
Ratio (%)	3.7	3.7	3.7	3.7	3.7

15.3 Results

15.3.1 Spatial Characteristics of Convenience Stores

A convenience store normally covers an area of 50–150 square meters, with its internal space being divided into shopping area, resting area, cashier service area, and storage area. Due to its limited space, the space streamline organization of convenience stores is different from one another. Based on our observation, there are less types of goods in a convenience store than a normal comprehensive store, and the simple display of goods and low shelves can help customers locate the goods they need in the shortest time possible. As a small commercial space in

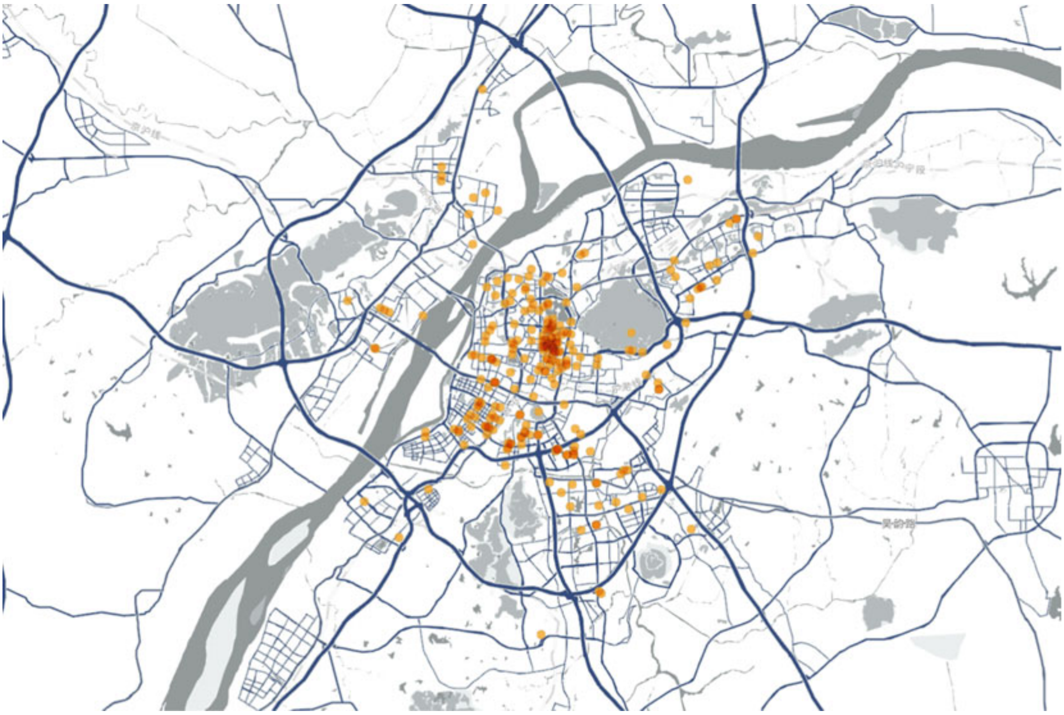

Fig. 15.2 Location of the convenience stores in the central city of Nanjing

the street, the convenience store has some consideration for consumers' rest and stay, which is reflected in its corresponding design in space. The resting area in the convenience store is normally a personal area with a social distance of more than 50 cm. The sense of distance makes the resting area no longer a simple public territory, but a transitional stage from a public territory to a secondary territory.

An observation of customer behaviors reveals that people are more like to stay at the entrance of the convenience store than at other places on the street. The monitoring and prevention function of people inside the convenience store has greatly improved the security inside and outside the store. Non-consumption behaviors occur more frequently at night and usually last longer, leading to more opportunities for communication, and consumers generally feel that shop assistants in convenience stores are more friendly. A sense of comfort in the convenience store is also reflected in the types of non-consumption behaviors, as people tend to eat, communicate, read, entertain, and rest in the store.

During the period of epidemic control, the range of service of 24-h convenience stores in the community has changed from the 15-min life circle to a single closed community. Its service function has changed as well, with more focus on providing necessities and public services for the community, so that residents can maintain a normal life during the epidemic. Multi-level services are offered in addition to ordinary goods, including coffee preparation, laundry, express delivery, photocopying, etc.

15.3.2 Place Attachment of Residents

In order to understand residents' evaluation of various dimensions of convenience stores before and after the epidemic control, this study lists the variables of external factors, internal factors, and place attachment. The average values of each variable in the two periods are obtained through processing questionnaire data. The correlation coefficient matrix analysis of external factors, internal factors, and place attachment is then

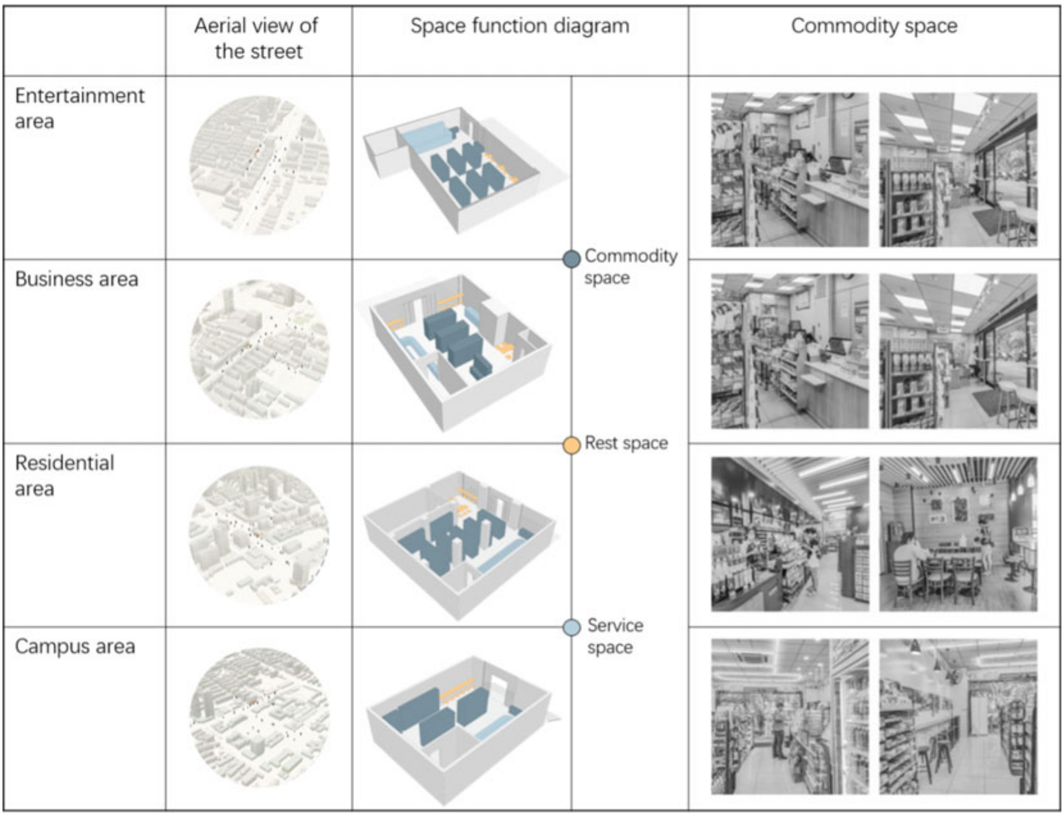

Fig. 15.3 Four types of typical convenience stores

conducted, respectively. In the last step, samples analysis is carried out on hierarchical regression to verify the influence of each variable on place attachment, as well as the similarities and differences of the influencing factors of place attachment in different periods (Tables 15.2, 15.3 and 15.4).

Table 15.3 gives the hierarchical regression analysis in the normal period, with three models involved. The independent variable in model 1 is the population factor. The external factors of convenience stores are added to model 2 on the basis of model 1, and the internal factors of convenience stores are added to model 3 on the basis of model 2. As is shown, the result of model 1 fails to pass the F test ($F = 0.798$, $p > 0.05$), which means that demographic factors have no impact on place attachment. By contrast, the change of F value in model 2 is significant ($p < 0.05$), indicating the importance of the external factors of convenience stores. In addition, the increase of the R-squared value from 0.080 to 0.584 explains a 50.5% rise of place attachment due to the external factors. Among them, proximity and convenience have considerable positive effects on place attachment. Moreover, the significant change of F value in model 3 ($p < 0.05$) and the increase of R square value (from 0.584 to 0.783) show that the internal factors of convenience stores contribute to a rise of place attachment by 19.8%, with public place imposing a remarkable positive impact on place attachment (Hauke and Kossowski 2011; Arndt et al. 1999; Dao-de 2000).

Table 15.4 gives the hierarchical regression analysis during the period of epidemic control, which is consistent with the hierarchical logic in Table 15.2. The result of model 1 does not pass the F test ($F = 0.722$, $p > 0.05$), meaning the limited impact of population factors on place attachment. The significant change of F value in model 2 ($p < 0.05$) illustrates the impact of

Table 15.2 Pearson related—standard format

	Average value	Standard deviation	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Place attachment (1)	3.590	1.102	1													
Age (2)	2.462	0.874	0.177	1												
Sex (3)	1.596	0.495	0.002	0.031	1											
Occupation (4)	2.442	2.146	0.063	0.558**	0.098	1										
Community location (5)	2.519	1.163	0.034	− 0.009	− 0.105	0.016	1									
Living conditions (6)	2.385	0.690	0.259	0.383**	− 0.168	0.267	0.088	1								
Near (7)	4.135	1.121	0.673**	− 0.005	0.065	− 0.123	− 0.130	0.058	1							
Easy access (8)	4.135	1.121	0.541**	0.096	0.029	− 0.205	− 0.175	0.135	0.844**	1						
By the way (9)	3.846	1.178	0.666**	0.204	− 0.176	− 0.112	− 0.155	0.291*	0.773**	0.818**	1					
Doorway space (10)	3.635	1.329	0.768**	0.199	− 0.169	− 0.004	− 0.129	0.263	0.652**	0.600**	0.778**	1				
Commodities (11)	3.827	1.098	0.786**	0.167	− 0.023	− 0.008	− 0.066	0.219	0.800**	0.705**	0.768**	0.776**	1			
Services (12)	3.712	1.177	0.706**	0.323*	0.032	− 0.003	− 0.146	0.405**	0.610**	0.595**	0.731**	0.721**	0.826**	1		
Rest place (13)	3.404	1.209	0.780**	0.024	− 0.082	− 0.123	0.029	0.304*	0.596**	0.524**	0.623**	0.692**	0.719**	0.648**	1	
Additional facilities (14)	2.904	1.390	0.607**	0.134	− 0.143	− 0.025	0.201	0.285*	0.399**	0.311*	0.470**	0.511**	0.490**	0.402**	0.700**	1

* $p < 0.05$, ** $p < 0.01$

(Population factors: including age, sex, occupation, community location, and living conditions; external factors of convenience stores: including near, easy access, and by the way; internal factors of convenience stores: including doorway space, commodities, services, rest space, and additional facilities. The following three tables are the same)

Table 15.3 Hierarchical regression analysis results (n = 52)

	Layer1					Layer2					Layer3				
	B	Standard error	t	p	β	B	Standard error	t	p	β	B	Standard error	t	p	β
Constant	2.365*	0.889	2.661	0.011	–	− 0.327	0.733	− 0.445	0.658	–	− 0.185	0.572	− 0.323	0.748	–
Sex	0.112	0.322	0.347	0.730	0.050	0.194	0.239	0.811	0.422	0.087	0.162	0.195	0.829	0.412	0.073
Occupation	− 0.007	0.076	− 0.094	0.925	− 0.014	0.042	0.055	0.775	0.443	0.083	0.056	0.044	1.259	0.215	0.109
Community location	0.015	0.134	0.114	0.910	0.016	0.121	0.095	1.265	0.212	0.128	0.082	0.078	1.057	0.297	0.087
Living conditions	0.430	0.238	1.803	0.078	0.269	0.165	0.180	0.917	0.364	0.104	− 0.059	0.155	− 0.383	0.704	− 0.037
Near						0.579**	0.194	2.982	0.005	0.589	0.216	0.175	1.238	0.223	0.220
Easy access						− 0.347	0.213	− 1.634	0.109	− 0.353	− 0.138	0.169	− 0.819	0.418	− 0.141
By the way						0.480*	0.189	2.534	0.015	0.513	0.020	0.178	0.111	0.912	0.021
Doorway space											0.234	0.119	1.957	0.057	0.282
Commodities											0.118	0.201	0.590	0.559	0.118
Services											0.118	0.155	0.758	0.453	0.126
Rest place											0.288*	0.128	2.246	0.030	0.316
Additional facilities											0.068	0.089	0.763	0.450	0.086
$R2$	0.069					0.584					0.783				
Adjusted $R2$	− 0.010					0.517					0.716				
F	$F(4,47) = 0.877, p = 0.485$					$F(7,44) = 8.809, p = 0.000$					$F(12,39) = 11.721, p = 0.000$				
$\triangle R2$	0.069					0.514					0.199				
$\triangle F$	$F(4,47) = 0.877, p = 0.485$					$F(3,44) = 18.109, p = 0.000$					$F(5,39) = 7.162, p = 0.000$				

Dependent variable: place attachment
*$p < 0.05$, **$p < 0.01$

Table 15.4 Hierarchical regression analysis results (n = 52)

	Layer1					Layer2					Layer3				
	B	Standard error	t	p	β	B	Standard error	t	p	β	B	Standard error	t	p	B
Constant	2.261*	1.009	2.240	0.030	–	− 0.977	0.934	− 1.046	0.301	–	− 0.968	0.919	− 1.053	0.299	–
Age	0.051	0.243	0.208	0.836	0.037	0.037	0.182	0.204	0.839	0.027	− 0.020	0.190	− 0.105	0.917	− 0.015
Sex	0.087	0.350	0.248	0.805	0.036	− 0.009	0.277	− 0.031	0.975	− 0.004	0.286	0.279	1.025	0.312	0.119
Occupation	− 0.057	0.096	− 0.598	0.553	− 0.103	− 0.050	0.074	− 0.675	0.503	− 0.090	− 0.048	0.071	− 0.670	0.507	− 0.086
Community location	0.013	0.146	0.092	0.927	0.013	0.071	0.109	0.646	0.521	0.069	0.118	0.112	1.053	0.299	0.116
Living conditions	0.468	0.271	1.728	0.091	0.273	0.518*	0.226	2.291	0.027	0.302	0.343	0.230	1.492	0.144	0.200
Near (epidemic control)						0.586**	0.161	3.633	0.001	0.540	0.490**	0.168	2.925	0.006	0.452
Easy access (epidemic control)						0.035	0.205	0.170	0.866	0.035	− 0.263	0.232	− 1.131	0.265	− 0.265
By the way (epidemic control)						0.184	0.191	0.964	0.341	0.178	− 0.063	0.206	− 0.304	0.763	− 0.061
Doorway space (epidemic control)											0.224	0.171	1.306	0.199	0.257
Commodities (epidemic control)											0.283	0.282	1.003	0.322	0.278
Services (epidemic control)											0.024	0.294	0.083	0.934	0.024
Rest place (epidemic control)											0.112	0.217	0.514	0.610	0.132
Additional facilities (epidemic control)											0.045	0.132	0.339	0.736	0.057
$R2$	0.073					0.520					0.628				
Adjusted $R2$	− 0.028					0.431					0.501				
F	$F(5,46) = 0.722$, $p = 0.610$					$F(8,43) = 5.833$, $p = 0.000$					$F(13,38) = 4.941$, $p = 0.000$				
$\Delta R2$	0.073					0.448					0.108				
ΔF	$F(5,46) = 0.722$, $p = 0.610$					$F(3,43) = 13.379$, $p = 0.000$					$F(5,38) = 2.206$, $p = 0.074$				

Dependent variable: place attachment (epidemic control)
*$p < 0.05$, **$p < 0.01$

external factors of convenience stores. In addition, the increase of the R-squared value from 0.073 to 0.520 shows the effect of the external factors, which leads to a 44.8% rise of place attachment. Among them, proximity has a significant positive impact on place attachment, so do the rest of the factors. The result of model 3 fails to pass the F test ($\text{det}F = 2.206$, $\text{det}P = 0.074 > 0.05$), indicating the limited influence of internal factors on the place attachment during the period of epidemic control.

Fig. 15.4 Public space in the convenience stores is occupied by other functions (photographed by the authors)

15.4 Conclusions and Discussions

This paper takes the 24-h convenience stores and their communities in the central city of Nanjing as a case to study place attachment in different communities, with the analysis on the impact mechanism of place attachment. The study has found significant spatial factors contributing to place attachment. The survey results highlight the importance of the community support system represented by 24-h convenience stores during the period of community lockdown, which helps to understand how to provide physical and mental support for residents in face of the still ongoing epidemic and future public health emergencies.

By comparing the community impact of the convenience store space in different periods, we can see that in normal times, distance and public space are factors that greatly influenced place attachment. In contrast, during the lockdown of COVID-19, only distance has a significant impact. In general, distance between the convenience stores and the residents will affect place attachment to the greatest extent. Therefore, it is important to set up a sufficient number of convenience stores in a 15-min circle in order to guarantee accessibility. In addition, the combination with other public facilities and commercial facilities is also important, so diversification is needed for convenience stores. In normal times, public space for social interaction in the stores can maximize the impact on place attachment of residents.

The conclusion of this study supports the positive role of convenience stores to win residents' place attachment in the community. But there is also the need for convenience stores to further optimize the layout of outlets, increase service categories, and improve public space, so as to be closer to the community, reflecting their value in the resilient community governance system as much as possible, and playing an active role in ensuring life services and community safety during the period of epidemic control. It is also possible to further enhance the identity and sense of recognition of the convenience stores through the distinctive creation of space and atmosphere, create public places with radiating influence toward urban communities through formal, functional, and characteristic innovations, and cultivate community relations through traditional community activities.

The suggestions for the transformation of the physical space inside the convenience store mainly include two aspects: goods and space. Most consumers believe that the convenience store should increase the variety of goods and provide featured goods, should offer more concise indoor design and layout. More importantly, it is necessary to increase the area of the resting space, set up areas that can be perceived and prevented by individuals, and arrange the resting area in a more integrated area. The view of the resting area should be relatively open, facing the street but separated by glass windows. In addition, face-to-face seats and flexible furniture can also promote interpersonal communication, which is conducive to creating a sense of belonging in the convenience store, thereby enhancing residents' place attachment and help build a resilient community (Fig. 15.4).

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16 Sustainable Housing Provision in Post COVID-19 Era in the Developing World: Challenges for the Architects

Oluronke Odunjo and Sharon Odunjo

Abstract

The surge of urbanization in the developing economies of the world has resultant effect on housing condition. However, housing is pivotal to the overall well-being and total quality of life of individuals and is believed to be both the cause and cure of Coronavirus pandemic, a respiratory problem plaguing the world today. This is due to the fact that people spend more time in houses during lockdown. This paper therefore examined the impact of housing conditions on the Coronavirus pandemic in the developing economies of the world in order to suggest strategies that will make architects create a sustainable environment for human habitation in the post-pandemic era. A historical survey method was employed and data was collected from secondary sources. The paper finds that there are various dimensions to housing condition which aid the spread of the pandemic and have impacts on residents' health. The paper therefore suggests that architects need to provide functional and flexible spaces, connect houses to the outdoors and adopt the principle of universal design among others in order to allow air into the building.

Keywords

Surge of urbanization · Developing economies · Housing condition · Coronavirus pandemic · Architect

16.1 Background

The World Health Organization (WHO 2004) sees housing as the residential environment, neighbourhood, micro district or the physical structure which mankind uses for shelter. Housing includes the environment of a structure, the necessary facilities, equipment and the devices needed for the physical health and social well-being of the family and the individual. Housing is a unit of the environment which has a profound influence on the health, efficiency, social behaviours, satisfaction and well-being of the community. One issue that stands out in housing is the factor of physical health and social well-being of the individual and his household which presupposes an uncompromising stance in the total comfort, which housing is expected to provide. This therefore exemplifies the inexorable linkage between housing and health.

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In the last three years, Coronavirus pandemic has become a bickering issue in all the countries of the world and housing is regarded as both the cause and the cure. Housing is a fundamental human right and it is entral in the battle against COVID-19. Without adequate housing, it is impossible to carry out social distancing and good hygiene practices. Thus, housing has become the front line defense against coronavirus pandemic (UN 2020). It is attributable to the increasing realization that the house environment produces some dangers to human health and life (Kothari 2001; Luthi 2001).

Several studies have affirmed that the psychological well-being of man is dependent on the quality of the house he lives in among others Ellaway et al. (2001), Breysse and Forr (2004), World Health Organization (2004), Gary (2006), Bonnefoy (2007), Vasconcelos et al. (2011), Odunjo (2014) and Battersby (2015). All these studies have related housing problems to the psychological well-being or socio-emotional health and social-well-being in terms of healthy and happy living. This is described in terms of human behaviour vis-a-viz dwelling design and maintenance, in relationship with housing safety and accidents. According to Patrick et al (2003), residential injuries are linked to the home environment which may happen because of home design (stairs, lighting, flooring, railings and windows). Others may happen due to poor maintenance of home design elements such as electricity and household appliances (WHO 2004). Also, fear and crime have insidious effect on human lives and they are linked to factors related to building design, condition, quality, management and the immediate house environment. Thus, residential environment plays important role in determining individual well-being and health status. The World Health Organization (WHO) reckons that it is the home, not the clinic that is the key to better health delivery system. The impact of poor housing is on the increase in the world and it has caused series of health challenges which has led to death in many cases (Bonnefoy et al. 2003). All these health challenges can be ameliorated if adequate consideration is given to housing quality, in terms of design and adequate provision of the needful.

In the developing world, unprecedented urbanization has been a common feature since the last century (Awolola 2014; Odunjo 2020). This has been in form of rapid population growth and physical expansion of cities in which housing problem is prevalent. As population increases and space becomes limited in the city, housing problems escalate. Poor housing conditions such as slum, overcrowding and high density are associated with greater spread of COVID-19 and people have to spend more times in homes. Though, this is not the first time in human history that pandemics affect cities, limited literature relating to housing and pandemics existed before the emergence of COVID-19 pandemic (Matthew and McDonalds 2006). According to Wade (2020), urban research relating to pandemics mainly focussed on issues such as inequalities that make poor and marginalized groups more vulnerable to pandemics The recent pandemics has brought to the fore the issue of housing vulnerability to pandemics and has resurrected interest in this topic. As housing is a medium of spread, better knowledge of the adaptation measures is needed. This paper therefore assesses the impact of housing condition on Coronavirus pandemic. It uses the developing world as a case study and at the end; enumerates the challenges of architects for sustainable housing design at post COVID-19 era.

16.2 Conceptualization and Review of the Literature: Housing and Public Health

Poor housing conditions are associated with a wide range of health conditions, including respiratory infections and asthma. Addressing housing issues offers public health practitioners an important social determinant of health and public health has long been involved in housing issues. In the nineteenth century, health officials targeted poor sanitation, crowding and inadequate ventilation to reduce infectious diseases. Today, public health departments can employ multiple strategies to improve housing, such as developing and enforcing housing guidelines and codes, implementing "Healthy homes" programmes to improve indoor environmental quality, assessing housing conditions, and advocating for healthy affordable housing.

Housing is an important determinant of health and substandard housing is a major public health issue (Sharfstein and Sandel 1998). Each year in the United States, 13.5 million nonfatal injuries occur in and around the home (Warner et al. 2000), 2900 people die in house fires (Kartel 2000) and 2 million people make emergency room visits for asthma (National Hospital Ambulatory Medical Care Survey 1998). The public health community has grown increasingly aware of the importance of housing as a social determinant of health (Marmot and Willinkinson 1999), yet defining the role of public health practitioners in influencing housing quality has been challenging and the responsibility for social determinants of health is seen as lying primarily outside the scope of public health, but left at the door of the architects that design the houses.

Thus, housing and health as concept is wide in nature and requires a holistic approach in analysis. Healthy housing does not mean a specifically designed imaginary house, rather it simply means one that provides an environment that is safe, comfortable and hygienic and the one that empowers individuals in achieving their aim. An attempt made to describe healthy housing was "adequate housing" which is defined as more than having a roof over one's head. The conditions of adequate privacy; adequate space; physical accessibility; adequate security; security of tenure; structural stability and durability; adequate lighting, heating and ventilation; adequate basic infrastructure, such as water supply, sanitation and waste management facilities; suitable environmental quality and health-related factors; as well as adequate and accessible location with regard to work and basic facilities. All of these should be available at an affordable cost and are said to be the conditions for a house to be adequate (Bonnefoy et al 2003). In a more concise manner, Pollack et al. (2010) summarized all these conditions to be the physical conditions within homes; conditions in the neighbourhoods surrounding homes; and housing affordability, which do not only shape home and neighbourhoods conditions, but also affect the overall ability of families to make healthy choices.

16.3 Methods

The research is qualitative in nature and historical survey approach was adopted, while content analysis was employed in the presentation of the data collected.

16.3.1 Urbanization in the Developing World

Every country in the developing world is experiencing urbanization in different dimensions. Urbanization is the increased concentration of people in cities rather than in rural areas (UNCHS-Habitat 2011). Demographic Partitions (Urbanization in 2013) describes urbanization as the process by which towns and cities are formed and become larger as more people begin living and working in central areas. It is the gradual increase in the number of people living in urban areas, with subsequent decrease in those living in rural areas (World Health Organization 2018).

The population of towns and cities in the developing world has been growing at a fast pace with the population doubling in almost every three to four decades. The effect of this trend on the physical, social and the natural environment is heavy. According to Abanyam and Dankano (2019), urbanization in the developing world are faced with numerous challenges such as high population density, inadequate infrastructure, lack of affordable housing, pollution, slum creation congestion and poverty.

It is estimated that by 2050, more than two-thirds of the world's population will live in cities, up from about 54% today. This rapid, often unplanned urbanization brings risks of profound social instability, risks to critical infrastructure, potential water crises and the potential for devastating spread of disease such as COVID-19 that is being experienced presently global Risks (2015). Nigeria as a typical example experienced one of the fastest rates of urbanization between twentieth and twenty-first centuries Fadamiro et al. (2005). Today, there are more than 840 urban centres and well over 10 cities with a population of over 1 million (Table 16.1). The result is overcrowding and increased pressure on facilities.

Thus, urbanization problems are by nature both generative and cumulative. The rapid population growth has serious problems for physical and socio-economic development because of the inability of the existing institutions to cope with the challenges of high dependency rate. However, the Delos Declaration of 1962 made it clear that measures should be taken to prevent the uncontrolled expansion of metropolitan areas and to organize them in a more humane way. Similarly, many international academic bodies have devoted their energies to exploring ways of understanding urban processes and how they can be manipulated for human welfare. In the same manner, the United Nations conference on the human environment which took place in Stockholm in 1972 devoted three of its twenty-six declarations to the built environment. Economic and social development is essential for insuring a favourable living and working environment for man and for creating conditions on Earth that are necessary for the improvement of the quality of life.

In order to curb urbanization therefore, governments of the developing world need to adopt an integrated and co-ordinate approach to development with a view to protecting and improving the human environment for the benefit of people. Planning must be applied to human settlement and urbanization with a view to avoid adverse effects on the environment and obtain maximum socio-economic and environmental benefits for all. Therefore, there is need to check urbanization in order to make towns and cities livable and workable.

16.3.2 Housing Problems

Rapid urbanization in the developing world has substantially increased the need for urban housing (Olotuah 2000). Housing the teeming population and provision of the required services is a formidable task for successive governments. During COVID-19 lockdowns, people were restricted to their homes for most of the day and this highlighted serious housing failures and inequities. Stay at home orders led to a heightened awareness of both positive and negative

Table 16.1 Urban population in Nigeria (1921–2025)

Year	Total population (in millions)	% Rural	% Urban
1921	18.63	95.2	4.8
1931	19.93	93.3	6.7
1953	30.30	90	10
1963	55.65	89.8	19.2
1973	79.76	78	22
1991	88.5	68	32
1996	102.52	60	40
2000	128.8	56	44
2005	147.6	51.8	48.2
2010	168.4	48	52
2015	190.9	44.9	55.1
2020	214.5	41.8	58.2
2025	238.4	39.1	60.9

Source Awolola (2014)

aspects of housing and changed how people experience and interact in homes. As a result, housing problems and their effects on the physical and mental well-being of occupants were brought to the forefront.

Though, there is no country in the world that is void of housing problems; there are various dimensions to housing challenges in the developing world. What is obtained is slum or squatter settlements which is haphazard or unplanned pattern of development of housing in which large sections sprang up through the efforts of the informal sector without any form of regulation (Fadamiro et al. 2005). According to BBC (2022), many new immigrants to cities in developing world cannot afford housing and as a result, they are forced to build temporary accommodation in spontaneous settlements. These settlements are commonly known as "shanty towns". They are also called favelas (Brazil) or bustees (India).The main features of a shanty town are: houses are made from scrap materials such as wood and metal sheeting; often, housing does not have services such as sanitation, water or electricity and the settlements are usually crowded. This can aid the spread of Coronavirus pandemic as slums are unsafe and unhealthy and characterized by lack of windows and indirectly lack fenestration which can cause shortage of breath.

Also, the monumental deficiency in housing in the developing world manifests both in qualitative and quantitative terms. Buildings are often congested as the urban population is largely made up of low-income earners who are mostly in irregular and informal employment. They have housing problems such as lack of space. This is because the proportion of the population living in urban centres has increased phenomenally over the years. The incidence of this population in urban centres created severe housing problems, resulting in overcrowding in inadequate dwellings with lack of spaces for individual activities and is a catalyst for the spread of Coronavirus pandemic.

Having access to quality affordable housing is fundamental to reduce poverty. Many people are moving from rural areas to cities for work in the developing world and therefore need to be housed in an affordable shelter. However, the developing world is plagued with the problem of unaffordable housing with resultant effect on homelessness, thereby aiding contact with an infected person. Hence, there is need to guarantee a sustainable growth. For this reason, it became one of the objectives of UN Sustainable Development Goals number 11. The aim by 2030 is to put housing at the centre of specific policies to reduce drastically the quantity of people living in conditions below the minimum standards (UNCHS-Habitat 2022).

There is also the problem of shortage of adequate housing facilities. The shortage of water supply for example is a problem for cooking, bathing and most importantly for toilet activities. During the lockdown, proximity to source of water was a big challenge and residents used to go far places to fetch water. Erratic power supply is another challenge as houses always have epileptic power supply, as a result of which some are in constant use of solar power or generator. Also, many houses share housing facilities such as toilet in Brazilian type building and problems may emerge. For example, a person in isolation may spread the disease to other occupants which may lead to death if care is not taken.

Furthermore, poor housing conditions such as overcrowding and high density are associated with greater spread of *COVID*-19. However, people have to spend more time in homes that are overcrowded, damp or unsafe. According to Adesola (2017), overcrowding is a specific happening clinically observable and definable. Overcrowding occurs when organisms are brought together in such a manner and numbers as to produce physical reactions of stress; important among these reactions is stepped up activity of the adrenal glands. When these reactions to stress are widespread and sustained, they are followed by physical weakening, sometimes rage and violence of extreme passivity and a breakdown of orderly group behaviour. What may follow is a tidal wave of death, ending when the population is no longer crowded. Thus, when a house or room is overcrowded, a single contact

Table 16.2 Occupancy ratio in selected cities in Nigeria

Town	Household occupying room (%)	Average number of persons per room
Lagos	74.2	4.1
Ilorin	38.2	2.6
Kaduna	73.5	3.8
Benin City	48.0	2.2
Ibadan	4.1	–

Source Awolola (2014)

with *COVID-19* carrier will aid in the transmission of the disease to the other. Also, overcrowding is an aberration to the disease in the sense that there is shortage of air supply to the occupants of the building (Table 16.2).

In considering the global need for housing in the United Nation Development decade (1960–1970), it was stated that over 1000 million people in Africa, Asia and Latin America had about half the total population homeless or living in houses which purported danger to human health which is an affront to human dignity. In addition, it was estimated that over 200 million inhabitants would crowd into the cities during the development decade. In recognition of the magnitude of present and future housing needs, the United Nations estimated that an annual rate of housing construction of 8–10 housing units per 1000 person is needed in the developing world to overcome existing differences and meet future needs which have not been complied with by some countries. Other infectious diseases commonly associated with overcrowding are tuberculosis, meningitis and measles (Adesola 2017). Studies have shown that overcrowding could be a determining factor for deleterious social behaviour (such as prostitution and juvenile delinquency) and certainly is a hazard to health (Olotuah 2006; Odunjo et al. 2015).

The quality of the environment in most urban centres is another concern. This is dependent on organization as spatial units. The slow process of urban planning and zoning in the face of rapid urbanization in most developing countries has resulted in poor layout of buildings with inadequate roads between them and inadequate drainage and provision for refuse evacuation (Fadamiro et al. 2005). Thus, there is a high incidence of pollution (especially air pollution) and inadequacy of open spaces for other land uses. All these constitute urban poverty consequential of rapid urbanization. This manifests in the environmental stress experienced by the urban dwellers.

As Odunjo (2020) puts it, Coronavirus spread finds expression in an environment characterized by high densities of buildings, lack of space for open air living between houses, poor health and substandard housing. In addition, housing condition is a cause for concern. Housing condition relates to the physical characteristics of houses such as damp. A lot of houses are characterized by dampness and studies have linked dampness to a number of health problems, including respiratory issues such as Coronavirus pandemic. Another aspect that has to do with housing condition is whether the house has access to a garden or outside space for recreation which was brought to the fore during lockdown.

16.4 Results

16.4.1 Challenges for the Architects in Post COVID-19 Era

In order to avoid future pandemic in relation to respiratory problem, architects need to provide functional spaces in houses to allow for enough air to come in. Attention should be paid to materials used for construction, size of windows, doors and courtyards for cross ventilation to take place. Also, regular advice needs to be given to clients on the need to design based on standards. The minimum standards specified for air spaces, setback and built up proportion should be adhered to in order to create a healthy and livable housing environment. In Brazilian houses where facilities are shared, the number of housing facilities provided must commensurate with the population on ground.

Throughout the pandemic, people were confined to their homes and every work is carried out in the different spaces of the home. Thus, the house must be made more versatile to accommodate more range of uses and spaces must be made more flexible. The flexibility of the house allows the space to evolve as the demands of the user change. Flexibility can include using active features such as movable walls and flexible elements like multi-use rooms, vast floor to ceiling heights, use of modular furniture, etc.

Following the global health crisis, people are craving increased connection to the outdoors. This has driven increased demand for private balconies and outdoor open spaces especially in high-rise multi-family residential units. Shortly, residential developments that focus on primary aspect of living such as increasing fresh air through natural ventilation and access to nature through biophilic design strategies will have an edge.

Also, there is need for conceptual retrace of communal spaces in housing developments such as multi-storey apartments in post COVID-19 era. As ventilation of corridor spaces play a role in minimizing the spread of COVID-19, external communication corridors should be examined with architectural solutions that promote privacy by hiding users from being seen from the street or nearby apartment blocks. In this wise, numerous elevators may be needed to accommodate demand.

To future-proof new residential designs in the post COVID-19 era, universal design principles need to be embraced. Thus, the house must be fully functional under normal conditions, with an added ability to function in a pandemic situation. The primary aim of the design must be to minimize the likelihood of transmission through structural, physical and practical means. Therefore, the building has to account for three spaces according to Patil (2022):

(i) **Spaces with restricted access**: A space near the entrance of the house for self-sanitation so that airborne particles can be minimized into the house.
(ii) **The threat-reduced internal space**: Humans interact and socialize with each other at various levels of intimacy, frequently mixing formal work and private spheres. Such socializing in the confines of a private residence potentially exposes the occupants to pathogens unintentionally introduced by visitors. Any post-pandemic design needs to take this into account through functionally differentiating and compartmentalizing the internal spaces.
(iii) **Space suitable for isolation**: The residence will require a bedroom for isolation. The bedroom should open to an exterior, but self-contained, courtyard or open space to provide the isolating inhabitant with safe access to the outside environment. This space can also function as a transition zone.

Therefore, architects need to invent better typologies of houses and housing that responds to various communities of residents and their accompanying cultures. The residences must include the capacity to isolate within the house compound or environment plus the possibility of communal places. Greater care should be given to artificial and natural ventilation and lighting solutions to preserve good indoor air quality and mental well-being.

Architects engage primarily in the design and the supervision of the construction of buildings and other physical components of the built environment. They play the major role in the shaping, reshaping and management of the physical fabric of the urban centres and consequently its quality. There is therefore need for architect bodies advocating for increasing and maintaining the housing stock and the provision of adequate infrastructure in houses.

Architects can encourage the use of alternative building materials such as laterite bricks/stabilized laterite bricks and cement fibre roofing materials for construction of houses instead of living in squatter settlements or ghettos. The materials are cheaper compared with conventional building materials and architects could set the right examples by building their own houses using the indigenous approach and by encouraging government to adopt same for housing schemes.

Architect bodies could demonstrate their commitment to improving the lot of the urban poor by the rigorous pursuit of “Neighbourhood schemes” which emphasize public participation and partnership with a view to assist in the provision of infrastructure and the stemming of degradation at the neighbourhood level, e.g. the provision of central toilet facilities for compounds.

Architects could help in the increased design of self-help core housing project that is affordable depending on the income of the family. The self-help core housing project involves the provision of environmentally; friendly and structurally strong shelter units that can withstand a range of hazards. The architect can design in such a way that the owner of the house can start with the building of the core house such as living room or bedrooms to accommodate both horizontal and vertical expansion.

16.5 Conclusion

This study has discussed the impacts of housing conditions on Coronavirus pandemic in the developing economies of the world. The study revealed the dominant housing conditions which aid in the spread of the pandemic. It concluded that architects have a long way to go in post-pandemic era towards tackling future respiratory problems, and therefore suggests strategies that could be employed towards the creation of a sustainable environment for human habitation.

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17 Impact of Environmental Design Changes on Primary Healthcare Services in Mohalla Clinics During COVID-19: Findings from a Rapid Ethnographic Study

Amarjeet Mohanty and Gourab Kar

Abstract

The Mohalla Clinic (MC) scheme was launched in Delhi, India, to provide primary healthcare services accessible to underserved populations at their doorstep. Starting with one clinic in 2015, the scheme has expanded to 518 clinics today and more are planned. While studies have documented the success of the scheme and its popularity among beneficiaries such as the elderly, children, women, and migrant populations, there is limited research on how the environmental design of MCs impacts the quality of healthcare delivery. This is especially relevant as many MCs have been converted into COVID-19 testing centers. Therefore, this qualitative research investigated how environmental design changes necessitated by COVID-19 impacted healthcare delivery in MCs. Field studies were conducted in two phases. First, a rapid ethnography of 24 MCs was conducted followed by semi-structured interviews with thirty-five medical staffs in nine MCs. Findings suggest that environmental design changes negatively impacted healthcare delivery. Space accessible to the patients was reduced by 66%–75%, exterior openings were reconfigured to offer healthcare services, covered waiting spaces were inaccessible, restrooms and drinking water facilities were unavailable, crowding of patients increased, and guidelines for ventilation were unmet. While these design changes may be reversible, workarounds devised by users during this time offer actionable insights on how to create pandemic-resilient community clinics. Findings from the study can inform the development of guidelines for the design of flexible and resilient MCs which can effectively respond to contemporary and future public health emergencies.

Keywords

Primary healthcare clinics · Mohalla clinics · COVID-19 · Environmental design · Rapid ethnography

17.1 Introduction

In July 2015, the state government of Delhi, India, launched the *Mohalla* or Community Clinic scheme to provide quality primary healthcare services accessible to underserved populations at their doorstep (Sharma 2016). The first Mohalla Clinic (MC), located in the Peeragarhi area of North-west Delhi, was a two-room clinic, made of prefabricated materials. The clinic

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housed the doctor's room, a pharmacy, a laboratory with testing kits, a restroom, and a waiting room with amenities such as a drinking water dispenser, a token vending machine, and a television set. As of April 2022, the MC scheme has expanded to 518 clinics and estimates suggest that over 60,000 people are treated each day in these clinics (Govt. of Delhi 2022). While Delhi plans to expand the scheme to one thousand clinics, more than a dozen Indian states have either started or planned to create community clinics modeled on Delhi's MC scheme (Lahariya 2020).

MCs have been popular and cater to 10–20% of outpatient attendance at government healthcare facilities (Lahariya 2017). Since MCs are located within the community and offer healthcare services at zero cost to the beneficiary, they are accessible, available, and affordable to the poor and underserved populations (Khanna and Srivastava 2021). Most clinics are within walking distance of the beneficiaries, which reduces time to reach, and money spent on transportation. Studies have documented that most beneficiaries are the elderly, children, women, and the migrant population (Agrawal et al. 2020). Most patients visited the MCs to avail free medicines and diagnostics. Across all studies, 85% of those attending MCs were satisfied with the quality of healthcare service, which is significantly higher than the 55% for government hospitals (Lahariya 2020). During the COVID-19 pandemic in early 2020, the clinics played the role of providing essential primary care services in Delhi, and later in August onward, many MCs served as a facility to provide expanded COVID-19 testing.

While the MC scheme in Delhi offers a case study of how to provide accessible and affordable healthcare services to poor and underserved populations, there is scant research on how the environmental design of MCs impacts the quality of the healthcare delivery service. This is important for two reasons—first, studies suggest that prior to COVID-19, MCs were overcrowded, lacked adequate waiting areas, and did not offer inclusive environmental access to the elderly and people with disabilities (Sah et al. 2019). Second, during the COVID-19 pandemic, MCs were 'converted' into COVID-19 facilities by use of 'temporary and ad-hoc' solutions such as restricting patient entry and use of doors and windows as portals for patient-staff interactions. Given this context, there is an urgent need to relook at flexibility and efficiency of healthcare facilities to deal with the rapid epidemiological, social, and economic changes necessitated by COVID-19 (Capolongo et al. 2020).

Recent literature on pandemic-resilient healthcare design suggests need for a two-pronged strategy to address the structural, organizational, and technical challenges of upgrading healthcare facilities in response to the COVID-19 pandemic (Capolongo et al. 2020). First, there is need to consider design strategies which include factors such as site location, building typology, flexibility, space programming, and user-centeredness. Second, there is need for operational strategies which consider factors such as patient safety, ventilation and air quality, finishes and furnishing, and healthcare information systems. A recent study by an interdisciplinary team of architects, engineers, clinicians, and medical planners explored how to create a flexible and resilient hospital environment that addresses need for both infectious disease care and safety for all users (Schroer et al. 2021). The authors distilled their findings into seven principles of pandemic-resilient healthcare design which include the need to: (1) offer a versatile design, (2) be surge-ready, (3) support patient and staff well-being, (4) offer clean air and surfaces, (5) offer facilities to isolate, contain, and separate, (6) design for clear circulation, and (7) offer spaces and places that allow for a seamless transition between the physical and digital realms.

While the nascent body of literature on design of pandemic-resilient healthcare environments is timely, these recommendations are primarily intended for hospital settings and may not translate to the context of the MCs. This is because the environmental design factors such as the scale, typology, layout, site location, and functional space programming of MCs differ significantly from hospital settings. A study of the 'temporary and ad-hoc' design and operational strategies adopted to convert MCs into COVID-19 facilities may offer novel insights on the viability, feasibility, and desirability of these design decisions. Additionally, staff in MCs operate with minimal protective gear, hand hygiene protocols are difficult to enforce, and the recommended social distancing norms are frequently violated. Therefore, this study uses qualitative research methods to uncover challenges in the delivery of healthcare services in MCs, especially in the context of environmental design changes necessitated by the COVID-19 pandemic. Research questions seek to inquire about how the changes in environmental design features such as floor plans, layouts, waiting spaces, openings, and ventilation impact the human–environment interactions and influence the quality of healthcare service.

17.2 Materials and Methods

An exploratory research approach was adopted with field studies in two phases—first, a rapid ethnography of 24 MCs (see Fig. 17.1) was conducted and was followed by semi-structured interviews in nine MCs with thirty-five medical staffs. Field studies were conducted over 8 months between December 2021 and July 2022, and informed consent was obtained from participants engaged in the study. Rather than start with a hypothesis or generate research questions at the outset, the focus was to observe the human–environment interactions in the MCs. This approach offered an in-depth understanding of the MC sites and their context and enabled the research team to gather insights about human behaviors rather than having to focus on hypothesis testing (Cranz 2016). Findings from the research would provide evidence for future design decisions to improve the human–environment interactions in MCs.

Ethnography is a social research method where the researcher spends a significant amount of time-observing, listening to, and asking questions about people's everyday activities. The process enables the researcher to gather the information that can help shed light on the topic of interest (Atkinson 2007). Rapid ethnography—as the name suggests—is ethnography conducted over a brief, compressed, or intensive period and focuses on human experiences and activities in a setting with various challenges (Vindrola-Pardos 2021). To experience the MC from the patient's perspective, the researcher assumed the role of a participant observer to undertake rapid ethnography in six MCs. In this role, the researcher visited the MC during the hours of operation (10 am–2 pm), registered at the reception desk, waited in the waiting space, consulted with the doctor, collected prescribed medicines in the pharmacy, and finally exited the MC. These sessions lasted between 30 min and an hour, mostly varying due to the wait times between registration, consultation, and pharmacy. The use of a participant–observer method of data collection was carefully considered and limited to only six MCs. In all such instances, consent was obtained from staff members of the respective MCs prior to the study.

Following the participant observation sessions, the researcher conducted non-participant observations in 18 MCs. Since the researcher had gained familiarity with the layouts, activities, people, and processes in the six MCs during the initial participant observation sessions, it was decided to adopt a non-participant observer position for the rapid ethnography in the remaining 18 MCs. Non-participant observation offers a researcher the chance to get more intimate with the subject while maintaining their status as an outsider (Ciesielska et al. 2018). Although the researcher's identity and job are clearly defined by this division, there are ways in which the researcher can blend in with the backdrop. By doing this, the researcher can let people nearly forget about their presence as an outsider and enable the organizational activity to go according to its regular rhythm. Using this as a guiding principle, the researcher assumed a vantage point in the waiting hall to observe people and their activities in space for at least two hours in each location. Data were recorded through field notes—including scribbled notes, annotated diagrams (see Fig. 17.2), and sketches of the physical setting. In addition, photographs

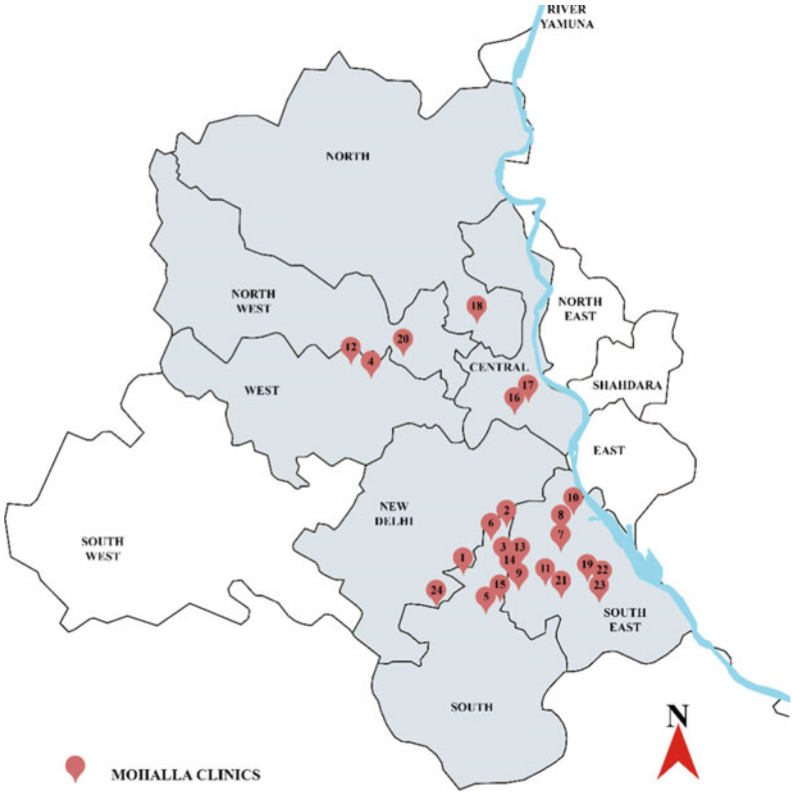


Fig. 17.1 Location of MCs site visited

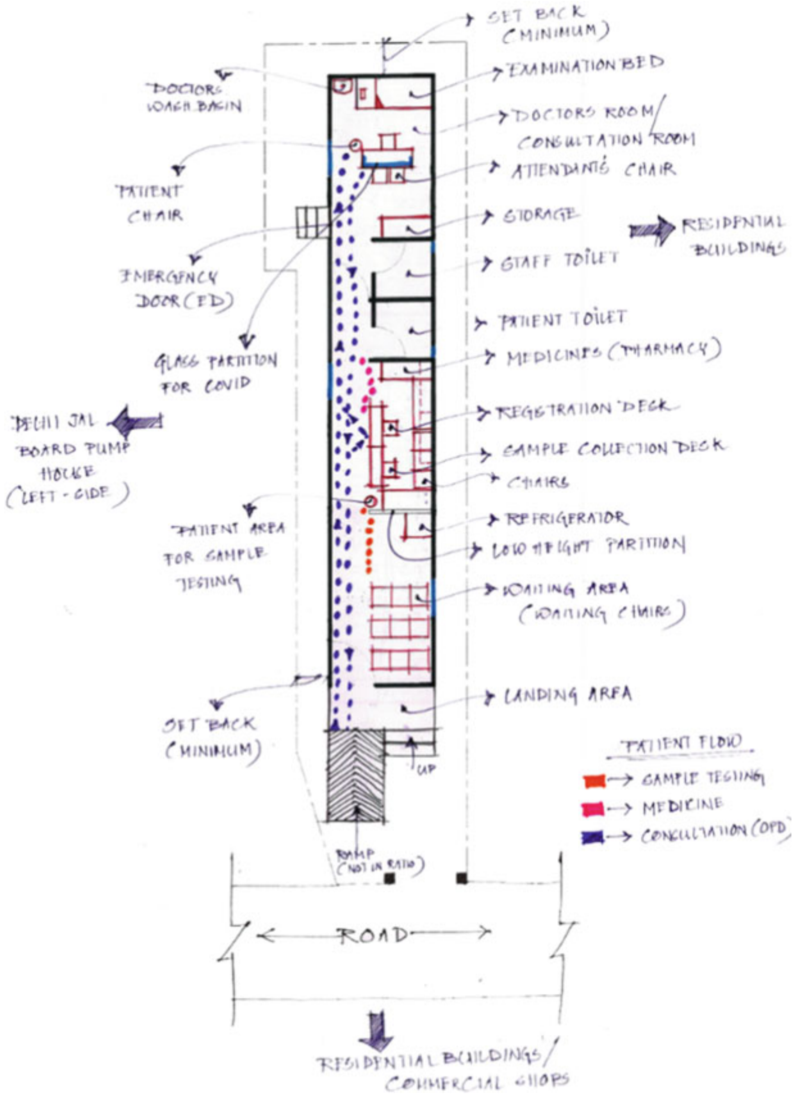
and video recordings were taken to capture the human–environment interactions, and floor plans were used to record patient workflows.

The rapid ethnography was followed by semi-structured interviews with nine doctors and twenty-six nurses in nine MCs. The experience of observational research and insights gained through the process provided evidence to develop a set of interview questions. The choice to go for a semi-structured interview was made since this approach offers a mix between open-ended interviewing methods and standardized questionnaires with predetermined response alternatives (Wethington and McDarby 2015). In a semi-structured interview, the researcher asks questions to enquire more about the participants' unique experiences. Along with the set of questions, the researcher used interview probes to clarify a point, ask for further explanations, continue the talk, or shift the topic (Zeisel 2006). To assist the researcher in the interview, floor plans and scaled-down models of the MC were brought so that the respondent could relate to questions concerning function, space, and activities in the MCs. The one-on-one interviews lasted between 45 min and a couple of hours and were conducted in the MCs within the operational hours (10 am–2 pm) (Fig. 17.3).

17.3 Result

The MCs visited were classified into three spatial typologies—(a) **Rectangular (R-type)—**60 m^2 *of floor area*, (b) **Elongated (E-type***)*—55.36 m^2 *of floor area*; and (c) **T-shaped (T-type)**—48.88 m^2 *of floor area*. The R-type MC was the dominant spatial typology with nineteen units, followed by the E-type with four units and one T-type unit. Five design features for each of the three spatial typologies of MCs were compared between the pre-COVID-19 (previous) condition and the in-COVID-19 (current) condition. The goal was to identify if there were operational changes between the two conditions, and if so, how these changes impacted the delivery of

Fig. 17.2 Sample fieldnotes



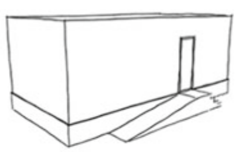
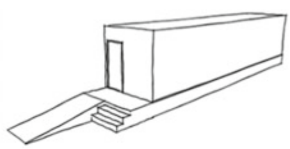
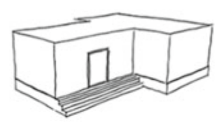
healthcare service. The design features which were compared included changes in the floor plans, modification of workflows, the provision of a door and window-based service, curtailment of waiting spaces, and changes in ventilation (Table 17.1).

17.3.1 Floor Plans

Analysis of the floor plans for MCs reveals significant operational changes between the pre-COVID-19 and in-COVID-19 conditions. Prior to the COVID-19 pandemic, patients and caregivers were allowed inside the MCs. They would visit the reception area for registration, wait in the waiting hall, meet the doctor in the consultation room, receive prescribed medicines in the pharmacy, and if needed, use the restroom. However, once COVID-19 safety protocols were put in place, the requirements for reduced occupant density resulted in a reduction of patients' access inside the MCs. For example, in the R-type MCs, the accessible floor area for patients was reduced by 36% (see Fig. 17.4). The corresponding reduction in accessible floor area for

Fig. 17.3 Sample photographs

Table 17.1 MCs' typologies

		
R-Type Area = 60 sqm (approx.)	E-Type Area = 55.36 sqm (approx.)	T-Type Area = 48.88 sqm (approx.)

patients in the E-type MC was 35% (see Fig. 17.5), while for the T-type MC the reduction was 24% (see Fig. 17.6). In addition to the restrictions for patients' access, interior layouts were reconfigured by rearranging furniture. Specifically, tables and chairs were placed adjacent to the door and window openings in the waiting hall so that registration and consulting could happen at the door, while pharmacy services could be offered through the window. In this new layout, patients would wait outside the MC after registration at the door and come back to the door for consultation. Post-consultation, they would turn up at the window for pharmacy services. The sharing of the registration and consultation services at the entry door resulted in operational challenges, and patients were unable to use the waiting space or access the restroom. The reduction in patient entry and access inside the MC resulted in an increase in useable storage spaces for critical medical equipment such as vaccine freezers to store COVID-19 vaccines and immunization vials, as well as essential COVID-19 medication.

17.3.2 Workflow

Prior to the COVID-19 pandemic, the typical workflow for a patient was entry followed by

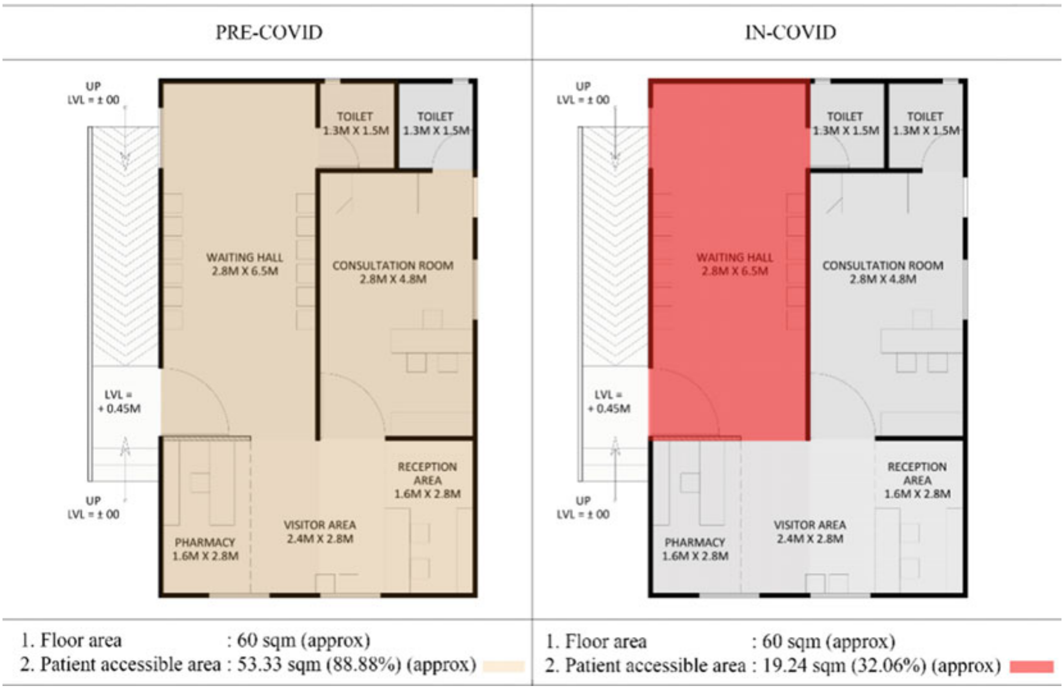


Fig. 17.4 Typical floor plan comparison of R-type

registration, waiting if needed, consultation, pharmacy, and exit. The typical patient workflow was the same for the MCs irrespective of their spatial typologies. However, with the introduction of COVID-19 safety protocols, patient entry inside the MC was reduced or eliminated, resulting in significant changes in the patient workflow. The study compared the distance traveled by a patient between entry and exit in the pre-COVID-19 condition and the in-COVID-19 condition. On average, the typical path length for patients visiting the R-type MC reduced by 40% (see Fig. 17.7). The corresponding reduction in typical path length for patients in the E-type MC was 51% (see Fig. 17.8), while for the T-type MC, the reduction was 50% (see Fig. 17.9).

The reduction in patient entry and access inside the MC resulted in significant challenges to accommodate divergent patient workflows. In certain instances, patients would visit the MC for doctor's consultation, while others would visit the MC only to receive medicines from the pharmacy. In both instances, patient registration was at the door which doubled up as the doctor's consultation space. The intersection of different patient workflows in the constrained environment resulted in the crowding of patients near the door. Using the door as the consulting and registration space led to an increase in service times, and the doctor–patient interactions could no longer be private. The workflow conflicts were so severe that in a few instances patients would leave in frustration without availing of the healthcare service they had come to the MC for.

Analysis of the patient workflows as well as interviews with doctors and staff suggest that the single point of entry–exit was a key impediment in the design of the MCs, irrespective of their spatial typology. This became more of an operational bottleneck when patient entry–exit was restricted, and the entry door was reconfigured into a single portal for patient–doctor and patient–staff interactions. A few doctors suggested that a unidirectional patient workflow with separate entry and exit locations could offer a solution by streamlining the patient workflow as well as reducing the risks of infections. However, this approach would necessitate

Fig. 17.5 Typical floor plan comparison of E-type

fundamental design changes with consequences such as increased staffing requirements and added security challenges.

17.3.3 Door and Window Service

As discussed previously, the layouts and workflows for the in-COVID-19 condition were reorganized so that the doors and windows opening into the waiting hall served as portals for doctor–patient and staff–patient interactions. While this stop-gap arrangement was necessitated due to the COVID-19 safety protocols, it has led to operational challenges such as overcrowding near the door and communication gaps due to the difference in height between the interior and exterior. All three spatial typologies of MCs were designed to serve their functions from the inside; the provision to offer services along the perimeter through the door and windows was not considered in the initial planning stage of the MCs. Observations revealed that the door and the window portals created barriers to effective communication since the openings were too small, and the level difference between the outside and inside prevented effective communication at eye level. To overcome this challenge, a few MCs installed

Fig. 17.6 Typical floor plan comparison of T-type

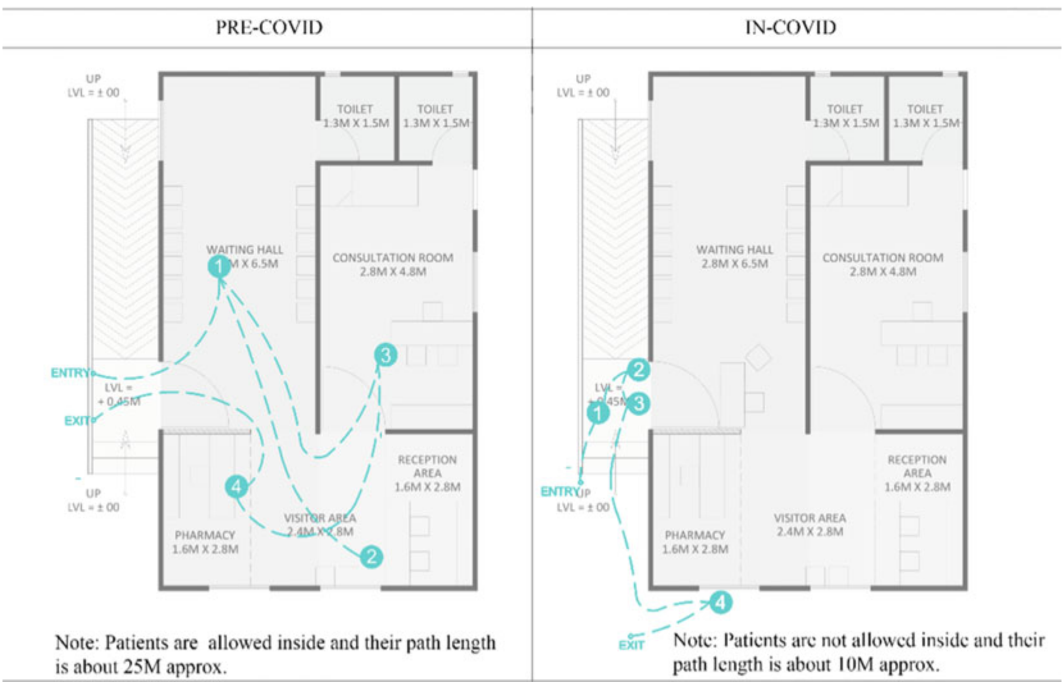


Fig. 17.7 Typical patient flow comparison in R-type

Fig. 17.8 Typical patient flow comparison in E-type

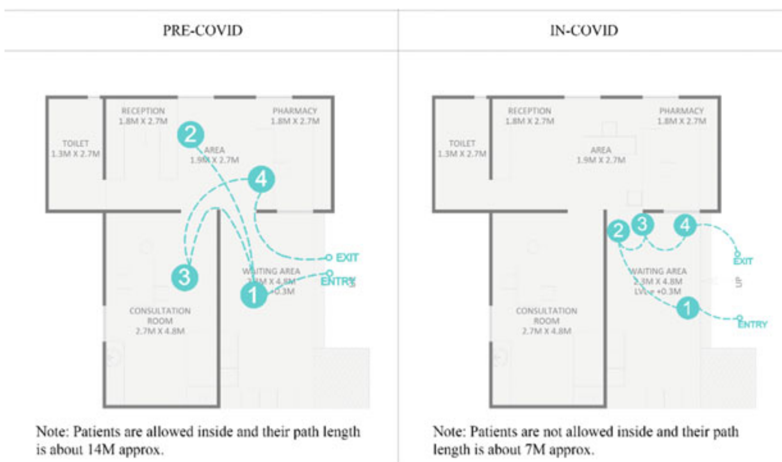


Fig. 17.9 Typical patient flow comparison in T-type

Fig. 17.10 Different challenges in door and window service; **a** level difference, **b** social distancing, **c** communication gap

prefabricated stairs with two to three steps in front of the window, while a few other MCs placed a sitting bench in front where patients could stand while interacting across the window (see Fig. 17.10a).

As the door and window-based services were distributed on the outside, the exterior space surrounding the MCs became a crucial design element. A few MCs had space along the perimeter to accommodate the crowd of patients, while other MCs had no access to 'spill-over' spaces. Therefore, in MCs with no exterior space, people stood in a queue on the road outside which resulted in overcrowding, conflicts with traffic on the road, and safety concerns (see Fig. 17.10b). A communication gap observed in multiple MC locations concerned the patient–staff interactions across the pharmacy window. The pharmacist needed to explain the medicine dosage to the patient. However, with the windowpane coming in the way of effective communication, it became difficult for the pharmacist to explain the dosage of medicine to the patient (see Fig. 17.10c). The difference in floor heights across the window compounded the problem. In some instances, patients left without taking medicine from the pharmacy. In MCs with multiple windows opening into the waiting hall, it was possible to offer separate window services for registration and doctor's consultation. This provision would attenuate some of the concerns raised about overcrowding and communication gaps. However, the decision to offer multiple window services in an MC was not limited only to the availability of windows; there may have been other administrative reasons such as staffing challenges.

17.3.4 Waiting Space

All three spatial typologies of MCs had designated waiting spaces inside. These varied in size from 18.2 m^2 for the R-type MC, 13.44 m^2 for the E-type MC, and 11.04 m^2 for the T-type MC, respectively. In the pre-COVID-19 condition, patients have registered at the reception counter and choose to wait inside or outside the MC for their consultation slot. However, during the in-COVID-19 condition, with registration and consultation taking place at the entry door, there were no designated 'covered' waiting spaces for patients. As a result, patients had to wait outside, either in the outdoor 'spill-over' space or in the street beyond. The 'spill-over' space varied from 21.56 m^2 for the R-type MC, 12.85 m^2 for the E-type MC, and 10.76 m^2 for the T-type MC (see Figs. 17.11, 17.12, 17.13). Observations revealed that waiting spaces inside the MCs were overcrowded, lacked adequate natural ventilation and daylighting, and seating capacity was limited to twelve seats. Patients preferred to wait outside, especially in the extremes of the summer and winter, since there were no heating, ventilation, or air-conditioning systems inside the MCs. Since waiting spaces inside the MCs were reorganized during the in-COVID-19 condition to serve as registration and consulting spaces, the waiting spaces were able to double up as additional storage spaces to store the essential COVID-19 medication as well as vaccines (see Fig. 17.14).

17.3.5 Ventilation

Ventilating a room or indoor space replaces the indoor air with outdoor air. The primary purpose of ventilation in a building is to provide healthy air for breathing by both diluting the pollutants originating in the building and removing the pollutants from it (Etheridge and Sandberg 1996; Awbi 2003; Atkinson et al. 2010). In the case of healthcare environments, adequate ventilation is essential to prevent and/or reduce airborne infections. All three spatial typologies of MCs were designed to be naturally ventilated through openings such as doors and windows. However, analysis of the floor plans and observations onsite revealed that the size, frequency, and location of openings on exterior walls of the MCs resulted in suboptimal natural ventilation. For example, in the case of the R-type MC, even though there were six exterior openings, their positions were such that only single-sided ventilation was possible (see Fig. 17.15a). Similarly, for the E-type MC with five exterior openings,

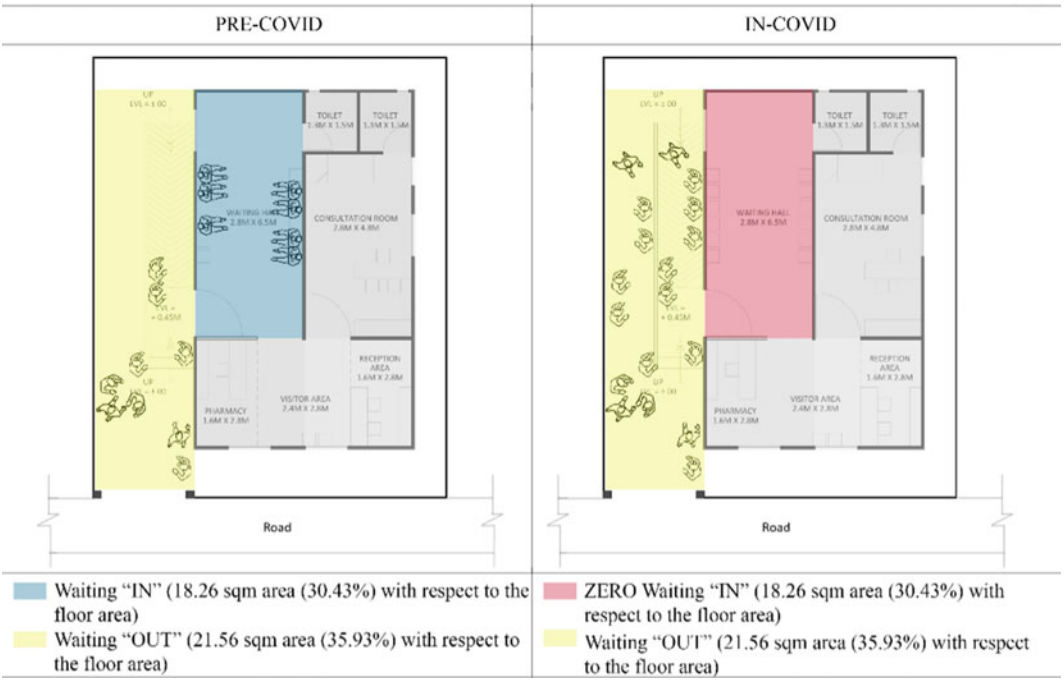


Fig. 17.11 Sample waiting area comparison in R-type

most of the spaces had single-sided ventilation with only the waiting space having cross-ventilation (see Fig. 17.15b). In case of the T-type MC, the layout offered a mix of single-sided ventilation and cross-ventilation (see Fig. 17.15 c). The ratio of openings to the floor area was 6.6% for the R-type, 5.7% for the -E-type, and 6.8% for the T-type, respectively. However, this is significantly lower than the 10% openings to floor area ratio mandated by the Delhi Development Authority (DDA 2016).

Ventilation standards for healthcare environments have been a cause for concern, especially during the COVID-19 pandemic. Revised guidelines by the World Health Organization to improve and ensure good indoor ventilation in the context of COVID-19 suggest measures such as: modifying the dimensions of the window or door openings, considering potential new openings, enabling cross-ventilation instead of single-sided ventilation, and the use of stand-alone air cleaners or HEPA filters if the other strategies cannot be implemented (WHO 2021). Field research in the limited sample of MCs suggests that very few, if any, of these ventilation strategies were adopted.

17.4 Discussion and Conclusion

Across the three spatial typologies of MCs visited, functional changes due to COVID-19 resulted in a 66–75% reduction in interior space accessible to patients. Interior layouts were modified by rearranging furniture and moveable partitions. The use of the entry door to the clinic as the patient registration and consultation zone resulted in overcrowding and conflicts in patient workflows. The absence of covered waiting space and lack of access to restrooms and water dispensers subjected patients to additional disadvantages. As a stop-gap arrangement, such a drastic reduction in spatial access was probably justified in the short term. However, in the medium term, there is a need to reframe design goals for MCs to adopt flexibility and future-proofing strategies for resiliency (Capolongo et al. 2020) Decisions about the floor plans and

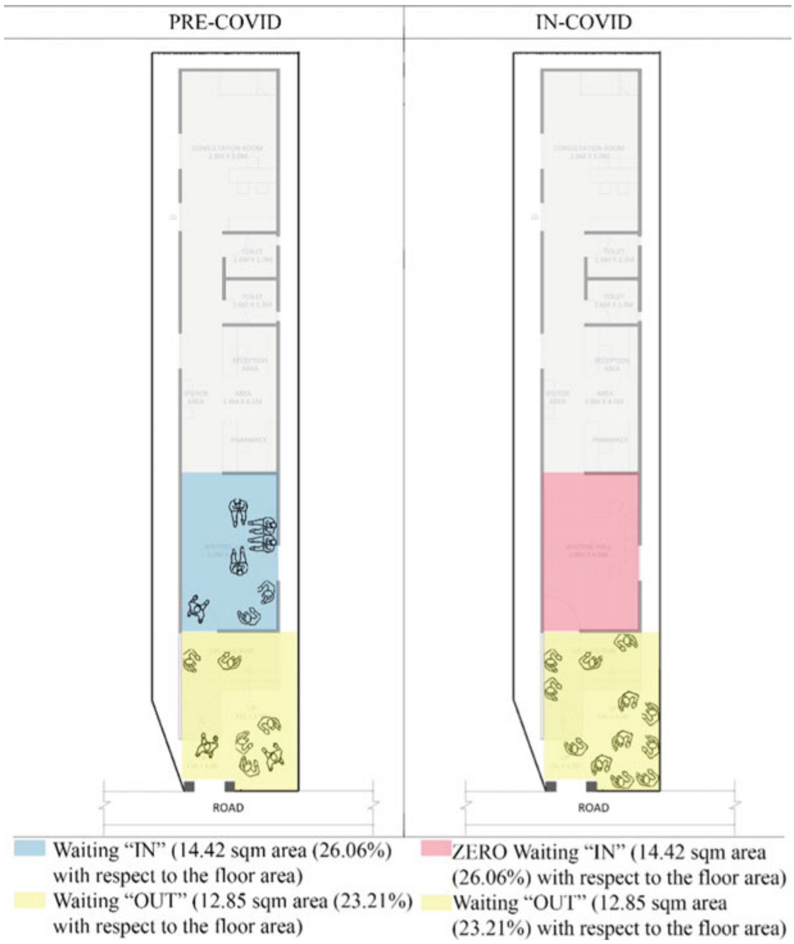


Fig. 17.12 Sample waiting area comparison in E-type

layouts need to consider the need for additional storage spaces as well as 'spill-over' spaces inside and outside of the clinic to deal with patient surges.

The reconfiguration in floor plans resulted led to a 50%–60% reduction in the path length traveled typically by a patient visiting the MC. The reduction in path length could be misinterpreted as an increase in the operational efficiency of the space. However, as environmental access was limited to the waiting space and registration, consulting, and pharmacy services were provided through the door and windows, there were conflicts in the patient workflows and an increase in service delivery times. Potential solutions to address the issue suggest need to consider a unidirectional patient workflow with separate entry and exit locations. Such an approach may necessitate new designs of clinics, or existing designs could be retrofitted to have unidirectional patient workflows. Such design decisions may have consequences for staffing and security.

As access to the inside of the MC was restricted, openings in the building's facade—the doors and windows—were repurposed as service delivery portals. While the relative merits of window-as-a-service-portal vis-a-vis the conventional consultation room approach need more fine-grained data for analysis, it is perhaps a good time to consider 'inside-out' layouts that utilize the window counter as a patient–staff interaction zone. The typical problems encountered while using the doors and windows relate to the difference in floor heights, insufficient size of openings, and resultant communication gaps between patients and staff. Potential solutions

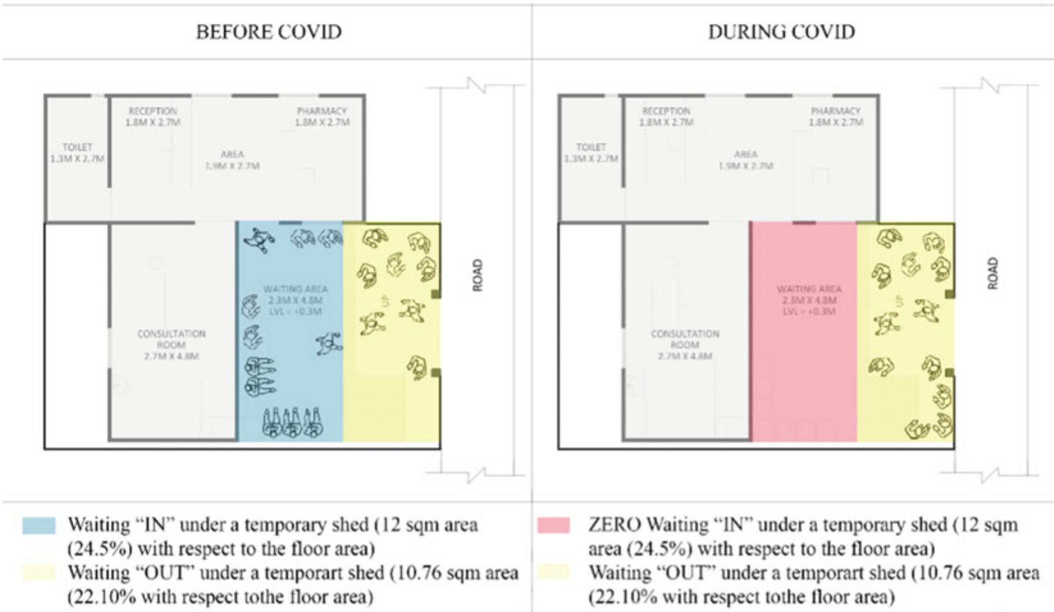
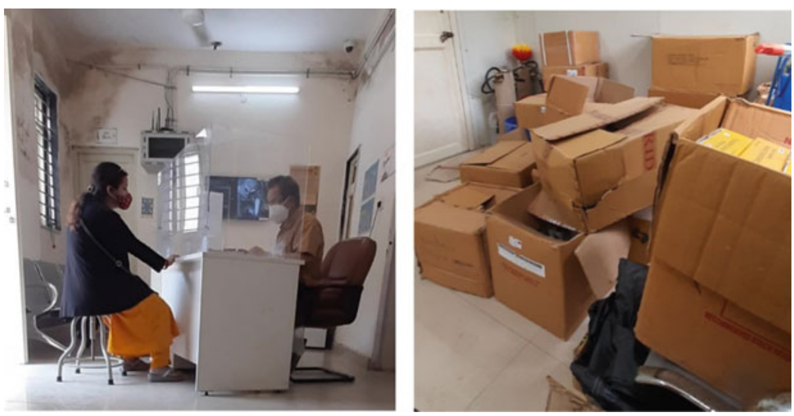


Fig. 17.13 Sample waiting area comparison in T-type

Fig. 17.14 Waiting space in MCs; **a** waiting space has been reorganized into other activities like; registration, consultation, and sample collection, **b** a part of waiting space has been used for medicine storage



could consider the design and development of flexible, modular building facades where one could modify the size and location of openings as required. The design choices for the openings would also impact other variables of the ambient environment such as daylighting and ventilation, as well as influence the staffing and security aspects of the MCs.

The design of waiting spaces—whether inside or outside of the MC—needs to be considered from the first principles. Waiting spaces inside the MCs were inadequate for the number of patients who were served by the space in the pre-COVID-19 condition. Current layouts have a one-size-fits-all approach with a capacity to seat twelve patients in the waiting hall. These spatial layouts are inflexible and cannot respond to the increased footfall of patients during a pandemic surge. The is a need to design flexible waiting spaces which respond to climatic needs and are informed by the cultural practices of the population. Waiting spaces should offer a mix of covered, semi-covered, and open-to-sky waiting areas to accommodate patient surges.

Fig. 17.15 MCs' typologies with different exterior openings in; **a** R-type, **b** E-type, and **c** T-type

Most of the MCs in the study were naturally ventilated. However, none of the clinics had at least 10% of the floor area as openings in the building envelope. The layouts and positions of openings could be reconfigured to enable cross-ventilation, and roof profiles could be modified to enable and improve the stack effect or other natural ventilation strategies. Simple strategies such as the use of a pedestal fan placed close to an open window and the use of wall or window air extractors could improve air circulation and indoor air quality (WHO 2021). A specific concern for natural ventilation in MCs is the levels of airborne pollutants, especially particulate matter in the ambient air during the winter months in Delhi. There is a need to reconsider ventilation strategies based on a multiplicity of factors such as site location, climate, prevailing wind direction, the topography of nearby buildings as well as the quality of the outdoor air.

In summation, findings from this research highlight the interrelationships between the five design features—floor plans, workflows, openings, waiting areas, and ventilation. Ad-hoc strategies to enforce COVID-19 safety protocols resulted in significant changes to the environmental design of MCs. While some design decisions maybe reversible, the experience of quickly repurposing space to meet COVID-19 safety standards provides strategies for design of safe and responsive healthcare environments. Juxtaposing these findings with the emerging body of literature on pandemic-resilient healthcare environments offers an interesting comparison. While there is convergence on the need for: (1) flexibility or versatility in floor plans and layouts, (2) clear channels for circulation and workflow, and (3) improved air flow and ventilation in both hospital settings and MCs, the unique social, environmentals and operational context of the MCs gives rise to additional design challenges. For example, there is need to reconsider the design of building fenestrations in MCs as the external doors and windows were the portals for patient–staff interactions. Additionally, the design of waiting spaces for MCs needs to be considered afresh given the need for flexible, safe, and surge-ready environments. In hospital settings, there is an emphasis on environments that support well-being as well as for seamless transitions between the physical and the digital experiences. While these concerns maybe also be valid for MCs, the pilot study did not identify these as critical factors which impacted the healthcare delivery experience.

The pilot study is by no means comprehensive. The research offers initial insights of how environmental design changes necessitated by COVID-19 pandemic impacted healthcare delivery in a limited sample of MCs. The use of rapid ethnography was a first step in understanding the contours of the issue and framing it through the lens of human–environment interactions. Limitations of the study include the short duration of the field research at each location. The focus of the pilot study was on capturing the diversity of design changes across the spectrum of MCs rather than an in-depth analysis of the human–environment interactions in each location. Future studies are envisaged to be of a longer duration at each location. This would enable the researcher to engage with the context and discover the cultural practices of the population. Findings from these studies would offer strategies to design pandemic-resilient community clinics that improve the quality and safety of the healthcare service for all users.

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18 Research on Resilience Regeneration of Old Community in the Post COVID-19 Era—A Case Study of Factory Community in Harbin

Jiayu Xie, Zhiqing Zhao, and JiXian Wang

Abstract

The epidemic era has affected and changed the residents' lifestyles, especially in China, where strict epidemic control policies have confined the majority of activities in the community. As a result, there is a growing demand for community space, and the existing spatial environment needs to be revised, especially in older communities. In the face of the impact of severe global public health events, the ability of community resilience becomes particularly important. This paper selects a typical old community named factory community in Harbin, which not only faces infrastructural problems due to its construction age but also has a more urgent need for resilient adaptation due to the aging population living there. This paper first constructs a research framework for community resilience and then explores the problematic aspects of spatial vulnerability from the residents' perspective. Besides, we draw on the Eisenhower matrix model to determine the highest priority resilience issues: activity space, parking facilities, and living facilities. We also propose some resilience enhancement strategies to deal with these critical issues by doing traffic diversion, public space creation, aging design, and barrier-free vertical transportation, which could provide a reference for other older communities of a similar type.

Keywords

Community resilience · Old communities · Satisfaction survey · Eisenhower matrix · Spatial resilience regeneration

18.1 Introduction

As the most fundamental component of urban systems, communities assume a crucial role in cities' spatial configuration and resilience enhancement, especially in the background of the new coronavirus. We are increasingly finding that communities are the most effective disaster management units (Koliou 2018) and that their resilience is directly related to the disaster preparedness of cities. In recent years, with the sudden outbreak of global public health epidemics, a great deal of research has been conducted to systematically learn from experience and improve our resilience to future epidemics (Wenping 2020).

In China, one type of community faces a more severe vulnerability problem: the residential areas built by the government or factory after the 1950s, which we call old communities. As their service age increases, they face problems such as a lack of public service support facilities and a chaotic

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environment (Chao 2011; Xinquan 2011). The earlier built-up spaces are no longer adequate for the current social function, so the community is gradually exposed to problems related to public safety and urban health problems. In addition, due to urban economics, relatively wealthy people have moved to new urban areas with advanced public services. In contrast, the composition of residents remaining in older neighborhoods has gradually become older and poorer, exacerbating the area's social problems. The epidemic exposed the vulnerability of already problematic old communities. Therefore, the question of how old communities should be renewed to achieve a healthy and sustainable development model has been a hot topic of thought in the past two years.

Nowadays, in the post-epidemic era, it is essential to learn from past experiences and build resilient communities in the face of the current spatial problems. Against the above background, this paper aims to explore the following research questions:

(1) Under the influence of epidemic, what are the vulnerability issues of spaces in the old community from the residents' perspective? Why do such problems arise?
(2) Due to the old community's limited economic and management capacity, how should the community prioritize issues among these numerous vulnerability issues to enhance environmental resilience most efficiently?
(3) How to enhance the health and adaptability of residents in the post-epidemic era through planning and architectural design, to strengthen the community's resilience in the face of unexpected disasters in future.

18.2 Theoretical

18.2.1 Literature Review of Community Resilience

Since "resilience" was introduced by ICLEI at the United Nations Global Summit on Sustainable Development in 2002, this concept has sparked urban planning research around the world. Resilience is generally defined as stabilizing, recovering, and adapting to risk shocks (Cutter 2008; Wang 2016; Chandra 2011). UNISDR 2009 defines "resilience" as "the ability of systems, communities, and societies that can resist, absorb, accommodate, adapt, transform, and recover from hazards in a timely and efficient manner" (UNISDR 2009). Community resilience is a scale refinement and extension of urban resilience. Community as the basic urban unit can significantly impact urban resilience. Mileti introduced the "Disaster Resilient Community" in 1999 (Mileti 1999). Since then, scholars have focused on the community scale and explored the concept of community resilience, evaluation system, and resilience enhancement strategies from a resilience perspective.

(1) **Community Resilience Evaluation System**

The community resilience evaluation system is the main way to carry out research from theory to practice and is the key research point. The researchers selected different evaluation components in different socio-cultural contexts. The content of the community resilience evaluation system usually includes social, economic, ecological, institutional, and community member dimensions. We can refine the evaluation content into two dimensions: spatial resilience and social resilience. Spatial resilience usually includes service facility resilience, infrastructure resilience, public space resilience, community environmental resilience, etc. Such as coastal communities assessed with critical infrastructure, transportation facilities, and mitigation measures (Sempier 2010). Social resilience usually includes disaster response governance capacity, learning self-healing capacity, social engagement, economic composition, and social relationship networks (Luo 2021). Such as Arbon assesses community connectivity, vulnerability levels, response, and recovery procedures for the US community (Arbon 2014). In addition, some studies combine spatial and social resilience in the evaluation system, such as Alshehri, who constructed a comprehensive resilience evaluation system using six aspects of social, economic, physical and environmental, health, information, and communication as evaluation components (Alshehri 2015). In general, each region's resilience system differs in its evaluation content according to its attributes. It can be categorized into two aspects: spatial resilience and social resilience. This paper focuses on spatial resilience and refers more to the evaluation system of spatial resilience in selecting indicators.

In addition, there are two perspectives to evaluating community resilience. The first perspective is from top to down, which means that these studies used interviews with experts and experienced technical staff, who usually possess a professional, academic, and official point of view (Sempier 2010; Arbon 2014; Alshehri 2015). The second perspective is from down to up, which means that these papers usually interview people of different structures in the community who stand in the perspective of public life, such as grounded theory and questionnaires (Zhou 2014; Davis 2005; Peacock 2010). This paper selects the second one, researching community resilience from residents' perspectives.

(2) **Community Resilience Enhancement Strategies**

There are three ways in the study of community resilience enhancement strategies. Firstly, the research cases still need to establish a resilient community system. They conduct a resilience evaluation and then propose a transformation strategy. Secondly, the research focus on a specific public event. To prevent event shocks, scholars carry out resilience evaluation and strategy studies. Thirdly, the research cases have established a flexible community system. The community was assessed for resilience cycles, then evaluated for feedback. Sustainable regeneration strategies are studied in this kind of cycle. The specific strategies can be summarized into four aspects: spatial strategy, facility capability enhancement strategy, governance strategy, and social system strategy (Himes-Cornell 2015; Toseroni 2016). The spatial evaluation content corresponds to the spatial strategy and the facility capability promotion strategy. The social resilience evaluation content corresponds to governance strategies and social system strategies.

In conclusion, community resilience has accumulated research in terms of definition, connotation, evaluation system, and improvement strategy. In particular, the literature on how to build the evaluation system and evaluate and sort out the evaluation content provides a reference for this research paper. However, the existing research in community resilience still has drawbacks. When studying the community resilience of specific issues, some cases are limited by the economic, institutional, external environment, and other factors in transformation and promotion. The research content should be analyzed from the perspective of specific problems. The areas with economic and management capacity constraints should prioritize resilience events and focus on the most critical issues to enhance resilience most efficiently. For example, Lucia Barchetta used the Eisenhower priority matrix based on the evaluation model in the historical urban regeneration evaluation. Take "urgency" and "importance" as the horizontal and vertical coordinates to evaluate the priority of each element of each dimension (Barchetta 2023).

18.2.2 Theoretical Framework

First, we build the goals and indicators of community resilience by the referee of the lectures. The main research content and purpose of the corresponding article, based on the summary and definition analysis of "community resilience", bring in the specific research context of "old community" and take "post COVID-19 era" as the recovery background of resilience system. In the post COVID-19 era, we pay more attention to the spatial pattern and environmental composition of old community, to achieve public space flexibility, facility flexibility, and environmental flexibility. Public space resilience is realized through four indexes: activity space, emergency space, street space, and entrance. Facility resilience is realized through rescue facilities, culture facilities, living facilities, and parking facilities. Environmental resilience is realized through seasonal adaptation, space ventilation, and space thermal comfort.

Secondly, according to the existing community resilience evaluation system, we distribute questionnaires to obtain resilience problems in old communities from residents' perspectives. Then we referred to the Eisenhower priority matrix method (Barchetta 2023), which defines the X-axis and Y-axis as "satisfaction" and "importance". It can screen the highest priority among many resilience problems. And then carry out corresponding analysis and improvement. Thus, we can compensate for more consideration of implementation ability and economic capacity in community resilience research.

Finally, a targeted space design is formulated according to the highest priority problems we found in the above analysis (Fig. 18.1).

18.3 Practical

18.3.1 Case Study Area and Basic Information

This old community is situated in Heilongjiang, the most northern province in China. As such, it has extreme seasons with an average annual temperature difference of around 50 °C (Fig. 18.2), which increases the difficulty for residents to have outside activities in winter, which presents a challenge for outdoor public spaces.

This case study covers an area of approximately 20 hectares (Fig. 18.3), with a relatively abundant supply of public services around the base. We conducted a field survey of educational facilities, infrastructure, sports facilities, and medical facilities around the site, and we found that public resources and services around the site are adequate when people can get out of the community (Fig. 18.4).

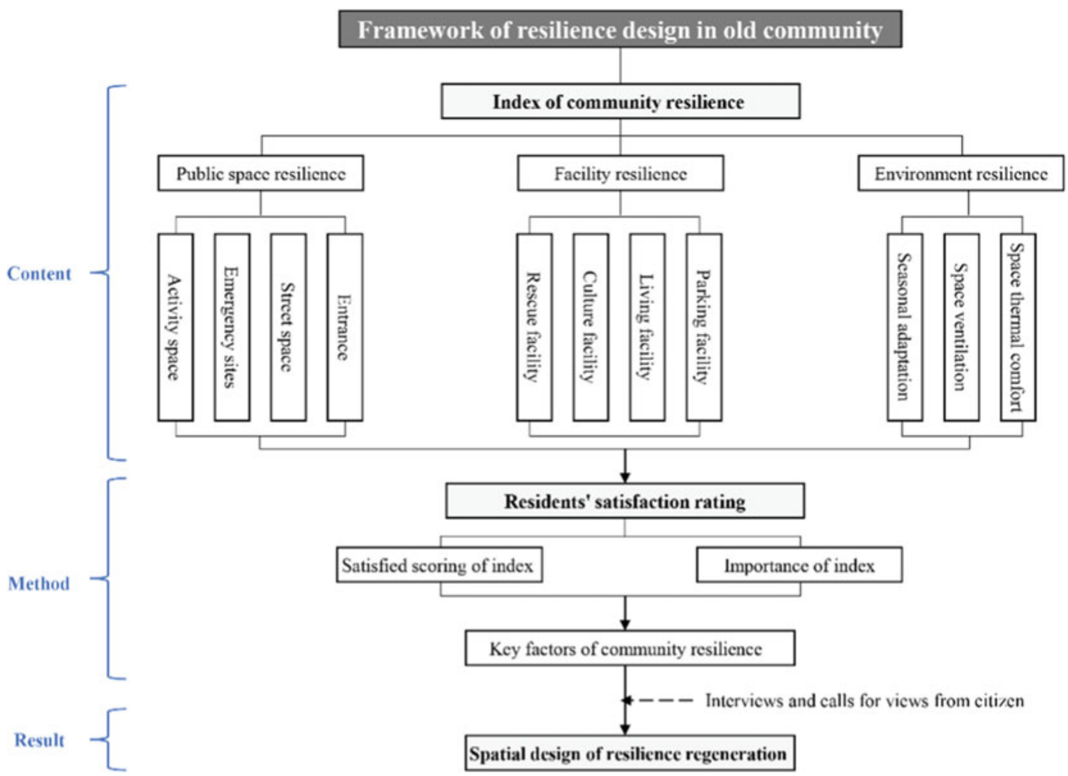

Fig. 18.1 Theoretical framework

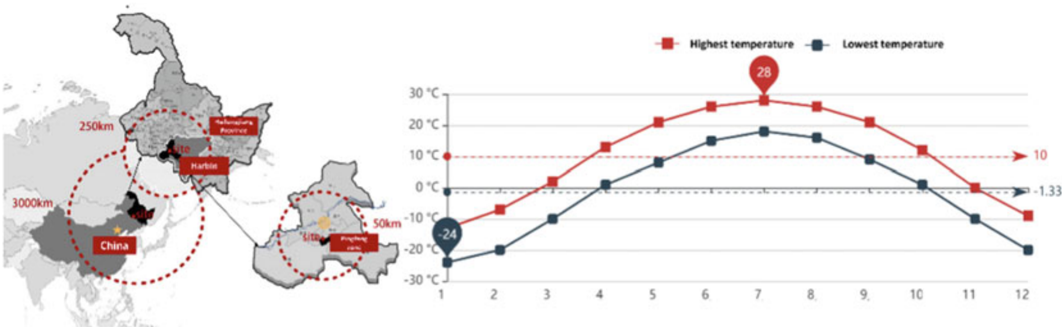

Fig. 18.2 Location and temperature of the case

This community was built alongside the factory to provide accommodation for the workers there. As a result, unlike modern communities, residents here are colleagues and relatives of each other, and they have a close and friendly neighborhood relationship with a stronger need for interaction. As the factory has grown, the people living here have gradually aged, and the area is now largely dominated by older people, which has exacerbated the community's challenges in the face of the epidemic.

Fig. 18.3 Site scale

18.3.2 Plan of Survey

Considering the aging of the residents, the research was conducted entirely offline, with face-to-face assistance to the respondents to fill in the questionnaire (Fig. 18.5), which was set up in two parts: firstly, the basic information of the respondents, including age, occupation, family members, etc., which helps to analyze the characteristics and demands of various groups of people; secondly, a survey on community resilience was conducted on the satisfaction and importance of the specific 11 resilience indicators we summarized above, which are divided into three areas: public space resilience, facilities resilience, and environment resilience. A total of 100 questionnaires were distributed.

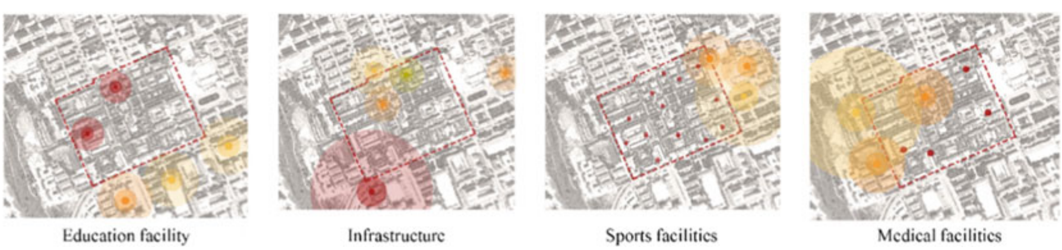

Fig. 18.4 Facilities around the site

Fig. 18.5 Researcher guided residents face-to-face in filling out a questionnaire

18.3.3 Behavioral Change in the Context of the Epidemic

In the first section of the survey on basic information about the respondents, it can be seen that the epidemic has had an impact on people's lifestyle and the social structure of the community.

(1) Changes in the Characteristics of Residents' Activities

China has maintained a strict epidemic prevention policy. When there are confirmed Coronavirus cases in the area, communities will be locked down, while the entrances and exits are strictly controlled to prevent the virus transmission. As a result, although the factory's community is used to be an open community, it became relatively closed in the background of the epidemic. Only four entrances were retained for community management, thus changing people's routes of movement, which increased the difficulty of enjoying the public services located around the community, such as shopping centers and gymnasiums. As a result, public spaces within the community have become more critical than before.

(2) Changes in the Social Structure of the Community

Unlike the advanced urban area, the factory's community was built as a supporting residence for the workers, which possessed a very close neighborhood relationship with a very enthusiastic need for communication between residents. However, the epidemic led to factory stoppage and an economic downturn. Hence, the younger generation who used to live here went out to work and no longer depended on the status of this factory, causing an increasingly older population who had to live alone to remain in the community. Facing this change in social structure poses a more significant challenge to build resilience in the community.

In conclusion, through the preliminary analysis of the site survey and questionnaire, we believe that this old community not only faces the problems of an aging environment and insufficient public space during the epidemic but also the challenge of aging population.

18.4 Methodological

18.4.1 Research Method

In response to the three research questions, this paper follows a three-step approach to studying community resilience (Fig. 18.6).

In the first step, we analyze the data obtained from the questionnaire, aiming to analyze the resilient problems in the spatial environment of this old community. During the evaluation, residents scored the satisfaction and importance of each 11 resilience indicators. Satisfaction scores represent the actual situation of the indicator, and importance scores represent the extent to which the indicator affects residents' lives.

In the second step, we referred to the Eisenhower matrix to analyze the highest priority resilience issues among many such problems, aiming to suggest a chronology of solutions for the community with limited money and management ability. It has operational and practical implications for the community that are less autonomous and economically challenged.

In the third step, the paper provides planning and architectural improvements to the community's resilience about the key priority issues in step 2, to improve the community's happiness

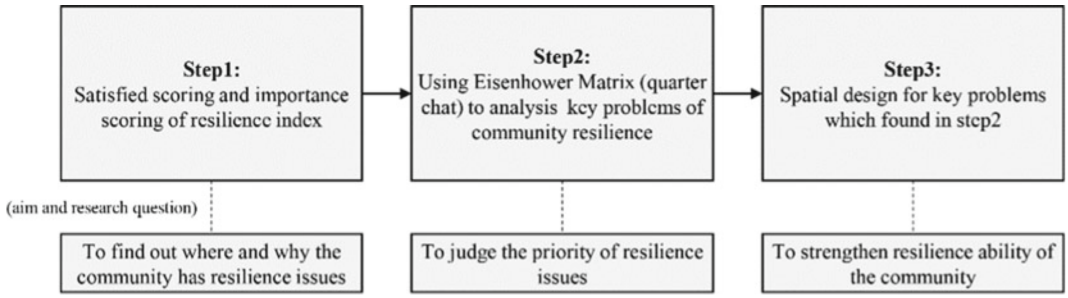

Fig. 18.6 Research design

and resilience in the face of similar disasters. It is worth mentioning that these improvements are locally implementable and available.

18.4.2 Evaluation Results

In the evaluation process, each indicator condition n is divided into five levels, i.e., n = {very dissatisfied, less satisfied, average, more satisfied, very satisfied} corresponding to an evaluation score of 1–5, m = {no impact, low impact, average, high impact, extreme impact} corresponding to an importance score of 1–5, then the single satisfaction value is $B = \sum^{i} ni \times \frac{Ni}{M}$, and the single importance score is $I = \sum^{i} mi * \frac{Ni}{M}$, where Ni refers to the number of residents who rated ni and M is the total number of residents who participated in this evaluation; thus, the satisfaction and importance of each factor in community resilience are calculated (Table 18.1).

This bar chart (Fig. 18.7) shows residents' satisfaction with this community resilience index. As we can see, the overall satisfaction with environment resilience is the highest. However, under this target, that seasonal adaptation is in a poor situation, with residents generally believing that there is no solution to the extreme weather in Harbin. Hence, the community is relatively comfortable in summer but reluctant to engage in outdoor activities in winter.

The second is public space resilience, which has a satisfaction value of 3.43, but there is a wide variation in different indexes. They were particularly dissatisfied with the small squares in the middle of each circle building, as they were overrun with clutter, temporary facilities, and vehicles, preventing the elderly from moving around.

The lowest overall satisfaction was facility resilience, which means that in this old community, there is an urgent need to optimize the spatial facilities, especially during the epidemic. People generally reported that the amenities were not convenient, such as waste disposal, lighting, and accessibility, and there was a lack of parking and cultural facilities in this community. In contrast, we were surprised that residents felt that rescue facilities and epidemic prevention facilities were adequate, which shows the work done by community staff and the government in these two years since the epidemic. We should focus our efforts to improve community resilience on restoring people's lives.

18.4.3 Priority Resilience Issues Judgment

Satisfaction reflects the effectiveness of community resilience work during the two-year pandemic, but it also reveals problems. Residents, as the main body of the community, have excellent reference significance in terms of their willingness, which is also the critical basis for the improvement of community disaster resistance in the next step. In order to reflect the advice of residents and the urgent problems, we referee to the Eisenhower matrix, which was initially an effective tool in the business field to help

Table 18.1 Results of survey

Target	Index	Satisfaction	Importance	Target satisfaction
Public space resilience	Activity space	2.7	4.25	3.4375
	Emergency sites	3.8	4.25	
	Street space	4.15	3.03	
	Entrance	3.1	3.25	
Facility resilience	Rescue facility	3.6	4.1	2.8625
	Culture facility	2.8	3.35	
	Living facility	2.25	4.43	
	Parking facility	2.8	3.8	
Environment resilience	Seasonal adaptation	3.1	3.1	3.86
	Space ventilation	4.43	2.8	
	Space thermal comfort	4.05	2.7	
Average score		3.343636364	3.550909	/

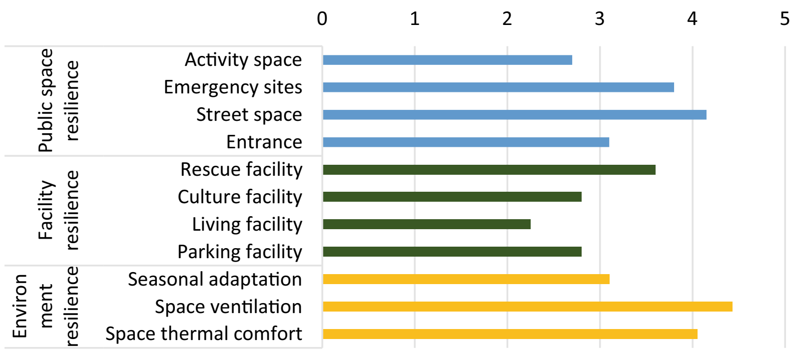

Fig. 18.7 Satisfaction from citizens of this community resilience indexes

enterprises prioritize tasks according to their urgency and importance. It was subsequently introduced more and more to various fields such as economy, consumption, and urban management. It is also known as the quarter chat, one of the main models in satisfaction research. It correlates the satisfaction and importance of resilience indicators to form a quadrant chart, in which the Y-axis reflects the residents' satisfaction scores, and the X-axis reflects importance scores. The quadrant chart is divided into four quadrants, with quadrants 1–4 named A, B, C, and D quadrants by us (Fig. 18.8).

In-depth analysis shows that Zones A and B indexes have a high level of satisfaction, which is an affirmation of the community resilience situation and work, and should continue to be strengthened in the future based on maintaining the status quo. The indexes within Zone C have a lower level of satisfaction. However, residents also consider them to be of relatively low importance, which means that although the actual presence of these indexes is poor, they currently have a moderate impact on the lives of residents. Although they need to be improved in the future, they are not a primary consideration in the current community resilience enhancement efforts. In contrast, the indexes within D zone processes have a higher importance but a low level of resident satisfaction, which suggests that this is the critical point of conflict that affects residents' lives, making them uncomfortable. These indexes are in urgent need of improvement. According to the statistical results, the critical problems that need to be addressed in the Harbin factory's community are currently focused on

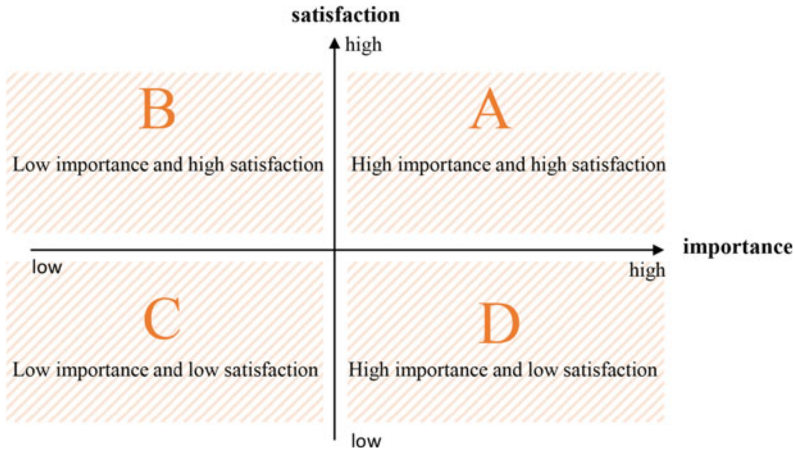

Fig. 18.8 Referee Eisenhower matrix to resilience quadrant chart

three areas: parking facilities, activity space, and living facilities (Fig. 18.9).

Firstly, as the factory's community was built in the 1970s, there was not much consideration for parking space at that time, so the original transportation space became limited when it entered the modern era. During the epidemic, private cars were favored by residents as a necessity for almost every household, especially in the post-epidemic era, stimulating the purchase of private cars, which made the parking problem more intense. As a result, we can find cars parked everywhere, even occupying the pavements and the activity spaces in the center of the compound, disrupting the spatial structure and traffic order.

Secondly, the activity space has become confined due to the occupation of vehicles and other facilities. Residents report that they hardly could play chess or chat outdoors in these two years because of the space limitations, which makes the otherwise harmonious and close community neighborhoods fragile and lifeless, especially for the elderly. The limited space for interaction and exercise is not conducive to the physical and mental health of the elderly.

Finally, there is a great deal of dissatisfaction and demand from residents regarding amenities. Due to the old age of the community construction, the spatial layout and building functions are no longer adequate for the present life. For

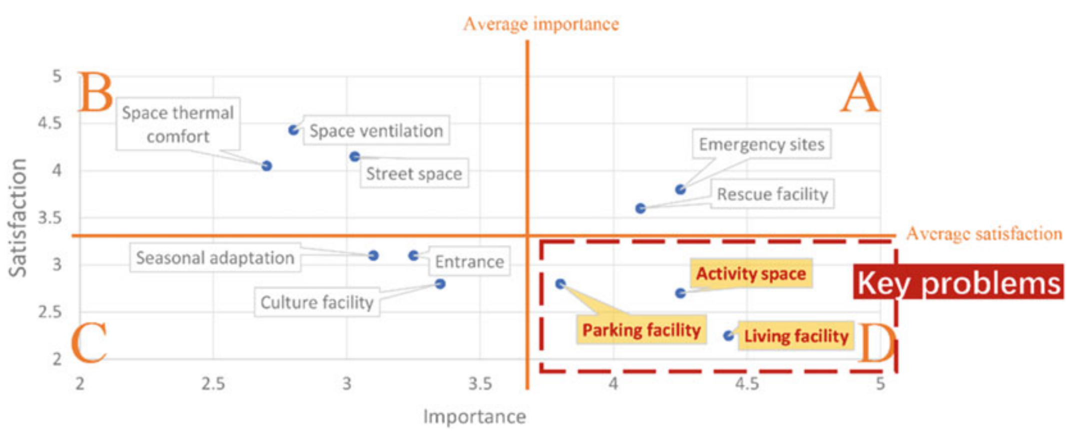

Fig. 18.9 Related analysis of the importance and satisfaction of resilience indexes

example, there are almost no accessible facilities designed for the elderly, which makes it more difficult for them to live alone. It forces them to stay upstairs for a long time during the epidemic, which shows that the residents also demand social space within each building. Meanwhile, the community's rubbish collection facilities were inadequate, and the accumulation of rubbish in the community made life even worse and unsatisfactory for residents, especially during the epidemic when the community's circulation system was closed, and even the city's transportation system was down.

18.4.4 Spatial Design of Resilience Regeneration

Through satisfaction surveys and Eisenhower matrix analysis, we can find that the key resilient issues of factory communities in the post-epidemic era focus on two aspects. Firstly, residents' demand for quality public space and interaction is reflected in the feedback on the activity spaces' resilience. The squeeze on other functions, such as parking, has led to a need for more public spaces. Secondly, the spatial mobility of the elderly walking alone during the epidemic state is mainly reflected in the feedback on the living facilities' resilience, which is more prominent for the age-appropriate design and barrier-free design in the living space. We designed public spaces and living spaces to respond to these two aspects.

(1) Upgrading Public Space: Combining Parking System and Public Activities

Due to the limited space in the old community, we plan to create a vertical space system in the conflict area between the original parking function and public activities, with the ground level being used for parking and the upper level for community activities. We also consider the accessibility needs and seasonality in this platform design.

Firstly, we demolish the inner courtyard shacks and sort out the temporary parking in the community (Fig. 18.10). We propose a vertical two-story space system, planning the parking flow and concentrating scattered vehicles on the ground level (Fig. 18.11). The ground floor of the parking space is used as a public green interaction space, while an activity platform is built on top of it.

Secondly, we divide and raise the public space level to gain south-facing light and avoid cold winds from the northwest. Raising the public space level and cutting the form make it possible to gain a larger area of light and more hours of light in the cold winter months when the sun's height angle is reduced (Fig. 18.12). It maximizes the use of natural light in the cold winter months and increases the resilience of the space throughout the season. Also, the vertical two-level spatial system enhances spatial efficiency and improves spatial resilience.

We completely consider accessibility design and introduce a ramp system in the raised public space system for the elderly (Fig. 18.13). The maximum height difference of each section of the ramp is 750 mm, the maximum horizontal length is 9000 mm, and the minimum ramp width is 1200 m. At the same time, the footrest platform will be expanded into a space platform of different functional characters as a transition tandem to increase spatial toughness.

Fig. 18.10 Sort out and demolish the inner courtyard shacks and temporary parking

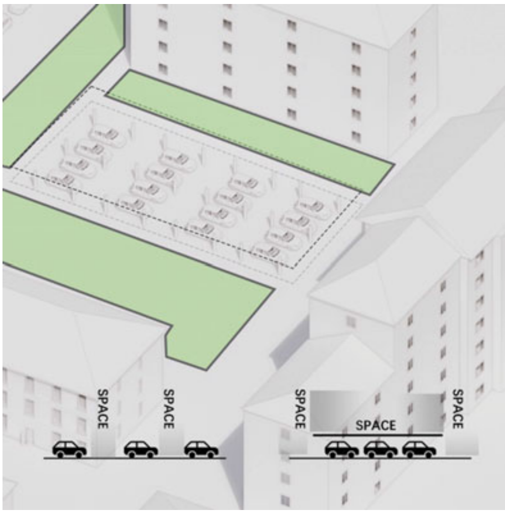

Fig. 18.11 Parking on the ground floor

Fig. 18.13 The accessibility design and a ramp system

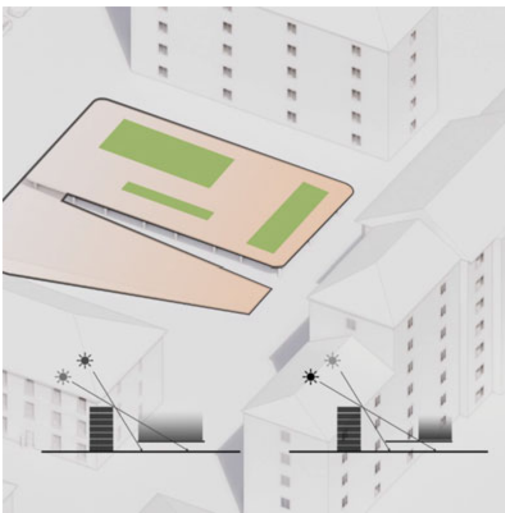

Fig. 18.12 Upper activity space when concerned with seasonable adaption and unique efficiency

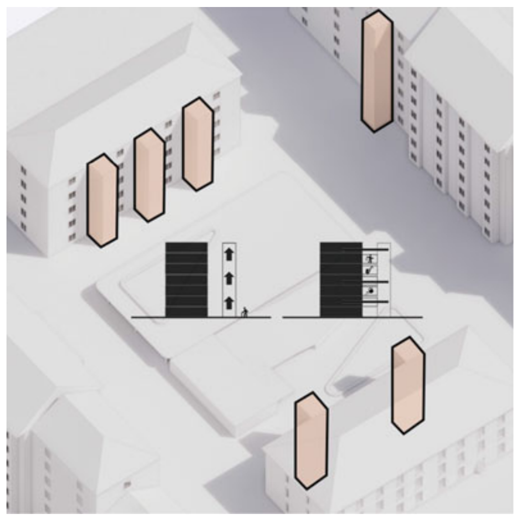

Fig. 18.14 Barrier-free vertical transportation

(2) Upgrading of Living Space: Barrier-Free Facilities and Indoor Interaction Spaces

In residential buildings, we promote new types of barrier-free vertical transport (Fig. 18.14). Adding an external steel lift to the traffic box solves the difficulties of vertical transportation for the elderly. This technology has already been implemented in many old communities in Harbin, which means that it is universal and feasible to solve the problem of inconvenient access for the elderly outside the building. Also, the connecting spaces can be used as a functional extension of different individualized community spaces. It forms a set of new indoor public space nodes where older people can engage in small indoor social activities at the lift connections on each floor. Thanks to its glass material, the elderly could also enjoy sunbathing here. For the cold Harbin, the addition of such auxiliary functional spaces can also act as a "spatial buffer", which has a positive effect on lighting the interior spaces and increasing their resilience effectively.

18.5 Conclusion

Through research on factory communities in the post-pandemic era, we found that people's needs have changed under the impact of the pandemic, which poses new challenges to spatial resilience. Through the literature review, we summarized the indexes of spatial resilience in the old community into three aspects: public space resilience, facility resilience, and environmental resilience. And then, we investigated spatial resilience from the perspective of residents. We found that the epidemic had confined most of the residents' activities within the residential area, causing the community space to become even more unavailable to satisfy people's demands, such as public activity spaces, living facilities, entrance spaces, seasonal adaptation facilities.

However, since limited financial resources and governance capacity often constrain old communities, how to efficiently and effectively improve spatial community resilience highlights this paper. We used the Eisenhower matrix methodology, combining the "importance" and "satisfaction" results scored by residents on each resilience index, to judge the highest priority and key spatial resilience issues among several problems, namely activity space, living facilities, and parking facilities. In response to these three resilience issues, we designed from the two aspects of activity space and living space, trying to solve these three resilience conflicts while considering the aging problem and extreme climate issues.

It is worth mentioning that different groups have different reactions to the epidemic and opinions on community resilience. For example, young people prefer co-working spaces in the community while epidemic, as well as spaces that are convenient enough to transport, which includes their parking needs for commuting. In contrast, older people prefer an excellent communal environment for more physical exercise and social interaction to release emotions. Therefore, it is also essential to consider inclusive design in limited community space in the post-pandemic era. In our design strategy, we also tried to respond to outdoor spaces from the perspective of different groups of people, designing a vertical two-level spatial system that considers parking and activity functions. We propose the strategy of re-enhancing the spatial resilience of the old community in the post-epidemic era from an all-round and multi-level perspective, which is expected to provide a reference for a similar type of community.

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19 24 H of Happiness: A Child-Initiated COVID-19 Response to Reopen Schools, Mitigate Prolonged School Closures and Rebuild Resilient School Communities

Ruchi Varma and Tarusha Mishra

Abstract

About 1.5 million schools were shut after March 2020 across India which impacted 247 million children enrolled at elementary and secondary schools. Children from poorest households were five times more likely to be out of primary schools than those from the richest (UNICEF 2020). The online mode of learning was largely been inaccessible for children from marginalized communities, economically weaker backgrounds and physical or mental disability. When COVID-19 struck, India witnessed mass migration, inequities surfaced and schools were closed for 600 days for the youngest students. This became the second largest school closure globally. Young students sent WhatsApp texts willing to be seen, heard and be part of the support ecosystem. One message from one child (age 11 year old) reimagined a holistic school reopening solution that was backed by evidence-based data collected by community, codesigned solution and actionable representation through a core team where children had an equal seat at the table. Through human-centered methodology, over 2000 + families are participated in the process between July 21 and March 22 translating into a child-initiated adult-supported effort—the highest form of participation (Hart, R. A. (1992). Children's participation: From tokenism to citizenship. Florence, Italy: United Nations Children's Fund International Child Development Centre.). The intervention not only embraced Sustainable Development Goals principles to leave no one behind, in particular such as SDG 3, SDG 4, SDG 11, SDG 16 and SDG 17, but gave birth to a systematic community-driven approach that activates SOPs, decentralizes power from state to school, prepares for resilience among new waves, school closures, shocks and stresses. Empowered young voices become change makers and active participants that push for change and long-term sustainability.

Keywords

Resilient communities · Children · Sustainable development goals · SDG 4 · COVID-19 · School closure · Codesign

19.1 Introduction

The Indian Education System is one of the largest in the world with more than 1.5 million schools, 8.5 million teachers and 250 million children from varied socio-economic backgrounds (UNICEF 2018). India envisions and commits to providing

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all its children an equitable and inclusive access to quality education aligning to SDG 4, as the signatory of Sustainable Development Goals (SDGs), along with its National Education Policy (NEP), 2020, and Right to Education Act, 2010. However, with the schools shutting down in India for 257 million children in March 2020 due to the pandemic (Sharma 2022), the entire school ecosystem was left perplexed to continue education. Schools have been understaffed, under-resourced and overburdened with work and responsibilities beyond academics in India (Datta and Kingdon 2022a, b). These challenges when combined with adverse impacts of pandemic-induced school closure still prevail even after they have reopened (Yadav 2022).

The massive disruption of the education calls for a need to build resilient school communities that can tackle any such future shock. Three main areas need our focus:

- People-centric approach: During the pandemic, developed countries like Canada and France shut their schools only for a few months, but resumed their education sector before any other sector in the country. Denmark and the Netherlands were focusing more on the reopening of the primary wing classes (nursery to 5th) so that students do not miss out on their foundational years of learning. India on the contrary had seen the second longest school closure due to COVID-19. Students below class 5th did not get a single opportunity to learn what school is for the next 2 years from 2020, whereas higher class students only visited school for exams. Two batches of tiny tots began their school life with online classes.
- Multi-hazard approach to prevent discontinuation of school: Even before the pandemic, multiple reasons have been causing student absenteeism in pre-COVID scenarios. These include pollution, heatwaves in summers and riots due to political unrest to name a few, quite critical to the achievement of SDG 13 in the context of natural disasters and hazards. While interventions should attend to the specific local hazards, a multi-hazard approach can enhance resilience to a broad array of potential adversities (Pfefferbaum et al. 2014).
- Community engagement and participatory approach: The participation of individuals and organizations that reflect the composition of a community contributes to its resilience (Pfefferbaum et al. 2014). A top-down approach in planning for reopening of schools left schools with no other option but to prepare for reopening in ad-hoc approaches. Governments have a unique opportunity to leverage SDG 16 and SDG 17 for innovation.

19.1.1 Emerging Culture of Codesign and Collaboration

In such a challenging and stressful environment, a school in Delhi, India, took a chance to leapfrog to accelerate the SDGs, initiate activities that align with NEP and allowed students as young as 9 year to participate in decision-making on matters that affect their everyday life. In 2019, the case school had collaborated to explore a human-centered design project that enables a vision to develop safe access to their school (Varma R 2021). The school for the study is located in the southern part of New Delhi. It comprises students from class pre-nursery to 12th with about 60% boys and 40% girls studying together. In the year of study (2021–22), the school had 2300 students. Students come from various social-economic backgrounds, disabilities, religion and neighborhoods. One hundred and ten staff members are divided into teaching, administrative and support staff. Each member of the school was impacted during school closure. However, it was one student from the design cohort that decided to reclaim his happiness and right to be at school in the pandemic.

19.2 Method and Process

Community resilience is about individual and community's ability to respond to change (Magis 2010a, b). The message sent by a student came at

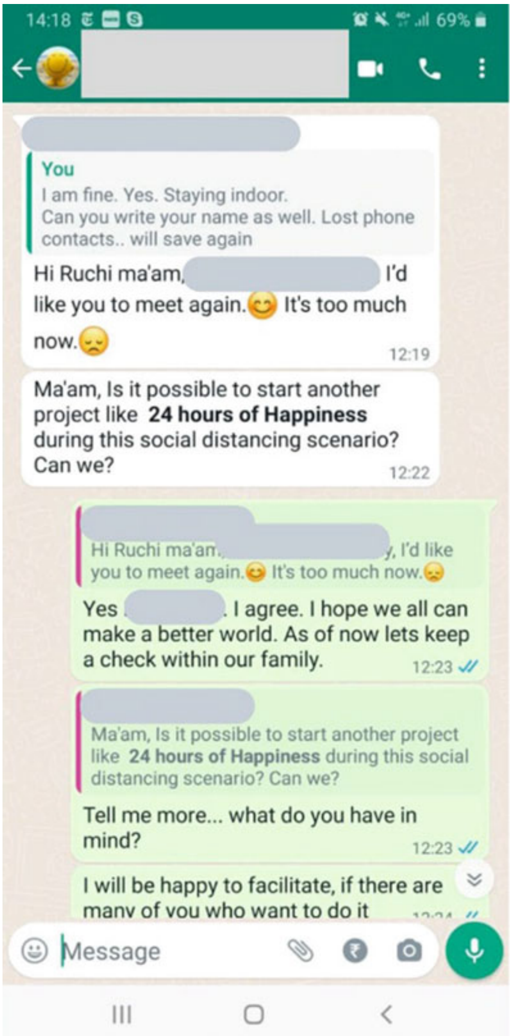


Fig. 19.1 Message sent by a school child at the peak of the second wave of the COVID-19 pandemic in India, asking to spend quality time with friends during socio-emotionally difficult times during COVID-19-induced school closure (Author 2021)

the peak of the second wave of the COVID-19 pandemic in India (Fig. 19.1). This child-initiated response demanded the larger community to come forward, extend care and compassion for those who haven't been to school for 1 year now and look at disruption as an opportunity for innovation. The starting point was to get in touch with the head of the school and seek interest to translate this into a child-initiated adult-supported effort—the highest form of participation (Hart 1992).

19.2.1 Ground Zero—Starting Point

The people who looked at school management, respective wing and day-to-day school transportation needs continued to do so in the COVID-19 pandemic. However, they did not have tools, data or a result-based approach that could help them grasp this complex problem.

To bring the students back to school, the first step was to look into the norms and SOPs prepared for schools. To solve the problem of discontinuation of education for children during COVID-19 pandemic, the central and state governments issued and revised guidelines and SOPs on reopening schools from September, 2020. The schools only reopened for senior students so that they complete their classes and do not miss out on college and higher education applications. Students from grade 8 and below, like our student and his classmates, only waited for their turn. In 2021, many international organizations like UNICEF and World Health Organisation (WHO) also came up with COVID-19 safety guidelines for school reopening.

19.2.2 Orienting the Community Through an Integrated Framework for Action

Any guideline and Standard Operating Protocols (SOPs) issued are always seen as an extensive document by the school. The schools review these documents but can only translate it into action based on the available resources, available capacity and funding. Pre-COVID-19, schools were oriented toward SDG goals and targets as part of the Sustainable Development mandate. The SDGs are structured in a result-based framework with goals, targets and indicators. Most efforts were at an alignment with the goal or at target level during school access project. No measurement tools were available.

A SDG-inspired strategy was adopted to engage the school in an action-oriented approach. A cohesive list of protocols to reopen schools was compiled from various guidelines. Similar to the spirit of the SDGs, the '8 Pillars of Reopening' framework became the core of the reopen procedure and all activities of the plan rested on these pillars to make reopening safe, equitable and compassionate. Each pillar was subdivided in sub-themes for creating specific streamlined working plans to reopen school and strengthened SDG 4 as well as SDG 17. Such a framework helped prioritize activities with school management and seed a community-led movement for school reopening (Fig. 19.2).

19.2.3 School Preparedness

The aim to create an effective plan started by measurement of the school preparedness on the eight pillars. The current school team, also referred to as the task force, was anchoring the planning of school reopening efforts with limited technical capacity. They were invited over an online call. The teachers regrouped on an online call after dinner hour to share responses. Break out rooms were created and teachers responsible for every pillar were interviewed by the team. The collective responses were put together in an empathy-based metric called the 'Compassion Scale', assigning schools' level of preparedness across eight pillars in five categories (Fig. 19.3).

The approach was to build community in a time when the school and teachers were impacted or continued struggling with loss of life, poor health—physical, mental and skewed division of labor induced by the pandemic. The name of point-based scale stemmed from an intention to bring the community together rather than punish for weak/poor preparedness.

Based on the results, the school was able to regroup and develop the next set of activities (Fig. 19.5).

It was clear from the baseline results that school reopening cannot be achieved by a single stakeholder group or school management alone. A call to the community (2000+ school families, 100+ staff members) was prepared where all parents, students and staff members were participated in orientation hour, online. Five such hours were planned, four of them for parents over a weekend. About 900 parents attended the live sessions.

The live sessions, or orientation hour, was to share the message of the student, onboard a community-led approach and motivate all stakeholders to participate. All stakeholders were

Fig. 19.2 Eight pillars include school overview, access and travel, sanitization, learning, health and well-being, marginalized community, finance and communications, covering 125 pointers (Author 2021)

I am very hopeful and confident about schools opening safely soon now. And happy about being in a great team to make that happen.

- Junior Wing Supervisor

Fig. 19.3 Testimonial of a school teacher after feeling a sense of confidence through the framework (Author 2021)

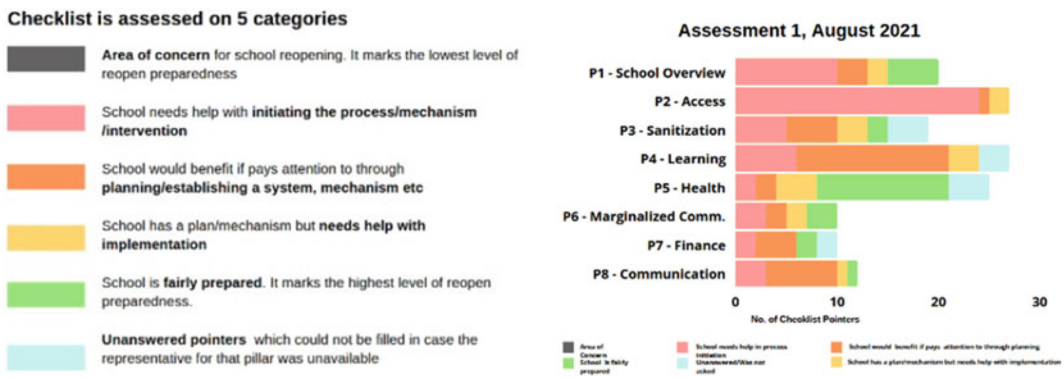


Fig. 19.4 Empathy based metric called the ‘Compassion Scale’, with 5 assessment categories (*image to the left*) mapped school preparedness across 8 pillars (*image to the right*) in (Author 2021)

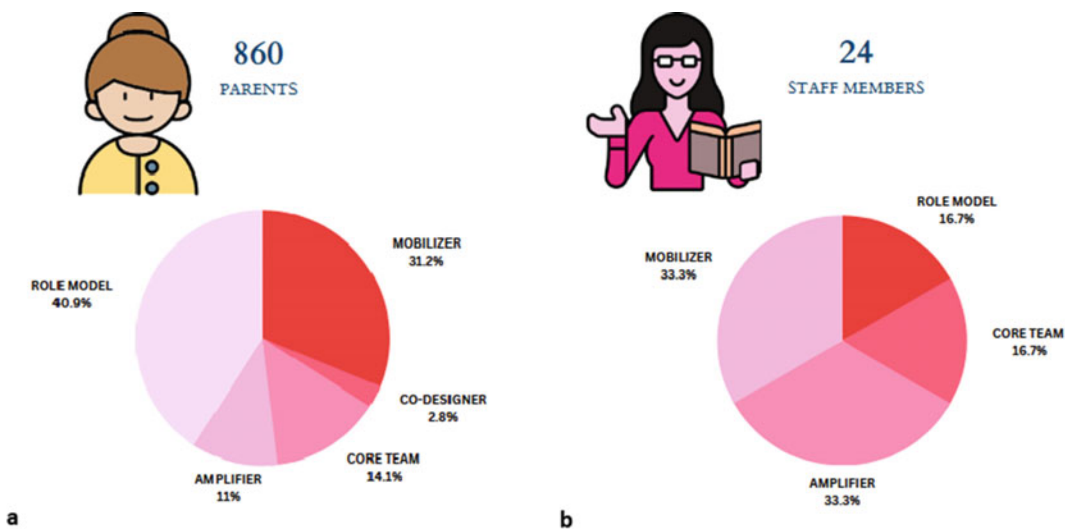


Fig. 19.5 Results of the roles selected by **a** parents, and **b** staff members to make their contribution in reopening the school safely (Author 2021)

asked to fill up a Google Form to take up one role from the following:

1. Core team: Be an active part of central reopen committee/team.
2. Codesigner: Build a blueprint of action; working closely with human-centered approach.
3. Amplifier: Simply use the power of social media to share the developments.
4. Mobilizer: Motivate peers to make this a community-led response.

19.2.4 Codesign Workshops

The human-centered design curriculum from 2019 and its activities were customized for the eight pillar frameworks. Three different cohorts were established within the school' community to participate in the codesign workshops to activate the blueprint through community-led solutions. Sixty-five students including our student who texted, his classmates and students from age 8,9,14 formed the cohort for children. Conventionally, children have not been involved in decision-making processes that impact their lives. The pandemic as a crisis was turned into an opportunity for empowering young minds and creating grassroot change at the school community level (Fig. 19.6).

The students were asked to join at 8 am to participate in nine online sessions held continuously over 1 week. Activity boards were designed on MIRO (later on Google slide due to familiarity of software) and students were added to breakout rooms to add their responses. Staff members would regroup at 8 pm, post-dinner preparation to codesign the blueprint. Parent sessions were planned on the weekend (Figs. 19.7 and 19.8).

The blueprint proposed three kinds of interventions—spatial; community intervention; and database led. Special considerations for the marginalised student population, those whose socio-emotional well-being was deeply affected and special challenges faced by female students and students with disabilities, were deliberated upon (Figs. 19.9 and 19.10).

19.2.5 School Reopen Blueprint—An Attempt to Rebuild Friendships

All workshops and activity outputs were recorded and documented. A team of skilled volunteers came together to analyze and create a vision of projects needed for the reopen plan. The student-led vision reimagined how classrooms can be used for activities in small groups and regrouping together as a class with social distancing standards is possible with outdoor classrooms in nature. Outdoor spaces were reimagined for preschool, junior students, as well as for senior students. The COVID appropriate designed access to school street complying to social distancing standards was also developed.

All these solutions overlapped with one or more of the eight pillars, just like the SDGs. Glimpses of the blueprint plan are mentioned below in Fig. 19.11.

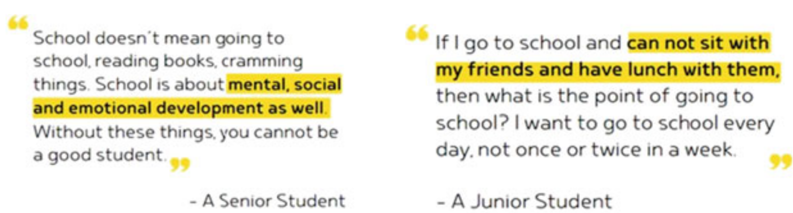


Fig. 19.6 Anecdotes shared by students on what does going to school mean in school closures (Author 2021)

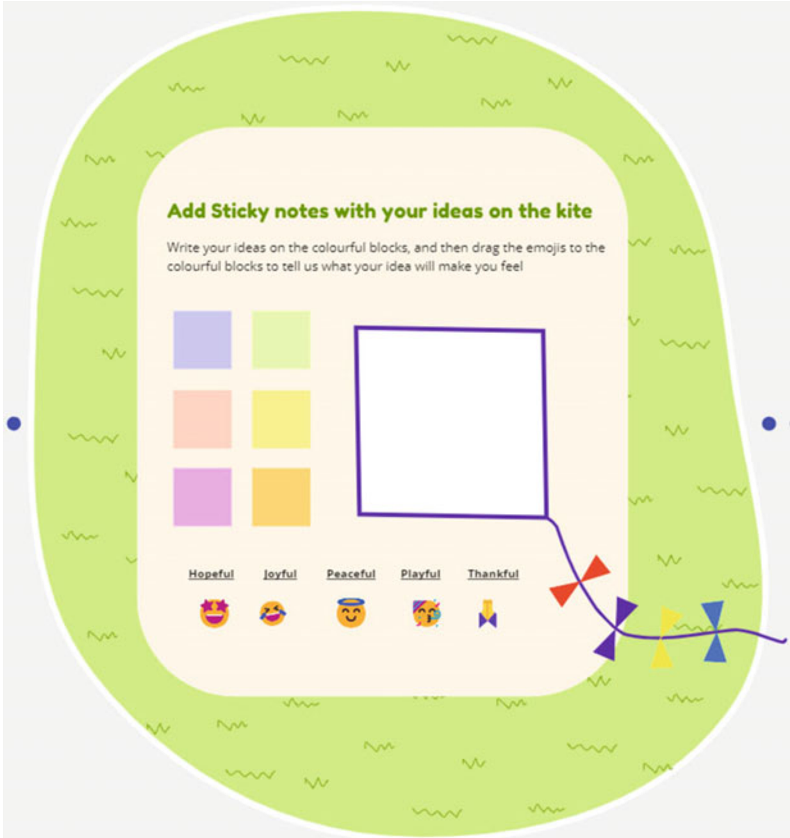


Fig. 19.7 Activity from the MIRO board shared with codesign workshop participants (Author 2021)

19.2.6 Executing with Core Team

Preparing a blueprint was a milestone for the school community. It showed a shared vision where everyone had relevance. In a harsh COVID scenario and onset of multiple waves, the blueprint pushed to a call for action. This has led to formation of a 50 member core team covering all stakeholder groups (Fig. 19.12a). Each pillar was designated a student from every wing, a parent and a teacher. The initial task force graduated to become a support council for this team. Final decision-making would be taken up by the latter, informed by the core team. Activities and online engagements were scheduled twice every week (Fig. 19.12b). Students who graduated as codesigners joined the Reopen Bulletin Team, sharing all the school reopening activities with the school community (Fig. 19.13).

19.2.7 Democracy Hour

Before working on the blueprint, a formal voting was conducted across students, staff and parents. Student voting was conducted across two days, by the student catalyst themselves (Fig. 19.14).

19.2.8 School Database

The blueprint had to be backed by an evidence of the school community. This is when the Core Team undertook the complete school database project. Pan school surveys were conducted with parents, students and staff members to collect all the data required to plan for school reopen as per the (SOPs) and guidelines (Fig. 19.15).

The survey findings have been organized into a dashboard tool for ease of access and dissemination (Fig. 19.16).

a

b

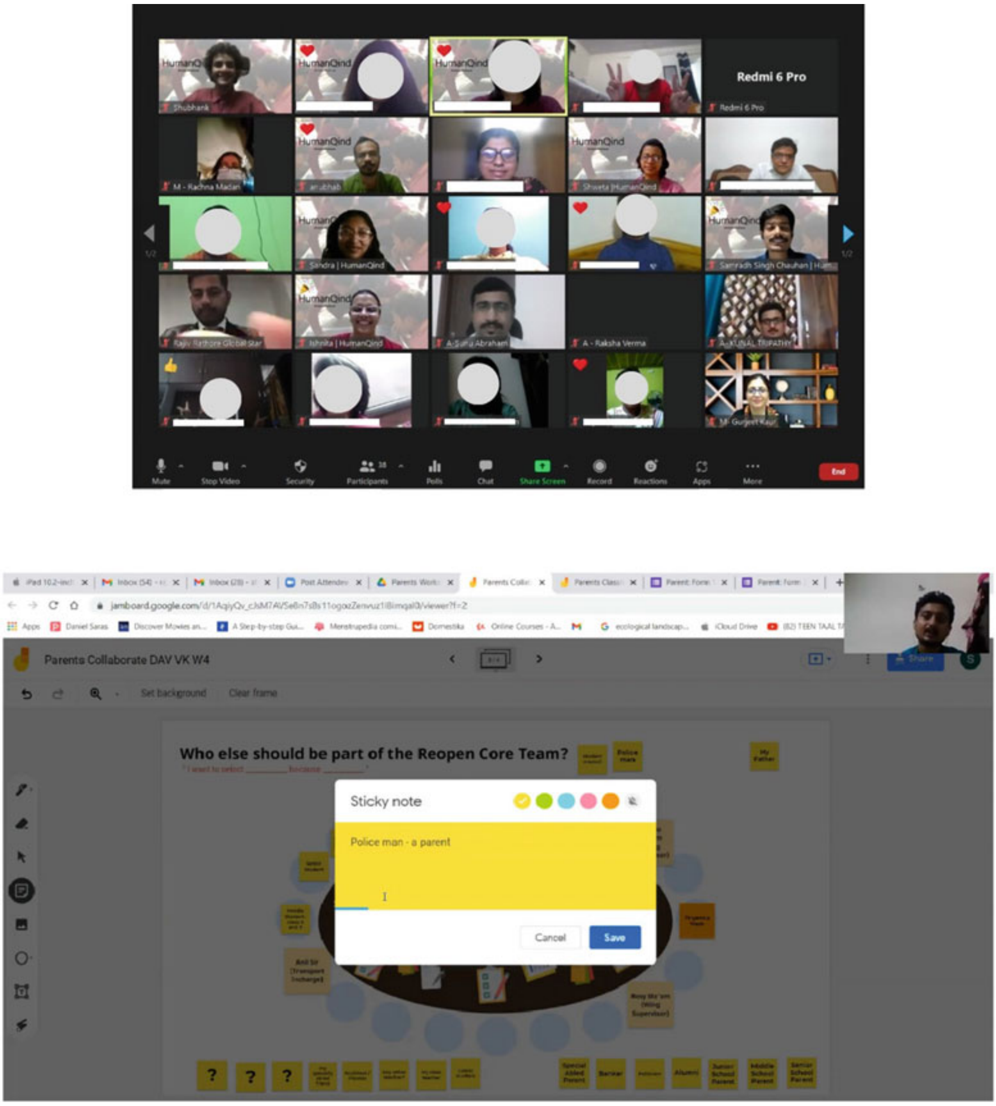


Fig. 19.8 **a** Students and staff members from codesign workshop where the participants shared and heard lived experiences during the difficult time of COVID-19, **b** Parents sharing their COVID-19 experiences from the same workshop (Author 2021)

19.2.9 Safety, Sustainability and Friendships

Many of the students were first-generation learners and came from low-income families. It was essential to translate technical data outputs into meaningful information. An in-depth analysis of the school database was undertaken to understand who were the most impacted within the school community and to have voices heard outside the school community. Data infographics played a key role penetrating into the school community. Insights on why children need trauma healing once they are back to school (Fig. 19.17), relooking at budgetary constraints, and reviving school as a work place for its staff members surfaced.

The project saw another cycle of sustainability in the new academic year. A virtual orientation session for parents was organized by the school

Fig. 19.9 Areas of proposed intervention—school street, school area/premise, classroom and timetable as per the codesign workshops with all the participant cohorts—parents, staff and students

for newly admitted students in academic year 2022–23 (Fig. 19.18). Incoming students and their families were introduced to evidence-based learnings and the continued collaboration on school reopening in post-COVID period, as a response to one of their students.

19.3 Results and Discussion

i. Pre-COVID, the voice of children never reached the decision-makers operating in the governance structures, unaware of what their primary stakeholders need and want. The project demonstrated that children can be seen as partners, thereby learning life skills and working collaboratively on real-world problem solution making. This insight also ties well into SDG 17 where such partnerships could accelerate the goals. The children along with the entire school community developed resilience to act in adverse situations.

ii. Through the project tenure, the school moved the needle from grappling with school reopen challenges to becoming prepared in reopening school by harnessing the strengths of their own community members. The project seeded process change and behavior change through a community-led, yearlong project initiated by a student. Multiple SDGs struck chord SDG 3, SDG 4, SDG 5, SDG 11, SDG 16. A repository of videos, data platform, analytics, core team, annual reports, knowledge documents, etc. have been developed to document the in-depth process and use it.

iii. The school developed an approach to look and learn from a multi-disciplinary team and promote community volunteerism. Young and elderly came forward to work and volunteer. Parents with professional expertise, students and staff members together reopened their school.

iv. The approach can be easily replicable to prepare school communities to become more resilient.

19.4 Limitations

Once the school reopened, the school and research team adopted the methodology into a city wide initiative with the government. Due to lack of resources (funding, human resources, changing priorities), the momentum in the particular project could not be sustained. All learnings and commitment by the school shifted to the current project with the city government.

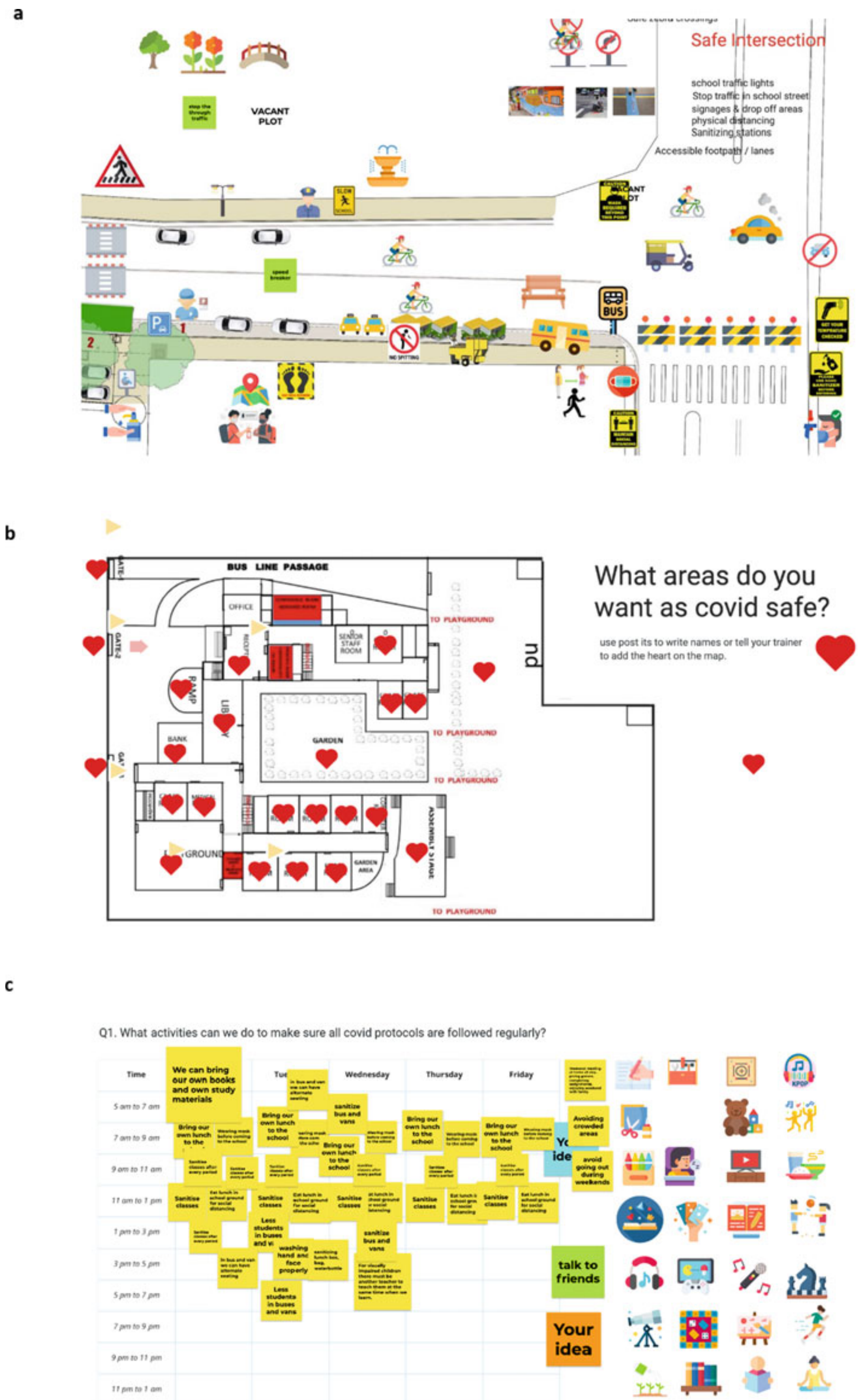
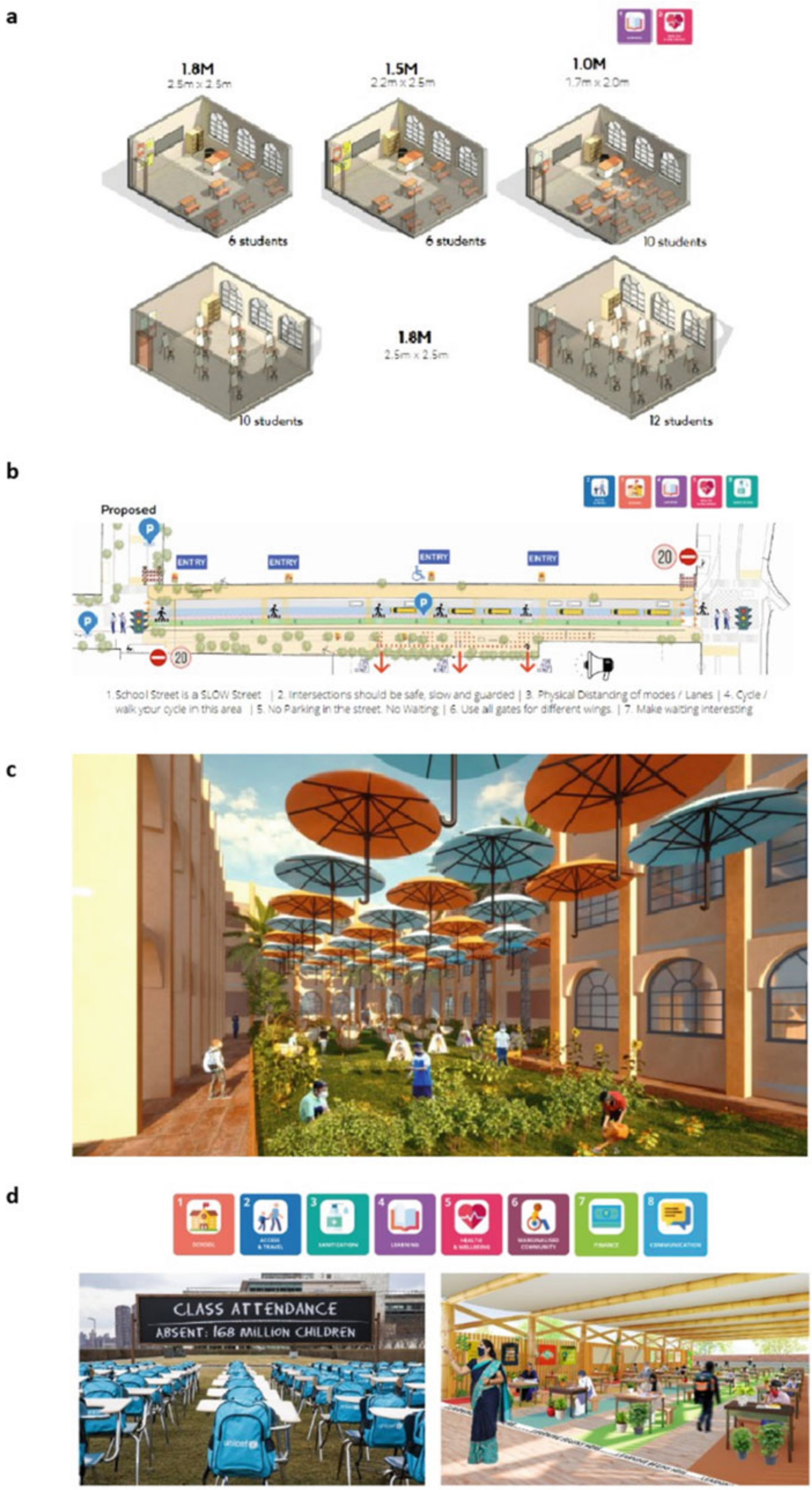
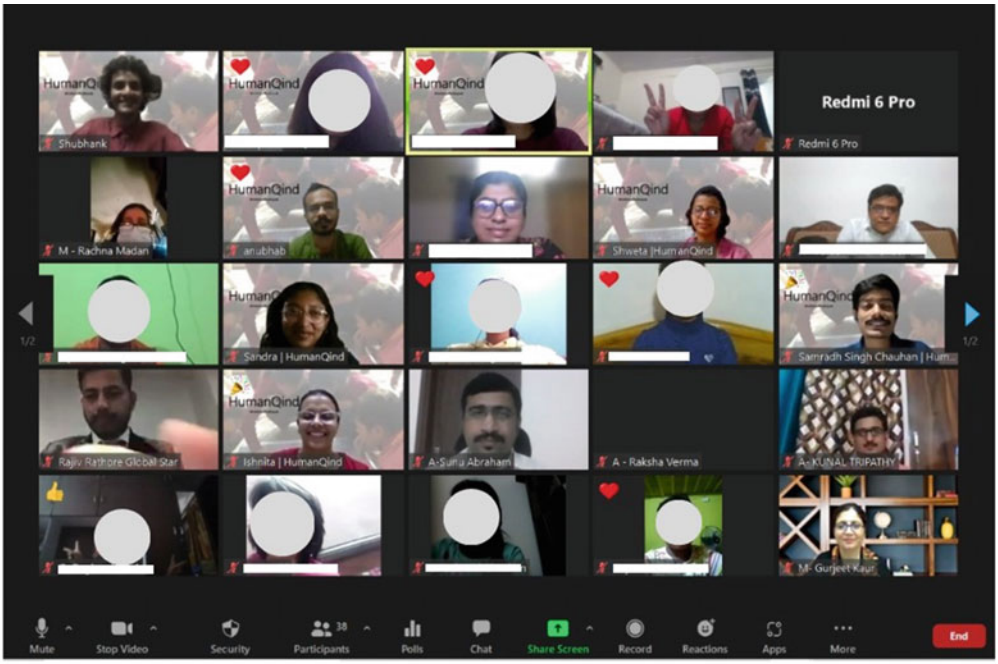


Fig. 19.10 Activity boards from the workshops showing **a** school street interventions for COVID appropriate behavior, **b** interventions required in different areas of school premise, **c** ways to codesign time table that could fill academic gaps and focus on socio-emotional well-being (Author 2021)


a
1.8M
2.5m x 2.5m
6 students
1.5M
2.2m x 2.5m
6 students
1.0M
1.7m x 2.0m
10 students
10 students
1.8M
2.5m x 2.5m
12 students
b
Proposed
ENTRY
ENTRY
ENTRY
ENTRY
20
20
1. School Street is a SLOW Street | 2. Intersections should be safe, slow and guarded | 3. Physical Distancing of modes / Lanes | 4. Cycle / walk your cycle in this area | 5. No Parking in the street. No Waiting | 6. Use all gates for different wings. | 7. Make waiting interesting
c
d
CLASS ATTENDANCE
ABSENT: 168 MILLION CHILDREN

◀ **Fig. 19.11** Proposed interventions from the codesigned blueprint by the school community, **a** seating arrangement in classrooms from a scientific perspective **b** school street interventions for safe school travel journeys **c** classroom with innovative social distancing approach, with shadows of an umbrella roof acting as social distancing enclosures, **d** innovative approach of holding classes in playgrounds as suggested by students themselves (Author 2021)

a



b

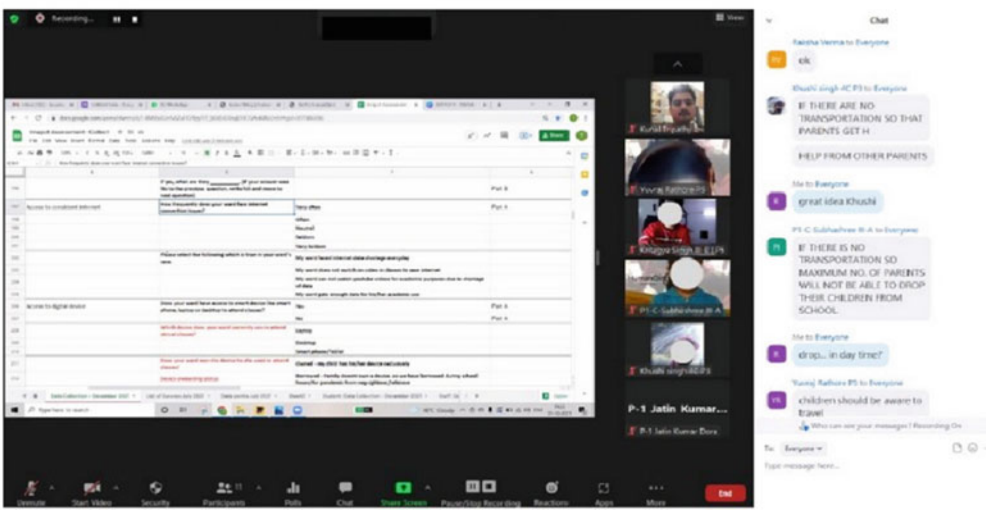


Fig. 19.12 **a** Reopen Core Team constituting parents, staff members and students, **b** Glimpse of the weekly meetings conducted with reopen core team

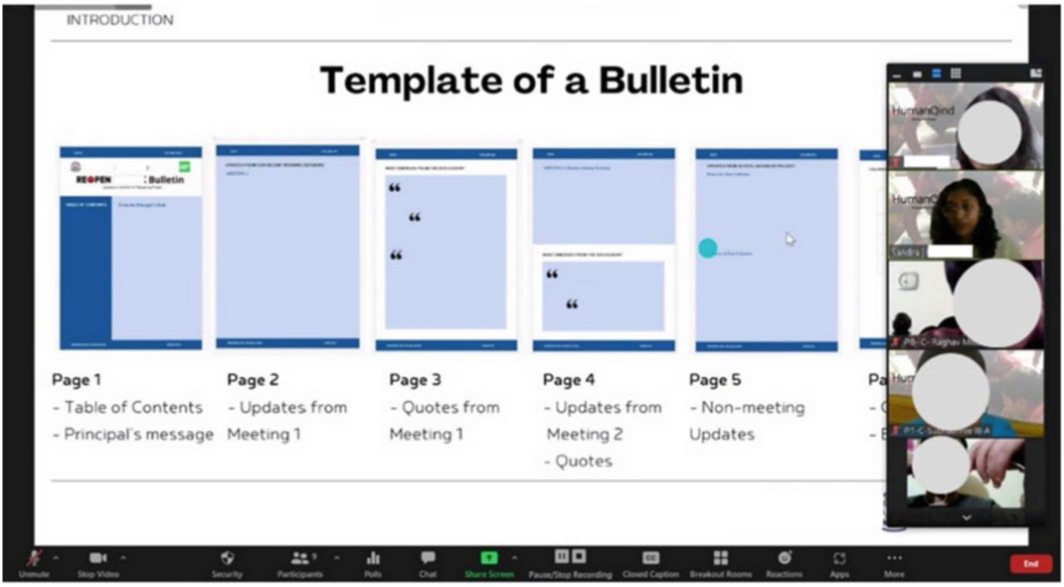


Fig. 19.13 Reopen School Bulletin Team having a working session online (Author 2022)

Fig. 19.14 Presentation prepared with codesign students to conduct voting exercise with all the students in online classrooms (Author 2021)

For replicability and systemic change, the team is continued to find opportunities to present to Disaster Management agencies and education ecosystems; however, only limited success has been achieved with presentations to some experts.

19.5 Conclusion

While the pandemic presented a huge crisis for children to continue their education and resurfaced inequities that have existed in the

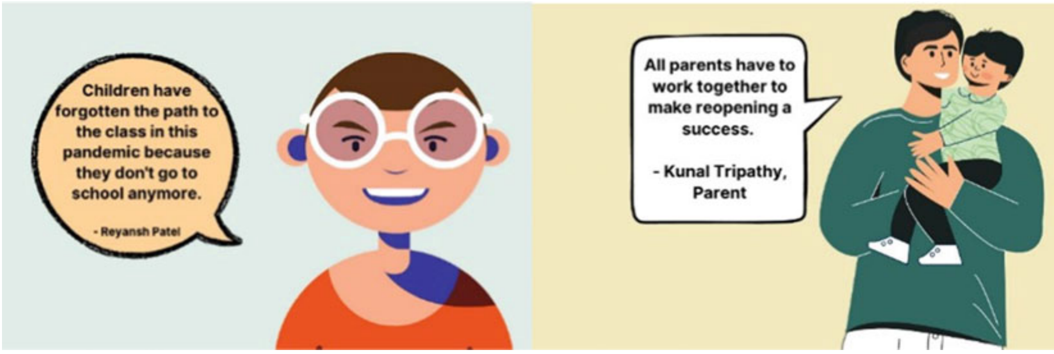


Fig. 19.15 Campaign posters prepared by students to motivate people to share data (Author 2021)

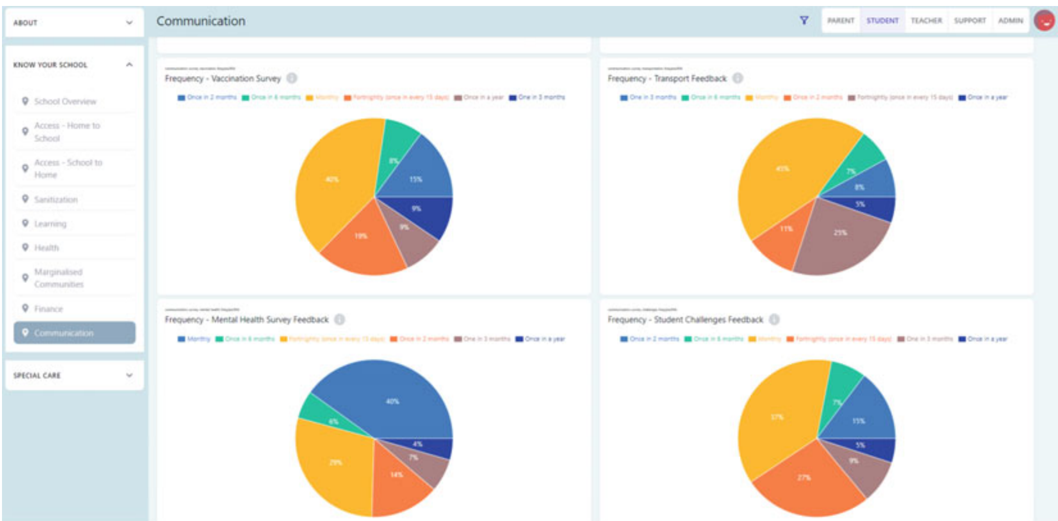


Fig. 19.16 Dashboard tool adding evidence to eight pillars for action-oriented planning for a continued safe school reopening (Author 2022)

education system, a children-led initiative from a private school in Delhi helped the children and adults to codesign reopening solutions, thereby strengthening trust and ownership in the school community in trying times. However, to become more resilient communities in the post-pandemic world, it would be critical to adopt innovative process and approach that review how can systems become more flexible, how areas of incomplete planning can be bridged and how more empathy can be centered for cocreating solutions that work for all. A top-down approach to decision-making limits school authorities, parents and children from making informed decisions for every member of the community in the school.

Fig. 19.17 **a** Infographics shown to students about the loss of socio-emotional well-being, **b** student responses in an online session of converting meaningful data to action they take to rebuild school community on friendships (Author 2022)

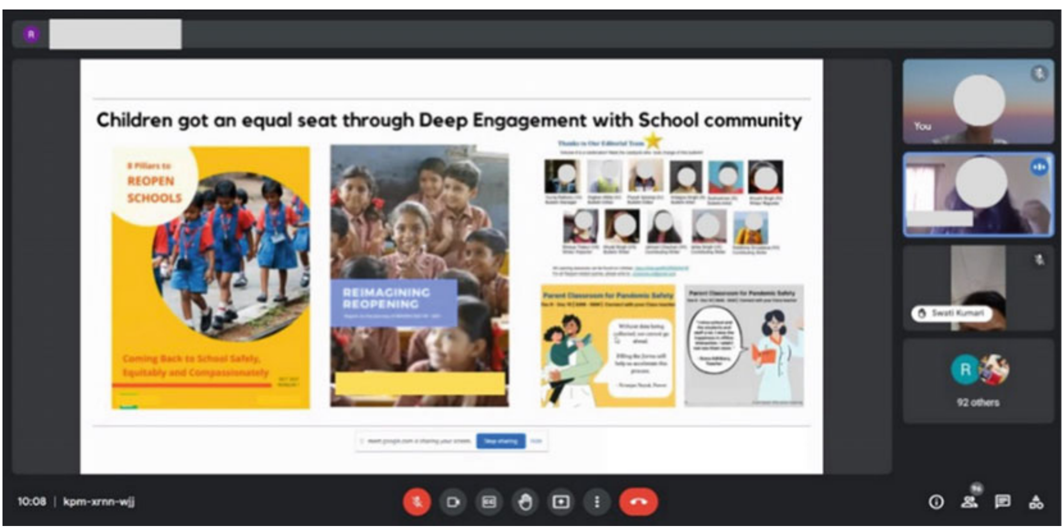


Fig. 19.18 Orientation organized with the parents of new admitted students (session 2022–23) (Author 2022)

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Part IV

Planning for Healthy Environments

20 VARCITIES EU Project: Visionary Nature-Based Actions for Health, Well-Being and Resilience in Cities

Sara Van Rompaey, Eleni Goni, and Denia Kolokotsa

Abstract

In an increased urbanized world, cities face several challenges and threats, and struggle to propose credible urban futures and new opportunities for their citizens. Social services and health facilities are significantly affected in negative ways owed to the increase in urban populations (70% by 2050). Air pollution and urban heat islands are exacerbating. Nature will struggle to compensate in the future city, as rural land is predicted to shrink by 30% affecting liveability. **VARCITIES** is an ambitious EU research project that puts the citizens and the “human communities” at the **centre of future cities’ vision**, in the belief that future cities should become **fully human-centred cities**. The project started in September 2020. Seven Pilot Cities are testing and implementing a series of innovative nature-based actions. The vision of VARCITIES is to implement real, visionary ideas and add value by establishing sustainable models for **increasing health and well-being of citizens** who are exposed to diverse climatic conditions and challenges around Europe through shared public spaces that make **cities liveable and welcoming**. VARCITIES sets the ambitious target to advance innovation across different urban scales by fully exploiting **nature-based solutions** from a digital, social and cultural perspective. Public spaces are envisioned as people-centred areas that support creativity, inclusivity, health and happiness for the citizens.

Keywords

Urbanization and urban planning · Cities · Environment · Resources and sustainability · Digital social innovation · Nature-based solutions · Vision for cities

The objectives of the EU project VARCITIES are:

- design visionary nature-based solutions which contribute to the shaping of future cities and the well-being of citizens in seven European cities.
- monitor and assess the sustainability and the impact of interventions through advanced key performance indicators (KPI) for health and well-being.

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- improve the sustainable transition to smart and future cities by creating a framework of locally adapted governance, business, financing (GBF) models.
- include various stakeholders in the co-design process and inspire sustainable and resilient future smart cities.
- achieve knowledge exchange, maximizing of EU investments, advancement beyond the state-of-art through clustering with other European initiatives and platforms.
- transfer, upscale and sustain best practices from VARCITIES through the development of a healthy cities Helix.

VARCITIES has identified seven European municipalities as the Pilot Cities of the project. These pilot cities will implement integrated and sustainable initiatives to increase the health and well-being of citizens.

The Pilot Cities are: Castelfranco Veneto (Italy), Chania (Greece), Dundalk (Ireland), Gzira (Malta), Leuven (Belgium), Novo mesto (Slovenia) and Skellefteå (Sweden).

The implementation of the Visionary Solutions (VS) in two pilot cities will be presented here:

1. Castelfranco (IT): A “Healing Garden” for elderly and people suffering from Alzheimer.
2. Leuven (BE): Hertogensite: regeneration of the former hospital site.

In **Castelfranco,** we have a **healing garden for the elderly and people suffering from Alzheimer:** six in total digital and social/cultural Visionary Solutions are being implemented with expected contributions to nine SDGs.

- VS1: Creation of garden access routes to ensure an improved access according to the needs of the garden users.
- VS2: Analysis and monitoring of psychological and physiological well-being for elderly people and people affected by Alzheimer.
- VS3: Full monitoring of microclimatic conditions in the different areas of the garden.

VS 2 and 3 form the basic actions in Castelfranco pilot. As part of these basic actions, analysis and monitoring of psychological and physiological well-being of elderly is taking place.

- VS4: Development of a green public spaces (re)design toolbox, and the establishment of the “local observatory on therapeutic effects of the landscape”.
- VS5: Implementation of virtual and ICT tools to support a rewarding experience of garden users and for the assistance of visitors with disabilities with the goal of increasing safety while visiting the garden. The goal is to increase safety while visiting the garden.
- VS6: Adaptive and intelligent visitor information systems.

The pilot area in **Leuven** for the VARCITIES project is the **regeneration of a formal hospital site** in the medieval centre of the city. This fully built area will be transformed into a green multifunctional district, re-opening the riverbanks and connecting with the city centre. The VARCITIES project is part of Leuven’s overall masterplan for the site.

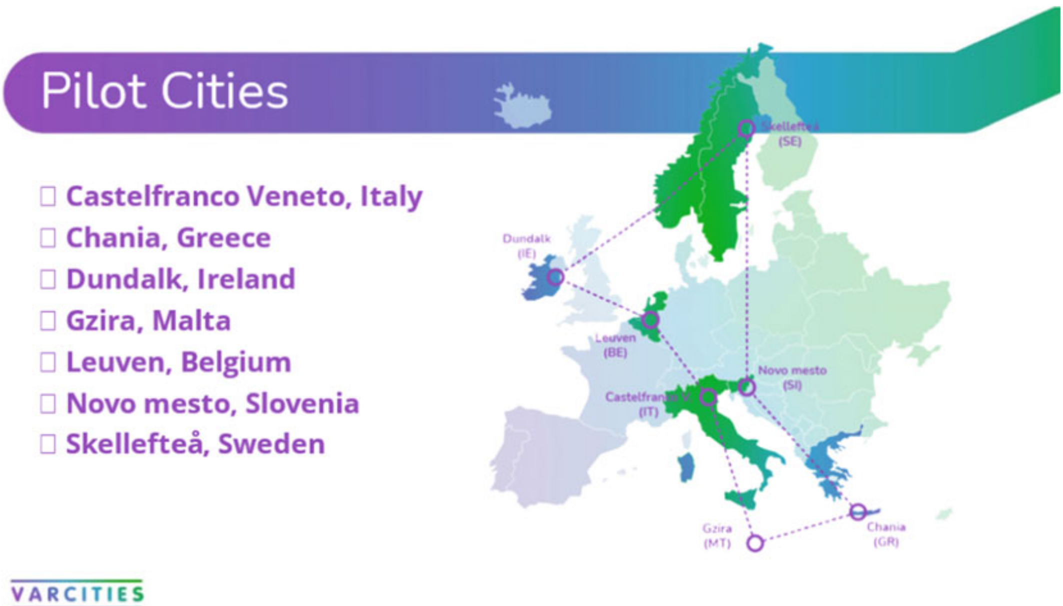
The area will become a multifunctional neighbourhood with different housing typologies, economical functions like hotels, shops, restaurants and cafés and co-working spaces. Cultural attractions like the new performing arts hall for the city and a museum site on the history and future of healthcare will be the heart of this area.

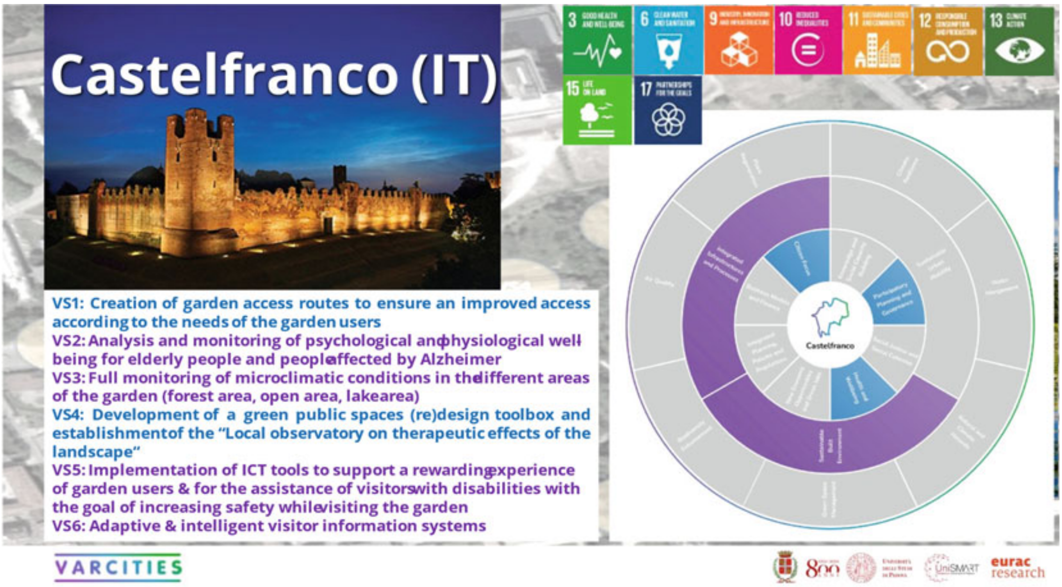
VARCITIES will finance and develop five different actions:

- VS1: Riverside urban living room linked to culture and heritage: inspired by the old, remaining parts of the town’s wall.
- VS2: Sensors for health and water measurements: Taking samples and evaluating both chemical and biological parameters would be

the best choice to detect some pre-post improvements related to water quality as a consequence of opening the water and greening of the surrounding borders and the site in general.

- VS3: Health trail with the "moving wall" and therapeutic sensory path for the elderly.
- VS4: IoT infrastructure for smart lighting and noise management.
- VS5: Mobility sensors: Measure the pedestrian and bike flows.



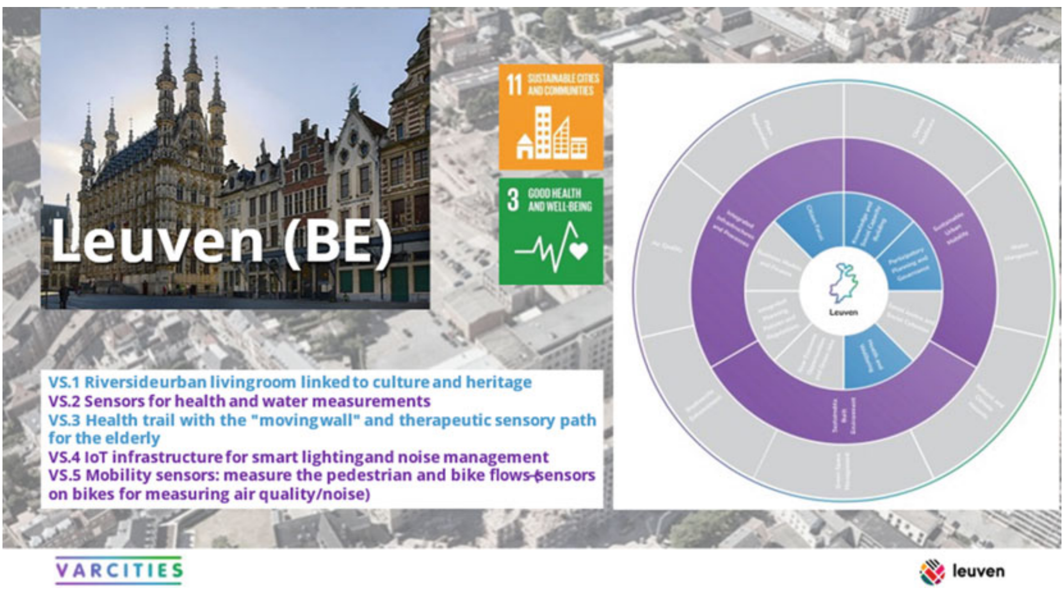

Castelfranco (IT)
VS1: Creation of garden access routes to ensure an improved access according to the needs of the garden users
VS2: Analysis and monitoring of psychological and physiological well being for elderly people and people affected by Alzheimer
VS3: Full monitoring of microclimatic conditions in the different areas of the garden (forest area, open area, lake area)
VS4: Development of a green public spaces (re)design toolbox and establishment of the "Local observatory on therapeutic effects of the landscape"
VS5: Implementation of ICT tools to support a rewarding experience of garden users & for the assistance of visitors with disabilities with the goal of increasing safety while visiting the garden
VS6: Adaptive & intelligent visitor information systems
Castelfranco
VARCITIES
eurac research


Castelfranco (IT)- Digital Solutions
VS2: Analysis and monitoring of psychological and physiological well-being for elderly people and people affected by Alzheimer
VS3: Full monitoring of microclimatic conditions in the different areas of the garden (forest area, open area, lake area)
VS2
VS3
EEG
Wearable devices able to simultaneously acquire multiple signals (EEG, EMG), to predict the level and trends of cognitive health
EYE-TRACKER
For recording eye movements during the visual exploration of the environment
VARCITIES
eurac research


Castelfranco (IT)- Digital Solutions
VS5: Implementation of virtual and ICT tools to support a rewarding experience of garden users & for the assistance of visitors with disabilities
VS6: Adaptive & intelligent visitor information systems
VS5
VS6
Images
Videos & sounds of the garden
Visualize environmental monitored data
VARCITIES
eurac research

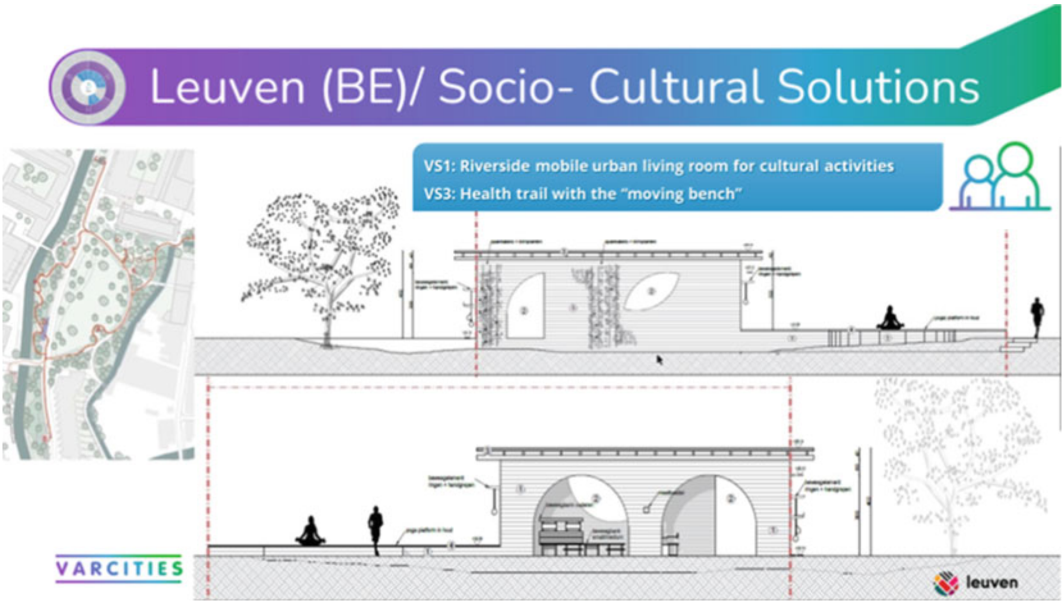

Castelfranco (IT)/ Socio - Cultural Solutions
VS1: Creation of garden access routes to ensure an improved access according to the needs of the garden users
VS4: Development of a green public spaces (re)designtoolbox and establishment of the "Local observatory on therapeutic effects of the landscape"
VS1
VS1
VS4
Osservatorio Locale per il Paesaggio della Castellana
FONTANESI
eurac research


Leuven (BE)
Regeneration of the former hospital site Hertogensite
VARCITIES
leuven


Leuven (BE)
11 SUSTAINABLE CITIES AND COMMUNITIES
3 GOOD HEALTH AND WELL-BEING
VS.1 Riversideurban livingroom linkedto culture and heritage
VS.2 Sensors for health and water measurements
VS.3 Health trail with the "movingwall" and therapeutic sensory path for the elderly
VS.4 IoT infrastructure for smart lightingand noise management
VS.5 Mobility sensors: measure the pedestrian and bike flows-sensors on bikes for measuring air quality/noise)
Leuven
VARCITIES
leuven


Leuven (BE)- Digital Solutions
VS2: Sensors for health and water measurements
VS4: IoT infrastructure for smart lighting and noise
VS5: Mobilitysensors to measure the pedestrian and bike flows
MEANS = smart lighting and integrated sound sensors
GOAL = to create a quiet place
8.1 Specifications of the WH2600 digital weather station
OUTDOOR DATA
INDOOR DATA


Leuven (BE)/ Socio- Cultural Solutions
VS1: Riverside mobile urban living room for cultural activities
VS3: Health trail with the "moving bench"
VARCITIES
leuven


Leuven (BE)/ Socio- Cultural Solutions
VS1: Riverside mobile urban living room for cultural activities
VS3: Health trail with the "moving bench"
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21 Tools to Promote Physical, Mental and Social Well-Being in the Built Environment-Takeaways from the Development Project 'the Urban Health Culture of the Future'

Helle Juul

Abstract

In 2019, Juul Frost Architects launched the interdisciplinary development project 'The Urban Health Culture of the Future', supported by Realdania with the aim to secure the link between health and planning. The project has resulted in the publication 'The Urban Health Culture of the Future' that features an analytical tool, four cases, contributions from the think tank, urban theories, and a toolbox, that we hope will inspire new strategic and multidisciplinary partnerships between local health and planning factors. The following paper presents excerpt or takeaways from the project, more specifically, from the tools developed. The aim of the tool is to ensure that considerations of health and well-being are explicitly reflected in planning. Thus, the tools can be used to promote the United Nations' Sustainable Development Goals, more specific Goal 3. Ensure healthy lives and promote well-being for all at all ages, and Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable.

Keywords

Health · Approach · Urban development · Planning · Culture · Architecture · Landscape architecture

21.1 Introduction

21.1.1 Urbanisation Challenges, Our Urban Health

Around the world, more and more people are gathering in cities. Today, more than 55% of the world's population lives in urban areas, and this is expected to rise to 68% over the next 20–30 years. As the population in urban areas grows, the design of cities and urban areas plays an increasingly important role in people's quality of life and health. This creates challenges and opportunities: on the one hand, many urban environments set the scene for inactivity and loneliness, among other things. On the other hand, health-promoting measures and initiatives can have a strong impact in densely populated environments.

Urbanisation creates a need for a new urban health culture that integrates health into planning and ensures the prioritisation of well-being in the built environment.

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21.1.2 The Urban Health Culture of the Future

In 2019, Juul Frost Architects launched the interdisciplinary development project ‘The Urban Health Culture of the Future’, supported by Realdania with the aim to secure the link between health and planning. ‘The Urban Health Culture of the Future’ is a holistic and interdisciplinary approach to the planning and urban development across various scales, categories of needs and sectors.

Through the project ‘The Urban Health Culture of the Future’ we have gathered knowledge, analysed best practice cases in different scales and developed applicable tools to promote physical, social, and mental well-being[1] through the close collaboration with an interdisciplinary think tank and with Holbæk and Aalborg Municipality as project partners.[2] Building on cases and best practice from Europe, the sketched interventions will be more feasible in economically advantaged countries and generally integrated cities.

The project has resulted in the publication ‘The Urban Health Culture of the Future’ (2022) that features an analytical tool, four cases, contributions from the think tank, urban theories, and a toolbox, that we hope will inspire new strategic and multidisciplinary partnerships between local health and planning factors.

21.1.3 Takeaways: Excerpts from the Tools

The following paper presents excerpts or takeaways from the project, more specifically, from the tools developed. The aim of the tool is to ensure that considerations of health and well-being are explicitly reflected in planning. We need to ensure that mental, physical, and social needs are addressed from a holistic and balanced perspective and across scale—followed by a focus on the concrete effects on our behaviour. Thus, the tools can be used to promote the United Nations’ Sustainable Development Goals, more specific Goal 3. Ensure healthy lives and promote well-being for all at all ages and Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable (Fig. 21.1).

21.2 Equal Opportunities for Well-Being

Health inequalities are increasing. The area where you live and your socio-economic background have a big impact on your chances of good health, the length of your life, and your well-being. Health inequalities are complex. School, housing, and health policies as well as planning and the physical environment are important factors.

21.2.1 Create Interdisciplinary Visions that Commit

If urban development is to contribute to well-being and quality of life of all, it requires shared visions as a basis for action. Visions that ensure shared goals, ambitions and commitment across municipal administrations, sectors, relevant actors, and different disciplines. Start by creating

[1] According to WHO’s definition of health.

[2] The members of the think tank and the two municipalities have continuously contributed with their experience and knowledge to the project. The think tank has been composed of complementary disciplines and chosen to ensure knowledge in the focus areas of the project. The members are: Bodil V. Henningsen, architect, Master in Strategic Planning, Aalborg Municipality, Urban Development and Construction; Christer Larsson, Architect SAR/MSA, KKH, former director of Urban Planning, Adjunct Professor of Architecture; Jasper Schipperijn, Professor, PhD, MSc, Department of Sport Science and Clinical Biomechanics, University of Southern Denmark; Jesper Lund Bredesen, doctor, divisional director H. Lundbeck A/S; John Pløger, Professor Emeritus, University of Agder; Karin K. Peschardt, landscape architect, PhD Strategic Planner, Holbæk Municipality, Planning and Business; Katrine Winther, anthropologist, Head of Social Initiatives AKB Taastrupgaard; Morten Klöcker Grønbæk, professor, PhD, D.M.Sc. Director of the National Institute of Public Health, SDU; Peter Hanke, chairman, Associate Fellow at Oxford University, Saïd Business School; and Rasmus B. Andersen, architect, team leader, Urban Development and Facilities, DGI.

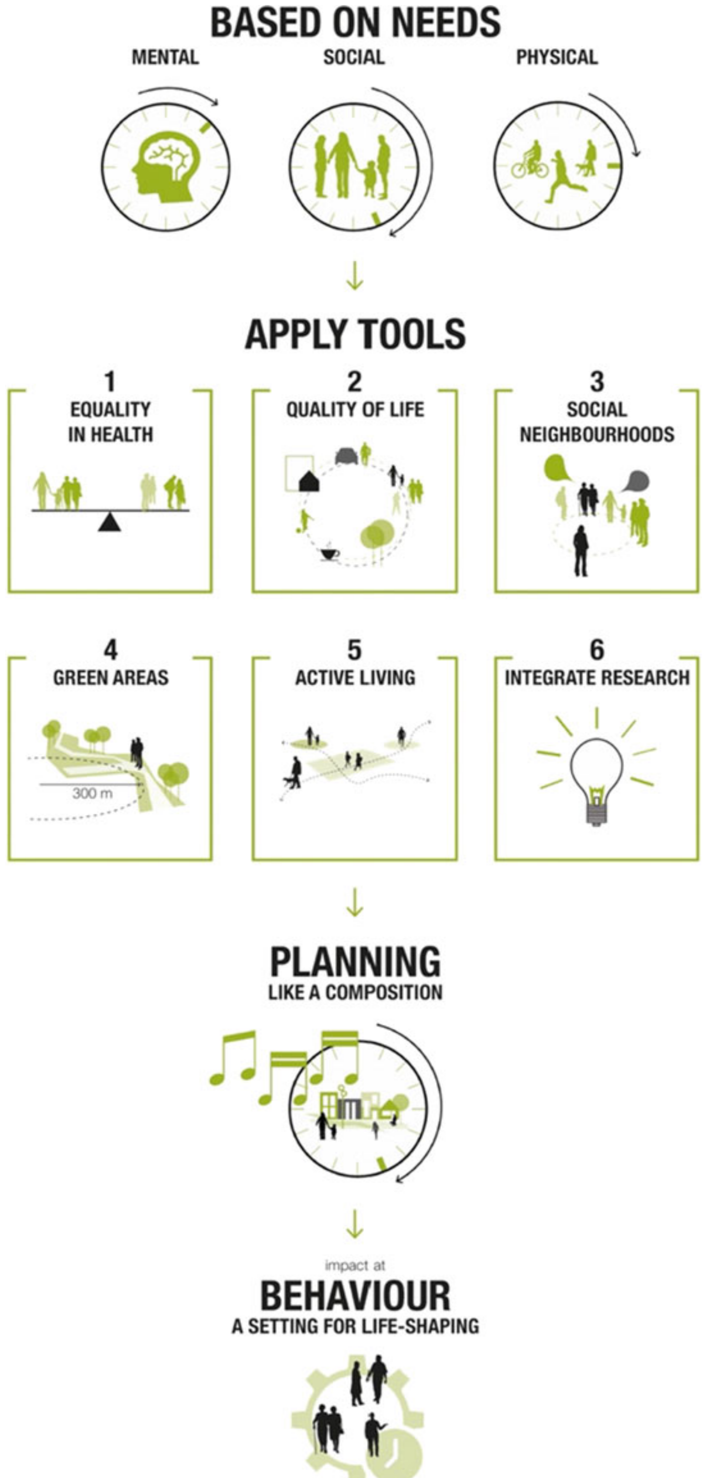

Fig. 21.1 Application of tools

shared visions that commit you to partnerships, and then make explicit demands. Ensure that pragmatism and demands do not stifle creativity in the visioning process, but rather let the vision define the requirements for development.

Set up multidisciplinary working groups that, together, can develop consistent visions for which all relevant actors feel ownership: make sure that all actors are able to see themselves, their concrete goals, and ambitions in the vision. This ensures commitment to and responsibility for the process and project. Highlight the effects that can be achieved by having a common direction.

21.2.2 Make Explicit Demands

Health-promoting planning requires a firm focus on the importance of both concrete and long-term interventions. The design of the city should make it easy to make healthy choices and invite movement, social encounters, and mental recovery. In concrete terms, this means ensuring that everyone has access to opportunities, choices and services that promote well-being and quality of life, e.g. recreational green spaces, safe pedestrian and bicycle connections, and healthy housing without noise and air pollution.

Explicit goals and requirements are needed in policies, strategies, planning documents and competition programmes. Such explicit objectives and requirements create greater awareness among all regarding the physical environment as the framework for new behaviours and lifestyles.

This gives planners a mandate to act which serves as a foundation for new planning practices. Well-being must be a norm in planning, not just an ambition.

21.2.3 Form Partnerships and Alliances and Invite More Actors in

We need to work together on the healthy cities of the future from a broader perspective. We need to look at city, housing, work, leisure, climate, sustainability, and social, physical, and mental well-being as interlinked factors. This requires a new, closely synchronised, and equal cooperation practice between administrations and disciplines as well as early involvement of relevant actors where everyone feels ownership and responsibility for the process.

Prioritise cooperation and appoint a cooperation officer who can organise cooperation across administrations, disciplines, and actors on an ongoing basis. The person responsible can ensure close communication about the project.

21.2.4 Plan Holistically Across Scales, Needs, and Sectors

Work holistically and based on needs across scales to ensure coherent urban development and synergies between interventions. For example, an integrated mobility and urban space strategy across scales can ensure space for the creation of more recreational and green urban spaces. Or use the 20-min city as a guideline for integrated urban development across scales, addressing the needs of the city and its citizens from a holistic perspective (see Sect. 21.5.1). Targeted urban development requires a basic needs assessment.

21.3 Take a Needs-Based Approach to Ensure Quality of Life for All

For some, well-being and quality of life are linked to physical, mental, and social well-being. For others, it is linked to self-realisation and zest for life or moods, cosiness, and atmosphere. The concept of health encompasses inherent paradoxes, stretched between asceticism, zest for life, absence of illness, self-discipline, and thousands of tips for prevention. Life is stages, life-shaping and changing values and preferences, thus 'the way we thrive' also changes (Pløger 2022; Hanke 2022). There is a need for a needs-based and coordinated approach, recognising the multiple, changing and sometimes conflicting needs that underpin different people's well-being and quality of life. Seek inspiration for your planning in the polyphony of music, a controlled diversity where every theme has its place: both the flamboyant motifs and the dull backdrops of everyday life (Hanke 2022).

21.3.1 Remember the Mental and Social Needs

There is great focus on movement, cycling, and physical activity—and that is good. But if we are to plan for the complexity of factors that affect our well-being, we need to understand well-being holistically as bodily, *social, and mental*. Work holistically with social, physical, and mental needs.

Work on the link between the environment and influential parameters in planning that can positively push our actions and behaviours. For example, social and mental needs can be addressed holistically: communities of action foster a sense of social belonging and invite participation in positive communities. This is also important for promoting mental health (Sundhedsstyrelsen 2022a, b).

21.3.2 Create Space for Everyone, the Many and the Few

Our cities are home to a diversity of people. We are growing in numbers and in differences. A basic premise for the cities of the future is to ensure that all people and social groups are considered and involved. We need to create space for everyone in the city—including those who differ from ourselves (Andersen 2022). This requires an approach that recognises that different population groups in different areas have different needs.

Work strategically with a demographic approach to the development of urban spaces and green areas, addressing needs across age, gender, education level, type of household, employment, culture, ethnicity, etc. This ensures coherence between the physical environment; residents' needs, and public and municipal spaces and services.

21.4 Demand Co-creation

We are fundamentally social beings. Loneliness and social isolation challenge our well-being, and social segregation erodes our empathy and tolerance for those who differ from ourselves. Put social well-being and loneliness on the agenda. Several countries already have a minister for loneliness (Bredesen 2022). The social contexts we live in and our interpersonal interactions with other people make us who we are. Participation and involvement in communities, belonging, trust in others and safety are all parameters of social well-being.

21.4.1 Prioritise the Social Architecture of the Place—No One Can Create Communities Alone

Continuously prepare the ground for communities to grow. We need to prioritise the social initiatives—even after the physical project is completed. One way is to work with social hosts and urban hosts to facilitate communities.

Create citizen-driven initiatives, such as cultural centres and cultural spaces, where volunteers can work as hosts introducing and building bridges between people using the space and ensuring that everyone is invited into the community. Hosts can welcome people and support users' needs and introduce them to other users—in other words, make it easy to join communities (Winther 2022). Strong local driving forces or a strong volunteer organisation can secure the hosting of communities.

21.4.2 Create Communities of Action and Strengthen Co-creation

Resident-driven communities around shared interests can bridge cultural and ethnic divides in residential areas, promoting social well-being and empowerment. This strengthens social cohesion and resilience. Initiating and sustaining activities require strong local driving forces: give local sports clubs, leisure activities, interest-based clubs, and associations a place in city spaces as catalysts for strong, inclusive communities that address loneliness (Peschardt and Henningsen 2022).

Realise innovative social interventions based on common interests and facilitate communities of action: places that engage individuals and groups in creating something concrete together, such as developing local products.(Winther 2022) Examples might be a baking pavilion that brings people together around different baking traditions or more practical communities around growing gardens, making ceramics, or repairing bikes. It is fundamental to ensure openness as to who can participate in the co-creation.

21.4.3 Reinforce the Temporary and Create Space for the Unplanned

Spaces for various spontaneous activities that attract a diversity of people, strengthen social life and encounters across differences. The meeting of different users is the prerequisite for tolerance: according to Richard Sennett, encounters with 'the strange' create a breeding ground for tolerance between different users of urban space (Juul 2009).

Create spaces that can be freely reprogrammed for temporary use and occupied by all for self-organised activities. Spontaneity intensifies urban life and gives ownership to the urban space, it creates eyes on the street and can increase safety, which strengthens social and mental well-being.

Address the city's need for complementary social and cultural venues. There must be urban spaces for everyone, but not all urban spaces must be for everyone.

21.5 Use Urban Nature as an Active Resource

Green urban environments improve health, well-being, and quality of life. Fatigue, negative stress, and irritation increase the further you live from green spaces. Conversely, spending time in green spaces is linked to lower stress levels and higher well-being, regardless of gender, age, or socio-economic background. (Skov & Landskab, LIFE, University of Copenhagen 2008). Improving access to good green spaces in disadvantaged neighbourhoods helps to address health inequalities (Braubach et al. 2017).

21.5.1 Put Urban Nature on the Agenda

Use urban nature and green initiatives as an active resource in urban planning. Parks, green belts, and gardens can invite people to exercise, relax and socialise across social and cultural divides.

Urban nature creates added value: it contributes not only to well-being but also to climate-resilient cities, CO_2 storage, enhanced biodiversity, pleasant urban spaces, and a good microclimate, as well as being able to counter noise and air pollution and increase housing prices.

Make demands on the number of green square metres, the distance to green areas and the number of trees. Use Green Standard 2.0 as inspiration in the preparation of policies and planning documents.[3] Work to increase the number of parks and gardens, transform urban roofs into green oases and kitchen gardens, transform grey facades into green and vertical forests, transform asphalt courtyards into natural spaces, promote urban gardens and urban agriculture, and create networks of green corridors linking parts of the city.[4]

21.5.2 Work with Landscape-Based Infrastructure and Hybrid Solutions

New solutions are needed to bring more urban nature and biodiversity into our cities. The coordinated work across, e.g., mobility and urban

[3] See: Presentation for Green Norm 2.0, methods and tools for more and better urban nature, https://thegreencities.eu/wp-content/uploads/2020/02/Gron-Norm-2.0.pdf.

[4] See e.g. Stefano Boeri Architetti's Urban Forestry manifesto for inspiration.

space can optimise traffic management and create space for new urban nature. This requires multidisciplinary and cross-sectoral cooperation.

Work on landscape-based infrastructure, where considerations of landscape and mobility are integrated. Prioritise landscape-based mobility plans, integrating planting and urban nature into the construction of roadways, station areas, stops, etc.

Apply hybrid programming to green spaces so that they have more than one function and/or can be used differently throughout the day. For example, work with nature-based climate adaptation that functions as recreational green spaces, movement paths or schoolyards, or integrate therapy gardens into existing parks and cemeteries where there is a setting for tranquillity.

21.5.3 Design Safe, Peaceful, and Wild Green Spaces —All year Round

The quality of parks and green spaces matters. Studies show that the combination of the experience characteristics 'safe', 'peaceful', and 'wild' has a strong influence on the health of urban residents (Skov & Landskab, LIFE, University of Copenhagen 2008). In the Nordic countries, it's not always green, but grey, cold, and wet for most of the year. The lack of daylight in winter affects our well-being. Therefore, green spaces need to be designed to promote activity and social life during the winter months.

Design green spaces with different spatial qualities to allow for mental recovery, social gatherings, and physical activity, without running and playing interfering with areas for rest and contemplation.

21.6 Plan for Everyday Movement and Physical Activity

Physical inactivity is a growing problem. Physical activity is well documented to prevent a wide range of common diseases and conditions, including type 2 diabetes and cardiovascular disease. It is estimated that physically inactive people live, on average, approx. seven years less than physically active people (Sundhedsstyrelsen 2022a, b).

21.6.1 Mix up the City and Pave the Way for an Active Movement Culture

Plan for physical activity as a natural part of daily life (Schipperijn 2022). In other words: focus on active living. Mixed use cities promote active living and provide a framework for active transport. This requires a break with the zoned city. Functions must be mixed to encourage new mobility habits and behaviours.

We must ensure access and short distances from home to the destinations and functions we use and visit in our daily lives: This supports movement in everyday life but also the local sense of belonging. Map functions, services, and mobility to ensure accessibility to housing, shopping, jobs, and leisure functions within 800 m in the city or individual district. That's the equivalent of a 20-min round trip.

Plan attractive, safe, and pedestrian-friendly local environments that invite people of all ages and abilities to choose active transport. Use mobility plans to ensure access to public transport in planning. Ensure people only must travel short distances to public transport linking urban areas to functions that cannot be located locally, such as hospitals, major educational institutions, etc.

21.6.2 Create Local and Social Recreational Opportunities for All, Regardless of Background

Access to local recreational facilities and services plays a role in physical activity. Movement and physical activity can create social encounters and communities, helping to build new relationships and cohesion across society. Integrate sport and exercise facilities into their surroundings and make them local meeting places that reach out and invite participation in movement, sports, play, exercise—and community.

Give as many age groups as possible—regardless of social and economic position—the opportunity to be physically active. Open closed facilities to invite more people in, and work with multi-use, hybrid programming, and overlap between activities to bring people together across generations.

Think beyond the needs of the athlete and look at local needs and habits. There must be a link between the needs of residents and public recreational facilities and municipal sports facilities. Make the local situation the starting point (Andersen 2022).

21.7 Build on Theory and Knowledge and Invite Researchers in

There is plenty of knowledge to draw on! Knowledge that needs to be brought into the real world and can contribute to urban development with impact and effectiveness. Health profiles, research in health promotion and prevention, research in how health design and nature-based therapy can be applied in practice and research in how to integrate physical activity into everyday actions creates an active everyday life and healthier lifestyles are all knowledge we can put to use. Invite the researchers in.

21.7.1 Use Theory as Inspiration for Innovation

Urban theories can inspire the development of new approaches to anchoring well-being and health planning and thereby change our behaviour in urban spaces. Use urban theory as a framework for analysis to understand challenges and to find inspiration for innovative solutions. Draw on theory from different disciplines and include conflicting viewpoints that can challenge and inspire the project's thinking and analysis.

21.7.2 Get the Hard Facts on the Table to Ensure Political Prioritisation

Health profiles and safety surveys are just a part of the knowledge that can be drawn on in health promotion planning. Use these to raise awareness of challenges and potentials. What is the impact of the choices we make? Get the facts on the table. Draw on knowledge from relevant studies to raise awareness and political priority for both challenges and impact of initiatives.

21.7.3 Invite Researchers in—From Start to Evaluation

Extensive research is being carried out on the influence of the physical environment on our well-being and health promotion and prevention. But there is a need to bridge the gap between research and practice.

Involve researchers from the start of the project so that they can contribute to the development of the project, as well as the process and evaluation of impacts. Researchers can support projects with knowledge of what works and ensure that follow-up research, evaluation, and impact measurement of interventions can be carried out.

21.7.4 Set-up an Independent Council and Get a "Second Opinion"

Open the professional discussion: invite independent and impartial experts into the development. Set up independent expert groups, councils, or committees to ensure a holistic, cross-disciplinary focus across urban development, sustainability, and well-being. They can be academics, policy makers, and representatives from community initiatives that bring together experience from both the public and private sectors. Together, they can provide support, advice, criticism, and expertise on the built environment.

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22 Healthy Cities Make Healthy People and Healthy Planet

Karin De Poortere and Jose Alejandro Gómez

Abstract

We acknowledge that it is time to put the health and general well-being of people at the center of our development, and the way to achieve it is to act under the beliefs of good social and territorial health, as the foundations of truly SDGs localization. Therefore, we propose that healthier lifestyles be at the very core of architectural creation, policymaking, territorial planning, and sustainable development, meaning a renewed architectural practice.

Keywords

Cities · Health · Planning · Territory · Architecture · SDG

This is not a new challenge. Beyond architecture, departing from contextual planning rooted in the territory and its social appropriation, we propose to open a brief yet powerful dialogue on the lessons that these last years have left us: the fragility of public health and the weaknesses of social architecture, territorial and city planning, in the face of new challenges. Nevertheless, those have generated an opportunity to act decisively in the scenarios of daily life, to create conditions that allow recomposing and re-naturalizing cities under better governance arising from communities and neighbors voices; generating different scales of action based on local architecture, the use of traditional materials in harmony with contemporary ones, promoting healthier environments that transform and in turn take advantage of the place, the landscapes, and the public spaces.

> Health and sustainable urban development are inextricably linked, and at the core of the Agenda 2030 and its SDG. Cities working for health and well-being are central to sustainable development. Health is created at the local level in the settings of everyday life, in the neighborhoods and communities where people of all ages live, love, work, study, and play. Health for all cannot be achieved without local leadership and citizen engagement. Shanghai Majors Forum 2016 (WHO 2016)

22.1 "Cities Are More Important for Health Than Hospitals"[1]

The concept of a healthy city is based on the contributions of public health policies in Europe in the nineteenth century (Velásquez and Bermúdez 2011) when it was intuited that health management and promotion should be done on a local scale. Since then, many reinterpretations, links, and ruptures have been built around the

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[1] John Wright (Brandon Institute for Health Research. In COP26 2022).

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relationship between cities and health. This paper wants to highlight that from the current territorial planning approach, a city's shaping and functioning are determinants for public health, so SDG 3 and SDG 11 goals are tightly linked.

In 1998, the Athens Declaration renewed the commitment of European cities to health and sustainable development (John 1989). These networks are expanded and strengthened over the years, following the postulates of the 2000 MDGs, the 2030 Agenda and the 2015 SDGs. In turn, the 2016 Shanghai Declaration, put the work of cities in favor of health and well-being as a fundamental element for sustainable development, emphasizing that health is forged at the local level, that is, in the settings of daily life, through good governance and public policies agreed upon with the communities.

Due to the pandemic, at the annual conference of the European Network of Healthy Cities, the structural inequalities of our societies are highlighted, reviewing the 2020–2025 goals, including programs for mental health and digital health, emphasizing the crucial role of cities in the global recovery from COVID-19 and remembering that without investing in healthy urban life we will not be able to achieve the SDGs and the 2030 Agenda (WHO 2020).

22.2 Healthy Cities Require a Comprehensive Approach

Our relationships with the environment have been deteriorating, and the scenario is not hopeful. Many of our cities reflect the imbalance in the relationship between men and nature, and even, the conflicting relationships among human beings.

Nowadays regions and especially cities signify epidemics, congestion, contamination, segregation, and even individualism. Those conflicting relationships stress the need for changes in cities, to foster resilience, to protect, improve, and restore, the population, territorial, and planetary health. So, we must wonder how to redefine our connections with the environment and with the whole living beings. We must move toward a paradigm shift that involves complex challenges and calls to action, and at the same time to understand if it would mean evolution or involution.

Cities can harm mental health, for example by causing mor acute levels of stress; cities can harm physical health, by exposing residents to air and noise pollution; cities can harm social health, meaning our ability to interact with others by, for example, causing loneliness (Nexus Planning 2022).

It is time for taking people's health and general well-being to be at the center of our development. As IsGlobal (2022) points out, the “connection between environment and health should be the foundation for future cities”. That is why it is urgent to rethink our links with territories and with other beings on the planet, moving from reflection to action.

The path should go through the exercise of architecture with a more comprehensive or broader vision, in which metabolic, regenerative, and circular urbanism, leads to changes not only in the landscape but in the relationships between us: planning for healthy territories and societies. We must **act in the everyday life realm**. Although big projects are essential for the optimal functioning of the territories, it is interventions on a citizen’s scale that generate a real impact on the conditions of everyday life.

We propose linking and facilitating reflection on ways or actions to foster “**Healthier Territories**”, **with long-term vision but with immediate actions** in the daily life of communities. And we suggest for these strategies to be reviewed in light of local agendas and the localization of the SDG, in terms of their relevance, adaptability, and impact as well, **based on the following principles** (Fig. 22.1).

22.3 Cleverly Participatory City

Consensus, alliances, and community involvement are the basis for the governance of territories and their social appropriation. But beyond that, a healthier city promotes co-creation and coproduction of space, giving real importance to what people need and want, favoring the bottom/up approaches.

Fig. 22.1 Principles for healthier cities. *Source* Authors

A healthier city must be cleverly participatory, and put information at the service of citizens, allowing free access to the promotion and enhancement of knowledge, pedagogy, and the dissemination of healthy lifestyles. It must also establish technical assistance mechanisms in the neighborhoods so that citizens and inhabitants can access knowledge directly and with constant advice from trained professionals.

These scenarios of public policies, norms, knowledge dissemination, training, and exchange, configure an evolution of the social contract, supported by technological innovations as activators of change, with inclusive methodologies of discussion, analysis, and consensus, giving credibility and generating social appropriation of the territory in innovative ways, acting in harmony with the natural and the built environment. Therefore, we must demand government active participation to guarantee the right to the city and especially to healthier environments and lifestyles for all.

UN New Urban Agenda-SDGs "recognize the importance of more accurate data, including commitments to improve the quality of actionable data for cities and development. The Million-Neighborhoods-Map, a new global tool designed to detect gaps in services in informal settlements, is valuable in helping to identify communities with limited access to street networks, which can be a good proxy for access to other services, such as power, water, sanitation, and other infrastructure" helping governments to acknowledge that situation and get resources to provide such services and thus improve community health, as proved in Dar es Salaam, Tanzania (Mahendra et al. 2021).

"Copenhagen uses a people-first approach while designing its urban spaces…When you co-create streets and public spaces with the people using them, you get spaces that work for them, address their concerns and over which they have a sense of ownership" (880 Cities 2021).

We want to highlight two good practices in Colombia: the first one in Medellin, where the Community Development Centers called "Articulated Life Units" and other social facilities have fostered meeting and exchange spaces in poor neighborhoods. The second is being developed in Bucaramanga, by "City Workshop" and its formulation of the "public spaces: the skin of democracy" strategy, whose central axis is citizen participation in the design and implementation of parks and urban facilities, through community co-creation and co-design, facilitating social appropriation of spaces and public actions (Fig. 22.2).

Fig. 22.2 Participation processes in Bucaramanga. *Source* Photos by the authors

22.4 Healthy City and Regions = Planet in Balance

Achieving the greatest global health is at the same time a threat and an opportunity because health is an outcome and an asset. Cities and territories are not isolated or dichotomous entities. The countryside not only provides food and materials to the cities, but their inhabitants also migrate attracted by agglomeration economics and, in most cases, for the false expectation of a better quality of life.

Rural and urban must be components of a continuum with symbiotic relations that recompose the ways of responsible production and consumption and go beyond individual models of behavior to more inclusive and ecologic models that recognize the importance of both physical and social environments as determinants of health. There must be more territories in balance, where rural communities, and small and medium-sized cities, share considerable production areas and markets, basic services, connectivity, health, education, and culture, which denotes greater opportunities and better standards of living, fostering a better redistribution of the population and major standards of living for all.

Concerning the management and planning of cities, our actions must cover the whole territory: urban–rural areas, and not only focus the efforts on the urban agglomerations leaving rural areas behind. It is rural that provides our city's food, water, raw materials, and ecosystem services. But the COVID-19 pandemic has shown the fragility of many of our cities in terms of total dependence on rural areas' supplies. So, our actions must be aimed at guaranteeing food security and basic services for the rural–urban continuum.

To apply technology and scientific procedures and methodologies, and in general, improving production and supply conditions implies not only direct action on agricultural production systems but also brings together a series of actions to improve the living conditions of the rural population, in terms of, for example, better systems and forms of education, health, housing, and connectivity. It also implies that cities implement more efficient self-production systems and rationalize consumption, generating production chains and nearby supply markets, urban agriculture, local markets, green belts, and urban pantries, and in general, opting for mechanisms that boost food security while protecting the environment. We find multiple good practices worldwide like actions undertaken in different Chilean and Spanish regions, betting on urban agriculture, still on very small scales, but as triggers for larger-scale actions complemented with organized agricultural communities.

Another case study with interesting results is China's effort to achieve rural revitalization and promote the integration of urban–rural coordinated development. The objective is to reduce the gap between urban–rural living standards for residents, free flow and equitable exchange of goods and services, and rational allocation of public resources, forming new types of urban–rural and industrial-agricultural relationships, integration and common prosperity, and rural modernization. For seven consecutive years "N° 1 Document" has been issued to build a new countryside, completely abolish agricultural taxes and tuition fees at compulsory rural education, establish a new cooperative medical system, and a rural minimum social security system (Han 2022).

22.5 Compact and Nearby City

We must promote close, diverse, and open communities, as well as more transparent land markets to counteract current social and territorial segregation. A Compact city, better connected to its surrounding territories, with a mixture of activities, and built areas proportional to the open and green spaces, can contribute to curbing its expansion, and the occupation of environmental or potential agricultural areas. Cities must be planned and built for proximity, avoiding overcrowding, a condition primarily related to social exclusion and correlated with increased infection rates and mortality. Besides, well-managed urban density or compactness reduces long daily trips and the cost of infrastructure services; it enables close social relationships and provides better health and living standards.

Our projects should be oriented to improve conditions in deficient areas, rethink the living spaces, policies, and actions, on social housing, and consider the new functional, health, and productive needs, to consolidate communities well integrated into the territory. In addition, expansion areas must be contiguous to the consolidated ones with existing infrastructures. If possible, renewal processes must be prioritized, improving the density of existing built-up areas, developing empty inland, and introducing strategies for controlling urban sprawl.

The management of healthy territories must focus on planning, design, and implementation of projects that improve connectivity conditions, better interior and public spaces and social facilities. They must encourage and facilitate the revival of derelict landfills: a city should be healthy from its center to its periphery, it has to improves and revalue marginal environments, it must be committed to innovating and materializing the concept of productive housing, to integrating production and residential sectors, to rationalizing the use and occupation of land, to establishing mechanisms for land management and for favoring local communities, and counteracting the displacement or expulsion of the resident or minority groups.

The case of the revitalization of the Bronx in Bogotá city center, are clear examples that remind us of the complexity of those actions, but at the same time the great opportunities they bring to build healthy territories. Likewise, Barcelona, and many other big cities, have undertaken reconfiguration processes of their urban layout with walkable superblocks, which, added to its network of neighborhood markets, have made it possible to return the human and pedestrian scale to a city designed more than 160 years and to promote better and healthier lifestyles.

22.6 Green and Biodiverse City

Climate change is the greatest global health threat and opportunity. But controlling emissions, making industries safer and cleaner, using renewable energy, and reusing and recycling, are not enough. Integrating air quality management and climate action planning provides an opportunity for cities to address both their climate mitigation and adaptation planning needs while considering the health of residents (C40 Cities 2021).

We must reduce people's and cities' carbon footprints while migrating to healthier lifestyles, promoting better biodiverse green and blue infrastructures, interconnected and nearby green parks and environmental areas at the service of the community. It is proven that green space is good for health. Green areas contribute to improving environmental conditions by increasing air quality, reducing the greenhouse effect, and capturing

Fig. 22.3 Cities for all. *Source* Photos by the authors

carbon. We also need to implement nature-based solutions and care for biodiversity, fostering networks of urban agriculture and nearby food supply, with communities involved in the generation of their own basic products, guaranteeing food security for families, encouraging responsible consumption and healthier habits.

Implementing green belts, preferably surrounding compact cities, in which agricultural and supply needs converge with environmental protection and conservation, helping to recompose urban–rural relations. They have helped to control and direct urban expansion, protected productive land, and contributed to climate change mitigation. The green belt of the Medellin Metropolitan Area (Colombia) as in many other cities worldwide proves that such strategies help recomposing our relations with the territory in a healthy way.

22.7 Inclusionary City

Democratic and harmonious societies arise by guaranteeing well-being, public health, and social interaction, and some of the best scenarios to achieve them are the networks of public spaces and urban facilities that promote people interaction and help to overcome urban social and spatial segregation. Thus, healthy cities must promote an increase in the quantity and quality of public spaces, and socio-cultural facilities, while promoting broad community participation in their design, use, and appropriation.

As inequality and segregation deepen worldwide, architects and planners must procure cities for diversity, happiness, and tolerance, fostering equal and healthy environments for all and giving special attention to the most vulnerable groups: children, women, and the elderly and poor people. Furthermore, the shaping of cities and their public spaces should promote physical activity, learning, rest, and leisure, meaning healthy lifestyles for all ages (Fig. 22.3).

"Most often, our cities seem as if they are designed for an athletic 30-year-old man, but cities should also be accessible to the 8-year-old and the 80-year-old among us (…). A city with an engaging and accessible public realm that invites seniors to take part in public life can address social isolation among seniors to a great extent. A city that has spaces for young people from all backgrounds to congregate can do a lot to instill a sense of belonging in them. We should also go one step further and think about creating multigenerational spaces where the old can interact with the young" (880 Cities 2021).

UIS University in Colombia, is redesigning its institutional and infrastructure strategies, consolidating its campus as a large open-access-urban-park, and additionally organizing recreational and educational activities for leisure and the meeting of children, youth, adults, pets, and for the whole community, fostering outdoor healthier lifestyles. Another reference is a former hostile, rival, and segregated territory like some “Comunas” in Medellín Colombia that began processes of physical and social integration and inclusion like in Juan Bobo project. Or Bogota’s public policy of “affectionate-environments” implementing a system of “care for the people who care us”, where women become the center of public action, as an inclusionary policy.

22.8 Well-Connected and Walkable City

Reimagining mobility doesn't just come from improving road infrastructures, sharing vehicles, reducing fleets, or simply moving people. Adequate mobility shrinks space and brings territories and people closer together; promotes walking and non-motorized means, but this is not enough. Mobility initiatives should lead with equity and innovation and with people and planet health in mind.

We propose to adjust mobility networks and their public spaces starting from neighborhoods to the region; better active transportation options for everyone wherever they live, with interconnecting pedestrian corridors; co-creating streets and public spaces with the people using them; reorganizing street components to get complete streets and public spaces that work for everybody; promoting green and active neighborhoods and thus making the city viable for proximity and social interaction while encouraging healthy living.

Prevention can give returns for investment in topics like promoting walking and cycling, creating webs of open and nearby green spaces, encouraging a healthy employment environment, road traffic injury prevention due to pedestrian spaces improvement, promoting physical activity in adequate open parks, housing insulation promotion by public financing, and so on (WHO 2014).

“For example, working to a common vision of safe urban design, a cluster of cost-saving interventions and approaches—such as safe green spaces, safer driving and encouragement of walking and cycling—can be identified, potentially resulting in multiple health, social and environmental benefits… Even small investments in the territorial realm promise large gains to health, the economy, and other sectors, with sustainable outcomes. Preventive approaches like exercise promotion in well-designed open spaces, non-motorized mobility promotion, urban farming, and healthy food supply, “contribute between approximately 50% and 75% to the reduction of cardiovascular diseases mortality in high-income countries, and 78% globally” (WHO 2014).

22.9 City of Memory, City with Future

Acting from the local level implies recognizing and protecting the city as a tangible expression of collective memory, traditions, struggles, and cultural heritage, as an important part of the world and its complexity. This knowledge is essential to learn from the historical responses to health crises and pandemics, and the strategies used in cities to overcome them.

Effective reading of places we inhabit becomes the promising scenario to generate environments that lead paths for the creation and social appropriation of healthier conditions, from the use of traditional and environmentally friendly materials to innovative solutions, 3D printing, biomaterials, floating cities, to eventually be able to project our cities toward a future with a higher quality of life.

In the twentieth century, cars and elevators determined the model of the urban; in the twenty-first century, innovation technologies, and sanitary crises are the ones. Learning from the present crisis, cost-effective interventions ought to be made to address environmental determinants of health, like the removal of lead from domestic paint and plumbing in at-risk neighborhoods; new materials must take lead in the construction sector to overcome landfill contamination, human health hazards, finite resources depletion, and so forth, so human and planetary health and sustainability could be guaranteed.

There are "eternal" cities formed naturally: Rome, Istanbul, London, and Moscow which have sorted some of their difficulties over time. Some were originally designed: Beijing, New York, and St. Petersburg; those over time transformed from invented to natural. Others are the opposite, for example, industrial cities in Russia such as Togliatti, Nizhny, and Tagil, remain designed for activities and functions that have remained in the past, cannot adapt, and cannot resist the challenges of changing socio-economic formations, and technological structures, they are unhealthy and must be attended (Gladkly 2022). How to create the conditions for the naturalization of urban structures and tissues designed, and their transformation from designed to naturally habitable? What is the role of the self-government of the city's communities in this?

22.10 Conclusion

This paper highlights that our territories are ill, the fragility of public health, the weaknesses of the territorial planning processes to prevent pandemics, and the inextricable link between UN-2030 Agenda's SDG 3 and SDG 11, symbolizing healthy cities.

Planning, design, and construction of territories are essential to promote human health and wellness. The right to the city and the right to health mean more beneficial environments and lifestyles for all. So, we must demand State and community active participation to guarantee those rights and to truly reach healthier cities.

Healthy cities must be planned or renewed to favors proximity, compactness, close social relations, low carbon footprint, and good living standards. As it is proven that quality green spaces are good for health, they must have green and public spaces near and accessible to all, proportional to the built areas, and sustainable mobility, use of renewable energy, and respect for biodiversity. And above all, healthier cities are those where State and citizens understand that health does not refer to hospitals, sewerage, or buildings alone, but to the whole built environment that welcomes and nurtures humankind and all its actions and relations.

If cities and their natural and built environments provide positive conditions for all to enjoy well-being, live in suitable environments, eat healthily, take care of their bodies, and productive activities do not negatively impact environment, we will be preventing diseases, promoting constructive and more equitable community relations, as well as providing more opportunities for everyone to develop properly as human beings and good citizens.

Healthy societies encourage more better relationships with the environment, synergies in the urban–rural continuum, and high standards of health and life for all, having a deep impact on the health of the planet and of civilization.

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23 Restorative Perceptions of Different Urban Residential Environments in Different Seasons in the Severe Cold Area: A Case Study in Harbin, China

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Abstract

Nowadays, China is urbanizing rapidly, however, the rapid urban expansion and social development have brought enormous psychological pressure on people. People's mental health has been challenged. In such times of distress, there is increasing importance on the restoration of the residential environment. However, the existing residential environment can not meet people's desire for a healthy environment. The purpose of this research is to explore how to create a healthier residential environment within established planning regulations and land-use constraints. Based on the residential planning policy of Harbin, this research compared the restorative effects of residential space in different kinds of environments. The residential environments were shown by photos taken every other month from summer to winter (July to January) with the same location and perspective. The restorative effects were evaluated by the PRS scale. Our results clearly showed that environmental elements such as *buildings*, *hard paving*, *trees*, *leaves*, and *snow* have a significant impact on restorative perceptions. Restorative perception varies seasonally in residential areas with different designed environments, and although this trend is not the same, none of the restorative perceptions are the best in summer. Our results highlight the important role of seasonal design strategies for the residential environment with restorative effects based on planning policy. This paper present provides a reference for the seasonal factors of residential construction and provides a healthier environment for the residents.

Keywords

Restorative perception · Seasonal variability · Residential outdoor space · Mental health

23.1 Introduction

With the rapid development of urbanization in China, the demand for residential buildings is increasing. However, nowadays urbanization

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processes and land recourses become increasingly scarce, as one of the most in-demand types of buildings, the construction of residential has shifted from horizontal expansion to vertical expansion (Zhou et al. 2021). In addition, the design of a residential area involves many elements, including architecture, transport, and landscape. Besides, the design has to meet lots of conditions, such as the minimum distance for sunlight, fire separation distance, and floor area ratio. There is a big difference between China and Western countries in residential layout form. China uses enclosed residential instead open residential (Wang et al. 2018). This model of enclosed residential improves safety but reduces the ease of living. Therefore, how to achieve a healthy residential is of paramount importance. Although the process of urbanization varies from region to region, all are harmed by this process. Studies in many countries and regions now prove that urbanization increases the risk of developing mental disorders. This hazard poses a potential threat to mental health through highly polluted environments (Rocha et al. 2015), neighborhoods (Ventimiglia and Seedat 2019), population density, and housing types. (Chen et al. 2021) The State Council of the People's Republic of China issued a Tutorial for Outline of the Healthy China 2030 Plan to meet these healthier demands, in 2016 (China.gov.cn 2022).

Restorative perception has a mediating role in the regulation of mental health. Attention restoration theory (ART) has been widely accepted as the basic theory of restorative environment. ART is the assumption that certain characteristic elements of the environment can increase the effect of the overall environment's restorative (Kaplan, 1995). Ulrich has theorized about stress reduction and pointed out that the environment has a restorative effect in regulating negative emotions (Ulrich 1983). And the restorative effect can alleviate the mental fatigue and energy consumption that people experience from work to life. In addition, ART proposes that people can benefit from entering situations characterized by four restorative qualities, that is, *being away*, *fascination*, *extent*, and *compatibility* (Ulrich 1983). Extensive research has shown that residential outdoor environments can promote mental health (Liu 2021) through residents' restorative perception (Hartig et al. 2014). The Perceived Restoration Scale (PRS) has been developed by Harting and has been widely used in related studies. The scale is based on ART theory and used to measure the restorative effects of the environment. This scale includes 16 questions and the four dimensions mentioned in ART theory with a seven-point scale (Hartig et al. 1997).

On one hand, there was a large number of recent studies that proved restorative environments have positive effects on people, such as reducing stress, sleep disorders, depression, and other negative emotions. On the other hand, different environmental elements have different effects. Current research on the mental health effects of outdoor environments was dominated by three studies on green, blue, and white spaces. These color environments have an impact on a person's mental health (Tao et al. 2022). Green space is a space characterized by green vegetation, such as a park, that is covered with green vegetation (Taylor 2017). With the development of urbanization, the interest in architectural attributes as a restorative factor in the environment is also increasing. There is a significant negative correlation between urban architectural properties and the recovery of urban streetscape (Lindal 2013). Besides, different people have different effects in the same place. Some findings suggest that the mental health benefits of restorative environments vary by gender, age, and cultural background (Triguero-Mas 2017). Other studies suggest that people of low socioeconomic status may benefit more from restorative environments (Triguero-Mas 2017).

Herein, the main aim is to detect restorative perceptions seasonally, by using questionnaire and photo quantification methods. The goal of this research is to examine the restorative perceptions of different kinds of environmental elements (buildings, hard paving, trees, autumn leaves, and snow) and the relationship between these elements and four restorative qualities. The hypotheses are that (a) there are differences in restorative perceptions among seasons; (b) environmental elements (buildings, hard paving, trees, autumn leaves, and snow) are significantly related to the restorative perceptions; (c) there are differences in the impact of environmental elements on four restorative qualities. If the environmental elements have a different impact on restorative qualities seasonally, implying that future seasonal designs for particular restorative qualities might be efficient to improve residents' healthy.

23.2 Methods

The research program was divided into photos and questionnaire collection phases (see Fig. 23.1b). The photos were taken in three seasons and reflected information on environmental elements through quantification. The questionnaire collected respondents' restorative perceptions of the above photos.

23.2.1 Stimuli

Previous studies have shown that photographs have the same restorative effects as real landscapes (Wang 2019). Besides, the use of photographs to replace the real landscape has certain reliability. Three residential areas are located in the main urban area of Harbin, in the northeast of China. A typical environment for each residential area was selected and photographed in three seasons (see Fig. 23.1a). Residential A has a better environment with the highest plant coverage rate. Residential B is an older environment and less vegetation is tended. Residential C lacks greenery and daily activities are concentrated in the platform area on the third floor. On the site, each group of photographs was taken with the same shooting direction and the same photographer standing at the same point in summer (5 August 2021), autumn (18 October 2021), and winter (17 February 2022), respectively. These pictures were photographed level with the eye of the observer (about 1.60 m above the ground) on clear days to control for similar lighting conditions. Three aerial views were got from the Internet (see Fig. 23.1a). Photos in residential B were cleared cars with photoshop CC 2019 to present comprehensively. Residential A and residential B had different vegetation colors that varied with seasons. However, snow cover in winter was different in these two residential areas. Residential A was concentrated on the ground, while residential B included vegetation and ground, and had deeper coverage. Residential C hardly changed at all. This survey used Perceived Restorativeness Scale (PRS) scale to evaluate every photo. The PRS scale has been proven to be a useful measurement of environmental residential restorative evaluation (Hartig et al. 1997). This research targeted young Chinese people aged 18 to 30.

23.2.2 Measurement of Restorative Perceptions and Seasonal Variability

This survey used an online questionnaire powered by www.wjx.cn and good reliability was obtained. The online survey was conducted from July 31st to August 11th, 2022. A total of 125 questionnaires were received, among which 5 were invalid, with a valid recovery rate of 96%. The restorative perception was measured by PRS. The content of this questionnaire examined four restorative qualities (being away, fascination, extent, and compatibility). The statement for *fascination* was, "This place is attractive to explore and discover." And for *being away* it was, "This place helps me to relax my tense mood." The statement for the *compatibility* was, "The elements grouped here are in harmony." For *extent*, it was, "This is a rich and varied place." For each photo, the participants rated the extent to which they agreed with the given statement (1 = not at all; 7 = completely). In this research, we had a group of young people (aged 18 to 30). Of these, 46 questionnaires were collected for males and 74 for females. 66.7% of respondents were from northern China (north and south are divided by the Qinling and Huai River) and 33.3% were from the south of China.

In this research, we utilized the grid element method (West 1969) to quantify the physical

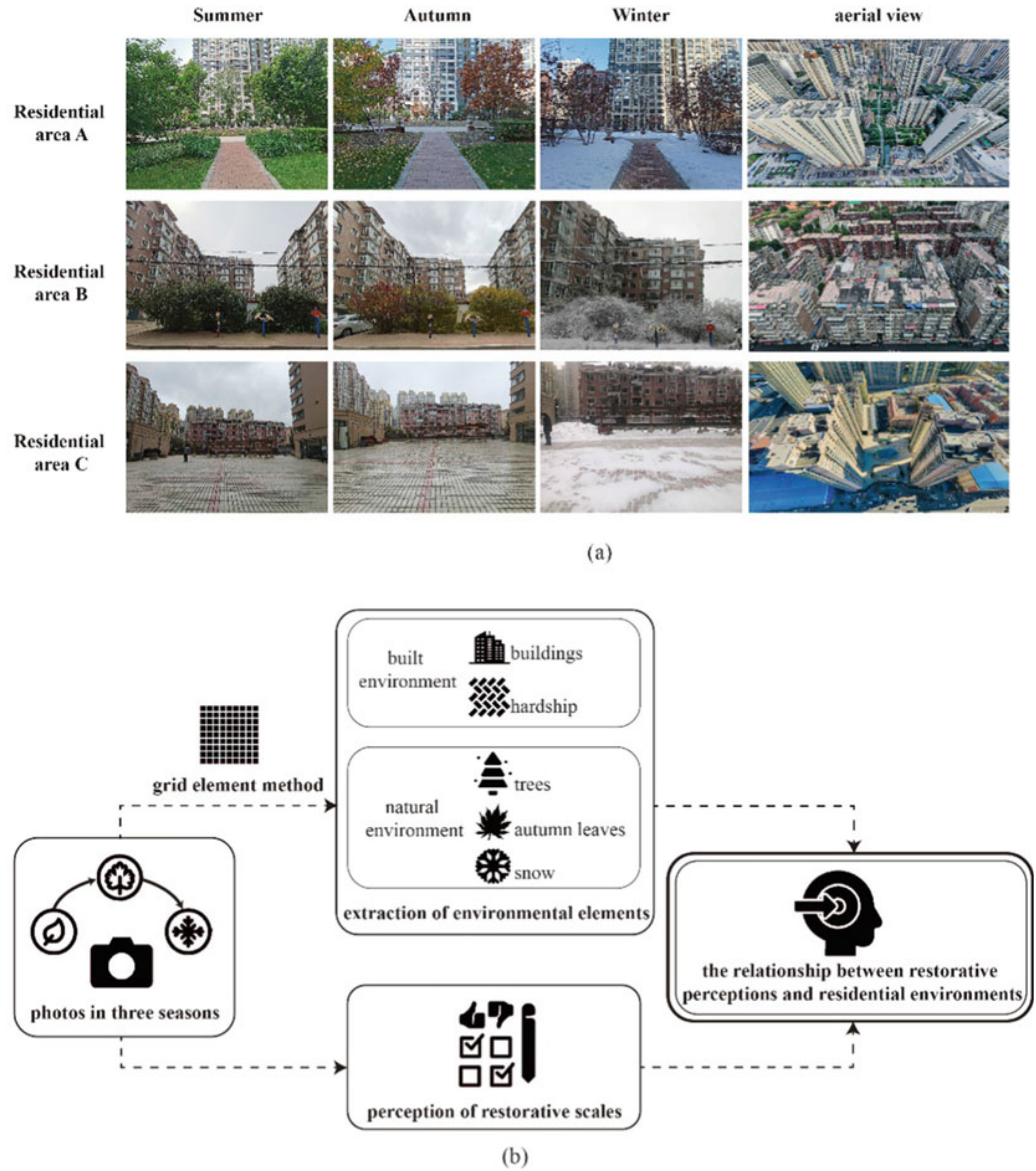

Fig. 23.1 The framework of the research program and residential photographs seasonally

environment of these residential areas. A grid pattern of 588 squares was laid over each photo by photoshop CC 2019. Only variable features that cover more than 50% of each grid were counted in the percentage of that variable relative to the total image. The variables included trees, snow, autumn leaves, hardscape, and buildings (see Fig. 23.2).

The variables for each photo are shown in Table 23.1. residential B has the most seasonal variation, however, residential C has changed little seasonally. In these three residential areas, trees make up the largest proportion (56.5%) of residential A and make up the least proportion (1.5%) of residential C in summer. In residential A, the proportion of trees in the photos in

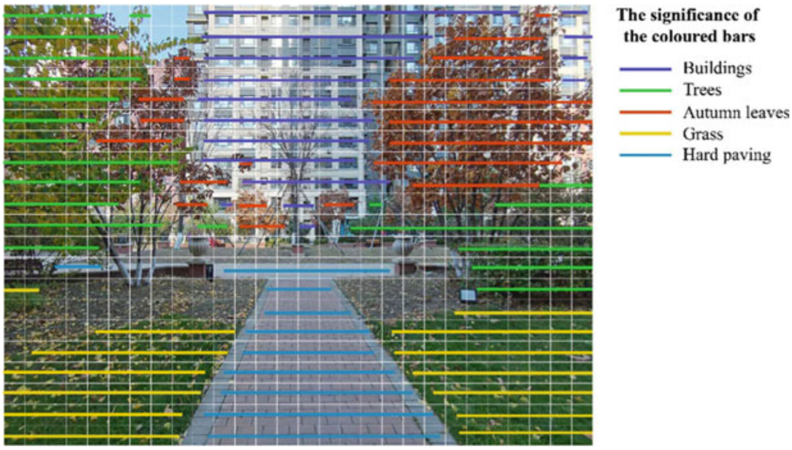

Fig. 23.2 Illustration of the use of the grid element method using the autumn of Settlement A as an example

Table 23.1 Descriptions of residential areas' natural and building environment

Sort	Seasons	Trees[a]	Buildings (%)[a]	Hard paving (%)[a]	Snow[a,b]	Autumn leaves[a,b]
Residential area A	Summer	56.5%	13.4	9.9	—	—
	Autumn	20.1%	17.3	13.3	—	16.0%
	Winter	—	29.6	8.3	26.2%	—
Residential area B	Summer	24.0%	33.5	14.6	—	—
	Autumn	24.0%	33.5	9.5	—	11.9%
	Winter	—	42.2	4.8	27.7%	—
Residential area C	Summer	1.5%	38.1	46.6	—	—
	Autumn	1.4%	31.5	46.6	—	0.5%
	Winter	—	40.6	12.2	45.4%	—

[a] % of the image
[b] seasonal features
[c] there are no such kinds of elements in the picture

summer and autumn has barely changed. In all residential areas, the proportion of buildings has changed little between summer and autumn. However, in winter, there's a 9–12% increase over the other two seasons. In terms of snow cover, the proportion of snow cover in residential A (26.2%) and residential B (27.7%) is similar. Residential C has the largest proportion of snow cover in winter which is 8%–9% higher than residential A and residential B. The locations of snow cover are different. The snow in residential B (27.7%) is covered in trees. Although the snow in both residential A (26.2%) and residential C (45.4%) are covered on the ground. Residential C has the largest proportion of it because of the larger area of hard paving (46.6%). The snow cover in residential A is on the ground and the snow cover in residential B is on the trees.

23.2.3 Data Analysis

This analysis focused on estimating the correlation of the relationships between objective residentials and restorative perceptions. At first, the interclass reliability of restorative perceptions scores was tested using SPSS 22.0. And then the one-way ANOVA was conducted to explore the differences in the effects of different seasons in these three residential areas. Finally, the correlation between different kinds of outdoor environments (buildings, hard paving, trees, autumn leaves, and snow) and restorative perception were analyzed with the Spearman correlation coefficient.

23.3 Results

23.3.1 Data Analysis

The restorative perception scores of nine pictures across three seasons were presented in Fig. 23.3. Generally, Fig. 23.3 indicated that seasonal transformation has an important influence on restorative perception. The restorative perception scores in residential A are much higher than the other two residentials among the three seasons, based on the mean restorative perception scores. Conversely, residential C was the worst performer in all seasons. The mean and standard deviation of the restorative perception scores in the nine photographs of the residential areas in Fig. 1a across the seasons are shown in Table 23.2. In the autumn residential A has the highest scores on all restorative qualities and PRS scores. Although residential B has the best autumn performance, it is still significantly lower than residential A. Although plants are the most abundant in summer and are considered to be highly restorative, summer restorative perception scores are not the highest compared to the two seasons of autumn and winter.

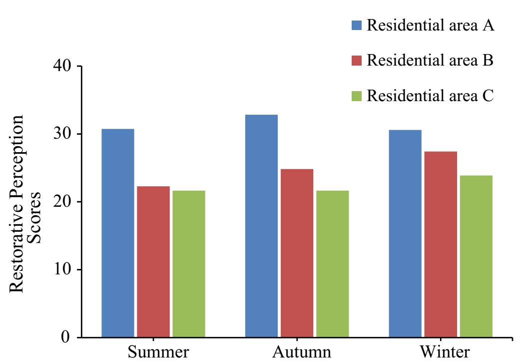

Fig. 23.3 Mean restorative perception scores (±standard error) among respondents for three residential areas across three seasons

The seasonal differences in restorative perception scores in the three residential areas were different. The one-way ANOVA shows that there are significant differences in restorative perception among the three seasons in residential B ($F = 2.466$; $p < 0.05$). In residential A, the restorative perception has significant differences in autumn from summer and winter. While there was no significant difference between autumn and winter ($F = 2.238$; $p > 0.05$). However, residential C ($F = 10.127$; $p > 0.05$) is not significantly different in any of the three seasons.

23.3.2 Effects of the Environmental Elements on Restorative Perceptions

Spearman's correlation analysis revealed that respondents' restorative perceptions are significantly negatively correlated with the proportion of the built environment (hard paving and buildings) and snow in the residential's environment (Table 23.3). Conversely, an increase in respondents' restorative perceptions is significantly and positively correlated with an increase in the proportion of the natural environment (trees and autumn leaves). Of these, buildings and hard paving have the greatest impact on restorative perceptions in summer (−0.373) and the least impact on restorative perceptions in winter (−0.145). Among the seasonal impacts, natural influences in summer and autumn have a positive effect. The leaves in autumn have the greatest impact on perceptions of restorative (0.471), with summer trees second (0.373). Snow in winter had a negative effect on restorative perceptions (−0.290).

There was a slight but non-significant difference in each score between the upper floors, while there was a significant difference between both the high-rise residentials and the multi-story residentials. In addition, aerial views of

Table 23.2 Mean and standard deviation (SD) of perception restorative and four typical characteristics

Sorts	Seasons	Being away	Compatibility	Fascination	Extent	PRS
Residential area A	Summer	8.12 (7.52)	8.05 (7.19)	7.02 (7.43)	7.55 (5.65)	30.74 (82.18)
	Autumn	8.17 (6.19)	8.43 (6.35)	8.43 (6.72)	8.54 (4.84)	32.83 (72.52)
	Winter	7.60 (7.27)	7.92 (6.67)	7.28 (6.91)	7.78 (4.86)	30.58 (73.81)
Residential area B	Summer	5.64 (6.50)	5.55 (5.76)	5.05 (5.78)	6.03 (6.57)	22.28 (76.35)
	Autumn	6.32 (6.02)	6.30 (5.72)	5.69 (5.53)	6.52 (5.38)	24.82 (67.19)
	Winter	6.80 (7.46)	6.98 (7.38)	6.57 (7.39)	7.06 (5.70)	27.41 (90.65)
Residential area C	Summer	5.42 (6.62)	5.33 (6.10)	5.08 (6.55)	5.83 (6.14)	21.66 (81.67)
	Autumn	5.42 (7.20)	5.33 (6.58)	4.93 (5.93)	5.98 (6.80)	21.66 (86.14)
	Winter	5.97 (7.71)	5.81 (6.76)	5.63 (7.56)	6.47 (6.94)	23.88 (95.67)

Table 23.3 Analysis of the correlation between architectural and environmental elements of residential areas and the typical characteristics and restoration perceptions scores of three seasons

Seasons	Typical characteristics	Building environment		Natural environment		
		Buildings	Hard paving	Trees	Leaves	Snow
Summer	Being away	−0.375**	−0.375**	0.375**	–	–
	Compatibility	−0.383**	−0.383**	0.383**	–	–
	Fascination	−0.284**	−0.284**	0.284**	–	–
	Extent	−0.266**	−0.266**	0.266**	–	–
	PRS	−0.373**	−0.373**	0.373**	–	–
Autumn	Being away	−0.281**	−0.127*	–	0.409**	–
	Compatibility	−0.315**	−0.135*	–	0.450**	–
	Fascination	−0.302**	−0.115*	–	0.417**	–
	Extent	−0.328**	−0.081	–	0.409**	–
	PRS	−0.350**	−0.122**	–	0.471**	–
Winter	Being away	−0.121*	−0.118*	–	–	−0.239**
	Compatibility	−0.148**	−0.171*	–	–	−0.319**
	Fascination	−0.113*	−0.142**	–	–	−0.255**
	Extent	−0.130*	−0.082	–	–	−0.211**
	PRS	−0.145**	−0.145**	–	–	−0.290**

** Correlation significant at 0.01 level (two-tailed)
* Correlation significant at 0.05 level (two-tailed)

residentials were analyzed in relation to perceptions of environmental restorative, with high-rise residentials (residential A (27.87) and residential C (24.97)) scoring higher in aerial views than multi-story residential (residential B (21.38)). This is possible because multi-story residentials were more cluttered in aerial views than high-rise residentials.

23.3.3 Effects of the Environmental Elements on Four Restorative Qualities

The results of the comparison of the magnitude of the influence coefficients in the relationship of the elements on the four restorative qualities showed that different environmental elements had different degrees of influence on the perception of restorative in different seasons. The built environment (buildings and hard paving) had the greatest negative impact in summer, but this impact was reflected in different restorative qualities in different seasons. The *compatibility* is the most negatively affected by the built environment in summer (−0.383**) and in winter (−0.148**), while autumn had the largest negative correlation coefficient for the *extent* (−0.328**). The four restorative qualities least affected by the built environment were not the same across the seasons. In summer it was the *extent* that had the lowest negative correlation coefficient. In autumn it was the *being away* that had the lowest negative correlation coefficient with buildings and the *fascination* that had the lowest negative correlation coefficient with hard paving. In winter it is the *fascination* that had the lowest negative correlation coefficient with buildings and the *being away* that had the lowest correlation coefficient with hard paving. Seasonal changes in natural environmental elements had the greatest positive and negative effects on the *compatibility*, and the least in the *extent*. In terms of the height of the building, this paper present that multi-story residentials had the most significant differences in *compatibility* ($F = 10.455$, $p < 0.0001$), based on the comparison of the four restorative qualities scores in Fig. 23.4. In summary, *compatibility* showed the greatest influence by the elements in all three seasons when compared across different restorative qualities. The *extent* was least associated with the natural environment in four restorative qualities.

23.4 Discussion

In the setting of Chinese residential construction policy, elements of the living environment have a significant impact on the mental health of residents. We confirmed the hypothesis that there was a correlation between restorative perceptions of urban residential environments. Also, seasonal changes and the season with the best restorative

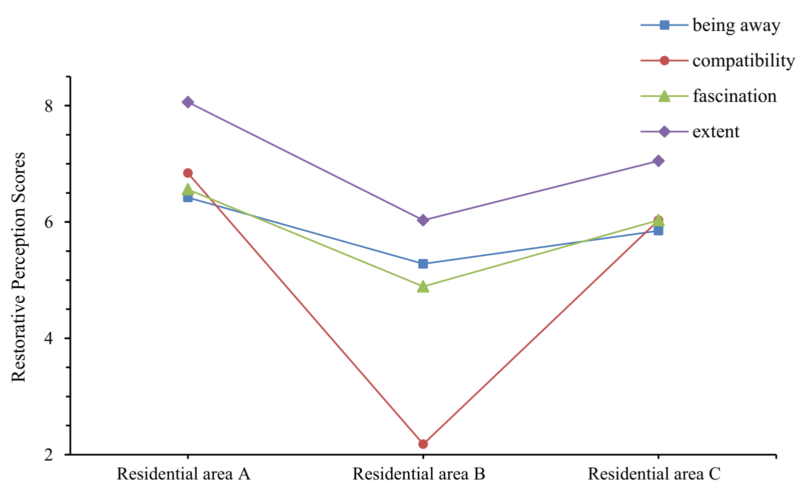

Fig. 23.4 Mean restorative perception scores (±standard error) among respondents for 3 aerial view pictures in three residential areas

perceptions are not consistent across residential areas of different environmental designs. The different seasonal natural environment elements have an important role in the analysis of restorative perception, and only green elements without other natural elements in a residential environment do not seem to be sufficient to improve perceptions of restorativeness.

23.4.1 Seasonality in Restorative Perceptions of the Outdoor Environment

The results of this research showed that residential restoration is perceived at different levels in different seasons. This is related to the different representative elements of the different seasons. In the northern part of China, trees are predominantly deciduous, and in the summer, vegetation growth is lush and the overall environment is predominantly green. This study supports Kaplan's restorative theory of nature (Kaplan 1995). Numerous studies have been conducted in detail in this area (Liu 2022, Hansen-Ketchum 2011) and found that the green environment has a strong restorative effect through multiple pathways of exposure (Fan 2011). In autumn, deciduous and evergreen trees commonly found in northern residential areas show different landscape effects (Kuper 2020). This research found that autumn has the best perception in the *extent* dimension compared to summer, suggesting that deciduous trees enhance the restorative perception of the *extent* dimension more in autumn than in summer (Table 23.3). In winter, the snow makes the environment appear significantly different from the other seasons, but the restorative perception in winter showed different trends in different residential areas compared to the other seasons. Snow covering hard paving only does not improve perceptions of recovery when the environment is already at its most restorative in summer and autumn. In residential areas with average perceived restorative scores in summer and autumn, snow was found to improve restorative perceptions considerably. Similar results were found by Vassiljev (2007) in which deciduous forests in winter have better restorative effects than in summer. In severe cold areas such as northeast China, where residents are prone to mental health problems due to the climate (Lindsay and Yantzi 2014), it is necessary to enhance the residential environments in conjunction with the snowy landscape. This research adds to the restorative characteristics of the winter environment in Chinese urban residential areas in response to rapid urbanization in China.

23.4.2 Relationship between environmental elements in residentials and restorative perceptions

In this research, we used objective measures such as the size of the area of hard paving, buildings, trees, autumn leaves, and snow to assess subjective restorative perception and four restorative qualities (being away, fascination, compatibility, and extent). Elements of the built environment including buildings and hard paving are detrimental to restorative perceptions, which were validated (Lindal 2013, Liu 2021). Although previous research had suggested that the natural environmental elements are conducive to physiological and psychological restoratives, not all elements of the natural environment have positive effects. For example, snow has both positive and negative effects. When snow covers trees, it has positive effects on three restorative qualities: *being away*, *compatibility,* and *fascination*. When the snow covers hard paving, it has a negative effect on the *being away*. Similar results (Finlay 2018, Bielinis 2022) found that the restorative effect of white space is uncertain. Trees without foliage also have a positive effect on humans as well as the restorative nature of white space, and forest environments with snow cover can relax mentally. Although the built and natural outdoor environments of residential areas are limited in design, the configuration of natural elements and the management of residential areas' properties can compensate for the negative effects of built elements and thus achieve healthy residential areas.

23.4.3 Relationship Between Residential Policies and Restorative Perception

Differing from Western countries, most of the existing residential areas in China are enclosed layouts. The enclosed layout has the advantage of being less noisy and safer. However, this prevents the rich natural environment in some residential areas from being enjoyed by more people. Nowadays, Chinese residential area construction policies are transforming from enclosed residential areas to open and semi-open residential areas (The CPC and the State Council 2016). The residential environment is not resident-friendly in the context of current policy and social development. So, in this context, designers should pay more attention to the seasonal changes in the natural environment of the residential areas and the proportion of the built environment. Though the residential design is limited by existing urban planning and land restriction policies, enriching the outdoor environment, whether in a high-rise or multi-story residential area, to provide a more fascinating and relaxing environment can improve residents' perceptions of restorative. These methods, as indicated in this study, are conducive to improving the residents' restorative perception and their mental health, thus achieving the SDGs.

23.4.4 Limitations and Future Research

In this research, only three residential areas are selected, which possibly lack representation. Even in China, there is a wide variety of residential types and this study only discussed the high-rise and multi-story residential common in Chinese cities. Some types of residential areas were not considered in this study. Besides, there is a difference between the restorative of photographs and the restorative of the actual environment. In a real environment, observers would complement the shape of the obscured object by understanding it (Nordh 2009), but the percentage of each environmental element in this study was the percentage of the foreground picture and no calculation was made for what was covered. This factor should be considered in future studies.

Although there are some limitations to this study, it helps the environmental design under the restrictions of established planning.

23.5 Conclusion

This study explored the restorative perceptions of environmental elements in different types of residentials. The results indicated that the restorative perception of the environment varies with the season. Restorative perception is not optimal in the summer and the degree of restorative perception varies from season to season for different environmental elements. This variation is the most significant in the *compatibility* and least in the *extent*. The study also compares the height of the building, with significant differences between high-rise and multi-story settlements in the *compatibility*. In spite of some limitations, these results provide valuable suggestions for not only seasonal interest in residential design, but also better year-round restorative perceptions for residents. In general, a reasonable environmental configuration of residential areas with appropriate housing policies is conducive to the residents' mental health, which is in line with SDGs. This study suggests the environmental design of residential areas as one of the effective means of achieving SDGs.

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24 Planning Response of Urban Community Governance in China from the Perspective of Prevention and Control of Children's Mental Health Risks

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Abstract

In the past 20 years, China's urban living environment may have undergone significant changes, bringing about many adverse effects. Many studies show that the urban community environment is related to the mental health of residents. At the same time, due to children's social and health vulnerability, their mental health is more vulnerable to environmental factors. Therefore, based on the literature research on children's mental health risk factors and urban community environmental health impact factors, this paper proposes the planning response method of China's urban community governance from the perspective of children's mental health risk prevention and control, clarifies the main body and implementation path of community governance, and proposes the planning strategy of community governance, which provides theoretical support and guidance for promoting China's healthy community governance.

Keywords

Children's mental health · Urban community governance · Healthy city

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24.1 Introduction

Due to society's rapid modernisation and urbanisation, children as vulnerable groups will face new health risks factors such as air pollution, imbalance of diet structure, and education pressure. Among children and adolescents under 17 in China, about 30 million people suffer from mental health problems such as emotional disorders and behaviour (Jieying 2008). According to the Survey on the Status of Chinese Children, about 21% of children feel depressed, 20.1% feel unhappy, and 22.1% lack good interpersonal relationships (Lijun and Dali 2016). The mental health risks faced by Chinese children need to be paid attention to and improved.

Children's mental health risk is affected by genetic, environmental, and individual factors, while urban communities provide a rich and diverse material space and humanistic environment for children's growth and development. As the basic unit of residents' life, the community is

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the essential governance subject to promote a healthy China. Community governance is a process in which residents, governments, social organisations, and other service institutions within the geographical space of the community jointly participate in decision-making, management, and implementation of community public affairs (Sullivan 2001). During the governance process, all participants need to play their respective roles. Community governance is a profitable way for children and their guardians in the community to express their demands. Therefore, it is of great practical significance to prevent and control children's mental health risks by utilising community governance.

The community environment affects children's mental health in many ways. As a critical node combining material and social factors in children's lives, the community scale is more likely to achieve the environmental characteristics conducive to children's mental health, such as a sense of belonging, comfort, and safety. Improving the community environment through planning and governance is a critical way to prevent and control children's mental health risks. Therefore, this paper attempts to summarise the characteristics of children's mental health risks at different ages, analyse the community environment influencing factors of children's mental health risks, explore the relationship between community governance subjects and the implementation path from the perspective of children's mental health risk prevention and control, and propose specific strategies.

24.2 Characteristics of Mental Health Risks of Children at Different Ages

In order to maintain the highest level of health in the whole life cycle, we need to consider life as a continuous process to consider its changing rules. Childhood includes many significant life course changes, such as life gestation and growth, education and learning transformation, and physical and mental vigorous development, and is a crucial stage in the life continuum. The target population of this study is children from preschool to school age (3–12 years old), which can be divided into three stages: infancy, preschool, and school age. Children's mental health problems are not only affected by current health risk factors but also closely related to short-term or long-term health risk accumulation at different stages. Therefore, identifying the characteristics of mental health risks at different age stages can provide a theoretical basis for the proposal and application of intervention measures.

24.2.1 Mental Health Risks of Preschool Children

Although preschool children (3–6 years old) still need to be cared for, they have specific independent activity abilities. The scope of activities has gradually expanded from family to community. Their actions, words, and intelligence have developed rapidly and show personality, emotion, and other behavioural characteristics (Yecheng 2010; Zhiwei et al. 2013). Preschool children have significantly improved their acting ability and scope compared with infants and young children, but their awareness of early warning and ability to deal with risks are significantly lower than those of school-age children.

Premature exposure to electronic products and excessive static living behaviours (sedentary, screen exposure.) lead to early detection peaks of health problems such as myopia and obesity, and children's psychological and behavioural problems such as hyperactivity, disobedience, and anxiety appear. In addition, under the influence of the background of a comprehensive second child and the traditional Chinese family concept, intergenerational care has a significant adverse effect on preschool children's mental health, but it has little effect after school age (Shicheng et al. 2017).

24.2.2 Mental Health Risks of School-Age Children

School-age children (6–12 years old) have made steady progress in their physical and mental development. Curriculum learning has replaced games. Families, communities, and schools have jointly become the influence environment. The emotional formation is gradually advanced. They have independent activities and essential logical thinking but are not yet mature. The mental health risks faced by school-age children are mainly anxiety, depression, and post-traumatic stress disorder.

Compared with general anxiety, the detection rate of learning anxiety is generally high. The detection rate of learning anxiety in school-age children in Yunnan Province is 60.7%. Problems faced at the learning stage, such as academic performance, the rhythm of work and rest, and interpersonal relationships, will impact children's anxiety (Huajun and Sha 2021; Duan et al. 2020). Post-traumatic emergency barriers are caused mainly by disasters, and the population incidence rate is about 8%. For example, in the early days of the outbreak of the new coronal epidemic in 2020, the detection rate of children's depressive symptoms in Hubei Province was 22.4%, which is consistent with the survey results of 20 provinces, cities, and autonomous regions in China (Xue et al. 2021).

24.3 Community Environment Influencing Factors of Children's Mental Health Risks

The risk factors for children's mental health mainly come from internal genetic factors and external material and social environment factors. The city is a population and social life community in a particular area, and its environment directly impacts children's mental health risks.

Based on defining the characteristics of children's mental health risks at different ages, to propose community governance measures for health risk prevention and control, it is necessary to analyse further the impact of community environmental factors on children's mental health. It will explore the relationship between various factors and children's mental health risks from both the physical space and the humanistic society.

24.3.1 Factors Affecting Physical Space

Physical space elements directly affect children's perception and sense through places or services to affect children's mental health or affect health risks by influencing behaviour, social interaction, physical activity, and other ways. The health risk factors of physical space are mainly manifested in the natural environment, built environment, services, and facilities.

24.3.1.1 Physical Environment

Physical environment refers to substances in contact with the body. Children's mental health risk factors in the community's physical environment are mainly reflected in air quality, noise pollution, light pollution, and soil and water pollution. As children breathe faster and have lower activity space, various air pollution sources in the community, such as car exhaust, cooking fume, and garbage smell, are more likely to trigger children's emotional reactions and even cause respiratory system damage, lung inflammation, and poisoning (Rahman et al. 2015). Different types of noise pollution, such as traffic, construction, and neighbourhood, will affect the activities and functions of children's nervous systems, resulting in psychological health risks such as depression and anxiety (Śliwińska-Kowalska and Zaborowski 2017). Children's pupils are more significant than those in adulthood, and facilities such as constantly or excessively bright light signs and building lighting in the community at night have too much contrast with ambient light, which is more likely to inhibit children's melatonin secretion and affect their circadian rhythm regulation (Youbin and Yuhua 2016). In outdoor sites for children's activities, tail gas sedimentation and melting water containing snow-melting agents will cause heavy metal or chloride pollution of soil and surface water, affecting children's intelligence and immune function development (Lanfeng et al. 2014).

24.3.1.2 Built Environment

(1) Green Space
Community green spaces such as water systems, parks, and pedestrian greenways have various promoting effects on improving children's mental health and rarely induce negative behaviours.
However, some regions will have children's mental health risks under seasonal climate change. The proportion of green space and accessibility determine the opportunities for children to come into contact with green space. Low green space indicators will reduce the connection between children and nature, reduce children's environmental perception and activity level, and lead to natural deficiency, psychological and behavioural problems, and other undesirable phenomena (Louv 2005). Micro-spatial visual indicators such as green vision rate, colour richness index, sky openness index, and transparency of green space will affect children's psychological feelings, such as a sense of safety, comfort, and pleasure (Sturm and Cohen 2004; Leiqing et al. 2019, 2017; Junwei and Jian 2015). Too monotonous and cold green space is not conducive to forming children's attention and imagination and even causes psychological health risks such as depression and obstacles (Yang 2016).

(2) Land-Use Mode
Land use indirectly affects children's mental health by affecting their physical activities. Land use includes development intensity, building density, mixed utilisation, and spatial form. The intensity of land development in the community will affect children's physical activity. The height of buildings is positively correlated with the amount of physical activity of children (Chenwei and Xili 2018). The overall density of buildings is negatively correlated with the amount of physical activity of children (Jia et al. 2019). The community environment with mixed land-use functions will promote children's physical activity (Baoxin and Wei 2018). Physical activity directly impacts children's emotions, personality, neural development, and other psychological behaviours. In addition, the architectural layout and spatial form of high-rise communities will change the microclimate environment of the community, which will affect children's immune, nervous, and skin systems to varying degrees (Yiran et al. 2020; Huiming 1997).

(3) Road Traffic
The increase in social activities and interface richness, population density, and walking accessibility of community streets will affect children's preference for activities and improve the safety of the school environment (Chandrabose et al. 2019). However, intersection safety, parking form, and pedestrian facilities will affect parents' monitoring, greatly determine children's physical activity decision-making (Fulton et al. 2005), and affect children's physical activity volume and psychological and behavioural development.

(4) Site and Facilities
In the recreation area of community public space, the composition of zoning functions, the composition of game elements, and the size of the connection area will affect children's social behaviour choices (Kaixin and Xili 2019), thereby affecting the healthy development of psychology. The accessibility of sports facilities and the cleanliness and beauty of the community activity environment will affect children's physical activities, and the choice of playing field pavement materials will affect children's sports and chemical injury risks (Zhengshi et al. 2015).

24.3.1.3 Services and Commerce

The service facilities in and around the community are closely related to children's mental health risks, including medical care, food environment, and tobacco and alcohol retail. The service scope and accessibility of medical service facilities will affect the first-aid time of children's accidental injuries and the availability of medicines for children with chronic diseases (Aubrey-Bassler et al. 2019). The type and accessibility of retail, catering, and other food facilities affect the types of food available to children and the balance of nutrition intake. Low-income communities are more likely to have a "food desert," thereby increasing health risks such as overweight and obesity of children (Wenwen and Bing 2014). The accessibility and visibility of tobacco and alcohol retail facilities will affect the exposure rate of children and adolescents, increase the exposure to tobacco smoke, and affect the health of children's nervous and respiratory systems (Barton et al. 2017).

24.3.2 Factors Affecting Humanities and Society

24.3.2.1 Family Environment

Children under the age of 14 can hardly identify the impact of their activities on their health, and their behaviour is more likely to be affected by their parent's wishes. The family factors that affect children's mental health are mainly family structure and family atmosphere. Family structure has a significant impact on children's growth and development. With the implementation of China's current two-child policy, the physical activity level of children in non-only-child families may be reduced due to the influence of parents' energy dispersion (Xiangying et al. 2013). In addition, family atmosphere factors such as the number of family sports equipment, parents' sports habits, and sports support for children are also crucial to children's physical activity (Songjun 2013; Xin et al. 2012).

24.3.2.2 Neighbourhood Environment

The form of Chinese community dominated by closed communities has weakened children's sense of community belonging and cultural identity, and the incidence of children's friendship opportunities and group activities has declined, which is not conducive to forming their social adaptability. At the same time, the ageing population has caused conflicts between community elderly care resources and nursing resources. Community medical, road transportation, and catering services have not paid enough attention to children, which has affected the fairness of children's mental health.

24.4 Community Governance Subject and Implementation Path from the Perspective of Children's Mental Health Risk Prevention and Control

The community factors that affect children's mental health risks are diverse and complex, involving the built environment, social economy, lifestyle, and other aspects, and also vary with children's age. In the world, governance at the community level in China is unique. It is an organic combination of in-depth national governance and the extension of autonomous organisations. The governance process monitors, maintains, and promotes the healthy development of individuals and communities. Therefore, in community governance, we should take people-oriented governance as the basic principle, define diversified governance subjects, rights, and obligations, and achieve the goal of preventing and controlling children's mental health risks through the implementation path of spatial refinement and intelligent service.

24.4.1 Governance Subjects, Rights, and Obligations

The main body of community governance is the decision-maker and actor of community development, which is directly related to the participation mode and resource source of community governance and is the essential element of community governance. At present, the main body of community governance is changing towards diversification. The basis for proposing implementation paths and specific strategies is to clarify the types of governance bodies and their rights and obligations in preventing and controlling children's mental health risks. The central bodies of urban community governance in China mainly include two community committees, owners' committees, community residents, community planners, property management institutions, and other social organisations.

(1) Two Committees of the Community
The two community committees are the community party branch committee and the community residents' committee. The two committees of the community play a leading role in community governance, in which the party committee leads the community's grassroots governance as a whole, and the community residents communicate with the superior government through the neighbourhood committee. The two committees of the community should organise and guide residents to reflect the needs of children's mental health risk prevention and control, promote the government to allocate construction funds, assist in formulating community conventions and community activities oriented to children's mental health, and organise community construction.

(2) Owner Committee and Community Parent Activists
The owners' committee is composed of the owners' representatives jointly elected by the community owners. The owners' committee should actively advocate the prevention and control of children's mental health risks in the community, put forward the willingness and requirements for children's mental health risk prevention and control to the neighbourhood committee and the property, and supervise the implementation of the property. Owners can spontaneously set up parent activist groups, provide timely feedback on the needs of children and guardians of different ages, and assist owners' committees, property management, neighbourhood committees, and other organisations in community governance.

(3) Community Planner
Planners should play a role in balancing the rights and interests of children's mental health in the community and the efficiency of government governance. On the one hand, they should assist children and guardians in expressing their health claims and translating them into planning results. On the other hand, they should assist the government in the fair allocation of public resources to ensure the efficiency of using various facilities.

(4) Property Management Organisation
The property is an enterprise entrusted by the owners' committee to provide paid community management services. It should actively cooperate with the owners to promote and educate children's mental health, organise community parent–child activities, build, manage, and maintain children's service facilities in the community, and ensure the safety of children in the community.

(5) Social Organisation Foundations
In order to meet the financial needs for prevention and control of children's mental health risks in the community, the neighbourhood committee can lead the establishment of special funds such as the Children's Development Fund. In addition to government subsidies, parents with children in the community should also be the main funders, and a particular person should be employed to operate, establish a reasonable and feasible fund expenditure mechanism, and use the funds to organise children's mental health-oriented activities and facilities, to ensure that children's health risks in the community are effectively controlled.

24.4.2 Implementation Path of Community Governance

The implementation path of community governance determines the participation form of each subject and forms a multifaceted network cooperation relationship. The implementation path of community governance from the perspective of prevention and control of children's mental health risks should include the rational decision-making process from the acquisition of children's mental health needs, the construction of intelligent service platforms, the research and judgement of children's mental health risks, and the optimisation method for the formulation of governance strategies and the implementation and evaluation of measures.

(1) Analysis of the Needs of Children and Guardians and Community Development
The efficiency of traditional household interview collection is low, and the information is sluggish.
The satisfaction of children and guardians with the safety and health of the community environment can be investigated through online questionnaires. The guardians of children can also reflect the needs of children's mental health and their own guardianship at any time through the Internet platform, forming a data platform for children's mental health. The community neighbourhood committee and the property management should regularly assess the physical and cultural environment of the community and find that the community environment has shortcomings in preventing and controlling children's mental health risks.
(2) Establish a Collaboration Platform and Define the Authority of the Governance Subject
With the wide application of Internet technology and smartphones, communication between community governance entities has long been separated from the shackles of traditional offline methods. Mobile phone software or minor programs in intelligent communities can be developed as online communication and collaboration platforms so that all parties can timely release, obtain information related to children's mental health risk prevention and control, and give feedback. Divide the rights and obligations of different governance subjects. All parties can complete the identification through the Internet platform and obtain the corresponding rights and services.
(3) Propose Community Governance Goals and Agree on Governance Strategies
Propose community governance goals based on children's health risk prevention and control needs and community development issues. Under the coordination of community planners, various governance entities jointly discuss and determine governance strategies suitable for the community, and develop detailed work plans. This includes project initiation, funding sources and expenditures, task allocation, and timeline for governance projects.
(4) Implementation and evaluation of governance measures
The completed community governance work plan oriented to prevent and control children's mental health risks can be implemented after being voted on by the owners' committee. The property company can implement the main construction management work. All governance subjects supervise the implementation process and provide feedback at any time through the Internet of Things platform to ensure that the implementation process conforms to the governance goals and effectively prevents and controls children's mental health risks in the community.

24.5 Planning Strategies of Community Governance from the Perspective of Prevention and Control of Children's Mental Health Risks

There are many common and different characteristics of children's health risk factors at the community level at different ages. However, we should comprehensively consider such factors as the coordination of interests of governance subjects, the implementation efficiency of governance paths, and propose advanced governance planning strategies to meet the prevention and control of children's mental health risks at all stages under the principle of improving the tolerance of physical space and humanistic and social elements as much as possible.

24.5.1 Community Physical Space Governance Measures

24.5.1.1 Conduct Spatial Micro-update

(1) Land Use
Increase the degree of land mixed-use within the scope permitted by legal planning, enrich community functions, and promote physical and social activities for children. The prosperous community functions will generate a variety of neighbourhood activities, which can prevent crime against children. In the renewal and reconstruction of old residential areas, the intensity of community land development should be adjusted, and buildings with poor quality should be demolished and transformed into green spaces or squares to eliminate negative space in the community and improve the community living environment, which will play a positive role in preventing and controlling children's mental health risks.

(2) Community Greening
Green plants can absorb noise, particles, pathogens, and harmful gases, regulate microclimate, and alleviate mental health problems, so we should try to increase the greening area of the community, promote vertical greening and roof greening in communities where conditions permit, pay attention to the selection of plant types, and rationally match evergreen trees and deciduous trees to ensure rich visual landscape, sunshade, and cooling in summer and ensure sunshine in winter. The species and proportion of low shrubs and herbs should be appropriately increased in selecting tree species so that children can closely observe plants' growth process and reduce the risk of "natural deficiency." The community greening space should appropriately add natural elements that children can approach and interact with, such as sand, rocks, and waterscape, to increase children's access to nature, improve children's perception and activity level, and improve the current situation of insufficient physical activity of school-age children. Community farms can also be built to guide children's cognitive development and physical exercise in crop planting, cultivation, and picking.

(3) Road Traffic
Improve the connectivity between the community and the surrounding space, ensuring accessibility for various modes of transportation such as walking, strollers, rollerblades, skateboards, bicycles, etc. For example, in Vobang, Freiburg, Germany, strict traffic speed restrictions and regulations on reducing the use of cars are implemented, and car-free housing is realised in certain areas. The straightforward traffic space planning principles have improved the walking and riding index of the community, as well as the children's sense of identity with the community space. Plants are planted on both sides of the road and around the parking lot to absorb harmful gas particles, reduce noise, reduce the damage to children's respiratory systems caused by motor vehicle pollution sources, and improve the safety and comfort of the environment.

(4) Activity Site
The children's playground should be set at a certain distance from the main roads in the community, in a sunny and well-ventilated area, to create a comfortable and safe physical environment. At the same time, it should avoid setting children's playgrounds in areas lacking "street eye" supervision, such as the side of the residential gable. The children's playground should be reasonably equipped with night lighting facilities. It is

not appropriate to set large light boards and LED screens in the field of vision to prevent visual pollution to children. In order to meet the use comfort of children of different ages, the community children's activity space can adapt to the activity needs of children of different ages through the combination of soft and hard pavement, such as setting grass, sand, and soft floor mats to reduce the risk of injury caused by the fall of children aged 0–6 years. Seats should be set around the activity square, and the seats should face the area with intensive children's activities to ensure that the vision is clear and there are no obstacles to cover to meet the needs of parents.

24.5.1.2 Adjustment of Service Facility Configuration

(1) Healthcare Facilities
The community health centre and special children's healthcare room should be built to ensure regular physical examination and vaccination for children in the community. The community medical and healthcare facilities should also have the functions of first aid and transportation for unexpected injuries and diseases of children. The location of community medical and healthcare facilities should be convenient to reach. In order to prevent the spread of infectious diseases, plants should be planted around the community medical facilities as a buffer zone.

(2) Sports Facilities
The children's sports facilities in the community should be combined indoors and outdoors to meet the user needs of various weather conditions and ensure the uniformity of layout. A small number of children's amusement facilities can be arranged in the area below each residential building. In order to meet the activity needs of children of different ages, different venues should be set up. For example, sand pits and pools should be set up for infants with weak activity ability, stone tables and stone benches should be set up for school-age children to meet the social function, and fitness equipment of various sizes should be provided according to the different body dimensions of children of different ages.

24.5.2 Community Humanistic and Social Governance Measures

24.5.2.1 Children's Participation in Governance

Establish a system for safeguarding children's rights in community governance, and adopt different forms of participation for children of different ages to enhance their level of participation. First, invite school-age children to participate in community governance and encourage children to express their health demands in the current research stage; In the implementation stage, increase children's practical participation and exercise their physical quality and social skills; Collect children's feedback in the later management stage to evaluate the service performance of community governance on children's mental health. Second, for the non-autonomous young children or the school-age children who have no time to participate, we should accurately grasp the children's activity needs and health risk factors through objective methods such as behaviour annotation observation and other aspects of their interests and obstacles in the community use, as an essential basis for community governance. In Edmonton, Canada, government delegations, YMCA, fire rescue teams, local enterprises, and other social organisations jointly carried out activities on the theme of Children's Day in the community, invited local children and their families to participate in discussions, and held recreational activities, to better understand children's health development needs and safety challenges.

24.5.2.2 Forming Community Conventions

Through community promotion and guidance, we aim to influence family lifestyle habits, create a civilized family culture that collectively safeguards the safety and health interests of children, advocate for healthy eating, regular exercise, and scientific care. Children's guardians should be fully aware of the health risks faced by children of different ages and the role parents should play in risk prevention and control. Posters are posted through the bulletin board.

24.5.2.3 Improve Community Welfare

Various residents' welfare can be carried out under the support of government financial subsidies and community children's development funds. For example, a community canteen will be set up to provide children with balanced nutrition, set up indoor and outdoor activity rooms for children in the community to provide safe sports places for children; a children's infirmary shall be set up to regularly conduct a physical examination, vaccination, and distribution of protective articles for children. In order to encourage the broad participation of community families, special rewards should be given regularly to families who regularly pay for the Children's Development Fund, such as free participation in community activities and a free collection of customised cultural and creative souvenirs and organic food. In Jakarta, Indonesia, the operation of healthy food carts has solved the problem of food malnutrition among children in low-income communities.

24.5.2.4 Carry out Community Activities

The community can set up a volunteer service team and a team of parents' activists, regularly carry out parent–child health education lectures, health knowledge competitions, fun sports activities, nutritious food salons, community garden experiences, and other activities, promote the learning of health knowledge and children's physical exercise, thus playing a role in preventing and controlling health risks. In order to stimulate children's initiative to participate in community activities, a family health evaluation mechanism can be established. Families who participate in activities and achieve good results can obtain points, and the accumulated points can be exchanged for school supplies. At the same time, community activities can also help children build a sense of neighbourhood belonging and community identity, which is conducive to developing children's mental health. In the "Fourteenth Five Year Plan," the Nanjing government strengthened the standardisation of the community minors' growth guidance centre and carried out community mental health publicity, consultation, and guidance services.

24.6 Conclusion

Childhood is a crucial development stage in the life course, which not only determines the health level of individual students but also relates to the future development potential of the country. As an essential means to protect public health, urban planning is significant in carrying out community governance at the community level to prevent and control children's mental health risks. By analysing the characteristics of children's mental health risks at different ages and their specific manifestations in the community environment elements, it is necessary to identify the participants and implementation paths of community governance and propose specific planning strategies from the perspective of space refinement and service intelligence; it can provide theoretical support and guidance for promoting children's mental health and promoting healthy community governance, thus improving the livable level of the urban environment.

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A Study of How Residents' Subjective Well-Being Affects the Design of Healthy Sports Parks in Cold Areas

25

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Abstract

In addition to providing physical and social interaction spaces, Healthy Community Sports Park improves residents' health and well-being under the influence of COVID-19. Healthy Community Sports Park is the "cell engineering" of a healthy city and the basic unit of a healthy city. Using qualitative observation and questionnaire methods, this paper analyzed two community sports parks with different characteristics in cold areas—one is a newly developed community sports park with perfect facilities, and the other is a park with inadequate facilities for a long time. The relationship between subjective well-being and community sports parks was analyzed by multiple regression with sports space perception and subjective happiness as the dependent variables, diversity, accessibility, park area, and interest in space types in community parks as the independent variables. The results show that: (1) The interest and spatial privacy of the activity facilities in the community sports park are positively correlated with the subjective happiness of residents, and the correlation between accessibility and subjective happiness is insignificant; (2) the spatial richness of water bodies and squares in the park is positively correlated with the subjective happiness of residents; (3) the design elements of the community sports park are related to the activity space and the age group of the user; (4) intelligent facilities show significant differences according to age segments, which are negatively correlated with the subjective satisfaction of people over 50 years old. For this reason, community sports parks should consider the functional needs of all ages, as well as diversity, accessibility, and spatial interest.

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Keywords

Healthy · Community sports park · Subjective well-being · Cold city

25.1 Introduction

As the world has become more and more urbanized since the Industrial Revolution began, urbanization has dramatically changed the world. A report by the World Bank (2020) indicates that 56% of the world's population lives in urban areas, with 64.72% of Chinese living in cities, and this trend is expected to continue. It is urgent to improve the quality of urban human settlements due to the high-density urban environment, the process of urbanization, and the rapid growth of urban populations (Guzmán et al. 2017). COVID-19 and the lack of public facilities have gradually become important factors threatening the physical and mental health of urban residents (Mori and Yamashita 2015). In this context, there is a growing global focus on achieving a high-quality living environment and improving the physical and mental health of residents. As early as the 1984 Toronto Health Conference, the World Health Organization (WHO) proposed the concept of "Healthy City," which proposed that "a healthy city should be an organic combination of healthy people, a healthy environment, and a healthy society, and should be able to continuously improve the environment and expand community resources, so that urban residents can support each other and thus achieve their maximum potential." In 2015, at the 70th session of the UN General Assembly, Member States formally adopted the Transforming Our World: The 2030 Agenda for Sustainable Development. From 17 Sustainable Development Goals (SDG), Goal 11 aims to "Make cities and human settlements inclusive, safe, resilient, and sustainable" by "Provide universal access to safe, inclusive, and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities" with target 11.7. The new Agenda states "Sport is also an important enabler of sustainable development. We recognize the growing contribution of sport to the realization of development and peace" (Transforming our world: the 2030 Agenda for Sustainable Development | Department of Economic and Social Affairs 2023). It can be seen that the promotion of sports activities has become a global issue (Duan et al. 2018).

Healthy physical activity can be effective in reducing non-communicable diseases in urban populations and improving physical and mental health. Therefore, paying attention to the sports activity area in the urban park is an invaluable task of park planning. Studies have shown that open spaces in cities have a positive impact on people's physical and mental health, which has become a widely accepted conclusion. Parks and urban green spaces provide spaces for health and promote sports, recreation, and social activities. Research is gaining traction, with Ulrich's stress reduction theory (Ulrich et al. 1991) and Kaplan's attention restoration theory strongly supporting the conclusion that the natural environment is beneficial to human health. It has been proven that the natural environment can reduce stress and improve attention (Kaplan 2001). That stress reduction can increase attention, while attention restoration also reduces stress. Other scholars have studied indirect ways of influencing physical and mental health, primarily the impact of green spaces on mental health by stimulating physical activity and social interaction (Chen et al. 2015). People prefer outdoor spaces for physical activity (Giles-Corti and Donovan 2002). It was found that 46% of respondents took part in community street workouts in their study. Brownson further confirmed this finding, reporting that more than 66% of respondents participated in sports (Brownson et al. 2000), while only 21 percent used indoor stadiums. Parks and trails within the community are a powerful choice for people to exercise (Booth et al. 2000). The stimulating effect of open space on physical activity has become a consensus. Proper physical activity plays an influential role in improving self-confidence and self-evaluation. Compared to other sports facilities, open spaces play a more visible and effective role in improving the physical and mental health of residents (Lachowycz 2013). Salis et al. (2016) conducted a survey of 14 cities around the world. The results showed that the number of parks was positively correlated with the health of physical activity in the urban population. Therefore, the relevant design elements of the park could have the potential to promote physical activity in a positive way.

Most of the existing research on community sports parks and happiness only focuses on some components of subjective happiness and rarely explores the differences between design elements of community sports parks and components of subjective happiness. Moreover, most of the existing research focuses on the overall pattern of urban parks and green spaces. From the viewpoint of health, it is rare that sports are chosen as the main topic of research, and it is impossible to explore how individuals feel about the space of community sports parks. In order to supplement the gap in the study of resident satisfaction in community sports parks, this paper discusses the differences in community sports spaces that affect people's subjective happiness at different ages, analyzes the similarities and differences in the impact of different design elements on subjective happiness through empirical research, and proposes the theoretical basis for the construction of community sports parks from the perspective of planning and design. Based on this, the following research questions are raised: (1) Do the design elements of sports parks have a positive impact on the subjective satisfaction of residents? (2) Which of the basic types of spaces in the design elements is optimal for residents' subjective well-being? (3) Are there differences in the impact of residents of different ages, genders, education levels, and health levels in sports parks? This paper expounded on the research methods in the second section. The third section evaluates the evaluation system of residents' subjective happiness. Fourth and fifth discuss the conclusions of data analysis and corresponding design strategies.

25.2 Theoretical Analysis Framework

25.2.1 Study Sites

Using Tangshan as a case study (Fig. 25.1a), which shows how urbanization and cold weather residents use community sports parks. The study was conducted in two downtown community parks with diverse demographics and activities: Shangri-La Community Park (Fig. 25.1c), a park that has been in existence for over a decade, and Renmin Park (Fig. 25.1b), a newly developed park. These two parks were chosen because they represent two parks with different characteristics in terms of scale, vegetation characteristics, and facilities. They are also very close to one another (about 500 m), creating a coherent study area and allowing a similar survey setting, reducing the variability of factors such as traffic, local residents, and weather conditions.

25.2.2 Research Methods

To assess the behavior of park users, the following methods were used, namely observation and structured counting (McCormack et al. 2014) and Pérez Tejera et al. (2018), and were used to assess the behavior of park users. In August 2022, through several field visits, the observation area and counting points of park visitors were identified and informed (Maestre-Andrés et al. 2016) (Fig. 25.1B2 and C2). In order to get the most comprehensive view of people and their activities in a given time period, we define the observation area as an adjacent area (no intersections) that can be managed by size and users' activity.

To ensure sufficient outdoor sports venues for urban residents, the urban planning should focus on the service scope of the residential sports park and provide space for a large area of community sports venues. Considering that this study focuses on the impact of community sports parks on individual subjective well-being, a comprehensive correlation analysis of different independent

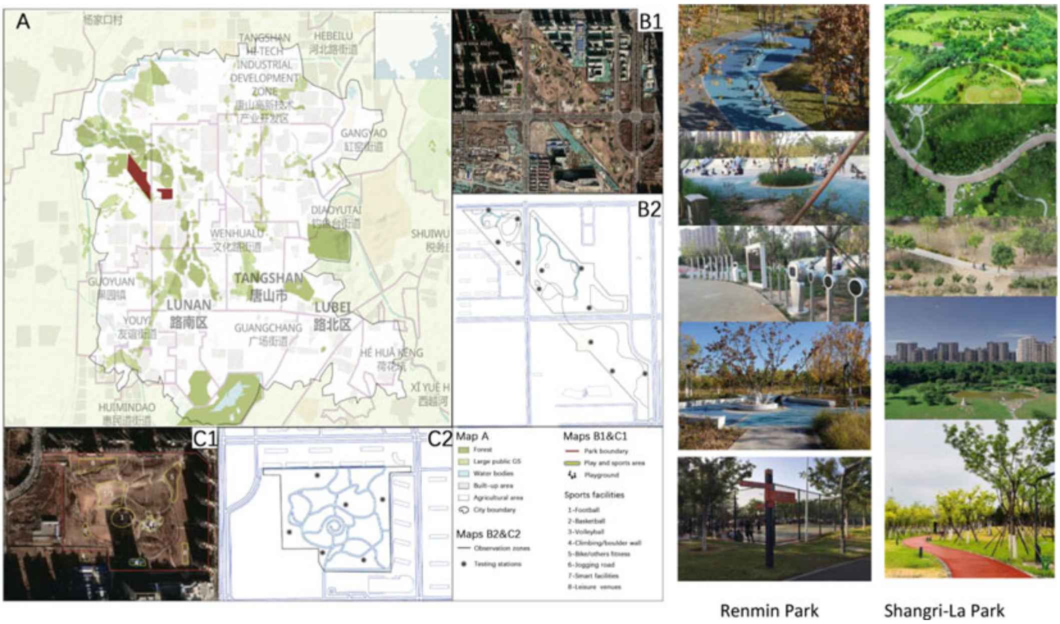


Fig. 25.1 **a** Overview map of Tangshan with the location of the study areas. Detailed maps of study areas (**b**) "Renmin Park" and (**c**) "Shangri-La Park" with specific activity areas in respective map parts

and dependent variables is required. Combined with the classification of community parks in existing research and the one-week pre-investigation, this study divides community sports parks into five dimensions: spatial richness, visual interest, intelligence, sociality, and vegetation diversity. In summary, this study collected data through questionnaire surveys (Table 25.1). Among them: (1) Individual health level, the health level of residents is measured using the questionnaire of the 12 summary tables of health surveys that are effective for Chinese groups and have reasonable reliability and validity, second edition (SF12-2v). (2) The five dimensions of the spatial perception level of the sports park use five levels of scores, and ask people how they perceive the situation in the two parks. (3) At the level of subjective well-being, the cognitive component is measured by the life satisfaction scale Subjective Happiness Cognitive Dimension (SWLS), and each question in this questionnaire uses a score of 5.(4) Theemotional component uses the Scale of Positive and Negative Experience (SPANE) to measure people's emotional situation over the past week, with a score of 5 for each question.

Statistical analysis and interpretation of results were analyzed by descriptive statistics using IBM SPSS Statistics 26 using demographic characteristic proportions and patterns of park users across groups. We used nonparametric testing and Bonferroni-corrected Spearman Car-Square applications to determine significant differences in park user patterns between two parks, between age groups, and between different temperature classes, with a statistically significant threshold of $p < 0.05$ (Stewart et al. 2018).

Considering that the factors affecting residents' subjective well-being include different levels such as endogenous factors of individuals and exogenous factors of the environment, this paper uses regression analysis methods for statistical analysis. In this study, the spatial perception of individual as well as the community sports park were taken as independent variables, while the cognitive and emotional components of residents' subjective well-being were analyzed as dependent variables (Fig. 25.2). In order to

Table 25.1 Index system

Variable	Indicator		Variable levels	
Independent variable	Individual social attributes	Gender	2 classifications	(1 = Male; 0 = Female)
		Age	6 level	($\leq$ 17, 18–30, 31–40, 41–50, $\geq$ 51)
		Education	5 level	(Junior high school and below/Senior high school/College/University/Master's degree or above)
	Individual health level	Level of physical activity	IPAQ 7 measurement	
		Body health	SF-12v2 12 measures	
		Mental health	SF-12v2 12 measures	
	Sports space perception	The diversity of sports space variety	5 levels (1 = poor perception $\sim$ 5 = good perception)	
		The fun of the activity space	5 levels (1 = poor perception $\sim$ 5 = good perception)	
		Smart facilities	5 levels (1 = poor perception $\sim$ 5 = good perception)	
		Quiet surroundings	5 levels (1 = poor perception $\sim$ 5 = good perception)	
		Plant diversity	5 levels (1 = poor perception $\sim$ 5 = good perception)	
Dependent variable	Subjective well-being	Cognitive ingredients	SLWS 5 questions, score: 5–25	
		Emotional component	SPANE 12 questions, scores: 24–24	

explore the perceptual differences of two distinct park elements, a comparative analysis of the regression models of the two parks was constructed, and in all models, block1 adds individualized attributes as independent variables; block2 adds individual health level elements; block3 further adds the perception level element of sports parks. By observing the changes in the goodness of fit R^2 in each block, the degree of influence of different levels of influencing factors on subjective well-being was explored and collinearity analysis was introduced for testing.

25.2.3 Questionnaire

In this study, questionnaires were distributed from August to September 2022. A total of 152 questionnaires were distributed, and 138 valid questionnaires were recovered, with an effective rate of 90.79%. The sample male-to-female ratio was 52.9:47.1, and people of all ages were also well represented in the sample, with some bias toward the highly educated in terms of educational attainment (Table 25.2).

25.3 Results Analysis

25.3.1 Analysis of Observational Results

As a result of our observations, we observed a total of 2314 groups of park use and activity patterns. We conducted observations during a 5-day observation period through observations of the two parks (Table 25.3). Renmin Park and Shangri-La Park both had a high percentage of adults and the elderly (68.7% and 70.6%, respectively), with significant differences among the younger age groups. Children in Shangri-La Park (age group 0–6 years old) accounted for

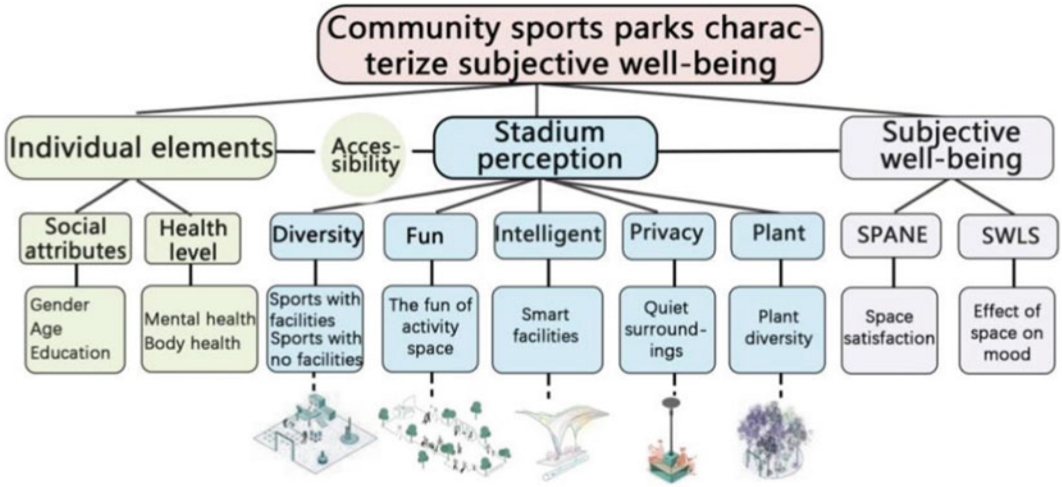


Fig. 25.2 Subjective well-being research framework diagram

Table 25.2 Part of the social-economic attributes of the samples

Social attributes	Variable	N	Proportion/%
Gender	Male	73	52.9
	Female	65	47.1
Age	$\leq$ 17	15	10.9
	18–30	73	52.9
	31–40	14	10.1
	41–50	11	8.0
	$\geq$ 51	25	18.1
Education	Junior high school and below	10	7.2
	Senior high school	15	10.9
	College	20	14.5
	University	36	26.1
	Master's degree or above	57	41.3

5.7% of the total population, more than the proportion of children in Renmin Park 4.3%, with a significant $P < 0.05$. However, we found that Renmin Park had more school-age children (estimated to be children aged 7–17 years) 7.6% than Shangri-La Park 6.1%, $p < 0.05$.

With the outbreak of the COVID-19 virus, the number of people living at home has increased, and residents have a stronger purpose in the park for long-term living in the same built environment (Awada et al. 2021). Only a few park users lie or sit on lawns or benches in two parks, while most are active on jogging tracks, sports venues, lawns, etc. More than half of the visitors 61% of the Renmin Park and 51% of the Shangri-La Park) carried out these exercises in the sports venues, while only about 4.59% of the visitors to the Renmin Park and about 11.89% of the visitors to the Shangri-La Community Park carried out passive sedentary activities such as relaxation, sunbathing, and reading. It is not difficult to see that the purpose of the use of community parks before and after the epidemic has changed dramatically. In addition, the intensity of people’s activities has increased regularly, and the mode of activity has changed in a positive direction.

Table 25.3 Proportion (%) of observed park user groups by different demographic characteristics, usage, and activity patterns in the two study parks in Tangshan

Characteristics(user groups)	Renmin Park (n = 1233 groups observed)%	Shangri-La Park (n = 1081 groups observed)
Age group		
Children (0–6 years)	4.3*	5.7*
School children/teenagers (7–17)	7.6*	6.1*
Adults	70.7	69.6
Older people	17.4	18.6
Activity type inside park		
Playing with children	12.39	10.67
Sports with facilities	33.18	18.55
Sports with no facilities	27.84	32.47
Activity with dogs	3.95	6.23
Passive		
Sedentary alone	4.59	11.89
Sedentary with other persons	9.05	20.19

Note Statistically significant differences in categories between parks based on Pearson's chi-square test. Significant differences are presented in *($p < 0.05$)

More active park use, such as active play with children, is also a common activity in both parks, accounting for about 10% of all group activities. Active sports activities are observed in the sports area, including football, basketball, volleyball, and table tennis in Renmin Park and volleyball areas in Shangri-La Park. The proportion of these activities varies significantly between parks, with the proportion of sports activities in the Renmin Park facility area being higher than in Shangri-La Park (Fig. 25.3). The highest number of young children observed on the playground in Shangri-La Park (41.9%) and fewer children (1.1%) on the activity field, while in Renmin Park, most of the children observed are on playgrounds and lawns, and some are located in sports venues. While students spend most of their time in sports areas, playgrounds and lawns, seniors mostly sit on benches or use less active fitness equipment.

25.3.2 Reliability and Validity Analysis

In this study, the reliability of the scales and data used was analyzed using the Krombach coefficient. The results showed that the reliability coefficient of the total table was 0.964. The coefficients of each latent variable were greater than 0.8, indicating that the questionnaire data have high consistency and confidence inside.

Using the Barlett spherical test and KMO value analysis, the validity analysis of the data and questionnaires has shown that the P value is 0.00 (P*0.01) which passes the Barlett spherical test, and the KMO value is 0.805 (>0.7), proving that the data in this study are suitable for factor analysis (Table 25.4).

25.3.3 Analyzing Differentiation

The data results summarize the relevant conditions of residents' health, subjective well-being, and perception of the two parks and sports venues (Table 25.5), and after testing, the average satisfaction and positive and negative sentiment scales of each group did not conform to the normal distribution, so the Kruskal–Wallis test method was used to conduct a nonparametric test of the differences between the groups of each

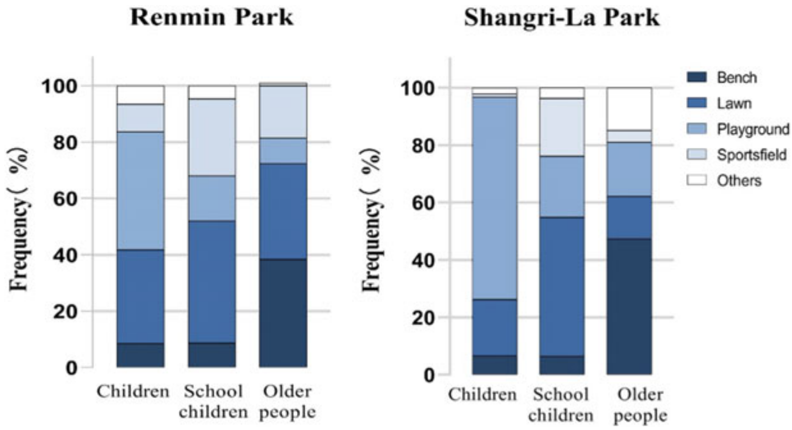


Fig. 25.3 Differences in the activities of residents of the two parks

Table 25.4 KMO and Bartlett's spherical test results

Sample a sufficient amount of the GMO measure	Bartlett's spherical test		
	Sphericity Approx. Chi-Square	*df*	Sig
0.805	3950.33	120.00	0.00

index. The data for both parks were derived from all samples, with a sample size of 138. The two parks do not show significant differences in terms of daily physical activity, health, or subjective well-being; however, considering sports venue perception, along with the dimension of plant diversity, there are significant differences between groups in each index (Figs. 25.4 and 25.5). Despite the superior facilities, Renmin Park's perception rating of the sports venues and the interesting spatial dimension is significantly higher than that of Shangri-La Community Park. The satisfaction and emotions of users of intelligent facilities are significantly different, as is the cognition satisfaction of park residents with quiet spaces. The perception of plant diversity in the two parks has no obvious difference in the subjective well-being of users. The characteristics of the two community sports parks were compared with indicators of various dimensions, and the Shangri-La parks with outstanding facilities were the lowest scores (Table 25.5). Comparing the satisfaction evaluation and the average emotional value of each dimension of the two parks, it can be seen that the satisfaction of the users of the Renmin Park has improved.

25.3.4 Correlation Analysis

In the collinearity test results of regression analysis, the VIF values of the variance expansion factor between the respective variables were small. The highest value was only 2.919, indicating that the collinearity effect between the independent variables was small and could not be considered. The results of regression analysis (Table 25.6) show that some of the individual attribute-level elements have different effects on different components of subjective well-being. Age and education level all have an impact on people's subjective well-being. Among them, older residents are generally more subjectively satisfied with community sports parks. However, people with higher levels of education in terms of emotional subjective happiness are usually in a lower emotional state. This result is consistent with the observed differences.

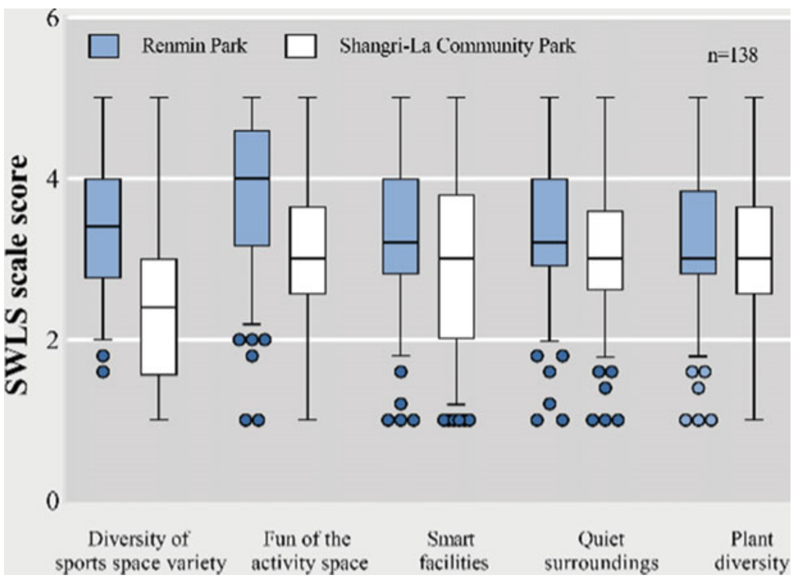
When individual attribute-level elements are added to Model 1, none of the elements in the model except age have an impact on people's life satisfaction or mood. After including individual health elements to Model 2, mental health and physical health have a significant impact on

Table 25.5 Analysis of the difference in satisfaction between the two parks

Sports park features	Park	SWLS mean	SD	Differences between groups	Significance	SPANE mean	SD	Differences between groups	Significance
The diversity of sports space variety	P1	3.38	0.884	54.3118	6.2044E-12**	0.77	0.753	32.9140	2.5622E-8**
	P2	2.48	1.130			0.23	0.786		
The fun of the activity space	P1	3.28	1.130	22.8390	2.2079E-9**	1.03	0.741	15.6821	0.000096**
	P2	2.48	1.052			0.68	0.725		
Smart facilities	P1	3.33	0.913	7.9770	0.009117*	0.63	0.765	3.3855	0.046889*
	P2	3.00	1.027			0.50	0.692		
Quiet surroundings	P1	3.35	0.877	6.7856	0.009695*	0.70	0.707	1.1232	0.290164
	P2	3.08	0.857			0.61	0.731		
Plant diversity	P1	3.22	0.892	2.6212	0.114	0.74	0.669	2.1373	0.144919
	P2	3.03	0.994			0.59	0.728		

Note: Significant differences are presented in *($p < 0.05$). For the age groups, the percentage of individuals is presented. P1 is Renmin Park and P2 is Shangri-La Community Park

Fig. 25.4 Analysis of the difference in satisfaction between the two parks in various dimensions



subjective satisfaction. Physical health has a greater impact on residents' emotions; in contrast, mental health has a positive impact on people's life satisfaction. With the increased R^2 value of the model, it is evident that health has a substantial impact on people's life satisfaction. The accessibility element added to Model 3 also has a positive effect on the optimal fitting of the model, but it is not obvious.

Finally, various features in the community sports park were added to the model in turn, and the R^2 value of each model was significantly improved. The Renmin Park model found that the perception dimension directly related to people's subjective well-being is community sports parks, among which diversified sports venues, quiet atmospheres, and spaces of interest greatly promote life satisfaction, while the

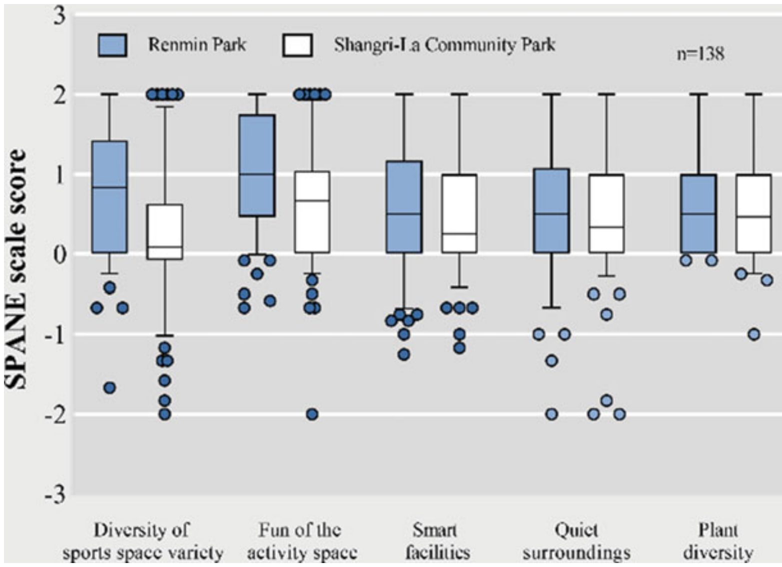


Fig. 25.5 Analysis of emotional differences in each dimension of the two parks

diversity of intelligent facilities and the variety of vegetation promote life satisfaction in a much lesser degree, while the number and area of sports facilities, the quiet atmosphere, and the diversity of vegetation greatly enhance people's emotional states, and intelligent facilities increase people's positive emotions also significantly. In the Shangri-La community sports park model, the R^2 change of the model after the introduction of sports space perception elements is greater than that of People's Park, which may be due to the significantly higher proportion of People's Park dedicated to various sports activities in a larger number of areas, and the demand for the improvement of facilities in various dimensions is stronger.

25.4 Discussion

In this study, taking the difference in spatial elements of the two adjacent community sports parks in the residential area as the starting point, comparing the differences in the influence of different activity space perceptions on the various components of people's subjective well-being, the study used questionnaire surveys, interview records, street scene picture analysis, and other methods to obtain the self-assessment health, emotion and life satisfaction data of the residents of the communities around the two parks, and obtained the following conclusions.

1. For different components of subjective well-being, spatial characteristics will affect them, and the dimensions of action are different. Sports space perception affects life satisfaction in the same way that physical and mental health affect life satisfaction, and the cognitive component model of Shangri-La Park shows that people's mental health can be greatly impacted by finding new park spaces with more complete facilities, guiding an impact path of "sports space perception—mental health—life satisfaction." Meanwhile, people's emotional state is mainly affected by the spatial perception of physical activity.
2. In different community sports parks, the perception of sports space will have an impact on people's subjective well-being. It should be noted that in most cases, the community sports parks with complete spatial type and high privacy have the greatest impact on people's subjective well-being—it can be seen that in the model's performance of the emotional component, the Shangri-La Community Park, which has a relatively single type of sports space and a quiet atmosphere, has a greater impact on people's emotions

Table 25.6 Regression model results of influencing factors of subjective well-being

Predictors		Cognitive component of subjective well-being								Subjective well-being of the emotional component							
		Block1	Block2	Block3	Block4	Block5	Block6	Block7	Block8	Block1	Block2	Block3	Block4	Block5	Block6	Block7	Block8
Social attributes	Gender	0.083	0.008	0.007	−0.001	−0.044	−0.047	0.002	−0.001	0.078	0.068	0.067	0.001	−0.013	−0.007	0.02	0.035
	Age	0.193***	0.239***	0.233***	0.217*	0.105	0.082	0.077	0.077	0.279***	0.301***	0.297***	0.15*	0.139*	0.102*	0.078*	0.064
	Educational attainment	0.006	−0.035*	−0.032	−0.038	−0.049	−0.028	−0.116*	−0.113*	0.028	0.022	0.024	0.011	−0.017	−0.013	−0.02	−0.036
	Origin	0.048	0.011	0.01	0.023	0	0.014	0.019	0.019	0.049	0.039	0.038	0.015	0.03	0.013	0.008	0.012
Health	Mental health		0.198***	0.194*	0.165	0.145	0.131	0.107	0.107		0.018	0.02	0.043	0.003	0.03	0.021*	0.035
	Body health		0.14	0.135	0.114	0.002	0.02	0.018	0.016		0.156*	0.152	0.092	0.069	0.048	0.036	0.02
	Accessibility			0.046	0.067	0.085	0.079	0.067	0.066			0.035	0.019	0.004	−0.028	−0.027	−0.016
Park1	Sports space variety				0.237***	0.146*	0.09	0.005	0				0.667***	0.405***	0.272***	0.153*	0.177***
	Space fun					0.447***	0.461***	0.258***	0.258***					0.398***	0.33***	0.251***	0.09
	Smart facilities						0.136	0.082	0.071						0.33***	0.226***	0.111*
	Quiet surroundings							0.598***	0.594***							0.332***	0.208***
	Plant diversity								0.023*								0.435***
R^2		0.038	0.119	0.121	0.175	0.335***	0.349	0.621	0.622	0.082	0.103	0.104	0.519	0.604	0.672	0.712	0.792***
Social attributes	Gender	0.083	0.008	0.007	0.021	0.016	0.024	0.085	0.08	0.078	0.068	0.067	0.04	0.007	0.026	0.003	0.007
	Age	0.193***	0.239***	0.233***	0.206*	0.2*	0.2*	0.031*	0.019	0.279***	0.301***	0.297***	0.096	0.085	0.04	0.015	0.016
	Educational attainment	0.006	−0.035*	−0.032	−0.037	−0.03	−0.024	−0.079*	−0.063	0.028	0.022	0.024	0.08	0.04	0.016	−0.028	−0.029
	Origin	0.048	0.011	0.01	0.071	0.07	0.068	0.022	0.024	0.049	0.039	0.038	0.073	0.062	0.05	0.038	0.039
Health	Mental health		−0.198*	−0.194*	−0.171	−0.165	−0.166	−0.137	−0.135		0.018	0.02	0.126	0.012	0.022	−0.001	−0.007
	Body health		−0.14	−0.135	−0.137	−0.144	−0.145	−0.068	−0.059		−0.156	−0.152	−0.046	−0.015	−0.031	0.018	0.02
	Accessibility			0.046	0.056	0.059	0.047	0.043	0.044			0.035	0.037	0.046	0.004	0.004	0.005
Park2	Diversity of sports space variety				0.212**	0.193*	0.167	0.062	0.065				0.697***	0.476***	0.363***	0.36***	0.347***
	Space fun					0.147*	0.097	−0.052	−0.065					0.605***	0.424***	0.315***	0.299***
	Smart facilities						0.094	–	–						0.392***	0.29***	0.242***

(continued)

Table 25.6 (continued)

Predictors		Cognitive component of subjective well-being								Subjective well-being of the emotional component							
		Block1	Block2	Block3	Block4	Block5	Block6	Block7	Block8	Block1	Block2	Block3	Block4	Block5	Block6	Block7	Block8
	Quiet surroundings							0.624***	0.626***							0.293***	0.256***
	Plant diversity								0.116								0.118***
R^2		0.038	0.119	0.121	0.161	0.163	0.168	0.485	0.492	0.082	0.103	0.104	0.524	0.736	0.721	0.863	0.933

Note ***, **, *are significant at the 0.005, 0.01, 0.05 levels, respectively; Since this study used stepwise regression during analysis, "_" indicates that the independent variables in the first column of the table are not significantly excluded from the final regression model in this model. Locations in the hierarchy regression analysis blocks that have not yet been brought in independent variables are left blank in table P1 is Renmin Park and P2 is Shangri-La Community Park

than their perception of their park space, which indicates that the park with weak sports function and strong privacy has important significance in people's emotional regulation.

3. In the comparison of the two sports parks, different perceptual characteristics of sports space have different effects on the various components of subjective well-being. (1) The number and area of sports spaces, the interest of the space, and the quiet atmosphere have three perceptual characteristics that have an impact on people's life satisfaction in all models, which shows that multi-type and dynamic sports activity spaces are the characteristics that people pay the most attention to in community sports parks. The diversity of intelligent facilities and vegetation plays a major role in people's emotional state. Although the satisfaction of intelligent facilities for all groups of people is not significant, it is worth noting that it has a significant positive promotion effect on the satisfaction of people under 40 years old (Fig. 25.6); The diversity of vegetation can clearly indicate how much residents attach importance to the community park environment. (2) In the perception of sports spaces at Renmin Park, only the rich variety of venues, the high degree of spatial interest, the amount of privacy, and the richness of plant life have a positive impact on people's life satisfaction, while at Shangri-La Park, only the variety of venues and the quiet environment affect residents' happiness with their lives. This may be due to the clear differences in the way people use the two parks. Shangri-La Park is primarily used for traditional recreational activities, which leads to the perception of only natural plant landscapes. This in turn improves their emotional well-being. (3) The number and area of sports activity venues, spatial interest, intelligent facilities, and diversity of vegetation are the main influencing factors affecting the subjective happiness of traditional community sports parks, which to a certain extent reflects people's evaluation standards for residential leisure activity spaces, and multi-species plants

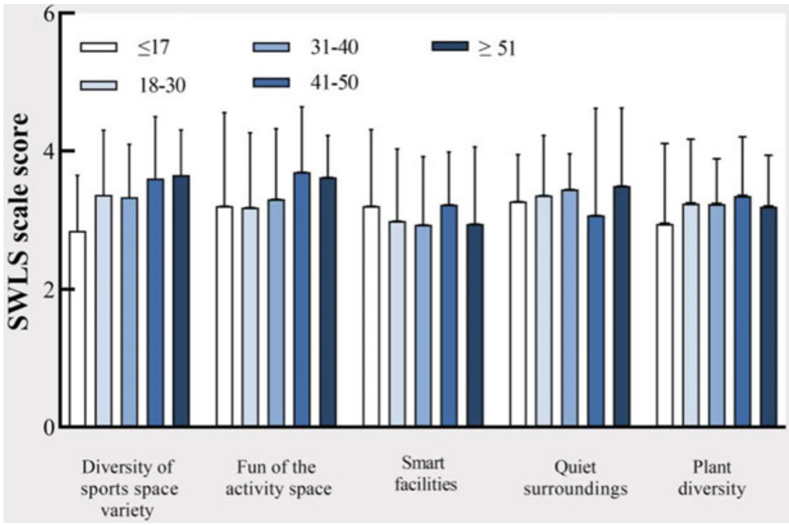


Fig. 25.6 Differences in the satisfaction of perceived elements in different sports spaces among people of different ages

that are more concentrated and can be perceived can play a better role in promoting people's happiness. In addition, plant diversity in traditional sports parks has a significantly more positive impact on people's emotional regulation than the environment with complete types of venues. This demonstrates the importance of public green space in community sports parks.

25.5 Conclusion

With the establishment of the SDGs, the intrinsic connection between people's happiness and the environment of community sports parks has gradually become an important urban issue. In 2016, The New Urban Agenda stated commit themselves to promoting safe, inclusive, accessible, green, and quality public spaces, including streets, gardens, and parks that are multifunctional areas for social interaction and inclusion, human health and well-being. This study further subdivides the research objects and examines the different components of community sports parks with apparent spatial characteristics, and through the examination of two neighboring communities with obvious spatial differences, the relationship between the space and subjective happiness of people in different environments can be revealed, proving the need for more detailed research on community sports parks and people's subjective happiness. Moreover, the research conclusions provide a basis for constructing a high-quality community sports park.

25.5.1 Create Diverse Spaces

Due to the difference in the influence of traditional and more recent community sports park spatial elements on different components of happiness, in the process of construction and planning of residential sports parks, the activity needs of residents in different places should be fully considered in the configuration of sports activity spaces, and the different dimensions of sports space should be accurately designed based on people's activity characteristics. Creating multi-generational environments, from creative housing solutions and recreational facilities, to public facilities, and community groups, can foster meaningful interaction between generations to provide a better quality of life for seniors and young adults. As we design the upcoming sports park space, we aim to fully understand the needs of residents of different ages. In addition, we aim to provide residents with a peaceful atmosphere through the variety of plants and design of landscape levels. As much as possible, this is done to reduce noise from neighboring spaces, improve physical and mental health, and reduce pressure on the city.

25.5.2 Fairness in Social Services

Community sports parks should be designed to be inclusive—targeted services and wayfinding based on age group characteristics, from clear signage and well-designed entrances, waiting areas and walking paths, to older targeted identification, etc.; intelligent monitoring can significantly improve the subjective well-being of all people except the elderly, and improve the quality of user activities. In traditional community parks, people's perception of use should be improved as much as possible by adding landscape design, and the environmental quality of residential areas should be improved. On the other hand, with the increasing emphasis on happiness today, the design of community sports parks should make sure to pay attention to people's perception in addition to material space. In the planning and design of parks, individuality and participation should also be emphasized to provide practical satisfaction. In addition to encouraging outdoor sports, the outdoor sports space required by urban residents provides the park's comprehensive benefits in every aspect. Also consider how community sports parks provide social benefits to disadvantaged groups through recreational, recreational, and athletic facilities.

25.5.3 Accessibility

Transportation is an important aspect of everyone's life because it allows citizens to meet their basic needs—work, socialize, and use public services. As of this writing, most cities in China's cold regions are still in the development stage. Therefore, urban resources are unevenly distributed. Therefore, the impact of accessibility on the happiness of the two parks in this study is not significant. However, it is easy to see residents' demands for parks with perfect facilities and high satisfaction. As part of the principle of scientific layout and reasonable planning, the early stage of park construction should be strictly monitored in terms of site selection and planning. This will ensure a healthy lifestyle for the residents, a scientifically reasonable access and equitably designed sports park system will be created.

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26 The Necessity of Natural Darkness for Humans and Biodiversity

Lisbeth Dam Kørner

Abstract

Our daily rhythm consists of night and day—darkness and light. This cycle is fundamental to our circadian rhythm, and all life on the earth has evolved under these conditions for millions of years. But because humans are primarily active during the day, we tend to forget half of our reality: the night and the necessity of darkness. This inherent bias in our collective thinking lets us ignore the most basic relationship that natural darkness is as essential for our circadian rhythm and the functioning of ecosystems as natural light. Many do not consider how artificial light at night (ALAN) alters the natural cycle of light and darkness and how this disturbs nature's and human's biological rhythms. Instead, the emission of ALAN is increasing by up to 10% globally, turning relatively dark cities into bright lightscapes (Falchi and Bará Salvador 2023). This rapid and significant increase in ALAN has drastically disrupted the natural light and dark cycles, severely affecting nature and humans. ALAN also plays a positive role in our society. ALAN binds us together culturally, economically, and socially. It allows us to navigate streets, supports experiences of safety, and forms inviting urban spaces after sunset. This review explores the severe impacts of ALAN and demonstrates that to bridge the seemingly opposing needs, we must understand our connectedness with nature and how we, as well as nature, need natural darkness to sustain health and circadian rhythm.

Keywords

Light pollution · Artificial light at night (ALAN) · Ecological impact of ALAN · Naturel darkness · Disruption of biological rhythms · Cycle of light and darkness

26.1 Introduction

I remember the Lighting Fundamentals class where the teacher asked rhetorically, "Which light source is the most important for humans?" It was, of course, the sun, and no one would ever question the importance of the sun for life on earth.

Later, we discussed darkness and how, since the invention of artificial light, the night has shifted from being dark to becoming ever more brightly—especially with the invention of the blue LED. I recall the first unsettling feelings I had, starting to understand that the invention of electrical light 150 years ago was disturbing the fundamental pattern of light and darkness. An essential pattern is controlled by the placement of

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our planet in the universe. All life on earth has developed under bright days and dark nights for millions of years, but the invention of artificial light turns this fundamental cycle upside down. The teacher explained this with such a distant facial expression and monotone voice as if she did not even hear what she was actually saying:

That ALAN is destroying habitats, disturbing the circadian rhythm for all life on earth. Regardless, we turn it on every night, and no one does anything about it.

It is not comforting to comprehend this knowledge. In comparison, even with a powerful action, other kinds of pollutions will take years to roll back. By turning a switch, light pollution can be solved. So simple. But light pollution is still not regarded as a regular polluter, even though increasing research states that ALAN is a large scale problem that disturbs basic biological cycles, not many regards light pollution as a real problem (Rich and Longcore 2006; Gaston et al. 2014).

While no one would dispute the importance of natural light, this review pleads for the importance of natural darkness for nature and humans.

26.1.1 Definition of Light Pollution

We must define light pollution to understand how to solve it. Light pollution is the excessive or misdirected artificial light that interferes with natural darkness. The International Dark-Sky Association (IDA) strives to protect the night skies and certifies darkened places on earth where it is still possible to see the dark sky. IDA divides the source of light pollution into three main categories. See Fig. 26.1:

1. *Glare*: Glare is the sensation of visual discomfort when bright luminance is directed into the eye. In addition to causing visual discomfort, glare also limits the perception of space, creating a wall of darkness that functions as a visual barrier that the vision cannot penetrate.
2. *Skyglow*: Skyglow is caused by the excessive use of artificial light, which can be seen as a brightening of the night sky. It is caused by the scattering of light in the atmosphere and by reflections from the grown into the sky. Under an overcast sky, reflected artificial light brightens up the clouds that bounce the artificial light back to the earth resulting in higher artificial light levels. This effect makes nights under an overcast sky brighter than a starry sky. Under a starry sky, the skyglow makes it almost impossible to see celestial elements (Kyba et al. 2012).
3. *Light trespass*: Light trespass refers to unwanted or unnecessary artificial light that falls outside of the intended area. Light trespass also refers ALAN that enters a building through windows, potentially causing sleep disturbance for the residents (Boyce 2014).

Light pollution occurs because ALAN is often overly bright, improperly shielded and poorly aimed. Different artificial light sources cause light pollution, including building exterior and interior lighting, billboards, factories, streetlights, sports stadiums, parking lots, and gas stations. Besides, since LED technology has become cheap and easily installable, also private gardens pollute the night sky (Bogard 2014).

26.2 Ecological Impacts of ALAN

This section describes how and why ALAN impacts humans and nature. ALAN affects two primary biological cycles, *the circadian rhythm and the photoperiodic timer*. The circadian cycle and the photoperiodic timer are predictable cycles synchronized to the natural cycle of light and dark.

1. *The circadian rhythm.* See Fig. 26.2.

The circadian rhythm is a natural, internal process that regulates various physiological and behavioral processes in living organisms. It is regulated by the melatonin hormone and follows the 24 hours dark/light cycle and is reset daily (Bradshaw and Holzapfel 2009). The circadian rhythm enables organisms to recognize daily changes and controls vital physiological events,

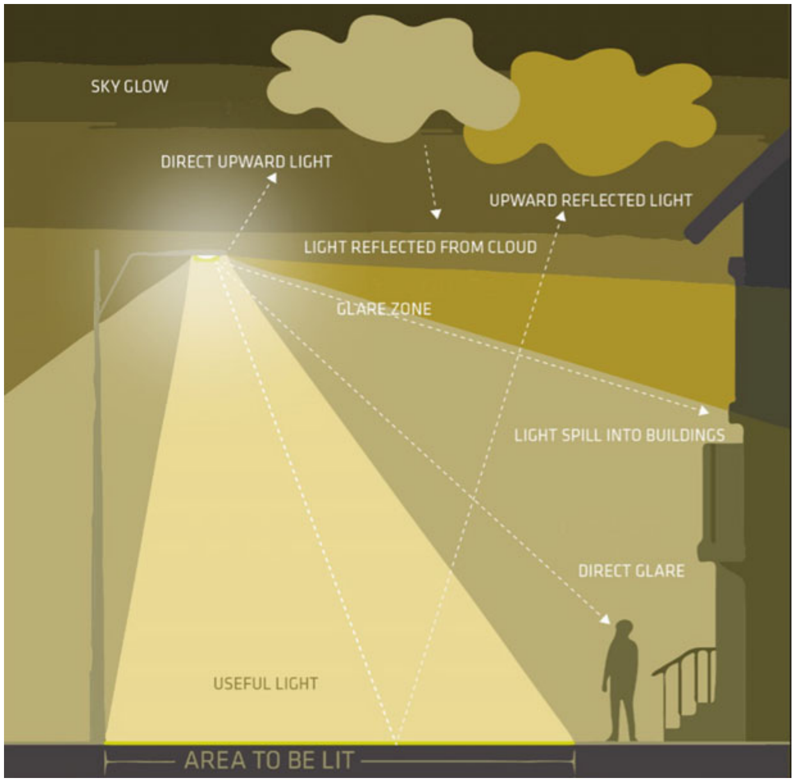


Fig. 26.1 Illustration of the various components of light pollution. *Photo* Author

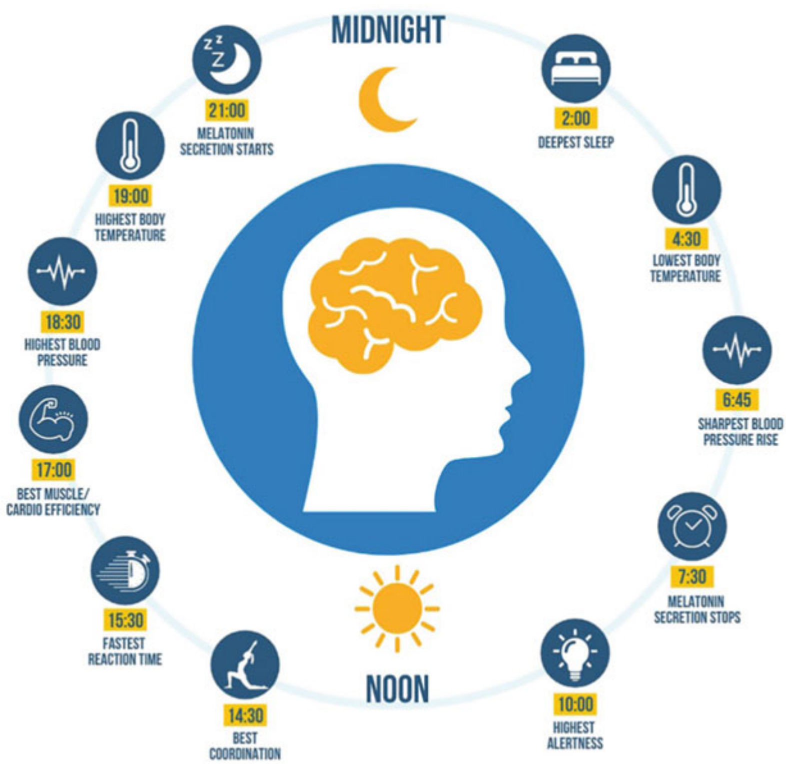


Fig. 26.2 Circadian rhythm for humans. *Photo* Shutterstock

including the sleep/wake cycle, hormone production, body temperature, heart rate, blood pressure, and metabolism (Fleury et al. 2020). The circadian input is detected by a special photosensitive cell in the back of the eyes [the intrinsically photosensitive retinal ganglion cells (ipRGCs)]. The ipRGCs do not enable vision but send signals of light or darkness to the internal master clock, Suprachiasmatic Nuclei (SCNs), that drives the circadian rhythm. The SCN transmits signals of light or dark to the entire body, including the pineal gland, which produces and secretes the hormone melatonin (Boyce 2014). At night the production of melatonin is high and falls in the morning. However, melatonin production is not simply regulated by the time of day but also by exposure to light or darkness.

Consequently, ALAN can alter melatonin production (Gaston et al. 2014). Melatonin receptors that obtain melatonin as a sign of darkness are found throughout the whole body in animals and humans. This way, melatonin signals the time of day to the body, synchronizing the activation of many physiological functions (Boyce 2014).

The human sensitivity to light follows the daily cycle, with blue wavelength during the day and yellow wavelength in the evening. Hence, exposure to blue light in the evening signals to the body that it is day and studies have discovered that exposure to ALAN, particularly in the blue spectrum, suppresses melatonin production, disrupting the circadian rhythm with severe consequences for human health, such as sleep deprivation, diabetes, and cancer (Navara and Nelson 2007; Boyce 2014).

2. *The photoperiodic timer*

Photoperiodism is the ability of plants and animals to use the length of day and night as a clue to determine seasonal events such as hibernation, migration, and reproduction. The weather and temperature are highly unpredictable throughout the year, but the changes in the length of the day and night are repeatedly the same every year. Photoperiodism consists of two components: a photoperiodic timer and a counter. In close collaboration, they act as a seasonal switch (Bradshaw and Holzapfel 2010). The counter calculates the dark/light cycles, and when a specific number of inductive cycles is reached, the photoperiodic timer triggers the corresponding physiological response, such as hibernation, migration, and reproductive processes. Once the response sets in motion, it cannot be reversed before the seasonal event is completed (Bradshaw and Holzapfel 2009).

ALAN can disrupt these patterns by being too bright, blue, and blinding. As all organisms of the earth have evolved to synchronize with the natural light and dark cycle, this disruption has enormous consequences for animals, humans, and plants, either directly because of the acute attraction to artificial light or more indirectly with disruption of the circadian rhythm and altering of the timing of the photoperiodism response (Gaston et al. 2012). The following sections explain more about the effect on different species.

26.2.1 The Impact of ALAN on Insects

The total number of insects is decreasing globally, and research indicates that ALAN might be one of the most critical drivers for their decline (Owens et al. 2020). Direct light and skyglow can impact insects' physiology and behavioral patterns. Direct artificial light (for example, from a streetlamp) immediately attracts insects. This attraction often leads to high mortality, where insects are caught in the light beam and unable to escape, becoming easy prey for predators such as bats and birds that hunt near ALAN. Skyglow blocks out the natural nocturnal light and celestial elements that insects use for navigation, with consequences for foraging and reproductive success in these species (Rich and Longcore 2006).

Skyglow also alters insects' patterns of activity and rest, causing diurnal pollinators and insects to prolong their foraging periods into the evening. At the same time, nocturnal insects delay their nightly activities, causing them to be more exposed to predation (Owens and Lewis 2018). Photoperiodism has been recognized in insects, and their primary response to longer nights is the diapause state, but photoperiodism also regulates seasonal morphs, growth rate, and migration strategy (Numata et al. 2015; Saunders 2009).

26.2.2 The Impact of ALAN on Bats

ALAN can have a significant impact on bats, as it can disrupt their natural behavior and activities. For example, bright lights can cause confusion and disorientation in bats, making it difficult for them to navigate under migration or nocturnal commuting flights and locate food and roosting sites. Many light-tolerant bats' species in urban areas have been observed foraging from insects caught in light from streetlamps, but some evidence indicates that bats primarily fly to ALAN because they are attracted to it directly, not because of the food (Müller et al. 2009). Nevertheless, this way of foraging is so frequent among bats that it is regarded as a common habit for many bat species, although it is not natural and influences the competition, survival, and reproductive performance of both insects and bats (Rich and Longcore 2006). Additionally, ALAN can attract insects and other prey to the light, so light-shy bats will not find food in their natural habitats. ALAN also affects bats more indirectly and disrupting the circadian rhythm. Potentially, this can result in problems with breeding, growth, foraging, and communication (Voigt et al. 2018; Heideman and Bronson 1994).

26.2.3 The Impact of ALAN on Birds

ALAN has a significant effect on the timing of daily and seasonal activities for birds living in urban areas, leading to an extension of the duration of their activities, with the onset and cessation of singing and foraging, reproduction, and migration (Dominoni 2015; Silva et al. 2017). A study has compared European blackbirds (Turdus merula) in two light treatments. One kept in almost dark at night (0.0001 lx), and the other birds were exposed to light at night (0.3 lx). This study showed that ALAN affected birds' daily melatonin patterns, altering not only their timing of daily activities but also seasonal timing. Even though the birds were exposed to a low illuminance of only 0.3 lx, it reduced their melatonin release and the birds had higher activity during both day and night (Dominoni et al. 2013).

Migratory birds are exceptionally sensitive to ALAN. Several accidents where birds collide with buildings happen during their flight because the ALAN disorientates migrating birds. Migrating at night, birds use their magnetic compass for direction and the celestial elements for navigation and are therefore sensitive to ALAN because it disturbs their natural clues (Rich and Longcore 2006; Wiltschko and Wiltschko 2009).

Figure 26.3 AB illustrates this effect where migrating birds every year are caught in the New York tribute light of 9/11 and cannot fly away and then end up on the ground fatigued and unable to continue.

26.2.4 The Impact of ALAN on Plants

Sunlight is the main driver for plant growth and development, and the natural cycles of light and darkness are important for plants to regulate their growth and development. Photoperiodism in plants enables them to use light as a clue for seasonal changes and time their biological clocks accordingly (Bennie et al. 2016) The day and night length influences the growth of various plants and trees, and ALAN causes confusion for plants and interferes with their growth and development. ALAN can also interfere with pollination and seed dispersal in plants. (Singhal et al. 2019). Because ALAN can modify the apparent day length perceived by plants and consequently their photoperiodism response, ALAN can shift or delay seasonal events, causing excessive growth in plants and blossoming at inappropriate times—especially for

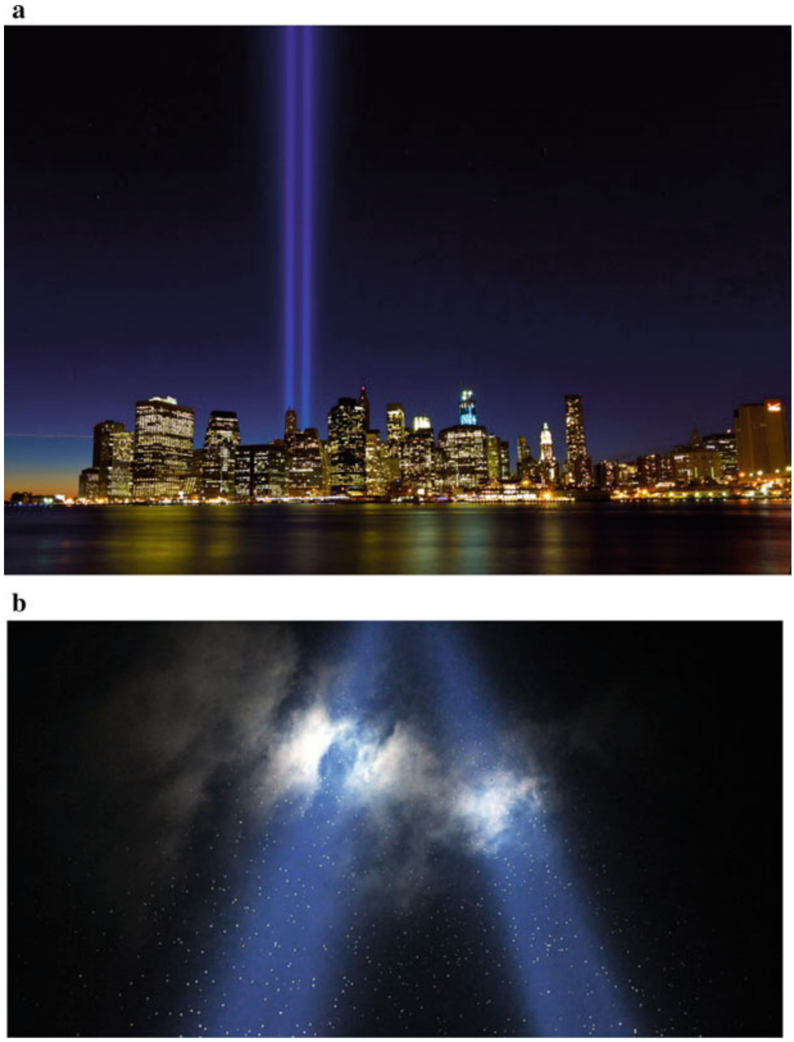


Fig. 26.3 **a** Light tribute on the 9/11 in New York. *Photo* Greg Chow. **b** A close look into the intense light sources reveals that thousands of migrating birds are caught and unable to escape the sphere of light. *Photo* Gary Hershorn

late-successional species, where photoperiod triggers budburst later in the spring (Ffrench-Constant et al. 2016).

26.2.5 Responsible and Sustainable ALAN

The addressed research from this review illustrates the importance of considering the negative effects of ALAN, which can disrupt ecosystems and the natural rhythms of plants and animals and negatively impact human health. Therefore, it is crucial to balance darkness and ALAN and use it sustainably. More additional research has been done in the field of ecological consequences of lighting pollution and has led to a collaboration between IDA and the Illuminating Engineering Society (IES) where they agree upon the following five principles for designing responsible ALAN (Hartley and Leibel 2020).

Start your design with darkness and only add light if it supports nocturnal placemaking and protects a view of the stars.

1. *Purpose*: All lights should have a clear purpose.
2. *Targeted*: Light should be directed only to where it is needed.
3. *Low lights level*: Light should be no brighter than necessary.

4. *Control*: Light should be dimmed down or turned off when not required.
5. *Color*: Use warmer color lights where possible.

These principles are relatively simple and helpful when designing lighting schemes that support humans and nature. See Fig. 26.4. However, lighting design should also include the human experience and aesthetics to achieve quality lighting.

26.3 Aesthetic Consequences of ALAN on Humans

The most significant aesthetic consequence caused by ALAN is the loss of view of the night sky and, as a result, the direct connection to the universe we have had for thousands of years. When the natural darkness loses its most powerful beauty, the aesthetics of the night is forgotten and often overlooked when creating lighting schemes today.

However, aesthetics should be addressed when installing ALAN. Municipalities and authorities almost always ask for ALAN to create safety and to fulfill requirements that do not consider the human experience and the dark adaptation of the human eye. However, ALAN forms the basic atmosphere in a space, whether appealing or not. The next section argues the importance of bringing aesthetics into the lighting schemes to create better lighting that supports humans and nature.

26.3.1 The Human Eyes' Adaption to Darkness

Since we evolved with dark nights, human vision has a well-developed night vision that can adapt to darkness, so we can see contrasts in low light conditions. The visual system continuously adapts to the brightest point in the field of view, making the surrounding areas seem darker. Hence, a bright light source creating glare makes it impossible to see outside the light cone. See Fig. 26.5. Thus, a bright light source will call for more light sources to brighten the surrounding areas. Moreover, as the vision transitions into night vision, the eyes become sensitive to higher light levels and blue/cold wavelengths. Therefore, using low light levels with warmer color temperatures will create fewer blinding genes increasing visibility (Boyce 2014).

26.3.2 Shades of Darkness

The night promotes an entirely different mood than the day, and throughout history, night and darkness are symbolically associated with chaos and mythical evil. This understanding is rooted in Western Christianity, where light is associated with God and darkness with evil (Edensor 2015).

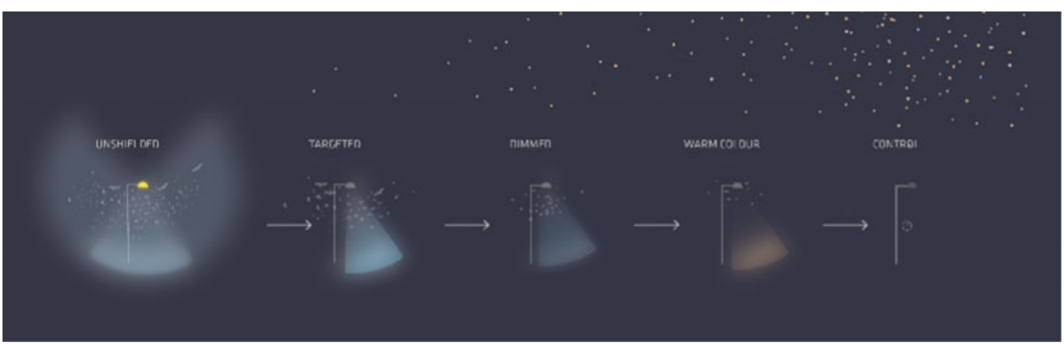
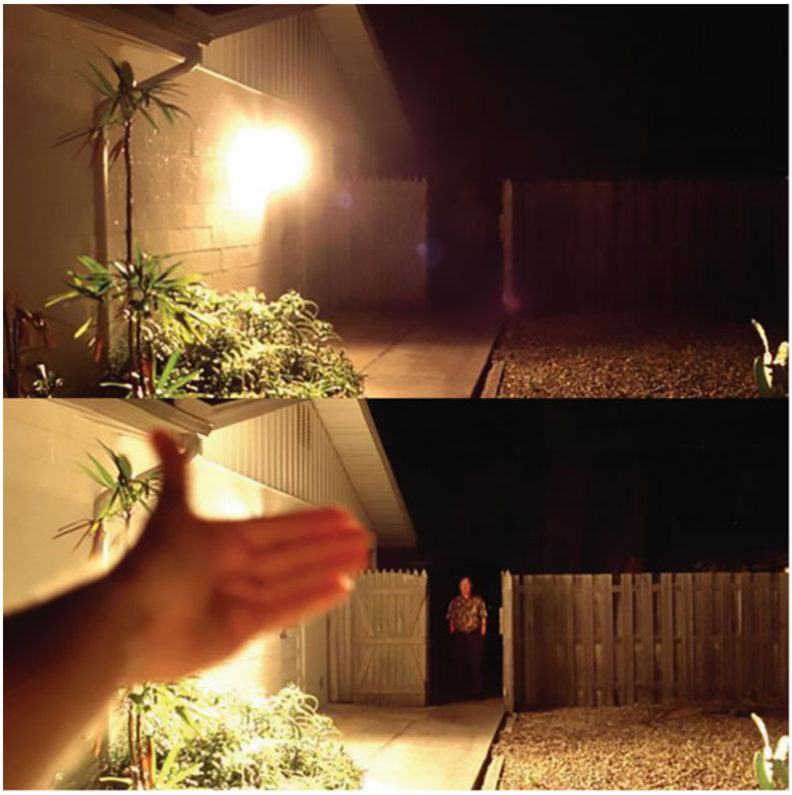


Fig. 26.4 Diagram of the principles shows how insects' attraction is reduced and the stars become visible when designing responsible ALAN

Fig. 26.5 Illustration of how glare limits the vision and how shielding the light improves visibility. Notice the discernability of the man in the gate and how the shadows are perceived brighter in the bottom picture where the light source is shielded. *Photo* George Fleenor



In this way, our understanding of light and darkness is two detached, disunited dimensions. It is in this understanding that ALAN is developed, and throughout history, ALAN has been linked to order and crime fighting, with the purpose of driving away darkness and crime from the night (Zardini 2006).

Consequently, humans have a cultural fear of the darkness, but the darkness is also sensually frightening because the sight loses the overview. The darkness conceals information about the environment and leaves us in the unknown, where we easily become anxious: "Is there a burglar in the dark that I cannot see?" In our fear, we light up the night, and because we rarely experience the dark, it is so foreign to us that we are unaware that darkness is a natural part of our cycle and that we actually need it (Rich and Longcore 2006). As stated earlier, we need darkness to sleep and to entrain our circadian rhythm, but darkness also contributes to intimacy and creativity and is the time for closeness, retreat, rest, and reflection (Bille and Sørensen 2007; Edensor 2013). These values are important to relate to the nocturnal experiences of urban green areas and provide the city with spaces for socializing and rejuvenizing after the sunset. It is often assumed that crime is reduced by increasing the intensity of ALAN. However, there is no scientific evidence that increasing light levels will increase safety and reduce crime (Boyce 2019). That being said, artificial light influences crime, and better lighting—not higher illuminance levels(!)—can lead to a drop in crime incidents, but high levels of ALAN will not reduce crime. Rather, it is the other way around. More and more research states that it is not a higher intensity of light but better lighting with dimmer light levels and warmer color temperatures that promote the feeling of safety and comfortable spaces' outdoors where people want to hang out in the evening (Painter and Farrington 1999; Boyce 2019; Hvass and Hansen 2022).

The word comfortable is a key point when designing ALAN. Lighting schemes are often the last part of a project and are commonly seen as a "generic add-on", with safety as the main focus, and the night is primarily considered as a constant that is total black. What if, before installing outdoor lighting, the question "Is there enough light?" was swapped for "Will the ALAN promote a comfortable aesthetic experience in this space that is appealing at night?". We need a holistic approach to outdoor lighting that considers darkness as part of the nocturnal experience and recognizes that the night is not entirely black but dynamic and dependent on time, place, and environment.

26.4 Reflection on ALAN and UN Sustainable Development Goals.

The UN Sustainable Development Goal does not refer directly to light pollution. However, as argued above, ALAN affects many aspects which concerns several SDGs. Therefore, ALAN plays a critical role in achieving several of the SDGs:

- SDG 3 *Good health and well-being*: Wrong exposure to ALAN can disrupt the circadian rhythm with negative impacts on human health.
- SDG 11 *Sustainable Cities and community*: Quality and intelligent lighting that promotes visibility and navigation by supporting the eyes' adaption should be included in lighting schemes in the future.
- SDG 12 *Responsible consumption and production*: Increasing the awareness of light pollution is not about turning all ALANs off but about using light and energy responsibly controlling ALAN by dimming and turning it off when it is not used.
- SDG 15 *Life on land*: ALAN can have a negative impact on terrestrial ecosystems, wildlife, and human health. Therefore, reducing light pollution can be seen as a measure to achieve some of the targets under SDG 15, such as by protecting biodiversity and promoting sustainable use of ecosystems.
- SDG 14 *Life below water*: Research shows that fish and other underwater species are especially sensitive to ALAN down to 0.01 lx (Liu et al. 2019). It is therefore important to consider ALAN near rivers and coastal areas.

We must think differently about ALAN and start to appreciate artificial light, not insist on it. We need to change the focus from the darkness as something frightening to understanding that darkness is a natural resource that we, as a part of the biodiversity, need and that everyone should have the right to access and be able to see stars at night.

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Part V

Healing through Design and Academic Research

A Narrative Essay on the Relationship Between the Biopsychosocial Model of Health and the Built Environment

27

Ab Rogers and Ashish Ranpura

Abstract

A correspondence between a Designer and a Neurologist, presented as a narrative essay on the relationship between the biopsychosocial model of health and the built environment. The discussion addresses how architecture, specifically that of the hospital, can apply scientific principles to understand how designed environments shape health behaviours and outcomes, bridging the gap between medical treatment and the architectural framework that supports it. It examines the benefits of utilising design as the 'third carer'—enabling it to actively support a patient's medical team (first carers) and family and friends (second carers) facilitating nurturing interactions and anticipating the needs of its occupants—exploring its potential to create inclusive clinical spaces that are adaptable, sensorially engaging, domestic in scale, colour and tactility, well-lit, acoustically controlled, and permeable to the natural world. The scientific understanding of illness has moved beyond strictly molecular and surgical models to a realisation that health is a combination of biological, psychological, and social factors. Therefore, the essay investigates the notion of the hospital as a tool for urban regeneration and the connections between the socio-economic and environmental factors that are vital to the success of medical treatment and the larger goal of health creation, exploring how our understanding of these connections can help re-imagine a built environment with the power to give users greater agency, better care and more control, enhancing health, welfare and quality of life.

Keywords

Healthcare · Hospitals · Neuroscience · Biophilia · Sustainability · History · Future

27.1 Introduction

In the video introduction to this conference, architect Jan Gehl recounts the story of the mid-19th-century cholera outbreak in Copenhagen. In the decades preceding that outbreak doctors had warned about overcrowding and unsanitary living conditions in Europe's city centres but Copenhagen, bounded by a city wall and building restrictions, was unable to adapt. When cholera hit on 11 June 1853 the loss of life was rapid and catastrophic. By October of that year, 7,219 people had been infected, of whom nearly 60% died.

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It is important to contextualise the science here. In the early nineteenth century germ theory was still in its infancy. The idea that tiny invisible creatures could invade our bodies to cause illness was, to most physicians, laughably unscientific. It was not until 1880 that Louis Pasteur would demonstrate the role that living microorganisms played in disease, and several decades more until this new understanding of hygiene would be widely accepted beyond the laboratory.

In that setting, a collaboration between doctors and architects must have been a revolutionary act. Bridging the cultures of science and design would have required open-minded curiosity, a sensitivity to language, and an ability to set aside short-term thinking in favour of long-term solutions. The housing development that resulted from this collaboration, Gehl tells us, remains one of the most successful urban developments in Copenhagen today.

The conversation that follows pays homage to that spirit of transdisciplinary collaboration. Ab Rogers is a designer and the principle of Ab Rogers Design, and Ash Ranpura is a neurologist and cognitive neuroscientist. Here, Rogers and Ranpura examine the historical and cultural forces that have shaped hospitals in the past and how changes in the scientific understanding of disease will shape the hospitals of the future. They then discuss specific details of their 'Living Systems' health centre design, which offers practical solutions to some of these theoretical concerns. Finally, the pair offer an optimistic view of the hospital as a 'Third Carer,' in collaboration with medical teams, families and the community, an institution integrated into the city rather than adjacent to it. Their dialogue concludes with a discussion of where we place value, both economically and morally, in the public space.

27.2 Neurologist: Part One

I'd like to start our conversation by thinking a little bit about the history of hospitals, to give us a sense of where we've come from and where we're going.

The word hospital shares its roots with the words hotel and hospitality, and it implies a place of rest and refuge. For centuries, this is about all hospitals were able to provide. While the wealthy could pay physicians to visit them at home when they were sick, the poor had to rely on charitable social institutions. In 1123 A.D., St. Bartholomew's Hospital opened in London under the cumbersome title of 'House of the Poore in Farringdon in the suburbs of the City of London of Henry VIII's Foundation.' At the time, Bart's (as it is now affectionately known) offered little more than a clean bed and decent food for the poor. Given the squalor these patients would otherwise have faced, the clinical environment that Bart's offered, however humble it may seem in hindsight, saved lives.

With the success of the Industrial Revolution in the early nineteenth century hospitals began to change from simple places of rest into technological factories for health. Doctors imagined the body as something like a mechanical device, operating by means of biological levers and gears and hydraulic tubes. Surgery became the dominant activity in the hospital—often with dire consequences for patients, whose post-surgical care was not generally considered an important part of the process. The hospital was no longer a place of rest and refuge but a clinical-industrial site where heroic doctors defied fate with dramatic and often bloody interventions.

The twentieth century brought us new optimism and the dizzying progress of the Atomic Age. Medicine first became cellular, then molecular, then nuclear, and most recently genetic. Nearly 900 years after its founding as a house for the poor, Bart's today is a centre of science and technology, where advanced diagnostic techniques can visualise the hallmarks of disease straight through flesh and bone, and keyhole surgery is performed with robots and lasers. And while the progress of medical technology at a hospital like Bart's is astonishing and undeniable, I can't help feeling that something important has been lost along the way. We have forgotten about the hospital's social mission.

Slowly and haltingly, a new era is dawning in medical practice, one in which clinicians seek to take advantage of technological progress without forgetting the lessons of the past. Rather than an industrial age mechanical model of disease or an atomic age molecular one, clinicians today understand sickness and health using a 'biopsychosocial' model. In this conception, sickness results when a biological factor affects a patient within a psychological framework situated within a social and political context. So, for example, a shift worker with few other options ends up working nights. This results in a circadian rhythm disturbance and mild immune dysfunction. Perhaps they smoke and suffer from a poor diet as well, leaving them susceptible to the occasional viral respiratory infection. Unable to take time off work to rest, the worker may have a very prolonged recovery period during which they are vulnerable to bacterial superinfection. Ultimately this would lead to pneumonia and severe cardio-respiratory disease. On presentation to the hospital, what is the doctor to say caused their illness? The bacterial infection? The viral infection that preceded it? Smoking and the psychology of addiction? The relentless tyranny of overnight shift work and disrupted sleep? Or the socio-economic circumstances that put them at risk in the first place?

This sort of joined-up, multifactorial thinking represents the next evolution in medical science. We no longer need industrial factories that manufacture health, and we are starting to see the limits of gleaming clinical temples devoted to science and technology. The healthcare of the future will focus on relationships: the relationship between the patient and the healers, and the relationship between the hospital and the community around it. Doctors and architects have to come together to devise new solutions built on this new understanding of sickness and health.

27.3 Designer: Part One

I agree that working together with doctors and architects can achieve a lot for healthcare—as evidenced in Copenhagen—and I think this collaborative approach can go even further, building a collective intelligence sourced from patients, doctors, nurses, engineers, designers, urbanists, architects, artists, acoustic, and lighting specialists and cultural producers, to generate solutions as complex and faceted as the people they serve.

Only the expanded vision afforded by a fully collaborative approach can enable us to consider the hospital from inside to out, exploring its potential as a public institution and as a conduit of care, examining every element of its user impact—from patient experience and staff welfare, outward to its role and influence on our cities and communities.

The latter is more vital than ever given the move towards a biopsychosocial model of health. As you explain, the connections between a person's health and their socio-economic and environmental circumstances are vital to the success of medical treatment and the larger goal of health creation. A greater understanding of these connections can help re-imagine a built environment with the power to give users greater agency, better care and more control, enhancing health, welfare and quality of life.

To serve this approach to our health the hospital cannot continue to function as an isolated machine solely dedicated to delivering clinical services and logistical processes. It must focus on the humans at its heart, sitting at the centre of their community, supporting staff, facilitating nurturing interactions, and anticipating the needs of its occupants.

We can think of a patient's care as being primarily provided by a medical team (their first carers) and through the presence and support of their family and friends (their secondary carers). In developing 'The Living Systems Health Centre'—our winning proposal for the 2021 Wolfson Economics Prize, we considered how a health centre itself might become a patient's 'third carer,' (Fig. 27.1) supporting doctors and nurses in delivering the science of treatment as well as the art of care.

This health centre is fuelled by a marketplace that sits on the ground level, while above, a raised public park offers access to nature—space to contemplate, relax, socialise, and exercise. This level also holds outposts that support a holistic approach to health creation through

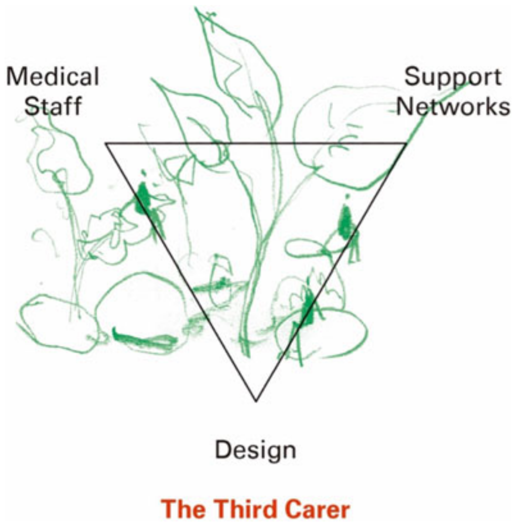

Fig. 27.1 The relationship between the three elements that make up the Third Carer/Ab Rogers Design and DRU+

social services targeting issues like debt, diet, and housing. Above this level is the tower of ward floors and surgeries, which are laid out in a repetitive circular plan.

The wards are built on a domestic scale and are full of tactile materials and calming and engaging colours. Each ward bed faces a window, and each window has a view out to nature.

Within the wards of the health centre a programme of sensorial engagement and nurturing moments of biomimicry—called the 'hospital clock'—has been designed to stimulate patients' circadian rhythms and fight isolation, inertia, and monotony. The programme is a series of nudges dotted across the day; natural soundscapes like bird song at dawn, light changes in synch with the sun's path outside, acoustically protected areas for rest, activities to get patients up and out of bed where possible, pocket parks between wards to give all access to fresh air and daylight. It seeks to give patients a sense of control over their day, to keep them connected to the outside world and help them to feel seen, considered, human, encouraging them to fight for their health.

As well as looking inward to the care of its citizens, the hospital must also reach outside its walls, expanding its sphere of influence, output and ambition, and becoming an active civic hub committed as much to prevention as to cure.

To fully utilise its power and position as a public institution, it must function as a regenerative tool, a catalyst for change, delivering a programme not only defined by its areas of specialty but by the social, political, geographical, environmental, and architectural needs of the communities it serves. It must champion localism, adopting an approach to hospital governance that sees it owned, staffed, and supplied by the very people who rely on it—employing local chefs, cleaners, and gardeners in place of anonymous subcontractors and inviting local volunteer groups to help in key areas. Broadening its focus activates the hospital as an anchor institution, enabling it to empower its citizens, improve their health and generate supportive investment in the local area.

The Living Systems Health Centre developed a network of engaging public spaces designed to dissolve the boundaries between the institution and its surrounding environment and encourage more open, relaxed behaviour. The marketplace at the base of the podium aims to bring healthy citizens to the grounds of the hospital, fostering a wider culture of care. It generates a hive of positive activity, inviting people to cluster around stalls selling fresh local produce, to sit and eat, to wander while examining dry goods and crafts. As well as helping strengthen local businesses, these interventions are recalibrating how people traditionally act in a hospital, reimagining it as a site of social, and cultural engagement.

For the hospital to function this way, it must be physically embedded in its local community, with activity, energy and life spilling out and infiltrating the world outside. If you put a bench in a park, people will sit. If you pedestrianise the streets, energising them with provocative, playful architectural interventions like tactile street furniture, raised platforms for pop-ups, generous piazzas for performance and public use—people will stop, gather, listen, dance, interact, and feel welcome and the wider landscape of the hospital will lose its negative stigma, becoming a backdrop for daily life. These landmarks can work with other green interventions, planting and trees, to disturb routine, ignite curiosity, and create memorable moments.

A network of green corridors (Fig. 27.2) can further help disperse the third carer philosophy from the hospital out into the surrounding environment. Organically formed from seasonal foliage to bring changing colour and scent, they can act to soften architecture and frame views. Linking key spaces, they will gently guide visitors, creating a natural flow of foot traffic between the city and the hospital so that entering it feels like permeating a welcoming, porous space rather than being dwarfed by a menacing monolith.

Radiating out across the living systems health centre's public park and popping up across the city, a family of pavilions containing different community-based activities continues this drive to offer more support and stimulation to citizens. Whether filled with community kitchens to help families and build supportive networks, urban allotments that encourage the growth of fresh produce, offer food education, and hold group activities, or performance spaces and makers studios that promote creativity and culture, these interventions can function as outposts for the hospital, spreading the art of care, encouraging connectivity, and drawing people out to enjoy their city.

27.4 Neurologist: Part Two

I love the idea of the hospital that reaches outwards, connecting to the community around it. Why don't hospitals and clinical spaces already do this now?

Where I live in Somerset, we have a thriving art and food culture. There is an active interest in local produce, farming, and community activities. Yet our GP surgery reflects no knowledge of or interaction with the local community. There are no collaborations with local arts organisations and no role in the many local food fairs or village festivals in the area. There is tremendous clinical expertise there and it is an exceptionally well-run practice, but it sits adjacent to our community rather than within it. Similarly, mid-size acute care and diagnostic facilities and larger hospitals tend to occupy industrial sites, outside of city centres in areas with massive car parks and good access to large roads. Hospitals are not really a part of our everyday lives, they are on the outskirts.

Fig. 27.2 Sketch of the Living Systems Health Centre in relation to the city surroundings, creating a green corridor/Ab Rogers Design and DRU+

Clinical spaces always imply an understanding of medicine. We build our clinical facilities in this way because we imagine that the body is a mechanical device and that illness is a technical disruption in our normal state of good health. We imagine that the solutions to this disruption must also be technological and likely industrial. This mechanical understanding of the body has enabled us to make tremendous progress in health care over the last century, but it is beginning to show its limitations.

We have highlighted the shift towards a biopsychosocial understanding of disease, and I think in the future we will move even further, towards what I call an ecological understanding. By 'ecological' I mean a few things. First, that the body doesn't flip between binary states of health and sickness, but that like all living systems it strives to maintain balance—what biologists call homeostasis—relative to its environment. Sickness is what we experience when homeostasis fails. Second, the causes of disease are never singular or mechanical but involve a disruption of complex regulatory systems. Disease is therefore always 'multidisciplinary' in terms of traditional medical categories. Finally, by ecological I mean to emphasise the relationships that are involved in regulating body processes. The biopsychosocial model is one example of ecological thinking: it is the relationships between a biological risk factor or pathogen with psychologically-driven behaviours and attitudes in the setting of social and cultural realities that create dysfunction.

How does ecological thinking differ from mechanical thinking? Imagine, for example, if we came upon a couple of trees in a forest with signs of leaf disease. We would certainly look at those individual trees to understand what was happening, but we would also be thinking about the environment around the trees. We might soon broaden our investigation to look at changes in insect populations, and perhaps changes in the predators that regulate those insect populations. We might consider changes in the fungal networks underneath the trees and whether changes in nutrients or even climate played a role. But no matter what approach we took, we would be unlikely to conclude simply that two trees had a disease—at minimum we would understand that the entire community of trees, possibly the entire species, might be at risk. Our concern would be for the forest.

In this way, human beings are no different from any other living organism. When we are healthy, we are in balance with the world around us. When that balance tips, it manifests as disease. We capsize. When that happens, the role of the hospital is to first right the ship, but then to make sure that balance can be restored. But that means clinical staff need the resources to support patients in non-medical ways and to play a leadership role in health promotion.

If we begin to think about our own bodies in ecological ways, as living systems rather than as mechanical ones, then I think the flaws in modern healthcare design and the advantages of the Living Systems Health Centre start to become apparent.

First, the Living Systems Health Centre is designed around the needs of patients rather than the needs of the institution. This is a radical, and admittedly very difficult position to adopt. For example, there is no space for car parking, so the hospital depends on public transportation and taxis for most of its traffic flow (of course with special access for ambulances and emergency services). The hospital is then allowed to sit in a beautiful park, so the building becomes integrated into its environment rather than imposed upon it. Patients and their families, not vehicles and industrial equipment, dominate the landscape. It is a human place and not an industrial one.

Second, the Living Systems design prioritises the needs of the staff. People who work in an acute healthcare setting are always under stress and time pressure. Providing a market with fresh groceries enables staff to pick up healthy food on their way home, allowing the hospital to relieve some of the burden of long and often anti-social hours. Emphasising cooking with multiple kitchens also enables staff access to high-quality fresh food where they are working, instead of the standard rushed high-fat, high-calorie fast food options they are typically offered. Careful consideration has been given to quiet places for staff to work, chat and relax in privacy. This design recognises the ecological nature of a complex institution like a hospital—staff will tend to treat patients as they themselves are treated.

Finally, the Living Systems design places gardens and ecological thinking in the centre of medical practice. In order for the pocket gardens to function well, consideration will have to be given to local wildlife corridors and which species of plants and insects are already present in the environment. Water and sunlight become crucial parts of the design process. More significantly, interaction with the garden becomes part of the clinical process. Informally, patients would have easy access to an outdoor space directly from the ward, encouraging early mobilisation. Families would have a space to sit and relax, without leaving the immediate vicinity of the patients. Formally, activities in the garden could replace more traditional rehabilitation activities, providing meaning and joy that can't be found in a gym. Overall, the incorporation of these gardens in a functional, rather than simply an ornamental way, allows the hospital to move away from industrial to ecological healthcare.

Regardless of whether hospital design moves in the direction of Living Systems, things must change. Healthcare spending is rising exponentially, while at the same time healthcare outcomes are declining. All around the world, medical staff are doing more with less and suffering from burnout. This results in medical errors, loss of staff through early retirement, and ultimately fewer young people seeking jobs in health care. Those staff that are in the system must find workarounds to meet their needs—the special computer trick that enables a doctor to enter a lab test that can't otherwise be ordered, the nurse that knows how to cobble together an infusion line when normal supplies have run out, the janitor that re-arranges the tiny supply closet so that boxes don't sit in the corridor. The ecosystem of the modern hospital is dysfunctional, and it is held together with heroic effort by hospital staff. We all deserve better solutions.

27.5 Designer: Part Two

I enjoy the clarity of your interpretation of our health as an ecology, constantly seeking balance in the face of change and flux. It helps to be able to visualise this ongoing battle for equilibrium across disparate but connected elements and it puts me in mind of my favourite permaculture quote on the topic of attacks on one's vegetable garden—'it's not that you have too many slugs, but rather that you don't have enough ducks.' Where our current hospitals fail is in the lack of communication and connection across the different elements and the resulting imbalance.

During our work in hospitals, where we are often tackling small, contained projects, we find ourselves facing isolated, internally divided factions and a general feeling of resistance to change —positive or not. As you describe, staff are asked to do so much with so little and the resulting status quo is so fragile that anything different is perceived as a threat. Everyone wants to work in a welcoming, comfortable, high-functioning workplace but currently, no one feels ownership over either the space or the challenges it faces. Working recently on the design of a cancer daycare centre for a PPE hospital, we discovered the existing site was a corridor with 24 chairs in a line against one wall. For patients there was no privacy or dignity and there was no sense of care or protection for these vulnerable people. When we asked the consultant in charge how something so inhuman and unfit for purpose had been allowed to come about he said he was not shown the plans until the scheme had been signed off and there was no opportunity for comment.

We can only change the environment if we can change the culture within it. As Paul Farmer said 'beauty…Is the ultimate vehicle for the distribution of dignity.' If we want to inspire ownership and investment, we must offer people spaces that make them feel valued, that they can believe in and take pride in. An environment that is loved and cared for will inspire those emotions in return—if someone walks into a toilet that is clean, comfortable and well-lit, they will treat it with respect, but if they go into a dirty, battered, broken space there is little impetus for care and consideration.

I believe this spirit of reciprocity and belief in the art of care is taking root and that the inner city is going through a radical, human-focused moment of change. We are starting to understand the power of our built environment to further health creation, and to fully harness the positive influence of biophilia and biomimicry both on mental and physical health and as an outward proponent of care and investment. These are not token or purely aesthetic gestures, but suggestions of an integral change in the way we view our cities and their impact on our lives.

To maintain this positive momentum in the future we must place the value of well-designed and considered public environments above their cost, recognising, as Florence Nightingale did, that the object and colour in the materials around us actually have a physical effect on us, on how we feel and assessing their cost accordingly, not as the sum expended on initial completion but on what it will amount to over the following decades.

Economist Mariana Mazzucato said ‘What happens when we confuse price with value? We end up undervaluing care.’ When we build a hospital with the main priority of keeping cost per sqm low, that hospital is obsolete before it is completed. Only when we look at its impact on the city and long-term value as a public institution, an anchor for health creation, a place of healing and a tool for community regeneration, can we truly assess what it is worth to its citizens.

27.6 Conclusion

The conversation between Rogers and Ranpura evokes an integrated and socially conscious conception of hospitals and of medicine. It moves beyond a focus on the mechanical aspects of health care—diagnostic imaging, surgery, drug delivery—to a focus on healing and recovery.

The line that Ranpura describes between hospitals as historical places of refuge, through the morass of the modern techno-industrial factory, comes back full circle to Rogers’ notion of the Third Carer. The pair’s descriptions of the practical implications of their view form a clear vision of what hospitals of the future might look like: patient-centric, flexible, and ecologically connected to the communities around them. It is an exciting, sweeping vision that encompasses not just a transformation of the hospital, but a celebration of health and of life itself.

Rethinking the Design of Architectural Space Thermal Environment—Thermal Landscape

28

Zhuoyu Yu and Dexuan Song

Abstract

In the context of global warming, building-related energy usage and pollutant emissions remain high. Therefore, it has become a consensus to provide a comfortable and healthy thermal environment with the least energy. At present, the existing architectural design language does not pay enough attention to the health and energy saving of space thermal environment. Based on this background, the concept of space thermal landscape was proposed according to the relevant theories of human thermal perception, dynamic thermal environment, and thermal synesthesia, and the concept, prospect, and characteristics of thermal landscape are analyzed. Rethinking the design of space thermal environment, put forward the design method of space thermal environment from four parts: water landscape building thermal landscape, maintenance of traditional thermal landscape, natural ecological thermal landscape, and local installation thermal landscape, liberated the space design language of architects from universalism, and explored thermal environment design from a new angle. It is expected to provide designers with new ideas and new directions in the early stage of thermal environment design and energy-saving design.

Keywords

Thermal landscape · Thermal environment design · Design method

28.1 Introduction

In the 2030 Agenda for Sustainable Development, Member States express their commitment to protect the planet from degradation and take urgent action on climate change. The Agenda also identifies, in its paragraph 14, climate change as "one of the greatest challenges of our time" and worries about "its adverse impacts undermine the ability of all countries to achieve sustainable development. Only by innovating in systems and technologies, can we reduce carbon dioxide emissions and control the rate of global warming. As far as buildings are concerned, new concepts and methods are needed to reduce the heating and cooling energy consumption of buildings. The creation of thermal environments has always been strongly tied to the process of architectural development. The construction of thermal environments is intimately tied to the

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development of residential buildings, which were first constructed as shelter from the wind and sun. Architecture is typically thought to concentrate on designing visually beautiful buildings and spaces, but in reality, space will engage people's various senses. The user can only fully and comfortably exist in a space when all of the sensory enjoyment and experience of that space are mobilized. Architecture is evolving toward refinement, so design thinking for refinement should also be modified from an architectural physics perspective on sound, light, and heat. For instance, early noise control has given way to the creation of soundscapes, and the emphasis on physical indications has given way to the importance of how various people perceive the sound environment. Thermal environment research, however, continues to focus on physical and thermoneutral indices, which frequently disregard the dynamic perception shifts of the thermal environment and only address the users' basic demands for cold and heat. Simple environmental control like this will result in wasted energy use and a lack of spatial attractiveness, especially in underground spaces that cannot accept the external natural environment for an extended period of time. It is also important to keep in mind that human heat perception is a quick reaction to the environment around the skin via the skin's cold and heat sensors, rather than to the space's entire physical environment. It is incorrect to assume that a user's thermal perception in a particular moment and location corresponds to the thermal environment of the entire area or structure. Therefore, it is critical to do more in-depth exploration and research on the thermal environment of a space, as this can both increase the area's appeal and offer the potential for energy savings. Strengthening the fine design of energy-saving design work and division of labor control may be a fair way to control building energy consumption at the moment when existing science, technology, and equipment performance cannot meet the long-term objectives of energy saving and emission reduction.

When the Franklin furnace was developed in the eighteenth century, radiant heating systems gave way to flow heating systems, and people started to think of buildings as hot air paddocks. Shade trees or water fountains progressively made way for air-conditioned indoor spaces after the development of air conditioning in 1902, which made it possible to regulate the temperature indoors. Nowadays, it seems that people can alter the temperature, humidity, and air quality of a space at whim because to advancements in air conditioning technology. Buildings are growing toward a closed atmosphere that is strictly regulated by air conditioning and other mechanical systems in order to improve environmental quality and achieve a non-deviation-free, non-stimulating, and stable indoor environment (Yingxin 2015). Since buildings are leading the charge in the fight against global warming and the greenhouse effect, the architect should approach energy-saving design from a fresh perspective and consider factors like space, light, temperature and humidity, wind, and air in the physical environment. They should also consider new structures and urban form tools (Rahm 2020).

Humans use a variety of heat regulating techniques (as shown in Fig. 28.1). A comprehensive skin system is employed to perceive the thermal environment, and the hypothalamus is subsequently used to control endocrine and metabolic body temperature. The major purposes of the anterior portion are to encourage heat dissipation and lower body temperature. The back section protects against cold and encourages the creation of heat (Yingxin 2010). Humans are able to be comfortable in a variety of thermal situations thanks to metabolism, which also allows them to intentionally change their muscle activity to generate heat. The ability of humans to quickly adapt to changes in the outside thermal environment through exercise, appropriate clothing, and diet within a given range creates more room for building energy conservation.

Thermal adaptation can be weakened by stable thermal surroundings and strictly regulated temperatures since they can reduce the occupants' ability to adjust. An organism's ability to adapt to environmental changes is a type of survival ability. It is also a type of adaptation

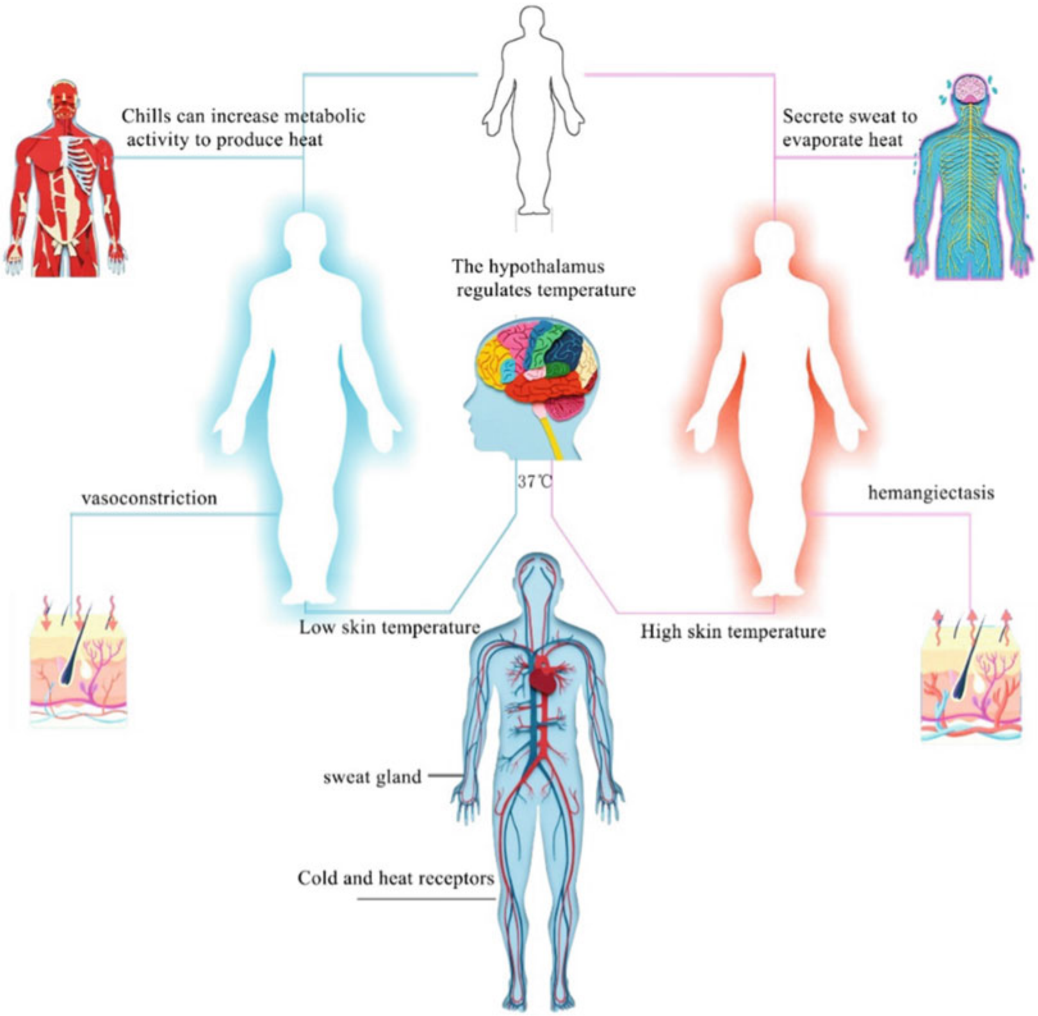

Fig. 28.1 Thermal regulation of human body (created by authors)

phenomenon, in that the organism makes a number of adjustments to accommodate the changes in its environment. The degree of environmental change and the length of adaptation are related to this process, and the effects of sustained stimulation and adaptation can be passed down to next generations through gene level solidification (Danian 2018). It is crucial for humans to adapt to their surroundings, and it is worthwhile to research how to do so without causing thermal stress to worsen. The current global standards for indoor environments in air-conditioned buildings are based on PMV, which is derived from steady-state temperature environments. An essential place to begin studying the science of human body thermal feeling is with thermal comfort research in steady-state thermal environments. The ultimate objective should be to comprehend human thermal comfort in the pervasive dynamic thermal environment.

A particular exterior stimulus might be regarded as pleasant or unpleasant based on signals from within the body, according to Michel Cabanac's science article from 1971. Alliesthesia, which is derived from the words esthesia (feeling) and allios (change), is a term to describe this phenomena (Cabanac 1971).

Human “sensation” is influenced by both the internal state of our bodies and the quality or strength of the input. When you're thermoneutral, you don't feel good about dipping your hand in hot or cold water, but when you're cold or hot, you feel extremely wonderful about it. This is the classic experiment on thermal synesthesia. People may feel the warmth and chill of the sun and the breeze as they walk down the avenue on a sunny spring afternoon. People will experience a unique sense of enjoyment from this alternating sensation of heat and cold (Heschong 1979). Instead of using equipment to create a stable thermal environment, if we are in a space with a “medium,” it can make us happier, more flexible in our thinking, and more tolerant of a range of situations. For example, a “medium” could be a cool breeze in the middle of a hot summer, a fountain, some sunlight, or some plants (Craig et al. 2015). This not only reduces people’s hot pleasure but also reduces their thermal stress.

Further investigation on thermal alliesthesia has been done in recent years by the team led by Professor Richard de Dear, and actual data supporting the application of the concept to the field of indoor thermal comfort has been provided. The idea of thermal alliesthesia offers a broad framework that accommodates the understanding of thermal comfort in stable as well as unsettled and heterogeneous surroundings. These results serve as a solid foundation for further investigation into the possibilities of synesthesia, which allows architects to make the most of dynamic thermal surroundings to provide thermal enjoyment. The idea of thermal alliesthesia will lead to new design and technical solutions to excite thermal feeling and combat thermal ennui in the built environment, which is significantly different from the steady-state model of thermal comfort (Parkinson and de Dear 2015). By adjusting local skin temperature, humans can buck the general trend in average skin temperature and increase their level of enjoyment (Parkinson et al. 2015). Researchers from the University of Berkeley also proposed the “personal comfort system” (PCS), which can efficiently conserve energy, to measure the human body’s capacity to produce comfort at ambient temperatures higher or lower than the subject’s neutral temperature (Zhang et al. 2015). The majority of current research focuses on how thermal synesthesia is used locally in the human body. From the standpoint of space design, thermal landscape puts forth the idea that altering the “thermal environment” in space causes the human body to develop sentiments that are good for it. This conceptual advancement may pave the way for creative design concepts and methods to develop favorable thermal landscapes that enhance people’s quality of life and get rid of unfavorable thermal settings. Future building standards and design guidelines may be able to broaden the previously limited temperature range with the help of the suggested thermal landscape, or the single temperature range may be replaced with a more flexible method of environment creation.

28.2 Concept of Thermal Landscape

A thermal environment that one or more people perceive, comprehend, and feel in space is referred to as a thermal landscape. The thermal expression of architectural design, the thermal form of architectural space, and the new architectural language all revolve around creating a dynamic, healthy, and enjoyable thermal environment. Thermal landscape is a pleasant thermal environment as sensed by the body, not a visual landscape. Creating a cozy and inviting environment is one of architecture’s fundamental purposes. There are numerous thermal settings in our daily lives, such as fireplaces, sunrooms, awnings, hot springs, gazebos, water features, green spaces, ondols, and so on, in addition to the natural environment that makes us happy. In contrast to the traditional thermal environment, the concept of thermal landscape is not only concerned with the thermal environment as it changes in terms of physical parameters, but also with how the human body responds to the changing thermal environment. This allows for the creation of a more dynamic and active thermal environment that is suitable for the human body and leads to a win–win situation in which both the building's occupants and the environment are improved while also using less energy.

Because the stability of the thermal environment cannot make the user more comfortable, it instead causes people to struggle against the heat of the inherent ability of the degradation, weakening the human body's thermal adaptability. Thermal landscape is the study of how people feel about the relationship between the environment and society. Unlike the traditional thermal environment, it focuses on data such as temperature and humidity. Therefore, the idea of a thermal landscape is put forth in order to create a dynamic and active thermal environment that is more suited to the needs of the human body while also paying attention to the thermal environment with changing physical parameters and understanding the human body's reaction to those changes. There are two types of thermal landscapes: natural thermal landscapes and man-made thermal landscapes. The term "thermal landscape" refers to all elements that have distinctive geographical or seasonal features and enhance thermal comfort such as hot springs, rivers, waterfalls, summer boulevards, valley winds, sea and land winds, and other naturally occurring thermal environments. Artificial landscape is the use of passive design and other technical means to optimize the thermal environment of "landscape," such as on the exterior of the building set fountain, water scene, stereo virescence, summer outdoor setting spray cooling device, road of awnings, bus stops heating facilities, winter sun room, northeast of fire resistance. Protect, promote, and expand the value of the thermal landscape, foster a calm and enjoyable atmosphere, and improve people's comfort and health.

There are three methods to use thermal landscape concept design strategies in architecture, as indicated in Fig. 28.2: The first method is to direct people to congregate in key areas by using heat as a spatial guide (1–6 in Fig. 28.2). The second method is to use conduction, radiation, and convection—the properties of heat transfer—to the development of the thermal environment in space (7–9 in Fig. 28.2). The third method comes from the viewpoint of space planning. The direction of the building, the size and placement of the windows, and the arrangement of the plane in accordance with the needs for various spaces' thermal environments should all be taken into consideration during the design phase. For instance, conference spaces, projection spaces, and exhibition spaces are not frequently used in China. While bedrooms, offices, and classrooms are places where people spend a lot of time and need to be situated toward the south of the building to receive sunlight, the space can be placed in the north of the structure. Additionally, to create a natural and comfortable thermal environment in the area, windows, skylights, sunshades, and ventilation systems must be extensively exploited (10–12 in Fig. 28.2).

28.3 Thermal Landscape Design

The construction approach for thermal landscapes was summed up by the good energy-saving design cases from home and abroad and the thermal landscape law. By combining the views of a thermal landscape and mastering its characteristics and construction techniques, energy-saving design of thermal landscape construction is made possible. Thermal landscape construction techniques include plant ecological thermal landscape, traditional thermal landscape maintenance, construction of thermal landscape by water landscape, and local installation of thermal landscape.

28.3.1 Thermal Scene of Waterscape Construction

If the designer can take into account creating a dynamic, healthy thermal climate for the interior in the early design, not only can it minimize air conditioning energy usage, but it can also lure people to stay in the building. People have an intuitive attraction for natural plants, water, and sunlight in a room. Including water features in the space helps to increase people's contentment with the thermal environment. As illustrated in Figs. 28.3 and 28.4: The world's largest indoor landscape waterfall is located in China's Xi'an

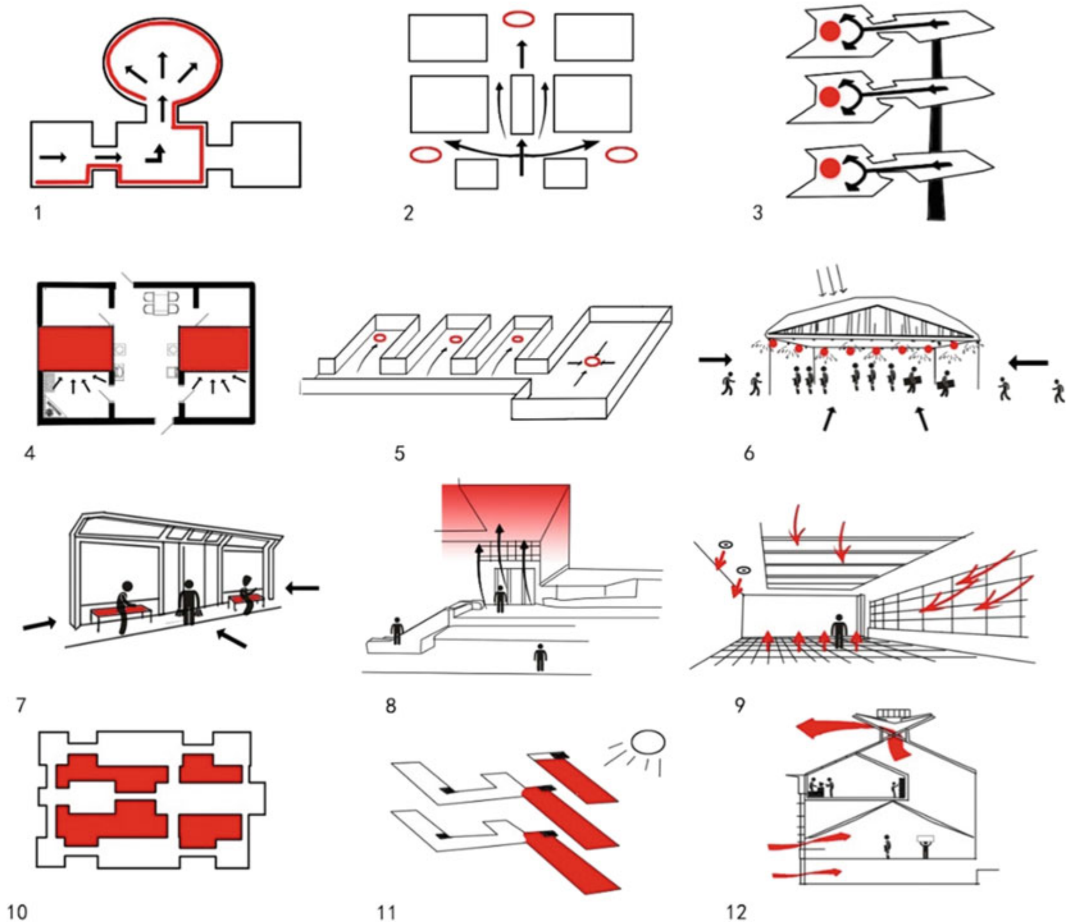

Fig. 28.2 Application of thermal landscape in architecture (created by authors)

Saige International Shopping Center. The waterfall measures 108 m in length. It is shaped by over 100 different types of water lilies and a super long flowing waterfall, producing an ideal water feature. When individuals touch the waterfall's water drops with their hands and feel the spray with their skin, it creates a more authentic feeling of experience. People automatically interact in their surroundings and are drawn to such water elements, which provide not only visual pleasure but also thermal pleasure through comfortable temperature and humidity. Keep cool while encouraging the growth of houseplants.

As shown in Fig. 28.5 there are numerous more techniques to create a water and thermal landscape in an architectural space, including mist spray, water curtain, spray ceiling fans, pool, fountain, and spray system.

28.3.2 Preserve Traditional Thermal Landscapes

People can experience distinct emotions in the scene; for example, they l feel comfortable in the natural scene and irritable in the closed scenario. At the same time, location is linked to people's lifestyles. The memory of a regional climate and the sensation of a spatial thermal environment are also influenced by the heritage of architecture, urban space, and living patterns. This spiritual sense of familiarity and recall is no longer buried behind the conventional setting, but we must pay

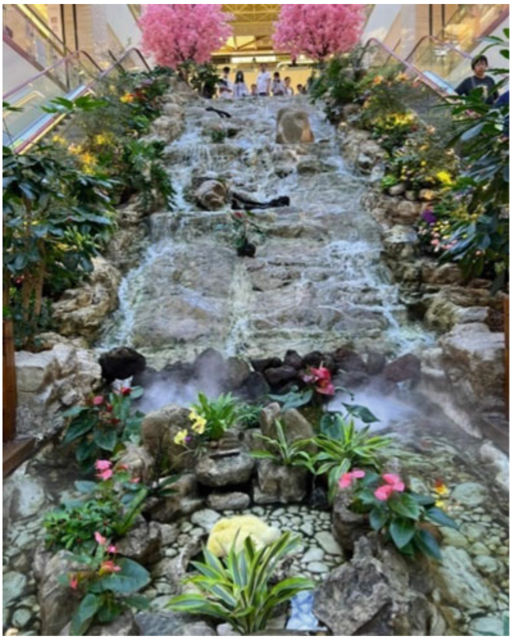

Fig. 28.3 Ducklings in the water in Xi'an Shopping mall

greater attention to the core soul of regional spirit, which must be inherited and kept. The heat of the recollection feels like a sentimental childhood object, and when it reappears, it feels especially close. The ondol in northeast China, the hot spring sauna in Nordic countries, and the bamboo woven dwelling in Southeast Asia are all examples. In harsh climatic zones, such as Finland, where the Hatwal Arena allows visitors to watch ice hockey while also enjoying a sauna, an appropriate thermal landscape design method can be used. Saunas were also erected in Finland's cable cars. This is due to the fact that Finnish people adore and are familiar with sauna as a traditional thermal landscape, so they frequently employ this method to preserve the traditional thermal landscape in the construction of buildings or structures. People's understanding of thermal landscape includes historical, geographical, and humanistic factors such as historical and cultural precipitation and the influence of living and growing environment, which are projected into a specific environment to generate some thermal landscape expectations and influence people's judgment. In a broad sense, the subjective impression of thermal landscape stimulates users' imagination or meetings to feel the beautiful surroundings through the historical and

Fig. 28.4 Indoor waterfall in Xi'an shopping mall

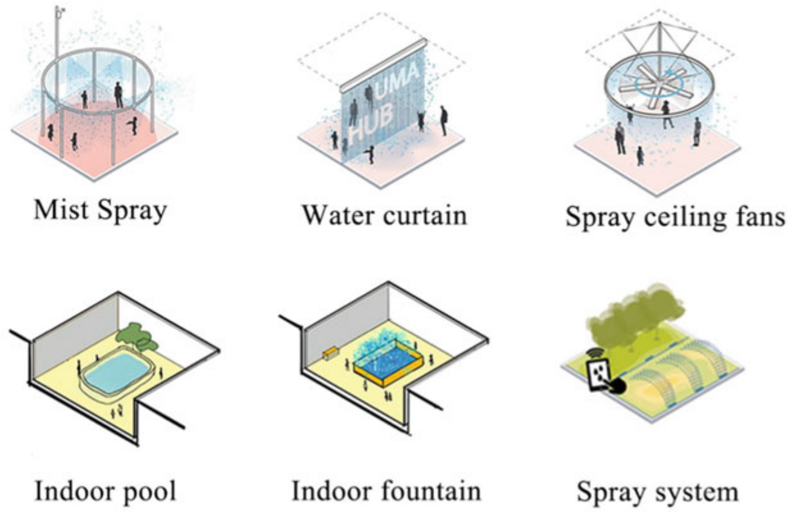

Fig. 28.5 Waterscape thermal landscape design method (created by authors)

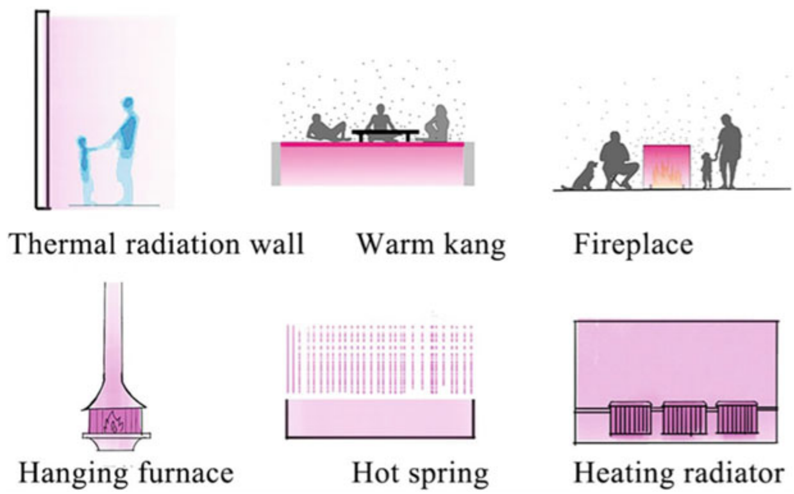

Fig. 28.6 Protection of traditional thermal landscape design methods (created by authors)

humanistic context, along with thermal landscape design. These settings, however, are heavily influenced by the individual's cultural background, thoughts, and emotions. Designers should consider the region and the traditional significance of the thermal landscape early in the design process to obtain double the result with half the effort. Traditional thermal landscapes with emotional support, as seen in Fig. 28.6, comprise thermal radiation wall, warm kang, fireplace, hanging furnace, hot spring, and heating radiator.

28.3.3 Natural Ecological Thermal Landscape

Thermal landscape is not an isolated landscape aspect. Thermal landscape can be separated into three levels based on human perception: visual, aural, and, of course, sensory. An vision of ice on a hot summer day, for example, evokes a sense of chill, as does a warm furnace on an icy day. The same is true in the sense of hearing: the whistling of wind, the splashing of water over a waterfall and the crackling of firewood give a change in "thermal experience." Humans have adapted the natural environment to be an environment where all characteristics (such as temperature, wind speed, sun radiation, and humidity) shift from day to night and from day to day. According to the research findings, a steady thermal environment and precise temperature control do not provide more comfort to people; instead, they may degrade people's intrinsic ability to endure thermal stress, consequently reducing thermal adaption. As a result, the bionic nature's simulated thermal landscape can not only interest people but also contribute to their health and comfort. The heart of Singapore's Changi Airport, as depicted in Fig. 28.7, is Forest Valley, a terraced indoor park with numerous spaces and interactive experiences, such as walking trails, flowing waterfalls, and quiet rest spots. The world's highest indoor waterfall—a "rain vortex"—from the eye top of the domed roof to the following seven levels of the Forest Valley Garden is among more than 200 different plants and trees. Under peak conditions, the falls flow at a rate of 10,000 gallons per minute, helping to cool the landscape environment and capture enormous amounts of rainwater for reuse around the structure. A five-story multi-story retail market surrounds the garden and is accessible by a series of vertical canyons. The waterfall cools the landscape, while the integrated dynamic glass shade system and revolutionary displacement ventilation system create exceptionally pleasant spaces for a variety of indoor activities and bring light to the lush plant beneath the roof. There are numerous approaches to construct a natural ecological thermal environment, as seen in Fig. 28.8. People will subjectively adore green flora and will seek out these green spaces. As a result, physical and psychological thermal comfort, as well as space environment construction, must be considered. This indicates that by developing natural quality spaces, architects may boost people's pleasure with the thermal environment.

28.3.4 Local Installation Thermal Landscape

In space, thermal landscapes can be constructed at specific space nodes based on people's demands, which can not only minimize energy consumption but also enhance people's adaptability to the environment, allowing for the most efficient use of energy. In many buildings, even if some rooms are not occupied, the air conditioning is still turned on, which will cause a waste of energy, and in summer can also be effective cooling fan, ceiling fans, and ventilation system, in the winter some crowded place using radiation wall, specific heating area can satisfy people's need for temperature, parts of the city set up fever chair, such as South Korea plus wind of transparent film, let a person sitting in cold weather won't miss the bus, more focused on their hometown or need to take a bus in the morning, after all the old fight cold ability is poorer, heating when the temperature dropped to 17 °C below chair can operate automatically, from 5 am to 12 PM in operational condition.

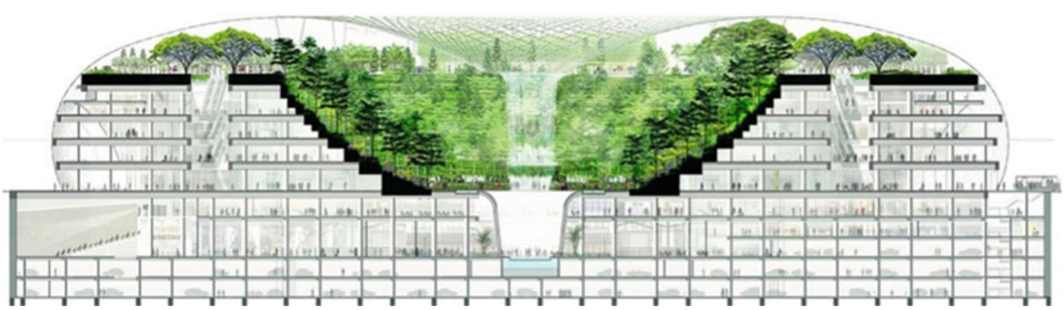

Fig. 28.7 Green landscape of Changi Airport in Singapore (https://www.archdaily.cn/cn/915723)

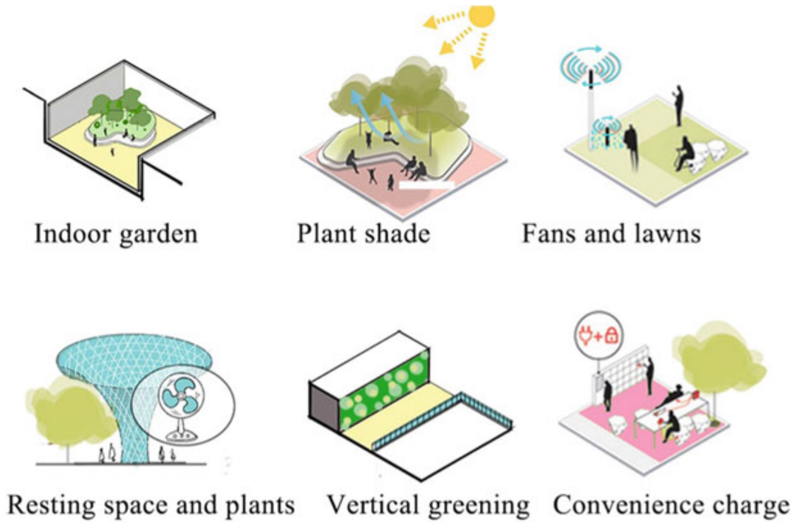

Fig. 28.8 Design method of natural ecological thermal landscape (created by authors)

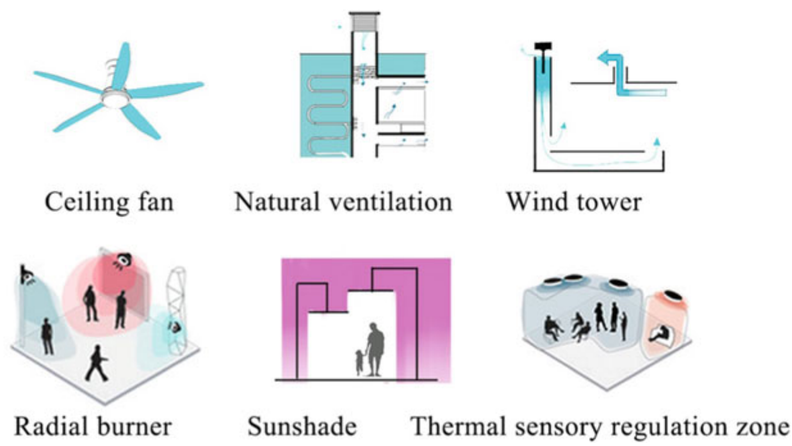

Fig. 28.9 Thermal landscape design method of local installation (created by authors)

Figure 28.9 depicts the design of a tiny device for regulating the indoor thermal environment. Ceiling fans and fans are frequently overlooked. Ceiling fans are not only more comfortable than air conditioners, but they are also significantly more energy efficient. With the advancement of science and technology, intelligent ceiling fans can actively recognize the color of the face, estimate people's chilly and hot temperatures, and modify the fan's speed. In the process of designing the space thermal environment, the space can be divided into temperature zones and combined with the rest area and charging area to design hot and cold adjustment positions, so that users of the space can heat up or cool down according to their own needs, which not only saves energy but also increases the fun of the space.

28.4 Conclusion

To achieve the SDGs, we are confronted with the need for creating fundamental changes to "business as usual" challenging our ways of understanding and operating and our impact on larger ecological contexts. The idea of a spatial thermal landscape is based on the idea of an acoustic landscape, which emphasizes how people perceive spatial thermal environments rather than their physical manifestations. The characteristics of the thermal landscape, such as spatial direction, location aggregation, composition diversity, and energy-saving adaptation, were examined in order to dynamically modify the indoor thermal environment in accordance with human demands and adaptability. Based on this, six techniques are suggested for each of the four construction ways of the spatial thermal landscape, which are waterscape construction, traditional culture, natural ecology, and local installation. The design strategy for thermal landscapes is suggested by the following points.

1. We can lessen people's excessive reliance on air conditioners if we pay attention to the formation of thermal landscape in the space. More plants and water features in the area can significantly increase occupant pleasure, according to designers. At the same time, we must take into account the thermal environment of outdoor space, promote outdoor recreation and rest, and cut down on inside energy use.
2. Traditional heating and cooling techniques including the hanging furnace, heated kang, fireplace, and ceiling fan should be considered. These age-old methods of temperature control not only help people remember traditional culture but also save electricity.
3. The human body's capacity for temperature adaptation is frequently overlooked. The internal temperature can be modified during building operation and management in response to temperature variations in the surrounding natural environment. The temperature does not have to stay constant from morning to night. It may be slightly lower at noon, in the morning, and in the evening. A little bit higher, mimicking rhythmic shifts outside.
4. Local thermal adjustment devices may be used in public structures or sizable areas. People can go to warm or cool places based on their own feelings when they require cooling and heating. The traffic space can lower the temperature and conserve energy in short-stay locations like transition spaces.

The discovery of this concept can lead to design idea and technique innovation, in accordance with the design concept of respecting nature ecology, to create a positive, can improve people's quality of life of hot landscape, get rid of those negative thermal landscape, pay attention to social and environmental characteristics, and coordinate the relationship between social and environmental factors. The research findings are anticipated to contribute significantly to lowering building energy consumption by offering new methods and standards for controlling the indoor thermal climate. A new way to combine architectural design and architectural technology will be made possible by the fundamental ideas and design techniques of thermal landscape, which will also broaden the study of building thermal environments and environmental control.

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29 Walkability Assessment Using Agent-Based Model: Why It Becomes An Advantageous Way

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Abstract

Highly walkable urban design has a significant impact on the health of residents. However, accurately evaluating the walkability of an urban design can be challenging for designers, urban planners, and policymakers. In the past, researchers have used both qualitative methods like auditing and questionnaires and quantitative methods to support a more accurate assessment of walkability. In this study, we conducted a two-phase review of walkability assessment studies in the Web of Science and ultimately selected three common quantification methods: space syntax (SS), geographic information system (GIS), and agent-based model (ABM). Our review found that ABM has several advantages, such as the incorporation of subjective factors, the integration of multiple factors, the ability to differentiate different populations, and numerous applications in public health. We compared these three methods in detail and discussed their strengths and weaknesses. We also identified current limitations of ABM and proposed potential solutions based on existing research. Overall, we concluded that ABM is a superior method for quantitatively assessing walkability, and we call for more architects and urban planners to use this method to design more walkable urban spaces and improve the health of residents.

Keywords

Walkability · Agent-based model · Space syntax · Geographic information system · Comparison

29.1 Introduction

29.1.1 Background

Sustainable development has become increasingly important in urban planning and architectural design since it was introduced in the United Nation's report Our Common Future in 1987 (World Commission on Environment and Development 1987). The 17 Sustainable Development Goals (SDGs) proposed by the UN's Department of Economic and Social Affairs, as the core content of the 2030 Agenda for Sustainable Development (United Nations 2015), provide guidance for countries to pursue sustainable development. Walkability, as an indicator for assessing the willingness of residents to walk in cities, is closely related to the goals of

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creating sustainable cities and communities (Goal 11).[1] At the same time, due to the impact of travel methods on obesity rates (Creatore et al. 2016) and cardiovascular prevalence (Howell et al. 2019), walkability is also important for Goal 3 good health and well-being.

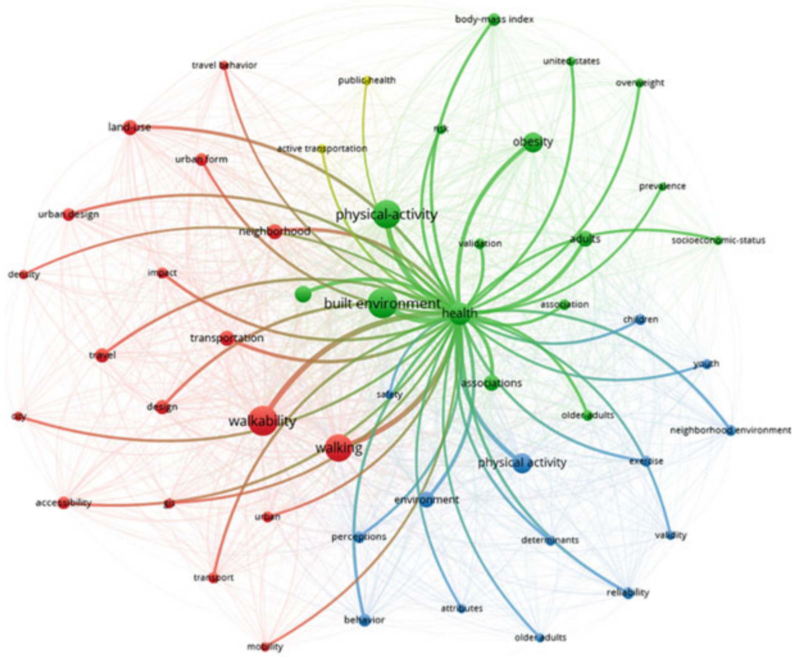
Throughout history, various modes of transportation have been developed and used, including walking, animals, carts and carriages, trains, automobiles, and planes. These modes have been shaped by technological innovations, societal needs, and economic factors (Zhao et al. 2010). The change in means of transportation also affects the urban form in turn. The emergence of non-human powered vehicles enables residents to complete longer-distance commuting in unit time, thus promoting the separation of residential areas from work areas and living areas, thereby promoting cities' rapid expansion and spread. The rapid spread of the city has forced more citizens to turn to cars and other means of transportation. Although governments around the world are trying to reduce citizens' dependence on cars through more intensive or frequent public transportation, the car ownership rate is still increasing year by year, which brings about the annual gasoline consumption and exhaust emissions growing at a very high rate. This also brings about an increase in respiratory diseases among the public (D'amato et al. 2001). Besides, research proved that choosing cars as a travel mode also contributes to the rise in obesity rates (Williamson 1999; Frank et al. 2004; Creatore et al. 2016) and the risk of cardiovascular disease (Howell et al. 2019). Figure 29.1 is generated by VOSviewer, based on all keywords searched for "walkability" in the literature on the Web of Science, showing the co-occurrence between keywords. The diameter of the circle and the thickness of the line represent the number of occurrences of individual keywords and the frequency of connected keywords co-occurring. Obviously, walkability and health are closely related, especially in the topic of obesity (as well as overweight).

A person's choice of transportation mode can be influenced by various factors (Calastri et al. 2019). While driving may be the most efficient option in terms of time (calculated by distance/speed), it may not always be the chosen mode of transportation due to other influencing factors. Financial cost is a key factor as well. The cost of purchasing, maintaining, and using cars can influence people's decision. Research has shown that factors such as the local climate, safety, greening of the walking environment, and the travel modes of others (Yin 2013) can all impact the choice of individual travel modes. Therefore, under reasonable urban environmental conditions, it is possible for citizens to opt for non-motorized means, such as walking, as an alternative to driving.

Now more designers and government personnel have realized that the concept of sustainable development should be integrated when building blocks, such as providing a good pedestrian environment to support the realization of SDGs and improvement of citizens' health. It is important to note that the construction of blocks is expensive and difficult to change. While sustainable optimization and renewal of completed projects are necessary and effective, if strategies can be introduced in the design phase before construction, better results can be achieved with less cost. Therefore, the accurate pre-assessment of block performance is of great significance. The pre-assessment of walkability is multi-dimensional, which requires multi-disciplinary approaches. In recent years, many studies have attempted to establish the relationship between the characteristics and walkability of each block, such as morphology (Elzeni et al. 2022), population (Mathew et al. 2019), economic status (Conderino et al. 2021), and microclimate (Boumaraf and Amireche 2022). The study methods range from the qualitative method such as auditing and questionnaire (Lee et al. 2020) to the quantitative methods such as space syntax (Koohsari et al. 2016b), geographic information system (Leslie et al. 2007) and

[1] While some areas may have limited transportation options due to socioeconomic and infrastructural factors, requiring people to walk, this is not the main focus of this paper. Instead, this paper focuses on how to encourage sustainable and healthy mobility in highly developed cities.

Fig. 29.1 Network visualization map showing close connection between walkability and health



agent-based model (López Baeza et al. 2021). The pre-assessment of the walkability of blocks now is more comprehensive and accurate.

This paper provides a comprehensive review of the literature on assessing walkability, discusses a series of evaluation methods for neighborhood walkability (space syntax, geographic information system, agent-based modeling), and compares their advantages and disadvantages from the perspective of analysis factors, analysis methods, analysis population, and analysis scope. Finally, we conclude that ABM is a better method to assess walkability while it has a great impact on improving built environment for health.

29.1.2 Search Method

Studies reviewed in this paper were identified by searching the Web of Science, a platform providing access to multiple databases and being able to select studies by the advanced query. This search is articulated in two parts. Firstly, all the published studies assessing walkability are retrieved, and the main methods of assessment are summarized based on those studies. Secondly, a separate search was conducted for each approach, and a set of studies are reviewed to evaluate the advantages and disadvantages of these approaches.

The query TS = ((“walkab*”) AND (“assess*” OR “evaluat*” OR “measur*”)) was used in the first stage, giving 2477 results from all databases, of which the earliest one was published in 1996. From these, we removed studies that were secondary literature (reviews, guidelines, and protocols), patent, and written in languages other than English. Titles and abstracts resulting from this selection were screened to identify research assessing walkability and its factors, and others were excluded. For example, most studies investigating the relationship between walkability and obesity were not reviewed as the effects of walkability are not the subject of this paper. Each of the remaining 538 potentially eligible abstracts underwent a secondary review as well as selection to confirm that the articles met our inclusion criteria of (1) using at least one research method other than a questionnaire or in situ survey and (2) concentrating on assessing walkability other than the influence of walkability. Ultimately, 65 of the 538 articles were selected for a thorough review.

In the second stage, based on the main research methods summarized in the first stage (space syntax, GIS, simulation, described in detail below), a specific literature search was performed for each method, with the search formulas TS = ((“walkab*”) AND (“space syntax”)), TS = ((“walkab*”) AND (“GIS” OR “geographic information system”)), TS = ((“walkab*”) AND (“Simulation”)). Searching results were compared with the formal 65 papers, and those missed in the first stage were added. Finally, 22, 19, and 11 studies were selected to be full-text reviewed through a selection to omit similar studies.

29.2 Advantages of ABM Over SS and GIS in Assessing Walkability

29.2.1 Advantage on Measuring Subjective Factors

Different or the same criteria are used to evaluate walkability through different methods, but the number and category of criteria are highly restricted by the method.

Space syntax has only two measures to objectively analyze space, which are integration and choice. These measures are derived from the theory that proposed by Hiller in the 1980s (Hillier and Hanson 1989), considering all the human activities that take place are influenced by the relationships between that space and the network of spaces to which it is connected. While some relationships between integration, choice, and walkability have been found (Hajrasouliha and Yin 2015; Koohsari et al. 2016a, b), the analysis results using space syntax without considering other factors are less stable. A study in Tokyo, Japan (Capitanio 2019), pointed out that the actual frequency of pedestrians does not match the degree of integration of space syntax. The study found that pedestrians prefer the more attractive route, even if the route is longer. Since space syntax has become an established and stable theory, there is little possibility to break new ground and add new measures to it, which greatly limits its accuracy for assessing walkability.

Using a geographic information system as a tool provides the capability of evaluating most of the objective factors, including land use, density, population, block size, and so on. GIS was first proposed by the Canadian government in 1966 to conduct land inventory projects and map the location of natural resources in each state (Maliene et al. 2011). It can project a variety of different data onto geographic models through georeferencing. With the development of technology, GIS has developed from 2 to 3D, and information such as the height of buildings, facade openings, and materials can be integrated into GIS through 3D architectural models (Yin 2017). However, it still faces difficulty in assessing the impact of perceptual qualities and other subjective factors, which are proved to be influential in studies examining their relationship through questionnaires(Ewing et al. 2006; Pikora et al. 2006).

The agent-based model (ABM), a technique trying to simulate the real world, shows its potential to handle it. As its name suggests, it is a method based on taking a subject/individual with a set of characteristics or attributes as a simulation object, namely an agent. Each agent is an autonomous decision-making entity that can make various choices based on its attributes and established rules (Wilensky and Rand 2015). With proper translation from factors to attributes and rules, it could be able to simulate people’s decisions on travel mode and route choice in different situations and built environment, which is the core of assessing walkability. The first studies that utilize ABM for evaluating walkability chose the interaction among neighbors as one of the factors influencing the travel mode decision. And the results show a greater accuracy that ABM could achieve, compared with GIS and other methods authors used before (Yin 2013).

Subsequently, several studies have examined the effects of climate and street thermal comfort on pedestrian travel decisions using ABM, and the findings provide strong and innovative evidence that uncomfortable street microclimates and rainy or hot urban climates all reduce regional walkability (Reinhart et al. 2013; Jia and Wang 2021). In addition to the above-mentioned effects of weather and interpersonal interaction, activity content and needs (Yang et al. 2021) and spatial perception (Silvennoinen et al. 2022) can also be incorporated into the influencing factors of walkability analysis using ABM.

29.2.2 Advantage of Calculating All Factors as an Integration

There are three methods used to analyze the outcome of factors and the relationship of walkability, which can be named independent analysis, computational analysis, and integrative analysis according to their analysis process.

Independent analysis is common in the field of space syntax and GIS (Azmi and Ahmad 2015) with few factors. It does have advantages in terms of ease of use and analysis of a single factor on walkability. Take using space syntax as an example, the software would provide independent results of integration and choice directly, without any additional operations, and researchers could use them to evaluate the walkability of the study area (Ali et al. 2018) or compare with the actual pedestrian flow to support future assessments (Koohsari et al. 2016b). However, its disadvantages are obvious and decisive. Walkability is the nature of a complex system, and attempts to assess the effect of a single indicator on it through simple isolation are hard to succeed.

Another common method for analyzing in GIS is computational analysis; however, this method is always being criticized for being too diverse and lacking standard processes. The computational analysis itself can be divided into two categories, one is weighted addition (Leslie et al. 2007; Al Shammas and Escobar 2019) and another is constructing new equations (Telega et al. 2021), both of them require a strong knowledge of mathematics and statistics, and there are scarce researchers, designers, and policymakers who possess this ability. Besides, no consensus has been reached on the weight setting or the appropriate formula. Some studies consider (Leslie et al. 2007; Hansen et al. 2009) each influencing factor equally, and after scoring each factor (e.g., density, land use diversity, connectivity, aesthetics), the scores are directly added up, and the total score is used to evaluate the walkability of this one area. Other studies have assigned different weights to similar factors based on previous studies or field research, etc. For example, for density, Al Shammas and Escobar (2019) set a weight of 0.19, yet Tsiompras and Photis (2017) set a weight of 0.13. This difference in weighting inevitably leads to differences in the final calculated walkability and makes it difficult to compare walkability across cities.

ABM can integrate some of the built environment factors, such as diversity and density, together into one simulation model, and then can simulate pedestrian flow by assigning different degrees of attractiveness to each location. For example, a study for Hamburg, Germany (López Baeza et al. 2021), constructed a real-world neighborhood scenario in GAMA (an ABM platform) and gave agents schedules to different places and derived correlation of diversity, density, path duration, path distance, and pedestrian density based on the simulation results. Moreover, some software provides a user-friendly interface and the ability to create wall elements as obstacles that further simplify this process (Fig. 29.2). This integration provides a common solution for walkability assessment, and while there are currently fewer factors that can be integrated, ABM is continuously evolving in its ability to integrate a wider variety of factors, as supported by a variety of technologies and research.

29.2.3 ABM Can Classify the Population Based on Their Characteristic

It should be highlighted that only the agent-based model makes it possible to evaluate walkability concerning special populations, such as the elderly, young children, and people with disabilities. Most of the studies consider the urban

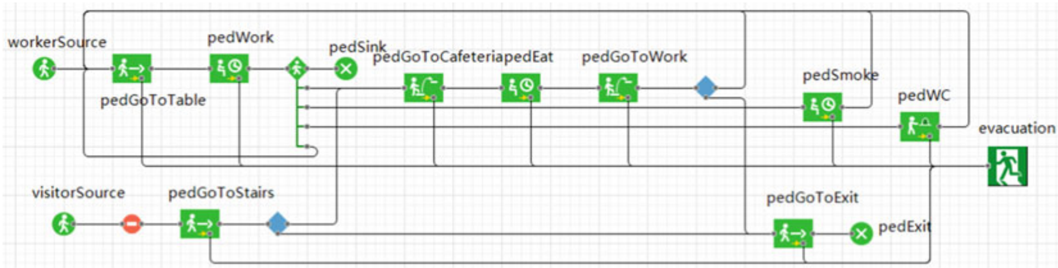


Fig. 29.2 Screenshot of AnyLogic showing a user-friendly interface

population as a whole and then analyze and evaluate walkability. However, the fact is that walkability should be evaluated quite differently for different populations. For example, people of different ages walk at different speeds, which can lead to variations in walking times. What is acceptable connectivity for younger people may be unacceptable for older people. However, these differences have been ignored in most studies, possibly due to technical limitations.

Taking the results of Zhu et al. as an example, they collected ten participants (mean age 68, SD = 8), compared their walking behavior in different environments and found that the elderly are less affected by the environment but more determined by their preferences and walking habits. Zhu pointed out that bringing these features into ABM would lead to a better understanding of occupants' behavior within the built environment.

Although some studies using GIS or space syntax have also done analyses for selected populations, the difference is that, except ABM, none of the current research methods can simulate and assess walkability in different populations at the same time, but only analyze them separately, which is not in line with reality.

29.3 Limitations of ABM and Its Potential Solution

Some studies and their results reveal the shortcomings of ABM when applied to walkability assessment, such as time consuming, difficult to build a model, and small analyzable scale.

Undoubtedly, ABM has been plagued by excessive computing time from the beginning of its invention. Although the computational power has improved with the development of technology, there has been an explosion in the attributes involved in the computation, as well as in the complexity of the computation, leading to a little reduction in the time required. In an agent-based modeling study of walkability in the Buffalo area, Li (Yin 2013) pointed out that the time required to analyze a residential lot is about 1 min.

This deficiency also causes a smaller analyzable scale. The median study area of 11 reviewed studies is 319,869 m^2. Although two studies have addressed large-scale study areas larger than 50 km^2, most studies remain their study area at the neighborhood-level scale.

Yet this dilemma has some potential solutions. Combining with machine learning, Zhang et al. developed an urban decision support system to achieve real-time prediction of an agent-based model of city traffic. The result shows a great improvement in computational speed, while the accuracy of the predictions is sufficient for decision-making. The big data method is another solution. Two conceptual studies combine big data and agent-based models to analyze multi-level pedestrian areas. Considering the large amount of data that agent-based modeling simulations can generate, big data-related techniques can be effective in improving the efficiency of obtaining useful results from the data, which leads to an increase in the scope of the analysis area.

29.4 Conclusion

The ultimate goal of walkability is to attract and support more people to choose walking as their mode of travel. In the past, limited by computational power and comprehensive cognition, walking likelihood was generally disaggregated into multiple factors as described above and analyzed individually or in combination. With the continuous development of agent-based modeling simulation and the progress of the discipline of complex systems, it is possible to simulate the travel choices, crowd density, etc., of complex urban systems. Therefore, the walkability of streets, regions, and even cities can be simulated and directly evaluated by simulating the proportion of pedestrians among residents. The advantage of agent-based model simulations is that they are more direct and comprehensive, allowing the environment to be assessed under the influence of multiple factors at once, while also incorporating findings from the public health discipline to assess the walkability of urban environments and the health enhancements they bring. Although there are still certain limitations in computational power, combining technologies in the direction of big data and artificial intelligence can effectively improve this shortcoming. In contrast, ABM has greater potential to accurately model the real world and assess walkability and its impacts on health.

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Changing Health Needs: Victoria Nurses' Home, 1927–1933

30

Di Lu

Abstract

The reconstruction of the Victoria Nurses' Home (1927–1933) was to perpetuate the glory of Queen Victoria and provide more accommodation for nurses in Shanghai's international settlement. Designed by German architect Rudolf Hamburger, this building is located in Shanghai's western district, which was considered a country with fresh air and light to overcome health problems caused by the urbanization of Shanghai. For functional reasons, it exhibits a modern style that differs from the surrounding hospitals. The architect created a healthy environment by regulating the body's relationship to Shanghai's semi-tropical climate through the organization of nurses' units, windows, terraces, and a verandah. The building's design process reflects how different people's ideas about health, from hospitals' supervisors, nurses, and health officials, are influenced by existing technologies, the local climate, body experiences, and popular fashions.

Keywords

Health · Medical architecture · Modern architectural history · History of ideas · History of Shanghai

30.1 Introduction

The Victoria Nurses' Home (VNH), primitively planned in 1927, started construction in 1930, and officially opened in 1933, was one of the earliest modern architecture in Shanghai. Its architect, Rudolf Hamburger, studied at the Technical University of Berlin in 1925 and was strongly influenced by Hans Poelzig. He came to Shanghai in 1929[1] as an architect for the Shanghai Municipal Council[2] (SMC), bringing the idea of modern architecture from Germany to Shanghai. In a booklet published around the 1940s, when introducing Shanghai to international audiences,

[1] In Eduard Kögel (2007) Zwei Poelzigschüler in der Emigration: Rudolf Hamburger und Richard Paulick zwischen Shanghai und Ost-Berlin (1930–1955), Hamburger came to Shanghai in 1930, while many archives about the design of Victoria Nurses' Home in SMA started in 1929, such as U1-14-2098. This contradiction still waits to explain.

[2] The Shanghai Municipal Council (SMC) was founded on 11 July 1854 by a group of Western businessmen to govern the daily operation and infrastructure of the Shanghai International Settlement. By the mid-1880s, the Council had become a practical monopoly over the city's businesses.

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a perspective of VNH was placed in the "Public Health" section (Fig. 30.1). The text put left to the image claimed that French and international authorities brought hygiene and cleanliness to colonial natives (Ellen Thorbecke, n.d.). This building's simple and impactful image makes it a symbol of how colonists protected natives from epidemic and endemic diseases.

In VNH's design process, the technological needs of medical institutions were not so complicated that spatial organization and the healing effects from some architectural elements were still highly valued.[3] Studies have shown that some of the features of modern architecture, such as terraces, balconies, and flat roofs, were linked to medical therapies in the 1920s and 1930s, such as light, air, or sun (Campbell 2005). Beatriz Colomina analyzed modern architecture through image analysis, showing the new internal–external vision relationships achieved through new materials, just like X-ray brings about (Colomina 2019). Paul Overy discussed modern architects' concerns with fresh air, sunlight, health, sanitation, water, cleanliness, and whiteness in the 1920s and 1930s from the perspective of power, race, and colonization (Overy 2008). Research around Vita-glass revealed the connection between new glass technologies and the obsession with the health benefits of ultraviolet light at that time (Sadar 2016; Espahangizi 2017).

However, since these modern ideas' transformation is a dynamic process in Shanghai, how did the architects integrate the varying ideas about health, all with the hope of finding fresh air and light, into this building's design? Also, what adaptations were made to create a healthy environment in Shanghai?

[3] According to Murphy et al. (2021), the "Block hospital" that occurred in the 1950s is a closed and mechanical system that emphasizes on the arrangement of different departments and equipment, rather than relying on natural air to create an open environment for users. Theodore (2016) uses the term "healing machine" to describe the design of the hospital in the second half of the twentieth century.

30.2 Materials and Method

30.2.1 Materials

This research's materials are primarily based on archives in the Shanghai Municipal Archives (SMA). It collects the communication documents between different departments of SMC and the hospital's authorities during the construction of the VNH, so we can access the whole design process.

Another research source is the public media, such as letters, popular magazines, and newspapers. Since this building was deeply involved in residents' daily life in the international settlement, foreigners living in this community would write to newspapers with their suggestions and opinions. These descriptions can help us access the body's experience and feelings about the daily use of this institution. In addition, since this building is a memorial to Queen Victoria and had huge public significance, there was a great deal of discussion in public when the Economy Committee decided to close the Old Victoria Nursing Home. These reports in newspapers contained a lot of information about architecture.

30.2.2 Methods

By looking at the whole process of the reconstruction of VNH and analyzing varying ideas from archives and texts, we can take a close reading of the architectural drawings and figure out how the design interacts with different opinions (Fig. 30.2). The approaches are as follows:

1. Analyzing the context behind the historical text in the state of knowledge of medicine, science, and technology of the time.
2. Collect relevant historical materials
   (a) Sort out the timeline of events and restore the whole process of VNH's construction by collecting the official information in the SMC annual report and announcements in newspapers.

PUBLIC HEALTH

Shanghai's geographical situation is semi-tropical and on the sea level; its population has grown tremendously during the short century that saw the town rising from a small coastal place to one of the biggest ports of the world. This, and the fact that the poorer class of natives are traditionally opposed to hygiene and cleanliness, should make Shanghai a breeding place for all kinds of diseases. Yet there is relatively not much difference between public health in Shanghai and in other giant cities. Thanks to the efforts of the French and International authorities, much has been achieved, though much more is to be done before conditions among the Chinese will equal western conceptions of health preservation.

Cholera and typhoid fever are endemic, though figures are considerably low, and all the dreaded diseases of the middle ages, such as leprosy and elephantiasis still exist among the masses of the poor. The foreigners know how to protect themselves and few are their casualties from epidemic and endemic diseases. For the Chinese, general enlightenment, free vaccination and medical care in many hospitals and polyclinics are provided by the authorities; survey of labour conditions, children's work and other social problems is exercised by the Council. Step by step, western science is penetrating into the wilderness of Chinese superstition, quackery, ignorance and dirt. The progress is slow but every victim snatched away from destruction and death by systematic medical treatment is a victory and gives hope to the brave pioneers to fight on till disease and suffering decline, and with the greatest possible safety for the population, a physical and mental regeneration of China's children will once more bring them back to the level of her glorious civilization which their ancestors began achieving with their healthy brains and strong bodies, five thousand years ago.

Fig. 30.1 Victoria Nurses' Home is a symbol of Shanghai's public health, from Ellen Thorbecke (n.d.) Shanghai Photographed and Depicted. North-China Daily News & Herald Ltd., Shanghai

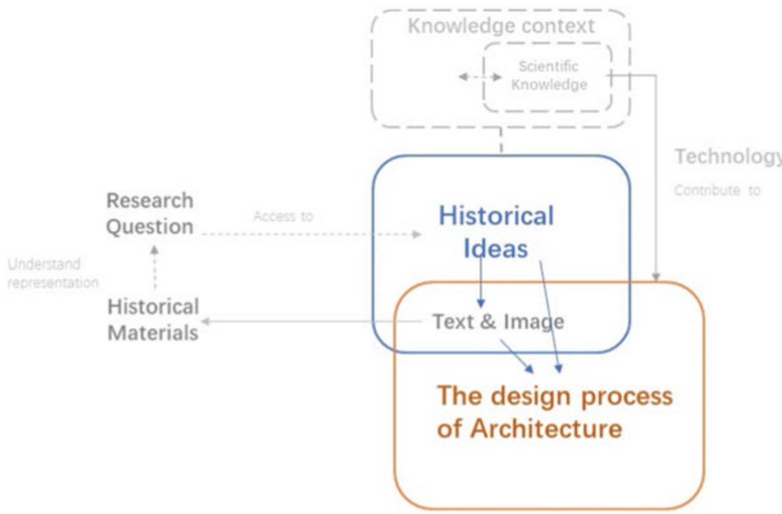

Fig. 30.2 Diagram of methodology, self-drawn by the author

(b) By collecting some letters from the SMA, Shanghai Library, and Bibliotheca Zi-Ka-Wei, we can approach the decision-making process regards to space, materials, and technology among different departments and persons with different statuses.

(c) Observing the spatial information contained in historical materials and attempting to access the thoughts and feelings about space at the time, along with the representation in text and image in historical materials.

3. After understanding the whole process of events and the different ideas from different actors, we can make a closer reading of the architectural drawings of VNH. Then making an archeological analysis and establishing the connection between space and social context, analyzing how space interacts with different ideas.

30.3 The Design Process of the Victoria Nurses' Home

30.3.1 The Close of the Old Victoria Nursing Home

The Opium War (1839–42), as a civilizing mission devoted to China's modernization, resulting in the opening of the Qing Empire's most commercially active coastal cities, including Shanghai. Shanghai's urban composition was significantly altered by the construction of a British settlement beginning in November 1843 (Roskam 2019). After that, the French, Americans, and British all established independent settlements in this area and continued to expand, making the area of the Shanghai Settlement greatly exceed the area where the Chinese lived. In 1862, the American and British settlements in Shanghai were merged and renamed the "International settlement of Shanghai" in 1899 (Fig. 30.3).

The Old Victoria Nursing Home was a gift donated by British residents living in Shanghai's international settlement in memory of Queen Victoria's Diamond Jubilee in 1899. It was originally built to provide skilled nursing for the foreign community living here and also to offer some wellness services in the institution. In (The North-China Daily News 1901), this building was completed and handed over to SMC to manage (Fig. 30.4). But this institution was later expanded beyond imagination and gradually became a general hospital, hence also having a name "Victoria Sanatorium" (Fig. 30.5).

The Old Victoria Nursing Home was located near the northern border of the international settlement, close to the Range Road, and was approached by the Hannen Road (The North-China Daily News 1901), considered one of the quietest parts of Shanghai (The North-China Herald and Supreme Court & Consular Gazette 1919). The lavatories and bathrooms are situated at the rear of each ward, separated by corridors (Fig. 30.6), and fitted with the most "modern" conveniences. The Old Home added a new wing and made some alterations to meet the patients' needs for comfort in 1913 (The North-China Herald and Supreme Court & Consular Gazette 1913a; The North-China Daily News 1913b).

The new wing was devised with a special form of ventilation. According to a sketch in SMA (Shanghai Municipal Archive 1913), the rooms for sanitary equipment were separated from the main building by a ventilating corridor, a short passage having windows on each side, preventing smell from reaching the patients' rooms (Fig. 30.7). Close to the new wing was a semi-outdoor verandah, which seemed be design as a diluted area for bad smells.

But what could not be stopped was that patients began to complain about the unclean air, unsanitary environment, and urban noise during the urbanization of Shanghai (Fig. 30.8). The traffic on Range Road was increasing daily, the clatter of passing tramed with their bells, the fire station built next to it. The increasing Chinese population also posed a problem. Some patients complained that the open space next to the Old Home is occupied by Chinese huts, making the surrounding environment unsanitary (S. M. C. 1922). A patient proposed that the hospital should move further to Shanghai's western district, since fresh country air, pretty surroundings, and a quiet atmosphere here are great factors in restoration to health (N. R. B. 1919).

Interestingly, many new hospitals in the 1920s and 1930s were planned in Shanghai's western district (Fig. 30.9). Just as the patient said above, this area, located outside the French and international settlements, still preserved lots of farmlands and water systems that had not been modernized. In 1922, the international settlement authorities planned to move the Old Victoria

Fig. 30.3 Shanghai's international settlement after 1899 (yellow area). Self-drawn by the author, referring to the Website https://www.virtualshanghai.net/Maps/Collection

Fig. 30.4 Primary site plan of the old Victoria Nursing Home. Self-drawn by the author, referring to SMA UI-14-2146

Nursing Home to the Western District and establish a new general hospital. They chose a site on Great Western Road because it was close to a residential area and didn't have a factory nearby (Shanghai Municipal Archive 1898). However, midway through the plan, Charles Ernest Rayner, a wealthy American businessman, donated "Country Hospital" to the SMC for the benefit of the foreign community of Shanghai, making the relocation of the Old Victoria Nursing Home suspended. The Country Hospital was also planned near the Great Western Road, designed by Shanghai's renowned architect Laszlo Hudec. This hospital's early Italian Renaissance style was chosen to meet the donor's preferences and to be a neutral form universally recognized by the international community (Xiahong 2012).

In 1922, the Economy Committee of SMC decided to close the Old Victoria Nursing Home considering that the deficits paid by the Council far exceeded the original gift. This decision caused huge controversy, with many people writing letters in newspapers against it

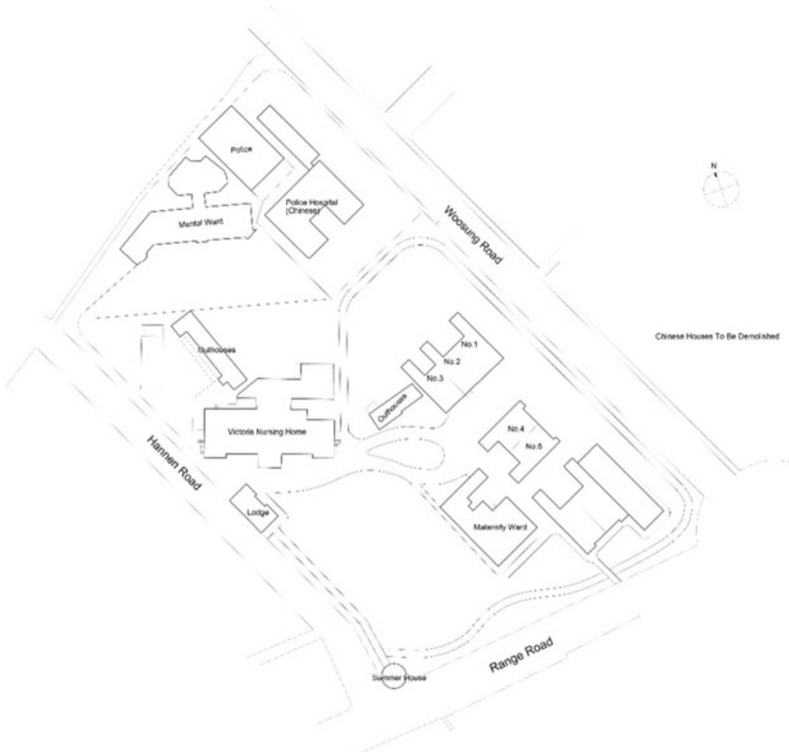

Fig. 30.5 Victoria Nursing Home Block plan in Shi Bao (1915). Self-drawn by the author, referring to SMA U1-14-2146

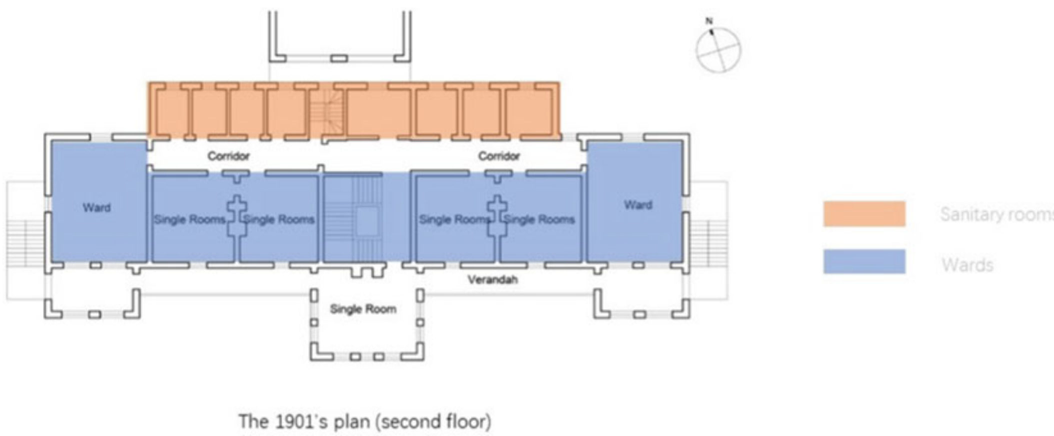

Fig. 30.6 Relationship between wards and bathrooms in The North-China Daily News (1901). Self-drawn by the author, referring to SMA UI-14-2146

(Macgillivray 1928), including the commissioner from the Health Department of SMC (Noel Davis 1928). In the same year, as the Country Hospital developed, its rooms were not sufficient for patients as well as staff (Shanghai Municipal Archive 1927a). They started changing the

Fig. 30.7 Sketch of renovations in 1913, from the commissioner of the health department Dr. Arthur Stanley (left) and the revised plan (right). Self-drawn by the author, referring to SMA U1-14-2146 and U1-14-2080

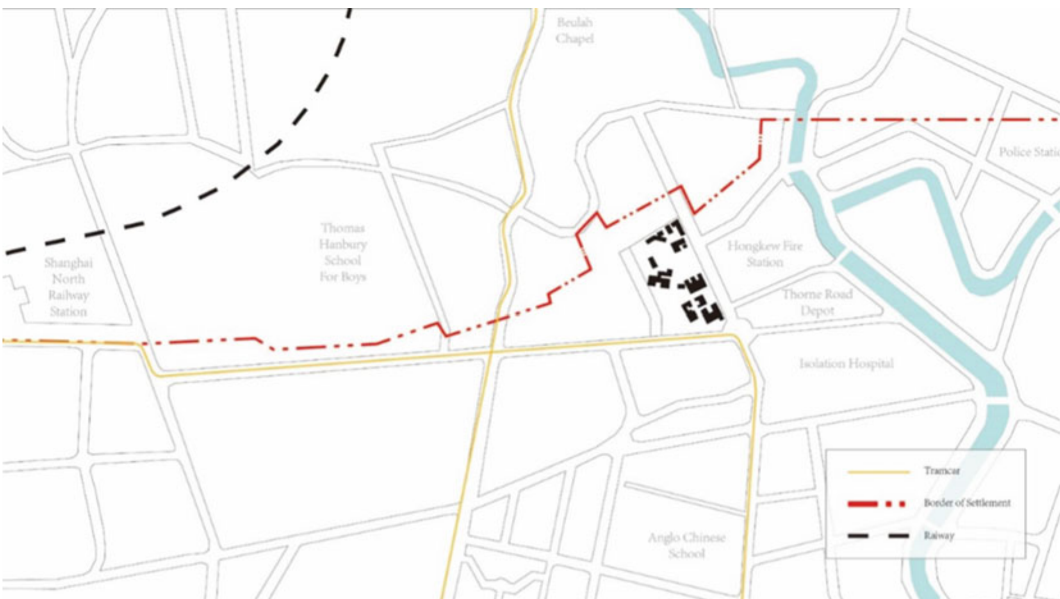

Fig. 30.8 Surroundings of the Old Victoria Nursing Home in 1928. Self-drawn by the author, referring to https://digitalcollections.library.harvard.edu/catalog/990152085090203941

rooms originally provided for nurses into patients' rooms (Shanghai Municipal Archive 1927b). In 1928, after discussions among different departments, SMC decided to build the "Victoria Nurses' Home" near Country Hospital (Fig. 30.10). This name kept the memorable meaning of "Victoria" and would give nurses from the Old Victoria Nursing Home, the Country Hospital, and other hospitals in the area a place to reside.

30.3.2 The Design Process of the Victoria Nurses' Home

Timeline of the design process. See Table 30.1.

Simple Lines

Why did such a modern style suddenly appear in Shanghai (Fig. 30.11)? In 1927, when the Country Hospital asked donor, Charles Ernest

Fig. 30.9 Western District in Shanghai is considered to be a country with fresh air. Self-drawn by the author, referring to https://digitalcollections.library.harvard.edu/catalog/990152085090203941

Rayner, whether he could help with the acquisition of land to build a new Nurses' Home, they promised the nurses' home would be built on very simple lines and the architecture would not be an "eyesore" to the occupants of the Country Hospital (Shanghai Municipal Archive 1927c). From the word "eyesore", it's hard to deduce whether this straight line style was accepted or not at that time. The archives in the SMA only tell us that the elevation was deemed unsuitable when reviewed in December 1929 (Shanghai Municipal Archive 1927d) and should conform with the elevation of the Country Hospital; however, no drastic changes were finally made.

The simple lines mainly have functional intentions as mentioned in the program statement submitted by architects to the acting commissioner of public works: "This building would be designed on broad and simple lines suitable to the functions of the various parts of the buildings" (Shanghai Municipal Archive 1928a). Standardized room units would also be

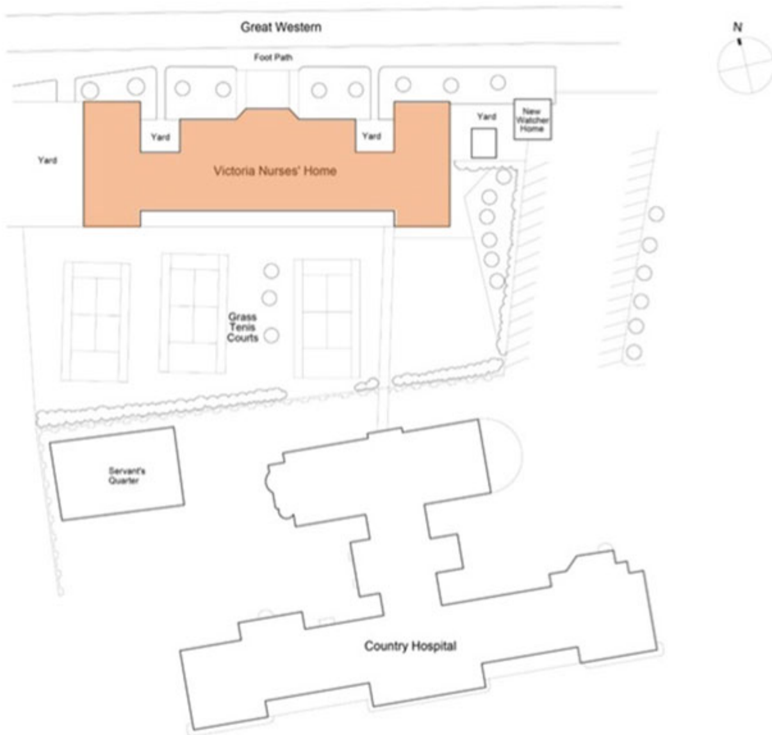

Fig. 30.10 Country Hospital and the Victoria Nurses' Home, 1933's site plan. Self-drawn by the author, referring to U1-14-2098 00235

Table 30.1 Timeline of the design process of VNH

Time	Events
1927	The economy committee of SMC contributed to closing the old Victoria Nursing Home, which caused great controversy, and the Country hospital started to prepare a new nurses' home
1928	SMC decided to build the Victoria Nurses' Home next to the Country Hospital. The architects were commissioned and started asking hospital's requirements
April 1929	The Victoria Nurses' Home Committee established
August–September 1929	Architectural drawings submitted for review
December 1929	The Victoria Nurses' Home Committee gave its opinion
August 1930	Architects proposed two revised plans A and B
September 1930	Plan B was chosen
December 1930	Design was finalized
1931	Construction began and equipment was installed
October 1933	Construction was completed, an opening ceremony was held

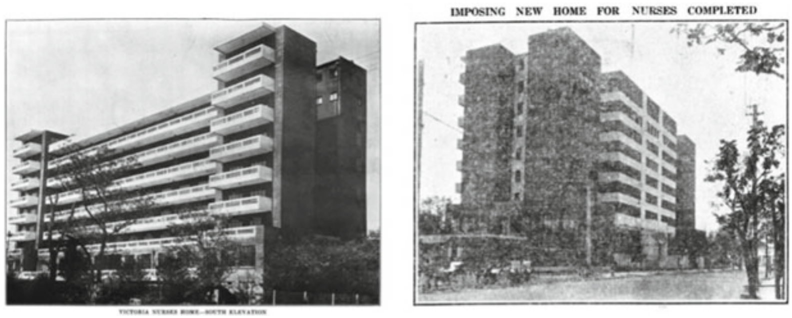

Fig. 30.11 South-east view (Left) and north-west view (Right) of this building, form the SMC report in 1933, and *The Shanghai Times* on 6 October 1933

convenient for the management, as disputes over room selection would be reduced (Shanghai Municipal Archive 1930a).

The Arrangement of the Nurses' Rooms

The building's second, third, fourth, fifth, and sixth floors are identical and provide accommodation for the nursing staff in individual bedrooms with a common verandah overlooking the gardens and facing south. The east end of each floor is occupied by a small flat for the matrons and home nurses. Each flat consists of a living room, bedroom, bathroom box room, and private verandah. The west end of each floor has a two-roomed apartment for senior nurses. All bedrooms are equipped with built-in wardrobes. At both ends of each floor on the north side are provided common tiled bathrooms.

The nurse's suggestions had a strong connection with the final rooms' organization. Before this program officially started, the Country Hospital's matron suggested to the superintendent that young matrons' rooms should be two-bed cubicles with bedroom-sized and that each cubicle should be opposite to a window, properly visited by the sun and air, and should not be opposite to each other (Shanghai Municipal Archive 1927e). The final plan shows that a single corridor connects the nurses' rooms and all the rooms face south. Five other functional blocks surround the nurses' rooms unit. The other rooms surrounding the nurses' unit form a prominent block, with some rooms facing the direction of the verandah with double-sided openings, allowing more light into the rooms as well (Fig. 30.12).

The Verandah's Climate Adaptation

A verandah that runs parallel to the corridor would be considered a valuable feature of VNH. Verandah, an open-air gallery attached to the outside of a building, was once considered a necessary architectural element for colonists to accommodate Shanghai's climate.

The prevailing hypothesis is that the "veranda style" was invented by colonists during the global expansion of Europe beginning in the seventeenth century in order to adapt to the tropical's climate. The early colonists misunderstood Shanghai as a tropical environment because of Shanghai's hot and humid summer. As the photos of SMC's Victoria Nursing Home (1901) and Municipal Hospital (1904) show, the verandah can protect rooms from intense light through shading (Fig. 30.13).

But "verandah" was less adopted in architecture after the end of the nineteenth century. Just like Laszlo Hudec wrote about Country Hospital (1926), foreigners living in Shanghai gradually discovered that the physical experience of the verandah was not suitable for Shanghai's semi-tropical climate. Country Hospital's strategy is that only a portion of the wards has a verandah:

> The question of verandahs, which are an absolute necessity in Summer, but a draw-back in Winter as they cut out part of the sunlight, has been solved by providing verandahs only for a part of the rooms in proportion with the number of cases, as statistics show that only about 60% of the rooms are occupied in Summer.[4]

[4] "Design notes about Country Hospital", Laszlo Hudec Fonds from University of Victoria Libraries Special Collections.

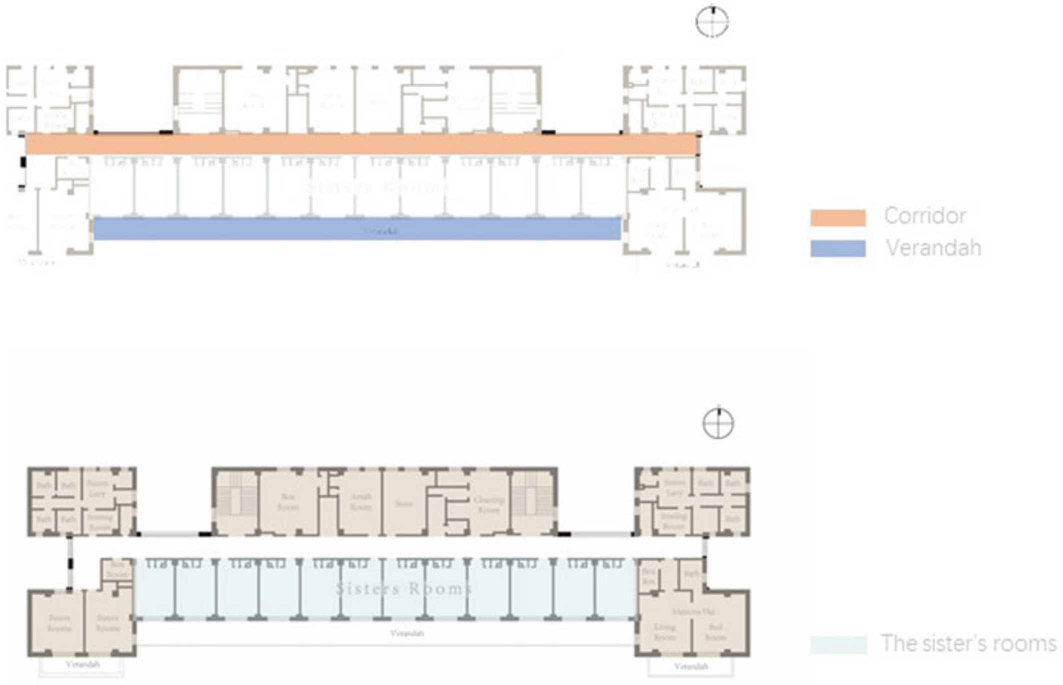

Fig. 30.12 Five blocks around the nurses' rooms unit. Self-drawn by the author, referring to Eduard Kögel (2007) Zwei Poelzigschüler in der Emigration: Rudolf Hamburger und Richard Paulick zwischen Shanghai und Ost-Berlin (1930–1955)

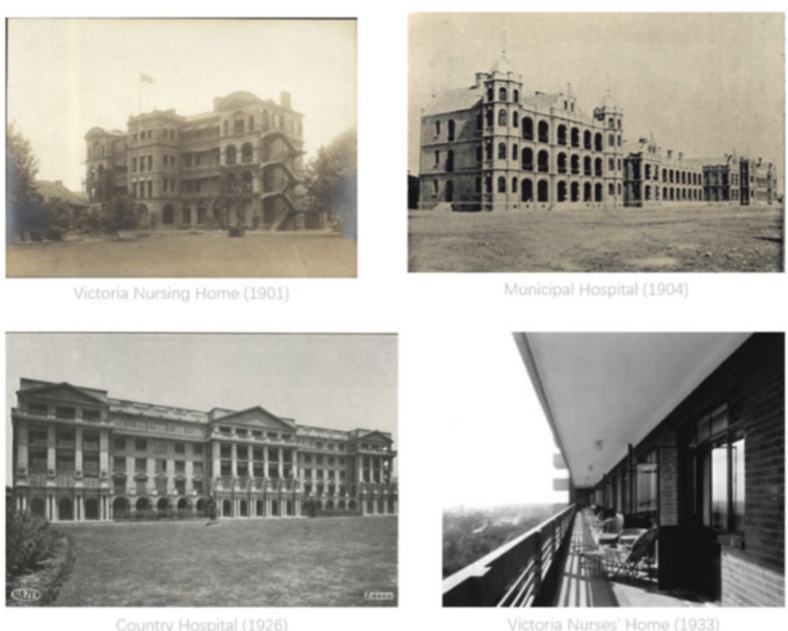

Fig. 30.13 Verandah of the Victoria Nursing Home (1901), Municipal Hospital (1904), Country Hospital (1926), and Victoria Nurses' Home (1933). From SMA U1-16-572, the SMC Report 1904, Sulzer technical review, no. 01 (1927), and Eduard Kögel (2007) Zwei Poelzigschüler in der Emigration: Rudolf Hamburger und Richard Paulick zwischen Shanghai und Ost-Berlin (1930–1955)

The VNH Committee was aware of the verandah's problems, both climatic and economic, so a plan with no verandah was also envisioned (Shanghai Municipal Archive 1928b). After the acting commissioner of public works recommended that the expense was justified in view of the great comfort of a verandah in summer (Shanghai Municipal Archive 1930b), it was decided by the VNH committee that a verandah was essential. The width and length of verandah were considered precisely. The final result is a verandah blocks the sun and gives the building a horizontal straight-lined look.

Health Anxiety About Bathrooms Location

There was a controversy about the location of the bathrooms in the rooms. In 1928, the hospital authorities required that nurses should have one bathroom attached to two or three nurses' rooms (Shanghai Municipal Archive 1927f). The architects took the advice, arranged two nurses' rooms equipped with a bathroom, and placed the toilet in the nurses' rooms for entry. But when the sketches were sent to the VNH Committee for review in 1929, they found it unsatisfactory that the only way to get to the bathrooms was through the bedroom:

> bathroom placed in front of the rooms butting on verandah, thereby spoiling both the rooms and the verandah…the W.C'S to be grouped in an adjoining room as in modern practice in buildings of this type. (Shanghai Municipal Archive 1927d)

The architect had to remind them that modern sanitation has replaced dry commodes, and changing the location to make people enter bathrooms independently from the corridor is unnecessary since bathrooms in bedrooms had been seen in many places, as in the Country Hospital and in many other semi-public and private buildings (Shanghai Municipal Archive 1928c). The entrance to the bathroom remains unchanged, but only a modern washbasin is retained.

The Refuse to Sub-ground Floor and the Obsession with Roof Garden

Some of VNH's photographs depict the entrance's unique spatial relationship. The north entrance leads into the vestibule, up the stairs to the second floor, and down the stairs to the ground floor (Fig. 30.14). The ground floor is reserved for a kitchen, while the dining rooms and lounges, writing room, and library are all on the first floor.

However, the original building plan had a sub-ground floor and placed most of the service functions on the sub-ground floor and first floor. When the NVH committee reviewed the design drawings in 1929, one of the main complaints was that a sub-ground floor several feet below ground level was not good because it did not get enough light or air. Their opinion is like that:

> all the common sitting rooms, dinning-rooms, writing-rooms, together with the kitchens and pantries would be better placed at the top of the building in accordance with modern practice in new types of buildings in shanghai and elsewhere. (Shanghai Municipal Archive 1927g)

The VNH Committee also objected to the terraces all around the building and claimed that these could be eliminated if the living rooms were placed at the top of the building with a roof garden (Shanghai Municipal Archive 1927h). In the architect's reply, the sub-ground floor was to keep the height of the building within a reasonable limit within the settlement (Shanghai Municipal Archive 1928d), and the common rooms and dining rooms were planned for the convenience of the staff and visitors, to avoid unnecessary traffic that could bother the private portion (Shanghai Municipal Archive 1928e).

Finally, the sub-ground was removed, and the building was overall lifted. The architect reduced one-story height by adding two rooms in each story (Shanghai Municipal Archive 1928f), preventing it from overshadowing the Country Hospital. The nurses' rooms stand on a two-story high plinth composed of service functions. The top floor has an additional roof terrace, facing north, where people can enjoy the sun (Fig. 30.15).

Disappearing Swimming Pool

The swimming pool was canceled because of Shanghai's climate and technological costs. In September 1929, when the superintendent of

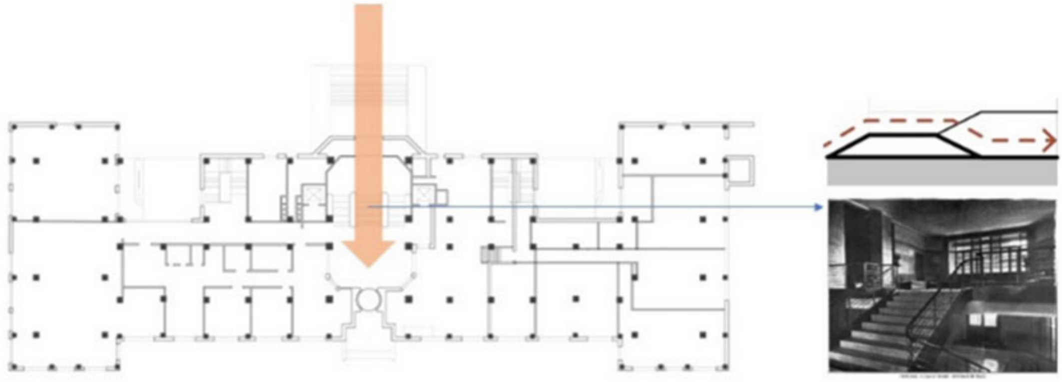

Fig. 30.14 Entrance of the VNH. Self-drawn by the author, referring to SMC report in 1933, photo from SMA UI-14-2089

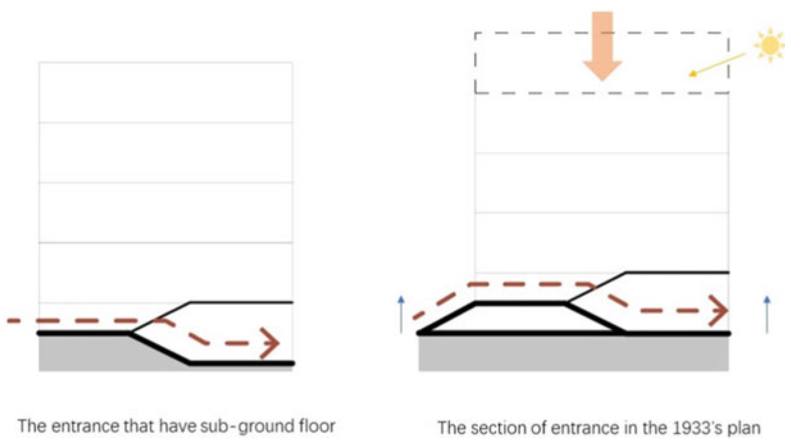

Fig. 30.15 Comparison of the entrance. Self-drawn by the author

Country Hospital submitted a program to the commissioner of public health (Shanghai Municipal Archive 1927i), with the advice of the assistant matron, they hoped to have a swimming pool and a gymnasium. From the architect's letter, we can deduce that the pool was placed centrally on the sub-ground floor, (Shanghai Municipal Archive 1928e) where people could take downstairs from the north entrance to the pool. Later, based on Shanghai's climate, the VNH Committee considered the inclusion of a swimming pool in the sub-ground floor undesirable, unless a mechanical system of ventilation is provided, it is likely to be extremely hot and uncomfortable during the summer months when it is mostly used (Shanghai Municipal Archive 1927g). Although the architect explained that most of the nurses cannot afford the membership of a swimming club to show necessity (Shanghai Municipal Archive 1928e), this function disappeared in the final plan. After the cancelation of the swimming pool, the sub-ground is no longer required.

30.4 Discussion

30.4.1 Health Issues Produced by Urbanization

The old site of VNH is located on the border of the international settlement and was considered a comfortable and quiet environment. However, as Shanghai's population increased, it was deemed no longer suitable for the restoration of health. Inside the border, the colonists continued to build transportation and infrastructure, and outside the border, the Chinese tried to modernize. The resulting noise and clamor affected the physical experience of the hospital.

Beyond the physical influence, there was also a moral and psychological rejection. The prejudice against the uncleanliness of the locals made this area mentally uninhabitable for colonists. The decision to close the old sanatorium and build a new one also reflects the intense relationship between different forces in this semi-colony. The economic committee of SMC did not feel obligated to provide medical care to the French or a large number of Chinese in Shanghai (Shanghai Municipal Archive 1901) but rather valued their fiscal deficits.

While the land along the Huangpu River in Shanghai was already occupied and developed, the western district of Shanghai outside the French Settlement and International Settlement was seen as a "Country", where they tried to go to find fresher sun and air.

30.4.2 Local Adaptation of Modern Architectural Ideas

In contrast to Country Hospital, the Victoria Nurses' Home adopted a modern style. The simple lines in the VNH were first considered more economical for equipment arrangement and space organization. Later, its style aligned with the "International style" trend initiated by the 1932 MOMA exhibition and became a symbol of successful colonial governance of public health in the booklet shown in the introduction.

Its design's consideration in location, functional organization, terrace and verandah, roof garden's utility, and health facility program all present that the architect is influenced by the idea of light-air-sun (German: *licht-luft-sonne*), which takes a primary role in 1920s German architectural discussion. In other public buildings built by SMC at the same time as VNH, similar terraced forms also occurred (Fig. 30.16). Rudolf Hamburger had a good relationship with Fuquan Xi, the first-generation of Chinese architect educated in German. "Light" and "air" become the guiding principles for the form of terraced sanatoriums in Fuquan Xi's Hongqiao Sanatorium.

Both modern ideas and local adaptations can be seen in spatial relations from interior to exterior. In a photograph of a nurses' dormitory, the relationship between "bed-window-people-outdoor landscape" shows a similarity to the spatial relationship. Sigfried Giedion illustrates on the cover of *Befreites Wohnen* (Liberated Dwelling) (Fig. 30.17). The presence of screen windows at the outdoor-indoor boundary, as well as the verandah to protect from Shanghai's summer sun, adds a layer of local allusion to this relationship.

This adaptation also involved local materials. The majority of the building's materials, such as glass and steel windows, were imported. However, architects were sensitive to the material situation in China. The final façade is made of dark red brick veneers with locally produced

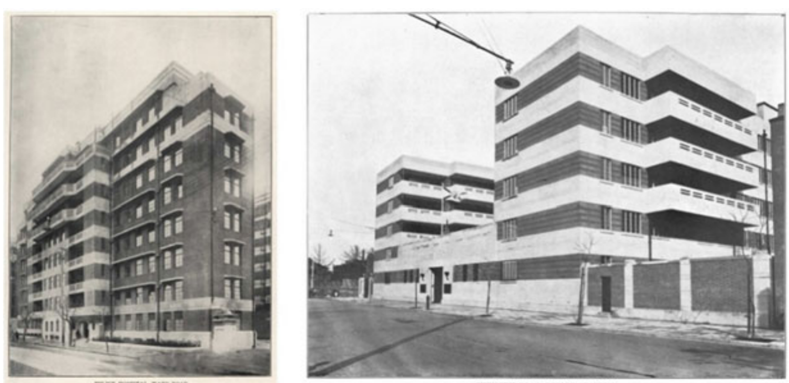

Fig. 30.16 Other public buildings built by SMC, from the SMC report in 1932 and 1933

Fig. 30.17 VNH's similar interior relationship with *Befreites wohnen*'s cover, from Eduard Kögel (2007) Zwei Poelzigschüler in der Emigration: Rudolf Hamburger und Richard Paulick zwischen Shanghai und Ost-Berlin (1930–1955)

Chinese Taishan bricks. An article published by Hamberger in *L'Architecture d'Aujourd'hui* showed how the interior of the VNH is decorated with bamboo for walls and curtains. The text that went with it said, "*Mais quel homme sensible n'est pas captivé par cette atmosphere indescriptible de la Chine*? (But what sensitive man is not captivated by this indescribable atmosphere of China?)" (Hamburger 1938).

30.4.3 Different Healthy Needs

"Limited" Air and Sun

During the COVID-19 pandemic, when machine air-conditioning was a weakness, it is a reminder for us how spatial principle can provide access to uncontaminated air (Murphy et al. 2021). Through the design of the verandah, the terrace, and the way the single corridor is set up, the architect made sure that the nurses' rooms got plenty of air and sun.

While air and sunlight are still only available to the minority. Just as the Country Hospital authorities demanded at the beginning of this design: "to have a small private tailors' room and a place for wash-Amash, so as to avoid Chinese staff wandering around the corridors." Chinese people using the elevators also needed to be separated from the rest of the hospital staff (Shanghai Municipal Archive 1927f). The Chinese, ironically, maintained glass, a material that ensures light and air. When the Country Hospital realized that they could not clean the dust from large areas of glass, they had to hire a local Chinese company to do the glass cleaning (Shanghai Municipal Archive 1931).

Different Opinions Based on Physical Experience

People's needs for healthy spaces are sometimes contradictory. It reflects the dynamic connections established between ideas, technology, and physical experience. Good health may be related to conventional ideas. The Old Victoria Nursing Home's bathrooms are separated from wards by corridors in the 1910's plan and the 1913's plan (Fig. 30.19).

This similar separation also occurred in the public school for girls (built also by SMC in 1912). Bathrooms were connected to the main building through a semi-interior space and hidden in the backside of this plan, not interfering with the symmetry of its main elevation (Fig. 30.18).

In 1929, the VNH Committee kept the idea that "the W.C (should) be grouped in an adjoining room" because of "modern practice in buildings of this type" and believed that the entrance to the bedrooms would spoil the air both in the bedrooms and verandah. The architect had to point out that modern sanitation has replaced dry commodes. In the end, the architect

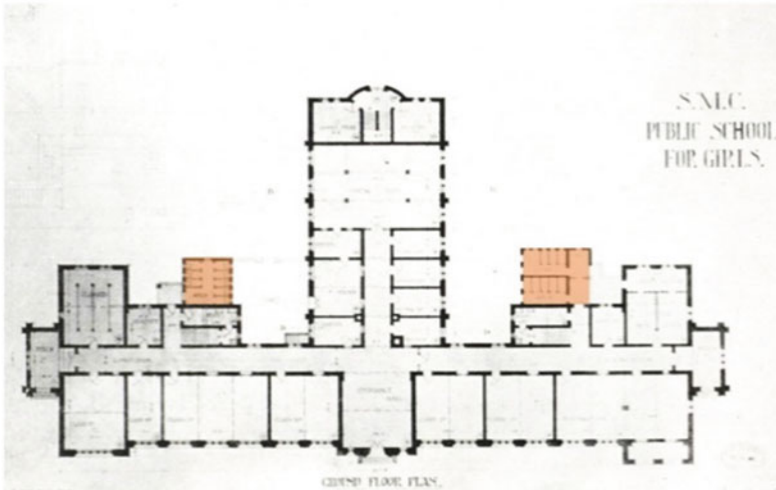

Fig. 30.18 Bathrooms hidden in the backside, from the SMC report in 1912

Fig. 30.19 Similar relationship between bathrooms and rooms. Self-drawn by the author

apparently compromised, and the final plan of the VNH shows a similar relationship between bathrooms and nurses' units compared with the old Home's plan.

Popular Culture's Influence

The healthy choice is not only based on our physical needs but also on popular culture. Roof gardens have been a fashion since the 1910s in Shanghai (Shi Bao 1915). So when the VNH Committee objected to the design of the sub-ground swimming pool considering Shanghai's climate, they also wanted to place common rooms and dining rooms on the roof, just "in accordance with modern practice in new types of buildings in Shanghai and elsewhere". The roof gardens' physical experience of "health" is first accepted for its spread in society, rather than the simple lines' style.

30.5 Conclusion: Changing Healthy Needs and the Built Environment

The design process of VNH presents how the built environment and ideas of health interact with each other. Various identities, such as architects, nurses, and authorities, have different ideas of health that are shaped by their physical perceptions of Shanghai's climate, their conventional experiences with technology, and their desire for a more modern and healthy lifestyle. Various ideas about health collide with each other and finally form this building.

This reminds us that when we talk about what design is "healthy", there are no fixed answers. Whose health are we built for? Are there any norms when we design for health? Are similar "healthy" architectural elements that can be used across different places?

The German architect, Rudolf Hamburger, brought modern architectural ideas into the Victoria Nurses' Home. While the VNH Committee accepted this modern style mainly for convenient management and efficient equipment arrangement. The idea of "health" and the image of modern architecture did not immediately establish a connection, and its elevation was first considered "unsuitable". As for nurses, although the standardized units in this building take nurses' individual privacy and living needs into account and maximize sun and light, some functions of sports facilities were finally canceled because of climate and funds. As for the Chinese, there was limited room for local staff, and few people paid attention to this building.

At a time when the technology of medical architecture was not so complex as to exceed the organization of the space, the VNH's design of windows, verandahs, and terraces demonstrated the spatial regulation of the relationship between the body, architecture, and local climate. The verandah stems from the colonists' impolite cognition of the local climate, but the architect precisely considered its size to make the verandah more accustomed to Shanghai's semi-tropical climate. The roof garden, reflecting a popular lifestyle at the time, was accepted smoothly, while the bathroom located in the room still suffered suspicion.

Acknowledgements Thank you for Prof. Yongyi Lu's exhaustive research about Fuquan Xi's "Hongqiao Sanatorium", underlining the importance of Victoria Nurses' Home, and inspiring me to find relative archives in the Shanghai Municipal Archives. Prof. Eduard Kögel and Prof. Li Hou's research offer a foundational context for this architecture and its architect.

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Implementation of Biophilic Design at Workplaces

31

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Abstract

Experiences of nature have various benefits on human health and well-being. In workplace environments, the integration of biophilic design strategies to incorporate elements and features of nature can enhance employee productivity, emotional state, and psychological well-being, mainly addressing the third goal of United Nations Sustainable Development Goals (UN SDGs). The literature abounds with studies providing empirical evidence on the positive effect of nature exposure in the workplace on employees. However, there is a lack of understanding of the status of such studies. To this end, the authors conducted descriptive analysis and a review on the applications, capabilities, and limitations of studies implementing biophilic design principles at workplaces. A total of 59 peer-reviewed articles that met the inclusion criteria were selected and reviewed based on the defined factors and sub-factors. The results show that the introduction of biophilic design elements into indoor, semi-outdoor, and outdoor workplace environments can promote employee health, well-being, and productivity. However, the literature gives limited attention to some of the identified categories/factors including "natural analogues", "emotion and mood", "physiological data", "non-visual sensory input", and "virtual reality". Based on the review findings, we have identified several knowledge gaps and opportunities for further research.

Keywords

Biophilic design · Workplace · Health and well-being · Literature review

31.1 Introduction

The exponentially increasing move to urban areas has significantly influenced human lives (United Nations 2018). Compared to rural areas, urban environments are more crowded, noisy, warmer, and polluted (Hartig and Kahn 2016; Paull et al. 2018; Wang et al. 2021). Urban lifestyle is usually associated with fast pace of life, long working hours, and social pressure (Facey et al. 2015; Lederbogen et al. 2011; Os et al. 2010). Furthermore, urbanites are disconnected from outdoor environments, being confined to small indoor spaces for a long time (Lederbogen et al. 2011). According to the United States Environmental Protection Agency (EPA) (EPA 2022), on average, Americans

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spend about 90% of their time indoors. The same can be assumed for the rest of the developed countries. The above-mentioned characteristics of urban areas and modern lifestyles contribute to the development of various health and well-being issues. On a different scale, in the workplace environments, stress, fatigue, and impaired job performance can result from inherent indoor environmental stressors (e.g. noise, inadequate lighting, odours, moisture, thermal factors, and poor ergonomics), or work-related issues such as prolonged working hours, poor organization of work, and negative workplace relationships (Ortiz and Bluyssen 2022; Williamson and Friswell 2013).

UN SDGs (United Nations Sustainable Development Goals 2022) comprise 17 goals designed to "achieve a better and more sustainable future for all". The third goal of UN SDGs is to "ensure healthy lives and promote well-being for all at all ages". Accordingly, the biophilia hypothesis proposed by E. O. Wilson in 1984 (Wilson 1984) suggests that the psychophysiological and cognitive costs of the above-mentioned working and living conditions might be counteracted by access to elements and features of nature within an urban context (Lyu et al. 2022; Mollazadeh and Zhu 2021). The biophilia hypothesis contends that we have an innate and deep-seated biological connection with nature (Wilson and Kellert 1993). In recent decades, the biophilia hypothesis has evolved into a design philosophy, biophilic design, to incorporate various forms of nature into the built environment (Kellert et al. 2008). A large body of research has demonstrated the restorative benefits of integrating biophilic design strategies into the built environment (Hartig et al. 2003; Koselka et al. 2019; Maund et al. 2019; Alcock et al. 2014; Berman et al. 2008; Berto 2005; Bratman et al. 2015). The restorative benefits of biophilic settings are mainly underpinned by two theories from environmental psychology perspective: attention restoration theory (ART) (Kaplan and Kaplan 1989; Kaplan 1995) and stress reduction theory (SRT) (Ulrich et al. 1991). According to ART, cognitive resources which are fatigued after prolonged and intensive use of directed attention are replenished by the experience of natural environments. On the other hand, SRT suggests that encounters with unthreatening natural environments favourable to human survival elicit adaptive responses entailing stress reduction and restoration due to our innate affiliation with nature developed through evolution.

The restorative benefits of biophilic design have been extensively investigated in different environmental settings and contexts including healthcare environments (Park and Mattson 2008), educational (Peters and D'Penna 2020), residential (Raanaas et al. 2012), and commercial spaces (Rosenbaum et al. 2018) to explore how the implementation of biophilic principles affect the quality of these environments and in turn occupant health and well-being. The workplace has been one of the typologies that have received increasing attention from researchers (Clements-Croome et al. 2022), fuelled by the exclusion of nature in workplace environments. A study employing an online survey of 7600 employees from 16 countries around the world indicated that 58% of respondents reported no live plants in their office, and 47% of employees reported no natural light (Browning and Cooper 2015). Several studies have shown that the application of biophilic design in indoor, outdoor, or semi-outdoor workplace environments benefits employee well-being (Korpela et al. 2017a), psychophysiological stress level (Ayuso Sanchez et al. 2018), work performance (Raanaas et al. 2011), mood (Chang and Chen 2005), and job satisfaction (McFarland 2017).

However, the literature lacks studies comprehensively investigating biophilic design implementations at workplaces (Sadick and Kamardeen 2020). Therefore, there is a gap in the literature regarding the status of biophilic design applications in workplace environments. In this work, accordingly, the authors review several relevant works to explore the limitations of existing biophilic design implementations at workplaces and potential for further research. The paper is organized as follows: the objective and methodology of the research are explained in Sect. 31.2. In Sect. 31.3, the classification and descriptive analysis of the reviewed literature is conducted. The applications, capabilities, and limitations of the literature and possible research gaps are introduced in Sect. 31.4. Finally, Sect. 31.5 presents conclusions based on the findings of the paper.

31.2 Objective and Methodology

The objective of this study is to develop a holistic understanding of the current state of knowledge regarding the applications, capabilities, and limitations of biophilic design at workplaces, and then establish potential gaps for further research. To this end, the study took three major steps:

- First, studies examining biophilic design at workplaces are classified based on the defined categories and subcategories.
- Then, descriptive analysis and a review of the studies around the selected themes are conducted.
- Finally, the applications, capabilities, and limitations of biophilic design research in workplace environments are identified and future research opportunities are introduced.

Scopus was used as the main database for this research given its high source coverage and citation-tracking capability. Published peer-reviewed journals and conference papers published in the English language were reviewed to ensure the quality of included references. First, the literature was searched using keyword combinations of intervention “AND” context “AND” outcome in the title, abstract, and keywords fields and the date range from 1981 to 2022. 717 references were obtained from the search. Next, titles, abstracts, and full texts of the publications were screened to find relevant literature. The inclusion criteria for this step are references that (1) focus on indoor/outdoor nature exposure at workplaces and (2) define a direct relationship between nature contact and employee health, well-being, and productivity. After limiting search results to these criteria, a total of 59 references were selected and reviewed (Table 31.1).

31.3 Literature Review and Findings

31.3.1 Classification of Studies in Biophilic Design at Workplaces

In this section, the selected 59 articles are categorized based on 12 factors and their sub-factors. Mollazadeh and Zhu (2021)’s research has been used as a reference while identifying classification criteria for reviewed studies.

1. Publication date: Articles are ordered by publication year to demonstrate the development in the field.
2. Publication location: Studies are categorized based on the geographic background to show the leading countries in the field.
3. Publication journal: Papers are classified based on the journal in which they were published to indicate widely used journals in the field.
4. Biophilic categories: This includes three major categories; “nature in the space” and “natural analogues” retrieved from the biophilic design framework proposed by Browning et al. (2014) and “outdoor nature exposure” included based on the literature review.
5. Biophilic patterns: Patterns included in the review are extracted from Browning et al. (2014)’s biophilic design framework and comprise “visual connection with nature”, “non-visual connection with nature”, “thermal and airflow variability”, “dynamic and diffuse light”, “biomorphic forms and patterns”, and “material connection with nature”.
6. Biological responses: Based on the reviewed studies and Mollazadeh and Zhu (2021)’s, Sadick and Kamardeen (2020)’s works, biological responses are as follows; “stress level”, “cognitive performance”, “emotion and mood”, and “health and well-being”.
7. Collected data: The subcategories are “psychological data”, “physiological data”, and “cognitive data”.

Table 31.1 List of keywords for retrieving records

Intervention			Context	Outcome
Biophilia	Nature experience	Window view	Workplace	Recovery
Biophilic	Nature contact	Indoor plant	Work place	Attention
Natural environment	Outdoor nature	Potted plant	Workspace	Health
Restorative environment	Connection to outdoor	Daylight	Office	Well-being
Natural setting	Indoor nature	Natural sound	Employee	Well-being
Natural element	Greenery	Nature sound		Stress
Nature exposure	Greenspace	Natural odour		Productivity
Exposure to nature	Green space	Smell		Cognitive performance
Nature connection	Green wall	Scent		Mood
Connection to nature	Green roof			Emotion

8. Sensory input: Sensory inputs are classified as "visual", "auditory", "olfactory", and "thermal" stimuli.
9. Environmental setting: The sub-factors are "indoor environment" and "outdoor environment".
10. Experimental approach: The studies are categorized into "field study", "controlled laboratory study", "virtual reality (VR)", and "survey-based study".
11. Delivery mode: This includes "real" and "virtual (simulated)".
12. Sample size: The subcategories are "less than 20", "20–50", "51–100", and "over 100".

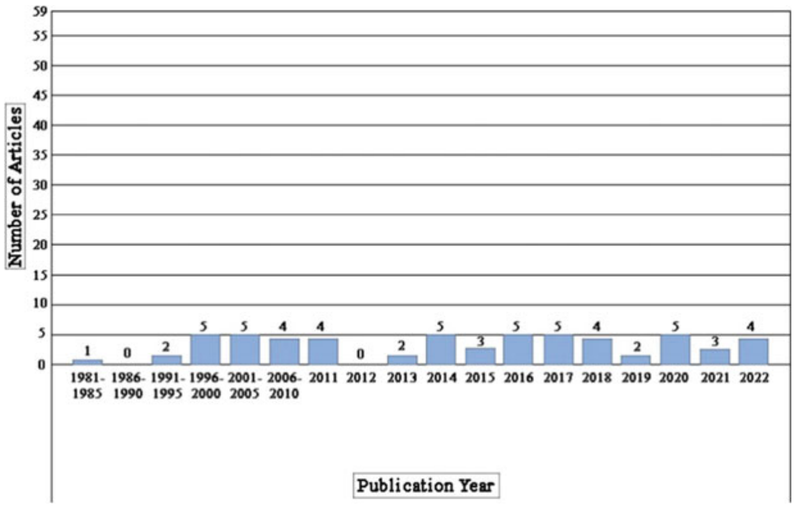
The reviewed studies are listed based on the above-mentioned factors and sub-factors in Appendix 1, Table 31.2 (factors 1–3), Table 31.3 (factors 4–5), Table 31.4 (factors 6–7), Table 31.5 (factors 8–9), and Table 31.6 (factors 10–12).

31.3.2 Descriptive Analysis of Reviewed Literature

In this section, the reviewed studies are analysed and discussed to point out the main concepts and features of biophilic design implementations at workplaces.

- Publication date: According to the chronological order of the development in the literature, a clear path of advancement in research has been observed since 2010. A significant portion of the literature (42 papers) was published between 2010 and 2022. The emergence of contemporary workplaces such as open-plan offices involving a variety of environmental stressors might be the reason for such a pattern since researchers have been triggered to work on the health and well-being of employees (Fig. 31.1).
- Publication location: USA (15p.) has the highest number of published articles followed by Norway (8p.). Finland (5p.), South Korea (4p.), Japan (4p.), and England (4p.) are also relatively leading countries in the field. Figure 31.2 highlights the dominance of the literature by developed countries in North America, Europe, and Asia.
- Publication journal: Among the 59 analysed articles, "Landscape and Urban Planning", "Journal of Environmental Psychology", and "Environment and Behaviour" were the most preferred journals (Fig. 31.3).
- Biophilic categories: Nature in the space is studied the most (51p.) followed by outdoor nature exposure (21p.). Natural analogues are utilized the least (11p.). The abundant use of nature in the space and outdoor nature exposure might be attributed to their ease of implementation and established positive effects on employees. Nature in the space and

Fig. 31.1 Distribution of the reviewed studies based on publication date



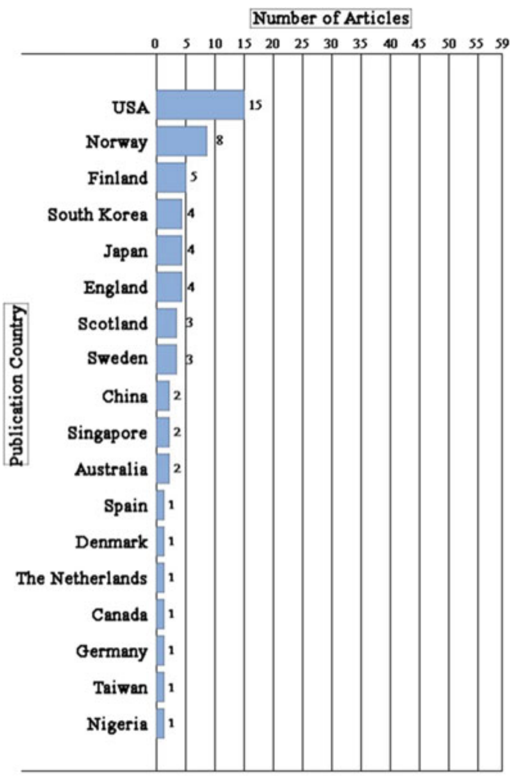


Fig. 31.2 Distribution of the reviewed studies based on publication location

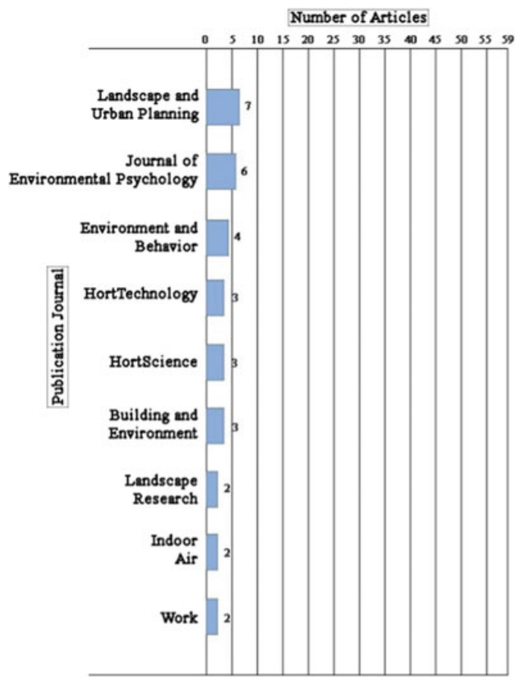


Fig. 31.3 Distribution of the reviewed studies based on publication journal

natural analogues are the common categories for workplace indoor environments. Natural analogues providing indirect connections with nature using colours, patterns, materials, and shapes found in nature have been particularly explored in recent years (since 2019).

- Biophilic patterns: The three most reported patterns are visual connection with nature (48p.), biomorphic forms and patterns (10p.), and dynamic and diffuse light (9p.), respectively. Visual connection with nature is especially a common biophilic pattern in studies evaluating the impact of plants, green walls, and a window view of nature on employee health, well-being, and productivity. Non-visual connection with nature (6p.) including nature sounds and natural odours is also explored depending on the research interest (Fig. 31.4).

- Biological responses: Health and well-being (35p.), stress level (27p.), and cognitive performance (23p.) are the most reported biophilic responses. The health and well-being of employees are especially the focus of research investigating the benefits of visual connection with nature and outdoor nature exposure. There is much less research on emotion and mood (15p.). The perceived less significance of emotion and mood of employees mainly due to businesses' goals of higher returns might be the reason for such a pattern.
- Collected data: Psychological data is by far the most reported collected data (54p.) followed by cognitive data (23p.). Physiological data is the least reported collected data (16p.). Regarding psychological data, self-reported questionnaires on health, well-being, job satisfaction, quality of life, and mood are employed. In terms of cognitive data, various tests and tasks are introduced such as stroop test, digit span test, and reaction time task to quantify cognitive function including attentional capacity and working memory. Furthermore, some researchers present heart rate, blood pressure, and skin conductance as physiological measures of acute stress reaction (Fig. 31.5).
- Sensory input: Visual cue is by far the most reported sensory input (27p.) in the reviewed studies. Furthermore, a considerable amount of research is devoted to the auditory sense (5p.). Olfactory (1p.) and thermal (1p.) modalities are almost completely overlooked despite their significant roles in the perception of environmental stimuli. Hence, there is a lack of research considering multisensory aspects of nature exposure at work.
- Environmental setting: Most of the reviewed studies (50p.) explore biophilic design implementations in indoor workplace environments including private offices, home offices, and open-plan offices. Besides, a considerable amount of research (21p.) is attributed to semi-outdoor/outdoor workplace environments such as terraces, gardens, and parks. These places provide employees with access to outdoor green spaces during micro-breaks and long lunch breaks to detach them mentally from work.

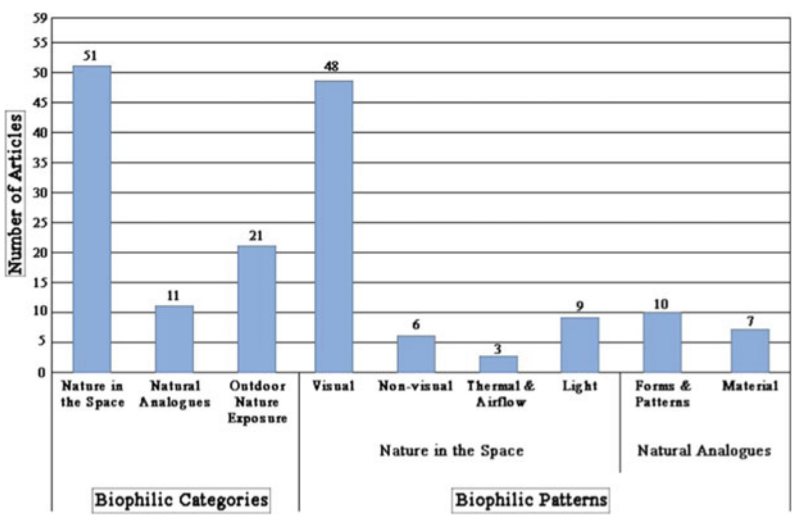
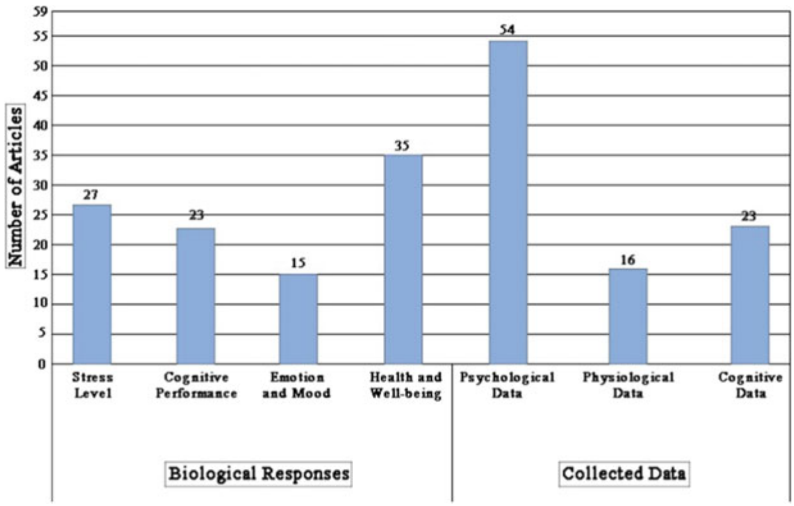


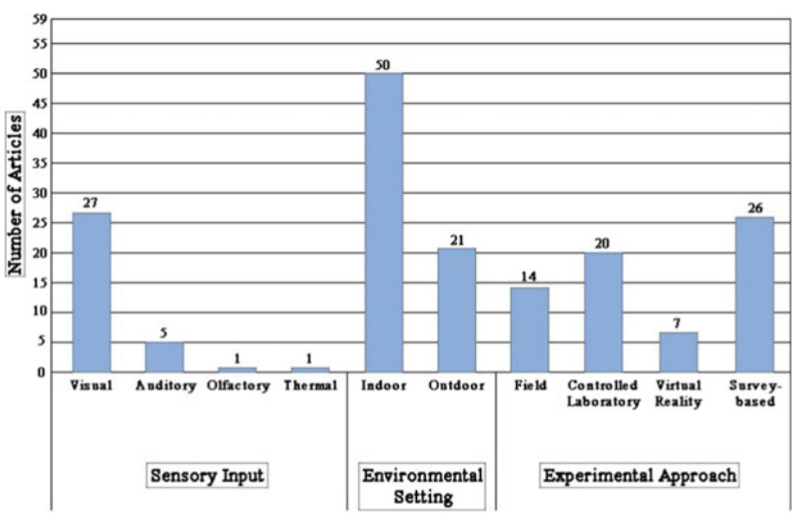
Fig. 31.4 Distribution of the reviewed studies based on biophilic categories and patterns

Fig. 31.5 Distribution of the reviewed studies based on biological responses and collected data



- Experimental approach: 26 studies are survey-based administering self-reported questionnaires for data collection due to their ease of conduction compared to other methods. While there are 20 studies conducted in controlled laboratories, including climate chambers, there are 14 field studies carried out in actual workplaces. Although these approaches produce valid and reliable data, the complexity of parameters and resources such as time and cost prevent the acceleration of knowledge in this field. Finally, there is less research on VR (7p.) despite the opportunities, it offers to overcome many of the limitations of controlled laboratory settings and field studies (Fig. 31.6).
- Delivery mode: Most of the reviewed studies employ real delivery mode (24p.) by either introducing actual natural elements or examining the use of outdoor natural environments. Virtual media including images, videos, and 3D models exhibited through plasma displays and head-mounted displays is also a largely reported delivery mode (14p.) since they promise to address some limitations of a real delivery mode related to the control and manipulation of environmental conditions and required cost and time.
- Sample size: About half of the reviewed studies (27p.) consider a sample size over 100. Most of these studies are survey based as it is

Fig. 31.6 Distribution of the reviewed studies based on sensory input, environmental setting, and experimental approach



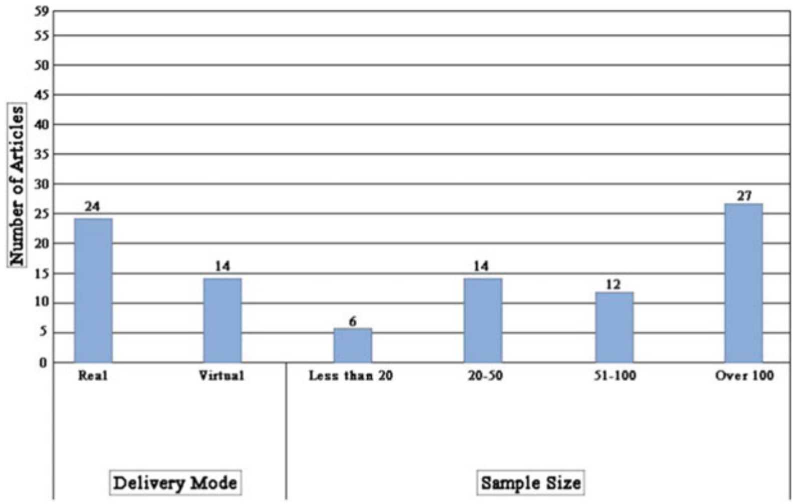


Fig. 31.7 Distribution of the reviewed studies based on delivery mode and sample size

easier and more affordable to employ a big sample group. There are 14 and 12 studies with sample sizes of 20–50 and 51–100, respectively. Finally, a few studies have less than 20 samples (6p.) (Fig. 31.7).

31.4 Applications, Capabilities, and Limitations

This section critically evaluates the literature to identify the capabilities and limitations of biophilic design research in workplace environments. It has been well-established that the introduction of biophilic design elements into indoor workplace settings (Browning and Cooper 2015; Korpela et al. 2017a; Sadick and Kamardeen 2020) and the use of semi-outdoor/outdoor natural environments (Raanaas et al. 2011; Browning et al. 2014; Shibata and Suzuki 2002) allow for recovery from mental fatigue, exhaustion, and psychological stress endemic in contemporary workplaces. Therefore, findings suggest that biophilic design strategies incorporating both indoor and outdoor nature exposure at work should be adopted for improved health, well-being, and productivity.

Despite the above-mentioned capabilities of biophilic design applications at workplaces, there are some limitations worth considering. Firstly, natural analogues receive less attention from researchers. Although some researchers demonstrated the positive effects of integrating elements/features of this category into workplaces on employees (An et al. 2016), there is potential for further research in this area. Occupants' less familiarity with this category and their vagueness regarding implementation might be the reason for such a pattern. Likewise, much less research is devoted to investigating other patterns of nature in the space including non-visual connection with nature, thermal and airflow variability, and dynamic and diffuse light than visual connection with nature despite their established benefits and the feasibility of implementation. These are major biophilic design patterns and there is a need for more research in this field to consolidate empirical evidence.

Regarding the outcome measures of biophilic design research, little attention has been given to the mood of employees. The emotions and feelings induced on occupants are essential at work, therefore, further research is needed in this area. Similarly, researchers should present more physiological data to quantitatively evaluate the impact of nature exposure on employees since most studies use self-reported measures. Another gap identified in the literature is that most research does not consider multisensory aspects of nature exposure while designing biophilic workplaces. Particularly, very little is known about how the incorporation of olfactory and thermal stimuli affects the restorative properties of such environments. As a non-visual connection with nature is a biophilic design pattern, it is recommended to provide employees with sensory-rich nature experiences to enhance their mental health, psychological well-being, and cognitive capacity.

In the literature, very few studies reported leveraging VR for biophilic design research in workplaces. VR addresses some limitations of widely used experimental tools by providing a high level of control over the environment (Sianoja et al. 2018; Roskams and Haynes 2020). VR systems provide more immersive, realistic, interactive, and engaging experiences of biophilic environments than photographs, videos, and screen-based displays (Wilson 1984; Alamirah et al. 2022). Besides, VR instruments are affordable and portable and require less time, effort, and expertise to produce the environments (Kuliga et al. 2015). Thereby, more research is needed to generate empirical evidence on the effectiveness and feasibility of VR as a research tool to assist in the development and testing of biophilic design proposals.

31.5 Conclusions

In this paper, descriptive analysis and a review of studies implementing biophilic design strategies at workplaces are carried out based on defined categories/factors. Moreover, the paper identifies the capabilities and limitations of current biophilic design applications in workplace environments and presents opportunities for further research. Specifically, while the literature extensively investigates nature in the space category, far too little attention has been paid to natural analogues. The impact of introducing biomorphic forms and patterns and material connection with nature into workplace settings on employees is not fully understood. Moreover, the literature is devoid of exploring the non-visual connection with nature, thermal and airflow variability, and dynamic and diffuse light.

Another part which the reviewed literature lacks is the limited focus on the emotion and mood of employees and few attempts to gather physiological data. More research is needed to better understand the relationship between nature exposure at work and employee mood. Furthermore, there is a lack of research incorporating other sensory cues into biophilic workplaces as most studies heavily rely on the visual contents of nature exposure at work. Thus, the relative contribution of different sensory modalities to restorative effects of biophilic workplaces needs to be explored. There are also many research opportunities with respect to experimental approaches such as the paucity of evidence on the potential of VR for biophilic design research in workplace environments.

Appendix 1

See Tables 31.2, 31.3, 31.4, and 31.5.

Table 31.2 Classification of the reviewed studies based on factors 1–3 (publication date, publication location, and publication journal)

Literature	Publication date	Publication location	Publication journal
Finnegan and Solomon (1981)	1981	USA	The Journal of Social Psychology
Shoemaker et al. (1992)	1992	USA	HortTechnology
Kaplan (1993)	1993	USA	Landscape and Urban Planning
Lohr et al. (1996)	1996	USA	Journal of Environmental Horticulture
Fjeld et al. (1998)	1998	Norway	Indoor and Built Environment
Leather et al. (1998)	1998	England	Environment and Behaviour
Larsen et al. (1998)	1998	USA	Environment and Behaviour
Fjeld (2000)	2000	Norway	HortTechnology
Shibata and Suzuki (2001)	2001	Japan	North American Journal of Psychology
Shibata and Suzuki (2002)	2002	Japan	Journal of Environmental Psychology
Shibata and Suzuki (2004)	2004	Japan	Scandinavian Journal of Psychology
Stigsdotter and Grahn (2004)	2004	Sweden	Design and Health
Chang and Chen (2005)	2005	Taiwan	HortScience
Bringslimark et al. (2007)	2007	Norway	HortScience
Shin (2007)	2007	South Korea	Scandinavian Journal of Forest Research
Dravigne et al. (2008)	2008	USA	HortScience
Aries et al. (2010)	2010	The Netherlands	Journal of Environmental Psychology
Raanaas et al. (2011)	2011	Norway	Journal of Environmental Psychology
Kim et al. (2011)	2011	South Korea	Journal of the Japanese Society for Horticultural Science
Largo-Wight et al. (2011)	2011	USA	Public Health Reports
Jahncke et al. (2011)	2011	Sweden	Journal of Environmental Psychology
Lottrup et al. (2013)	2013	Sweden	Landscape and Urban Planning
Evensen et al. (2013)	2013	Norway	Psyecology
Nieuwenhuis et al. (2014)	2014	England	Journal of Experimental Psychology: Applied
Brown et al. (2014)	2014	England	Environment and Health
de Bloom et al. (2014)	2014	Finland	BMC Public Health
Loder (2014)	2014	Canada	Landscape and Urban planning
Lee et al. (2014)	2014	Australia	Landscape and Urban Planning
Gilchrist et al. (2015)	2015	Scotland	Landscape and Urban Planning
Lottrup et al. (2015)	2015	Denmark	Landscape Research
Evensen et al. (2015)	2015	Norway	Environment and Behaviour

(continued)

Table 31.2 (continued)

Literature	Publication date	Publication location	Publication journal
Calogiuri et al. (2016)	2016	Norway	Work
Bjornstad et al. (2016)	2016	Norway	Work
An et al. (2016)	2016	USA	PloS one
Largo-Wight et al. (2016)	2016	USA	HERD: Health Environments Research and Design Journal
Colley et al. (2016)	2016	Scotland	Landscape Research
Korpela et al. (2017a)	2017	Finland	Landscape and Urban planning
Largo-Wight et al. (2017)	2017	USA	Journal of Workplace Behavioural Health
McFarland (2017)	2017	USA	HortTechnology
Korpela et al. (2017b)	2017	Finland	Journal of Environmental Psychology
Colley et al. (2017)	2017	Scotland	Environment and Behaviour
Ayuso Sanchez et al. (2018)	2018	Japan	Energy and Buildings
Yin et al. (2018)	2018	USA	Building and Environment
Sianoja et al. (2018)	2018	Finland	Journal of Occupational Health Psychology
Hyvönen et al. (2018)	2018	Finland	Frontiers in Psychology
Yin et al. (2019)	2019	USA	Indoor Air
Sona et al. (2019)	2019	Germany	Ergonomics
Chulvi et al. (2020)	2020	Spain	Journal of Building Engineering
Yin et al. (2020)	2020	USA	Environment International
Roskams and Haynes (2020)	2020	England	Journal of Corporate Real Estate
Chang et al. (2020)	2020	Singapore	Landscape and Urban Planning
Elsadek et al. (2020)	2020	China	Urban Forestry and Urban Greening
Aduwo et al. (2021)	2021	Nigeria	In IOP Conference Series: Earth and Environmental Science
Yeom et al. (2021)	2021	South Korea	Building and Environment
Aristizabal et al. (2021)	2021	USA	Journal of Environmental Psychology
Lei et al. (2022)	2022	China	Buildings
Yeom et al. (2022)	2022	South Korea	Indoor Air
Mihara et al. (2022)	2022	Singapore	Science and Technology for the Built Environment
Lyu et al. (2022)	2022	Australia	Building and Environment

Table 31.3 Classification of the reviewed studies based on factors 4–5 (biophilic categories and biophilic patterns)

Literature	Biophilic categories and patterns						
	Nature in the space				Natural analogues		Outdoor nature exposure
	Visual	Non-visual	Thermal and airflow	Light	Forms and patterns	Material	
Finnegan and Solomon (1981)	*						
Shoemaker et al. (1992)	*						
Kaplan (1993)	*						
Lohr et al. (1996)	*						
Fjeld et al. (1998)	*						
Leather et al. (1998)	*			*			
Larsen et al. (1998)	*						
Fjeld (2000)	*						
Shibata and Suzuki (2001)	*						
Shibata and Suzuki (2002)	*						
Shibata and Suzuki (2004)	*						
Stigsdotter and Grahn (2004)	*						*
Chang and Chen (2005)	*						
Bringslimark et al. (2007)	*						
Shin (2007)	*						
Dravigne et al. (2008)	*						
Aries et al. (2010)	*						
Raanaas et al. (2011)	*						
Kim et al. (2011)	*						
Largo-Wight et al. (2011)	*	*		*	*		*
Jahncke et al. (2011)	*	*					
Lottrup et al. (2013)	*						*
Evensen et al. (2013)	*						
Nieuwenhuis et al. (2014)	*						
Brown et al. (2014)							*

(continued)

Table 31.3 (continued)

Literature	Biophilic categories and patterns						
	Nature in the space				Natural analogues		Outdoor nature exposure
	Visual	Non-visual	Thermal and airflow	Light	Forms and patterns	Material	
de Bloom et al. (2014)							*
Loder (2014)	*						
Lee et al. (2014)	*						
Gilchrist et al. (2015)	*						*
Lottrup et al. (2015)	*						
Evensen et al. (2015)	*				*		
Calogiuri et al. (2016)							*
Bjornstad et al. (2016)	*			*			*
An et al. (2016)	*			*	*		*
Largo-Wight et al. (2016)		*					
Colley et al. (2016)							*
Korpela et al. (2017a)	*						*
Largo-Wight et al. (2017)							*
McFarland (2017)	*						*
Korpela et al. (2017b)	*						*
Colley et al. (2017)							*
Ayuso Sanchez et al. (2018)	*			*			
Yin et al. (2018)	*					*	
Sianoja et al. (2018)							*
Hyvönen et al. (2018)							*
Yin et al. (2019)	*			*	*	*	
Sona et al. (2019)	*	*					
Chulvi et al. (2020)	*				*	*	*
Yin et al. (2020)	*			*	*	*	
Roskams and Haynes (2020)		*			*	*	
Chang et al. (2020)	*						*
	*						

(continued)

Table 31.3 (continued)

Literature	Biophilic categories and patterns						
	Nature in the space				Natural analogues		Outdoor nature exposure
	Visual	Non-visual	Thermal and airflow	Light	Forms and patterns	Material	
Elsadek et al. (2020)							
Aduwo et al. (2021)	*		*	*	*	*	
Yeom et al. (2021)	*						
Aristizabal et al. (2021)	*	*			*		
Lei et al. (2022)	*		*	*	*	*	*
Yeom et al. (2022)	*						
Mihara et al. (2022)	*						
Lyu et al. (2022)			*				*

Table 31.4 Classification of the reviewed studies based on factors 6–7 (biological responses and collected data)

Literature	Biological responses				Collected data		
	Stress level	Cognitive performance	Emotion and mood	Health and well-being	Psychological data	Physiological data	Cognitive data
Finnegan and Solomon (1981)				*	*		
Shoemaker et al. (1992)				*	*		
Kaplan (1993)	*			*	*		
Lohr et al. (1996)	*	*	*		*	*	*
Fjeld et al. (1998)				*	*		
Leather et al. (1998)				*	*		
Larsen et al. (1998)		*	*		*		*
Fjeld (2000)				*	*		
Shibata and Suzuki (2001)		*	*		*		*
Shibata and Suzuki (2002)		*	*		*		*
Shibata and Suzuki (2004)		*	*		*		*
Stigsdotter and Grahn (2004)				*	*		
Chang and Chen (2005)	*		*		*	*	

(continued)

Table 31.4 (continued)

Literature	Biological responses				Collected data		
	Stress level	Cognitive performance	Emotion and mood	Health and well-being	Psychological data	Physiological data	Cognitive data
Bringslimark et al. (2007)	*	*		*	*		*
Shin (2007)	*			*	*		
Dravigne et al. (2008)				*	*		
Aries et al. (2010)				*	*		
Raanaas et al. (2011)		*					*
Kim et al. (2011)				*	*		
Largo-Wight et al. (2011)	*			*	*		
Jahncke et al. (2011)	*	*			*	*	*
Lottrup et al. (2013)	*			*	*		
Evensen et al. (2013)				*	*		
Nieuwenhuis et al. (2014)		*	*		*		
Brown et al. (2014)	*			*	*	*	
de Bloom et al. (2014)	*			*	*	*	*
Loder (2014)	*			*	*		
Lee et al. (2014)		*					*
Gilchrist et al. (2015)				*	*		
Lottrup et al. (2015)				*	*		
Evensen et al. (2015)		*			*		*
Calogiuri et al. (2016)	*		*		*	*	
Bjornstad et al. (2016)				*	*		
An et al. (2016)				*	*		
Largo-Wight et al. (2016)	*				*	*	
Colley et al. (2016)				*	*		
Korpela et al. (2017a)				*	*		

(continued)

Table 31.4 (continued)

Literature	Biological responses				Collected data		
	Stress level	Cognitive performance	Emotion and mood	Health and well-being	Psychological data	Physiological data	Cognitive data
Largo-Wight et al. (2017	*				*		
McFarland (2017)				*	*		
Korpela et al. (2017b)				*	*		*
Colley et al. (2017)	*	*		*	*		
Ayuso Sanchez et al. (2018)	*			*	*	*	*
Yin et al. (2018)	*	*				*	*
Sianoja et al. (2018)				*	*		
Hyvönen et al. (2018)				*	*		
Yin et al. (2019)	*	*				*	*
Sona et al. (2019)	*		*		*		
Chulvi et al. (2020)		*					*
Yin et al. (2020)	*			*	*	*	
Roskams and Haynes (2020)	*	*	*		*		*
Chang et al. (2020)				*	*		
Elsadek et al. (2020)	*		*		*	*	
Aduwo et al. (2021)		*		*	*		*
Yeom et al. (2021)	*			*	*	*	
Aristizabal et al. (2021)	*	*	*		*	*	*
Lei et al. (2022)				*	*		
Yeom et al. (2022)		*	*		*		*
Mihara et al. (2022)	*	*	*	*	*	*	*
Lyu et al. (2022)	*	*	*		*		

Table 31.5 Classification of the reviewed studies based on factors 8–9 (sensory input and environmental setting)

Literature	Sensory input			Environmental setting		
	Visual	Auditory	Olfactory	Thermal	Indoor	Outdoor
Finnegan and Solomon (1981)					*	
Shoemaker et al. (1992)	*				*	
Kaplan (1993)					*	
Lohr et al. (1996)	*				*	
Fjeld et al. (1998)	*				*	
Leather et al. (1998)					*	
Larsen et al. (1998)	*				*	
Fjeld (2000)	*				*	
Shibata and Suzuki (2001)	*				*	
Shibata and Suzuki (2002)	*				*	
Shibata and Suzuki (2004)	*				*	
Stigsdotter and Grahn (2004)					*	*
Chang and Chen (2005)	*				*	
Bringslimark et al. (2007)					*	
Shin (2007)					*	
Dravigne et al. (2008)					*	
Aries et al. (2010)					*	
Raanaas et al. (2011)	*				*	
Kim et al. (2011)	*				*	
Largo-Wight et al. (2011)					*	*
Jahncke et al. (2011)	*	*			*	
Lottrup et al. (2013)					*	*
Evensen et al. (2013)	*				*	
Nieuwenhuis et al. (2014)	*				*	
Brown et al. (2014)						*
de Bloom et al. (2014)						*
Loder (2014)					*	
Lee et al. (2014)					*	
Gilchrist et al. (2015)					*	*
Lottrup et al. (2015)					*	
Evensen et al. (2015)	*				*	
Calogiuri et al. (2016)						*
Bjornstad et al. (2016)					*	*
An et al. (2016)					*	*
Largo-Wight et al. (2016)		*			*	
Colley et al. (2016)						*
Korpela et al. (2017a)					*	*
Largo-Wight et al. (2017)						*

(continued)

Table 31.5 (continued)

Literature	Sensory input			Environmental setting		
	Visual	Auditory	Olfactory	Thermal	Indoor	Outdoor
McFarland (2017)					*	*
Korpela et al. (2017b)					*	*
Colley et al. (2017)						*
Ayuso Sanchez et al. (2018)	*				*	
Yin et al. (2018)	*				*	
Sianoja et al. (2018)						*
Hyvönen et al. (2018)						*
Yin et al. (2019)	*				*	
Sona et al. (2019)	*	*	*		*	
Chulvi et al. (2020)	*				*	*
Yin et al. (2020)	*				*	
Roskams and Haynes (2020)	*				*	
Chang et al. (2020)					*	*
Elsadek et al. (2020)	*				*	
Aduwo et al. (2021)					*	
Yeom et al. (2021)	*				*	
Aristizabal et al. (2021)	*	*			*	
Lei et al. (2022)					*	*
Yeom et al. (2022)	*				*	
Mihara et al. (2022)	*				*	
Lyu et al. (2022)	*				*	

Table 31.6 Classification of the reviewed studies based on factors 10–12 (experimental approach, delivery mode, and sample size)

Literature	Experimental approach				Delivery mode		Sample size			
	Field	Controlled laboratory	Virtual reality	Survey-based	Real	Virtual	Less than 20	20–50	51–100	Over 100
Finnegan and Solomon (1981)				*						*
Shoemaker et al. (1992)	*				*		*			
Kaplan (1993)				*						*
Lohr et al. (1996)		*			*				*	
Fjeld et al. (1998)	*				*				*	
Leather et al. (1998)				*					*	
Larsen et al. (1998)		*			*				*	
Fjeld (2000)	*				*				*	
Shibata and Suzuki (2001)		*			*				*	
Shibata and Suzuki (2002)		*			*					*
Shibata and Suzuki (2004)		*			*				*	
Stigsdotter and Grahn (2004)				*						*
Chang and Chen (2005)		*				*		*		
Bringslimark et al. (2007)				*						*
Shin (2007)				*						*
Dravigne et al. (2008)				*						*
Aries et al. (2010)				*						*
Raanaas et al. (2011)		*			*			*		
Kim et al. (2011)	*				*				*	
Largo-Wight et al. (2011)				*						*
Jahncke et al. (2011)		*				*		*		
Lottrup et al. (2013)				*						*
Evensen et al. (2013)	*				*		*			
Nieuwenhuis et al. (2014)	*				*					*
Brown et al. (2014)	*				*				*	

(continued)

Table 31.6 (continued)

Literature	Experimental approach				Delivery mode		Sample size			
	Field	Controlled laboratory	Virtual reality	Survey-based	Real	Virtual	Less than 20	20–50	51–100	Over 100
de Bloom et al. (2014)	*				*					*
Loder (2014)				*					*	
Lee et al. (2014)				*		*				*
Gilchrist et al. (2015)				*						*
Lottrup et al. (2015)				*						*
Evensen et al. (2015)		*			*				*	
Calogiuri et al. (2016)	*				*		*			
Bjornstad et al. (2016)				*						*
An et al. (2016)				*						*
Largo-Wight et al. (2016)		*				*		*		
Colley et al. (2016)				*			*			
Korpela et al. (2017a)				*						*
Largo-Wight et al. (2017)	*				*					*
McFarland (2017)				*						*
Korpela et al. (2017b)				*						*
Colley et al. (2017)				*						*
Ayuso Sanchez et al. (2018)		*			*		*			
Yin et al. (2018)		*	*		*	*		*		
Sianoja et al. (2018)				*						*
Hyvönen et al. (2018)				*						*
Yin et al. (2019)		*	*			*		*		
Sona et al. (2019)		*				*				*
Chulvi et al. (2020)	*	*			*	*	*			
Yin et al. (2020)		*	*			*			*	
Roskams and Haynes (2020)	*				*			*		
Chang et al. (2020)				*						*
Elsadek et al. (2020)	*				*			*		
Aduwo et al. (2021)				*				*		

(continued)

Table 31.6 (continued)

Literature	Experimental approach				Delivery mode		Sample size			
	Field	Controlled laboratory	Virtual reality	Survey-based	Real	Virtual	Less than 20	20–50	51–100	Over 100
Yeom et al. (2021)		*	*			*		*		
Aristizabal et al. (2021)		*			*	*		*		
Lei et al. (2022)				*						*
Yeom et al. (2022)		*	*			*		*		
Mihara et al. (2022)	*		*		*	*		*		
Lyu et al. (2022)		*	*			*		*		

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Analysis of Key Points in the Design of Hybrid Operating Room for the Future

32

Yaonan Ai, Yue Wu, and Shanshan Zhang

Abstract

Based on the trend of the development of hospital wisdom and the time-varying needs of future patient groups for personalized experiences, this paper combines domestic and international case studies of hybrid operating rooms and equipment manufacturers' data and uses a case study approach to summarize and refine the design elements of the intelligent application of hybrid operating rooms from the perspectives of function, environment, space, facilities and transmission, in order to provide ideas for the sustainable development of hybrid operating rooms. In turn, it will provide reference for the renovation and upgrading of existing general clean operating rooms in hospitals and the future construction of intelligent operating departments with hybrid operating rooms as the mainstay.

Keywords

Hybrid operating room · Key points of design · Patient-centered · Intelligence

32.1 Introduction

With the continuous development of 5G communication technology and artificial intelligence, the interactive experience and access to information are putting higher demands on the architectural space. On the one hand, the information age has changed the traditional hospital access model, with more and more consultation processes being replaced by electronic ones, allowing users to simplify the process of accessing medical treatment through mobile devices, while the corresponding architectural space of the hospital needs to be updated to match. On the other hand, with the demand for personalized patient care, the comfort and safety of the hospital space needs to be further enhanced to meet the requirements of different users while satisfying the medical treatment function (Deng 2021). In the context of both humanization and digitalization, medical buildings are gradually transforming into intelligent hospitals. The operating rooms, which are the main battleground for medical treatment, have also started to gradually transform into smart.

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32.1.1 History of Operating Room Development

The concept of the operating room originated in 1846, when a dentist in the USA performed surgery in a library under anesthetic (Du 2011). The operating room has slowly evolved since then, from simple operating rooms, decentralized operating rooms, centralized non-clean operating rooms and clean operating rooms to the fifth generation of digitally integrated operating rooms represented by hybrid operating rooms (see Fig. 32.1).

Although the simple operating room at the beginning was simple and performative, it really opened the prelude of surgical medicine. Due to the natural environment, the rate of infection was very high. And then operating rooms began to combine departmental and ward design, and a second generation of decentralized operating rooms emerged, with the French Universal Exhibition of 1937 as its landmark node. Centralized operating rooms began to appear in 1955, when the concept of central surgery began to emerge, but air purification laminar flow was not yet realized. The advent of the clean operating room in 1966 revolutionized the modern hospital, improving the medical environment in the operating room, reducing the risk of surgical infection and advancing the development of modern medicine. In the twenty-first century, with the advent of information technology, the development of imaging technology began to reach a new stage. In 2007, the birth of the fully functional complex operating room opened the door to digital health care.

32.1.2 Hybrid Operating Room

The hybrid operating room was proposed by the British academic Angelini in 1996 and first built in Monaco over 20 years ago, where doctors and engineers creatively assembled a contrast machine in a normal operating room, thus creating the prototype of a hybrid operating room. In 2007, Fuwai Hospital in Beijing built China's first hybrid operating room (Zhang and Luo 2015). Hybrid operating room is a new multi-disciplinary and combined treatment method, which refers to a new generation of digital operating room that combines multiple surgical functions such as surgery, interventional therapy and imaging examination (Wang 2012) (see Fig. 32.2). Unlike traditional clean operating rooms, the hybrid operating room minimizes intraoperative patient movement, allowing access to surgical information through the movement of multiple devices such as CT, MRI and DSA, in a sense achieving a truly 'patient-centered' approach. The hybrid operating room simplifies the procedural process and shortens the surgical cycle by switching and collaborating between devices, and the availability of real-time intraoperative patient data improves the efficiency of medical staff and enables 'smart' medicine (Bazzi et al. 2021).

The emergence of the hybrid operating room is an important exploration of the development of intelligent hospital surgery departments, which not only technically enables multiple surgeries to be performed in the same space, but also reduces the patient's medical treatment cycle and pain,

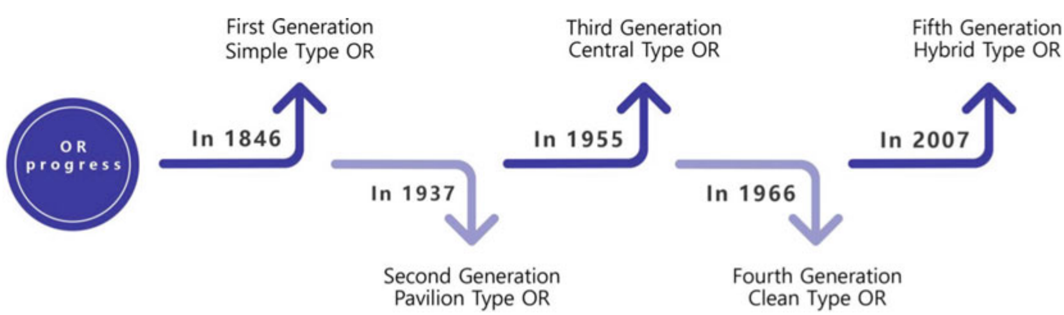

Fig. 32.1 Schematic diagram of the development of the operating room; OR: Operating room

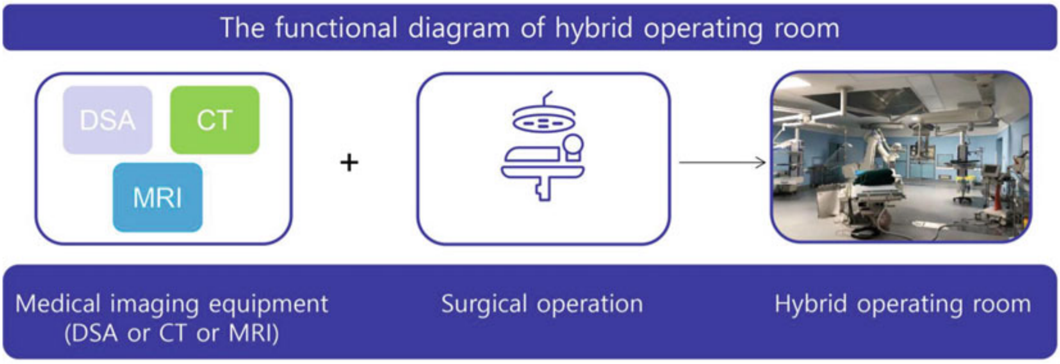

Fig. 32.2 Schematic diagram of the functions of a hybrid operating room; DSA: Digital subtraction angiography; CT: Computed tomography; MRI: Magnetic resonance imaging

and realizes a truly 'people-oriented' sustainable development idea. Due to its high cost and complex engineering skills, it has not yet been possible to design and assemble hospital surgical departments as a whole. Many old hospitals are facing the need to renovate and upgrade their clean operating rooms. Therefore, based on the construction cases of hybrid operating room at home and abroad, this paper summarizes the sustainable utilization strategy of hybrid operating room from the aspects of function, environment, space, facilities, transmission and so on, and puts forward the design key points.

32.2 Methods

The purpose of this study is to sort out the development context of hybrid operating room and the typical problems existing in the construction process of hospitals at home and abroad, so as to achieve the goal of patient-centered and sustainable development. In order to achieve the research goal, the case study method is chosen. Through the retrieval and analysis of the target cases, the common factors are extracted, and the effective factors are clustered to get the final design points. In order to conduct an effective case study (Yin 2003) according to this scheme, the following process was carried out in this study:

1. Identify and define the research question.
2. Selection of actual cases and cases of equipment producers.
3. Inductive extraction of effective strategies.
4. Propose design points.

Since case studies rely on collecting a large amount of information from multiple sources, this study combines cases from hospitals, equipment manufacturers and other cases to summarize the data cases collected, refine the analysis and identify the strategies that seem to be effective in each case. These commonalities were then combined into a set of possible strategies for future hybrid operating room projects to consider to improve their sustainability (Yong and Pearce 2013).

32.3 Results: Key Points of Design

32.3.1 Function Compound

32.3.1.1 Type Compound

A hybrid operating room, as the name implies, refers to the combination of surgical types, surgical and interventional procedures (Han and Zhang 2011). There are many types of hybrid operating rooms that have been built, which can be single-function composite, such as digital subtraction angiography (DSA) composite, magnetic resonance imaging (MRI) composite, computed tomography (CT) composite, or two, such as DSA + MRI, DSA + CT, or a combination of all three, DSA + MRI + CT (see Fig. 32.3).

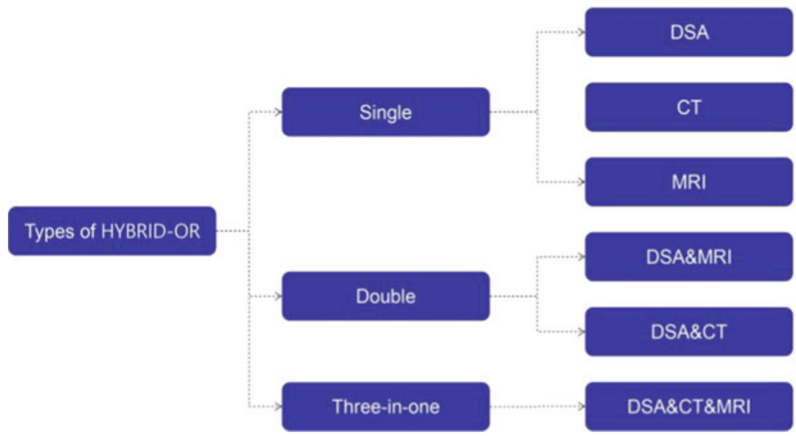

Fig. 32.3 Functional types of hybrid operating room

Hybrid operating rooms can be divided into single hybrid operating rooms and multiple hybrid operating rooms according to their functional types. As the hybrid operating room increases in function, the demand for space area also increases. Therefore, in the planning and construction stage, we should not blindly carry out large construction in order to pursue the diversity of functions of hybrid operating rooms. It should be combined with the needs of hospital departments and the number of patients, operating room operation data and other comprehensive consideration to choose a single hybrid operating room and a number of hybrid operating room combination form.

32.3.1.2 Process Compound

The hybrid operating room realizes the compound of medical process and reduces the secondary injury of patients, compared with the traditional hospital's multiple means of treatment, the hybrid operating room realizes the optimization of the process. The traditional mode of medical treatment from the primary hospital, first through the emergency vehicle into the hospital district emergency, followed by imaging, then surgery for rehabilitation, special cases may also be re-examined and secondary surgery, the process is more cumbersome and complex (see Fig. 32.4). The hybrid operating room simplifies and compounds the process, and through a more convenient mode of transportation, it is directly transferred from the primary hospital to the hybrid operating room of the higher level hospital, and the patient information network is synchronously transmitted over, and the surgical examination is completed within the same time, which saves the patient's treatment time and helps the patient's recovery. As the construction of hybrid operating rooms continues to increase, its application mode is also gradually diversified, whether in any part of the medical treatment of emergency, imaging or pre-surgery, can be directly transferred to the hybrid operating room of the higher level hospital, to a certain extent, to achieve the synergy of medical treatment between different medical institutions. At present, many institutions in China have already realized the compounded treatment plan of the process, and in the future, with the further development of 5G technology, it will be possible to realize cross-regional medical interaction on a larger scale.

32.3.1.3 Spatial Compound

In addition to function, the use of space should also be considered. There are two main models: a shared machine room and a shared operating room, equipment room and other auxiliary space. The first is the type of shared machine room; CT and MRI are generally considered to be stored separately in the design process of a hybrid operating room, as the examination equipment is large and requires a certain amount of space, and there are separate requirements for protection technology. In addition, the cost of CT, MRI and

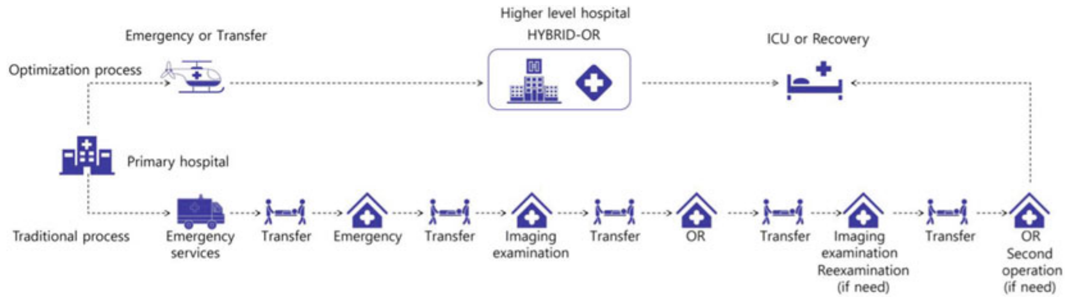

Fig. 32.4 Comparison of access patterns between the hybrid operating room and the general operating room

other equipment is high, so when the hybrid operating room is built in the hospital, it can be considered that two operating rooms share one machine, which not only saves the cost, but also meets the requirements of composite function. In terms of plan layout, the main design is the sharing of a machine room in the middle of two operating rooms (see Fig. 32.5a). The size requirements of the shared machine room are different, according to the manufacturer's equipment requirements, the size of the MRI room is generally about 40 m^2, and the size of the CT room is at least $30m^2$, taking into account the movement of the beds should be appropriate to increase the area of the room. And when the middle space is relatively limited, or when facing the transformation and upgrading of ordinary clean operating rooms, the middle space is not allowed, a similar triangle-like layout scheme can also be used to achieve the purpose of two rooms sharing one machine room (see Fig. 32.5b).

The combination of similar space units and shared surgical support space is more commonly used in hospitals. Generally more common in China is the design of shared control rooms, where two side-by-side hybrid operating rooms share a common control room (see Fig. 32.5c), while foreign countries are more worthy of our reference and study in terms of the composite use of operating rooms. For example, the design of the intraoperative imaging surgical area at Jacobs Medical Center, University of California, San Diego, has designed the hybrid operating rooms into separate areas to facilitate unified management and maintenance. The same control room manages the operational use of the four operating rooms. This treatment is also used at the Chiba West General Hospital in Japan, where the operation of surrounding operating rooms is regulated through a centralized control room, a new way of thinking about the intensification of operating rooms. This approach requires a larger area and should be used in the planning and design phase of the operating department for a reasonable partitioning of space. Of course, this way of arranging surgery not only increases the compound use of space, but also facilitates the functional partitioning between different types of operating rooms, which is a good reference for the intelligent transformation of hospital operating departments.

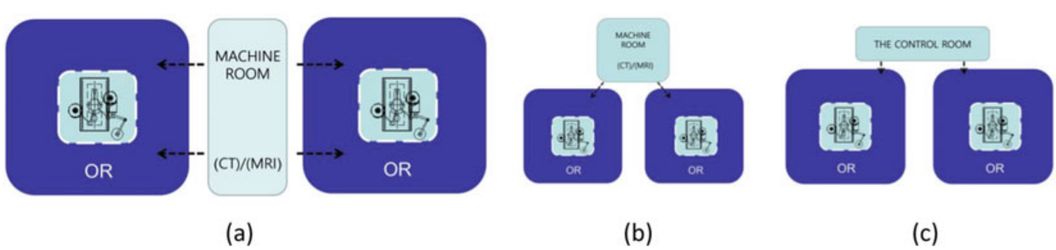

Fig. 32.5 **a** Composite use of space(1); **b** composite use of space(2); **c** composite use of space(3)

From the point of view of the hybrid operating room, it is necessary to make full use of the spacing of the axial network of the frame to meet the needs of different spaces such as equipment rooms, control rooms, magnet rooms and operating rooms, to achieve an organic combination of functional units and to maximize the use of space. At the same time, as far as possible, flexible space is reserved in each functional unit to provide the possibility of space carriers for the introduction and design of intelligent surgical robots in the future.

32.3.2 Variable Environment

The operating room is not an easy place to achieve decorative elements due to its requirements for cleanliness. But the operating room is not only a space for medical treatment, it is also a space where doctors work for long periods of time, and its environmental elements play an important role in the emotional regulation of medical staff and the adjustment of their working conditions. For some semi-anesthetic operations, appropriate environmental elements can also calm the patient's nerves and facilitate the operation.

At present, the walls and ceilings of hybrid operating rooms, without the necessary equipment, are the spatial carriers of environmental variability. And with the advancement of technology, artistic wall coverings are more often used in hybrid operating rooms. The unified installation of modular glass allows for the unified customization of patterns at the manufacturer to meet the individual needs of different hospitals. In addition to the single solid color background of the operating room, the addition of new elements of environmental pattern has a role in regulating the mood of the medical staff in the operating room. On the walls other than those integrated with equipment, large plants, landscapes or logo patterns can be selected for decoration to change the ambience of the operating room, so that doctors can properly relieve visual psychological fatigue after work.

Moreover, with the integration of systematic design, the different users of the facilities have new demands on the healthcare environment. Different groups such as children and the elderly have different needs for the environment. In the future, it will be possible to combine different hospital features and customize different operating room themes to achieve diversity in the environment and change the single working space for healthcare workers. An example of this is the different themes used to decorate the Tottori University Hospital in Japan, using a unified theme with elements such as the Sea of Japan and the desert mountains (Luo 2020) (see Fig. 32.6).

The visual environment does not only refer to the walls and other interfaces that surround the operating room, but healthy lighting in the operating room also plays an important role in the emotional regulation of patients and healthcare professionals. The practice of Hao et al. (2015) at Tongji University in Shanghai has shown that adding LED ambient light sources to areas such as ceilings has a positive effect on the emotional

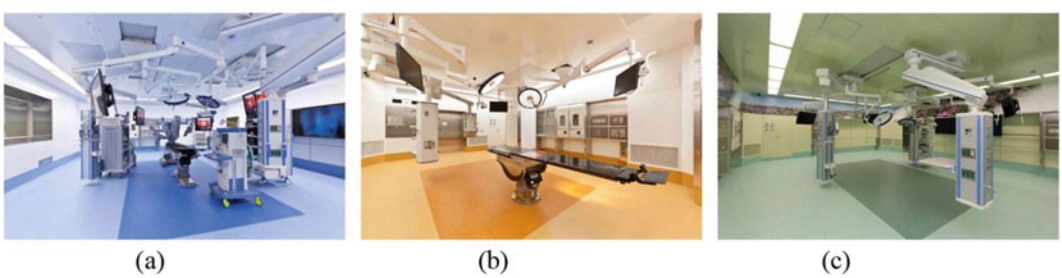

Fig. 32.6 **a** Sea of Japan theme operating room at Tottori University Hospital, Japan; **b** desert theme operating room at Tottori University Hospital, Japan; **c** mountain theme operating room at Tottori University Hospital, Japan (Luo 2020; reprinted with permission ©2020 Cnki)

regulation of patients and doctors. In the face of different groups, the lighting of LED light sources can be intelligently adjusted to choose different colors, patterns, illumination levels, etc., which can eliminate patients' uneasiness. At the same time, different themes of decoration will be combined with communication technology in the future to increase the characteristics of sensory knowledge, adjusting to the facial expressions and physiological indicators of the patient or doctor, and combining machine learning for human–machine interaction design to increase the characteristics of personalization.

32.3.3 Modular Space

The modular design of the space is mainly reflected in the design of mobile modules for the walls based on the variability of the space. The modules, which can be disassembled at will, enable the sustainability of the operating room. Traditional operating rooms cannot be changed after design. The modular operating room can be modified at any time. The modular operating room has a concave wall design, which enhances the efficiency of wall utilization. The usable area of the room is increased significantly and the variability of the space is enhanced. The equipment modules in the room can be moved on different walls as needed, and the equipment modules can be updated and replaced at any time according to the different needs of surgical functions, providing the possibility of upgrading the equipment in the operating room, which is realized in the following steps (see Fig. 32.7).

The modular design of the space is achieved by a high degree of integration in its construction design. The essence of this is in the design of prefabricated assembled designs for walls, ceilings, lighting and equipment ducting. The individual subsystems are designed and manufactured by different manufacturers, with uniform design and coordination of dimensional specifications, enabling standardized modular production, reducing costs, facilitating the refurbishment and maintenance of the operating rooms and enabling assembly in a relatively short time. At the same time, the modular and customized design of the space can also meet the needs of the current epidemic outbreak phase and the possibility of medical space for the emergency treatment of health emergencies.

32.3.4 Facility Assembly

The assembling of the facility is reflected in the integrated design of the entire hybrid operating room subsystems. The realization of the entire equipping has been continued from the design stage to the final construction operation, presenting the continuity of the system. In the design stage, the hybrid operating room, due to the multifaceted complexity of its spatial structure, the crane tower, shadowless lamp, laminar flow and other systems need to be pre-assembled and designed, and the positioning of equipment

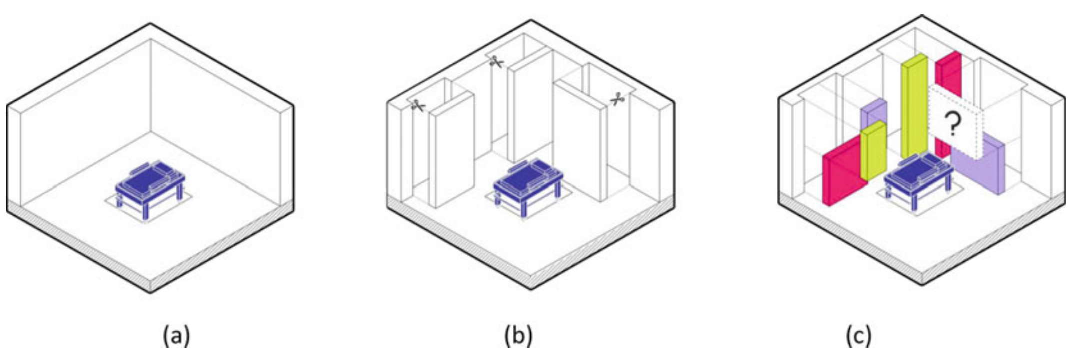

Fig. 32.7 **a** Original space; **b** removal of non-essential enclosing space to form an alcove; **c** Equipment module placement, allowing room for development

inevitably leads to crossover and collision problems. Through BIM information system modeling, it can more intuitively show the problems existing in the drawings, including the collision problems between different specialties, problems that do not meet the requirements of national and local codes, etc. The application of BIM technology can also carry out the analysis of the net space of the operating room, the analysis of the three-dimensional section construction of important nodes, the optimization of the division of decorative walls, the comprehensive optimization of electromechanical pipelines, etc. The informationization of BIM stage model, also can carry out the volume of work statistics, can intuitively understand the cost differences between different programs, for the overall control of the project more favorable.

During the construction stage, after the modular panels are cut and made by the factory, they are delivered to the site, and the staff will install them in order according to the BIM model, and all the installations do not require welding, which makes the construction easy. The whole construction process is less polluting to the environment and does not affect the design and use of other surrounding operating rooms. And there is less noise and dust. The assembled medical model integrates a number of compound projects such as medical equipment, construction engineering and medical information engineering, which are issued at the same time and designed in an integrated manner to ensure the coordinated operation of each system. The construction process can realize the requirement of no secondary processing at the site, which greatly reduces the use of workers, reduces the risk of engineering accidents at the construction site, shortens the time of on-site construction, and is of great significance for the renovation and upgrading of some operating rooms in hospitals.

32.3.5 Transmit Information

The hybrid operating room emphasizes real-time sharing of information, thus realizing the informatization of transmission, effectively breaking through traditional operating room information silos and other problems, and improving overall surgical efficiency. From a spatial point of view, it mainly refers to two parts, one is the interior of the operating room, where the surgeon needs to obtain real-time imaging data, patient physiological indicators, vital signs detection and other data during surgery, and deal with the real-time and stable transmission of information to ensure the surgeon's choice of access; the other is the exterior of the operating room, which mainly includes surgical teaching, telemedicine, consultation and so on (Yang et al. 2015). Through the real-time sharing of information inside and outside the operating room, teaching, consultation and remote online coordination of treatment can be achieved, further realizing the sharing of medical resources across regions (Davis et al. 2022) (see Fig. 32.8). In order to achieve this technology, 5G cloud computing services are essential to support the linkage of equipment and controls within the hospital. 5G cloud computing can be used to achieve faster information transmission and ensure rapid information processing and feedback.

In terms of time flow, the information transmission of hybridized operating room mainly refers to the acquisition and analysis of image data in three stages: preoperative, intraoperative and post-operative. The informatization of surgery mainly refers to the application of information technology throughout the process. Preoperatively, with the help of machine learning and other technologies, the planning and simulation of surgery is carried out, and the main surgical team performs centralized access to patient information and designs and plans the surgical plan. During the intraoperative stage, information switching of video can be completed quickly to assist doctors in completing surgical operations, while using 5G cloud computing technology to realize the possibility of simultaneous live broadcast of information on the surgical process, telemedicine assistance, director expert guidance and family contact interaction. At the same time, the nurse station within the hospital area, the information platform carries out monitoring of surgical information and ensures coordinated information control between

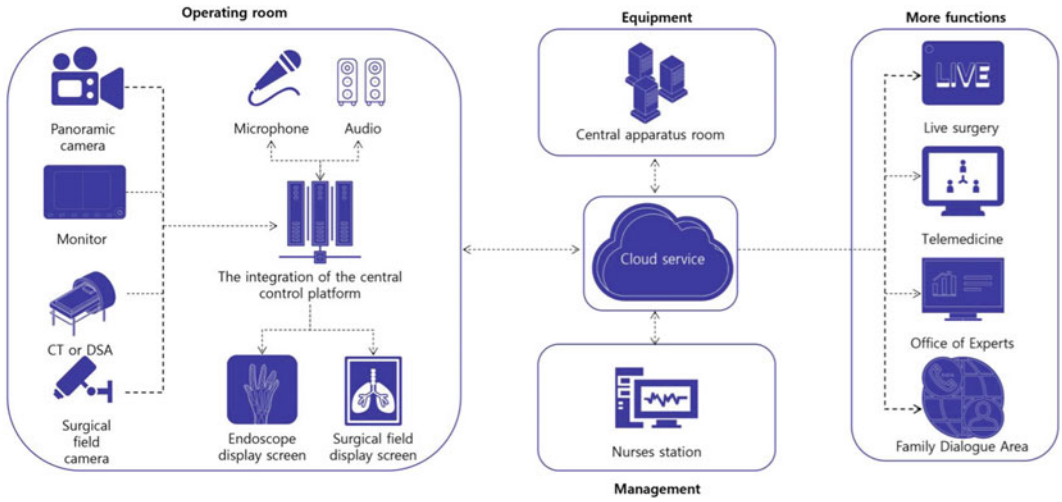

Fig. 32.8 Diagram of digital information transmission in the operating room

surgeries. In the post-operative stage, the digital platform is used to obtain and analyze the surgical information, and the relevant experts perform editing and editing to meet the functional requirements of storage and teaching of surgical data (Koizumi et al. 2021).

32.4 Discussion

This study analyzes and refines the design points of a future-oriented hybrid operating room through information such as completed cases in China and abroad and product introductions of equipment manufacturers. When conducting this study, it was difficult to obtain data from the operation and maintenance phase of the hybrid operating room, so it was difficult to extend the findings throughout the entire project life cycle. This study will be applied primarily to the planning and design phase of the project. Also, the design points identified in this study are mainly from an architectural perspective and do not cover all specialties to form a comprehensive set of recommendations.

In response to the wisdom of medical subject, future research contains the wisdom of the hybrid operating room as the main body of surgical department of construction, will further expand the research scope, into more case studies. Future research will further cooperate with medical institutions and equipment manufacturers to obtain a number of data including user satisfaction, operation time cycle, investment cost and so on. These data will further improve the level and direction of intelligent hospital construction.

32.5 Conclusion

This study distils five design points from an architectural perspective: function, environment, modules, facilities and transmission. The planning summarizes the requirements necessary for the construction of a hybrid operating room, which can be applied to update the development of today's operating rooms.

Looking into the future development of hybrid operating rooms, the application of ‘digital twin’ technology combined with artificial intelligence technology may become an important highlight. The digital twin is a virtual carrier that maps the lesion through VR technology to provide accurate feedback on the cause of the disease, increasing the treatment effect and reducing complications. At the same time, the virtual carrier of the digital twin can combine with the patient's personal case to carry out algorithmic self-learning, simulating and predicting the possibility of future illness of the body, and escorting the patient's personal health. Future digital development, 5G+ artificial intelligence, part of the surgery by robot-assisted completion, can achieve a number of functions such as reducing intraoperative radiation for healthcare workers, achieving telemedicine rescue and treatment for patients with new coronary infections alone, which has a significant impact on the sustainable development of medical treatment. The integration of humanization measures into the construction of hybrid operating rooms has revolutionized traditional medicine by shifting the center of work in the operating room to the patient rather than simply pointing to surgery (Liang 2007).

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Facing up to the UK's Food Crisis—A Design Exploration of the Self-Sufficient City for Resilience and Food Security

Jiayi Jin and Mingyu Zhu

Abstract

The increasing population and the aggregation of people in dense urban pockets add to the pressures on already complex and volatile global systems (WFP in Global food crisis, 2022). Food supply systems need to adapt and be resilient to not only natural phenomena such as climate change or the post COVID-19 crisis, but also in resistance to socioeconomic and geopolitical disturbances. The dependency of urban populations on external food systems makes these populations vulnerable to systemic breakdowns. This research looks at the looming food shortage in the UK (Bancroft in UK is 'sleepwalking' towards food shortages, farmers warn | The Independent in 2022), authors investigate design strategies for creating a more sustainable agrarian urbanism, which includes three classic urban utopias: Frank Llyod Wright's Broadacre City, Kisho Kurokawa's Agricultural City and MVRDV's Pig City. Three case studies provide ideas and notions of creating a self-sufficient city in the post-colonial era of the UK. The design hypothesis responds to the increasing pressure from population and consumption growth, and the decreasing farming land and food suppliers. The final resolved urban farming system is based on existing conditions such as waste flows and underused spaces, it adopts novel design strategies and interacts with different elements of self-sufficiency to generate a network of farms with highly dense, multi-level structures.

Keywords

Self-sufficient city · Post-colonial · Food shortage · Urban farm · Resilience city · Sustainability

33.1 Prologue: The Hungry Empire

The British East India Company was in business for 282 years (Bowen 2005). At its colonial peak with the North Sea as Britain's new passage to the world, the Empire had occupied approximately one-quarter of the world's land surface and governed around one-fifth of its population (Lloyd 1984). During this time, raw materials and other resources were expeditiously harvested from the land through the labour of indigenous people and valuable components were then shipped to Europe for processing and consumption. In the current age of economic colonisation one can observe similar trends. In 2015, amongst

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the total UK imports from non-EU countries, 123 million kilograms were of tea alone (ONS 2016). The UK imports almost 6 million tons of fresh produce annually, of which around 3.5 million tonnes are fresh fruits and almost 2 million tonnes of fresh vegetables. One in three imported fruits comes from South America—particularly Costa Rica, Colombia and Dominican Republic, while Asian and African countries contribute almost 25% of the fresh imports (ONS 2016).

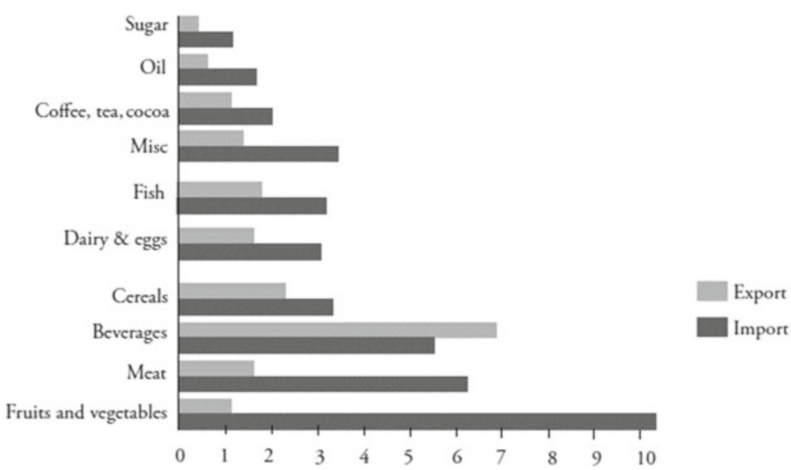
The UK leaving the EU and the subsequent transition period, along with the impact of the coronavirus (COVID-19) pandemic, global recession and supply chain disruption, have caused higher levels of volatility in trade statistics in the past two years (ONS 2022). In the meanwhile, British farms are reducing production to deal with the increased prices, fertiliser prices broke new records last month due to global factors including reduced supplies from Russia, disruptions to the supply chain, and a Chinese export ban. UK is "sleepwalking into food shortages" because of the rising costs of fuel, fertiliser and feed (Bancroft 2022). In 2021, almost half of the UK's food and feed along with two-thirds of the total land needed for its production is based abroad (GOV.UK 2021) with 84% of fruit and 46% of vegetables eaten in the UK imported as shown in Fig. 33.1, these vital food groups are particularly vulnerable to supply crises (GOV.UK 2021).

The UK's need for global trade autonomy as it departs from the EU, paint an even grimmer picture of a sustainable global future as it puts more pressure on its African, Asian and South American markets to gratify its food demands. In the meantime, the food crisis is a global issue, there is no guarantee that these agricultural exporters will forever cover the shortage. As the World Food Programme states, acute food insecurity now affects 345 million people in 82 nations, up from 135 million in 53 countries before the pandemic increase occurred in just two years (WFP 2022). Conflict, climatic shocks and COVID-19 are all contributing to the crisis escalation as the war in Ukraine raises the price of food, fuel and fertiliser. This increasing dependence on external resources to meet its demand for food is not only displacing the environmental impacts to other countries but also entrenching a deep rift in global production and distribution practices, particularly in countries that face severe food and resource shortages (WFP 2022). This can be read as a contemporary portrait of the unashamed exploitation of its colonial past, when the idea of economic progress was built at the cost of others.

33.2 The History of Shipping of the North Sea

Over several centuries, the North Sea has played a pivotal role in shaping the modern world and its civilisation. Since the 'discovery' of the new world in 1492, its vast expanse has embodied and

Fig. 33.1 UK food export versus import. *Source* Gov. UK, drawn by author



encouraged new forms of art, science, religion, architecture and other significant institutions. This was crucial in establishing a new socioeconomic and political world order which provided the structural geopolitical space for Northwestern Europe to develop in a capitalist direction. This became the very foundation for Britain's subsequent global ascendancy in the industrial era (Anievas and Nisancioglu 2017).

Trade and exploitation of resources in the new colonies became the understructure of the empire. As Britain moved to an industrial economy that focused mainly on manufacturing, the agrarian economies of its colonies suffered. Raw materials and other resources were expeditiously harvested from their land through the labour of indigenous people and valuable components were then shipped to Europe for processing and consumption taking away any profits that rightfully belonged to them. The tropical weather conditions and the nature of the land and soil in these colonies created the foundations for a global industrial economy that flourished by trading a range of raw materials from—textiles: cotton, jute and silk (India), to essential commodities: sugar, spices, rice, oil, tea and coffee (Africa, India and Ceylon) and precious stones: gold and diamonds (Africa) (Woodward 1902). In fact, the demand for 'exotic' tropical products like—sugar, whole spices and condiments became the very foundation for the practice of slavery and indentured labour in the new world.

Food was not just an adjunct to the British imperial might but fundamental to it (Collingham 2017). Even today, UK's relationship with its former colonies is very much necessitated by its increasing food demands. A recent government of UK survey depicts this increasing dependency on its overseas market (GOV.UK 2021), by comparing the high import values of what have today become the most basic commodities (sugar, oils, coffee, tea, fruits and vegetables) with its insufficient export returns. The UK is just 18% self-sufficient in fruit and 55% in fresh veg—the latter declining 16% in the past two decades. The production capacity is so small that food foundation analysis shows if everyone in the UK tried to eat their 5 a day from our current yield, the country would fall short by 2.1 million tonnes annually (Sandercock 2021). India, Ghana, South Africa, Australia, New Zealand continue to be UK's biggest import markets till today. Until now, imports have easily made up any shortfall, but as Brexit and climate change threaten to wreak havoc on the norm, experts are warning that greater self-sufficiency will be crucial.

The evolution of the role of the North Sea from an unfamiliar territory—the paradoxical land of the sea monsters that could not be conquered to a new land with its own laws, boundaries and infrastructure had a key role in the longevity of the British colonial empire. The proximity to the sea was paramount for the creation of a decentralised empire and a system of highly advanced maritime logistics. This adjacency for many years has encouraged the globalisation of trade and the continued success of a decentralised system of food production, manufacturing, trade and profits. The decentralisation has irreversibly altered the modes of living and consumption and led to a disproportionate increase in food demands in the UK. Much like the colonial trade that lasted over three centuries, the British food market even today is driven by its demand for 'exotic' tropical food.

33.2.1 The Empire and the City: The Flow of Change

Although the globalisation of traded goods long preceded the industrial era, industrialisation really reshaped whole societies and cities (Clark 2016). By 1815, over 2000 miles of canals were in use in Britain carrying thousands of tonnes of raw materials and manufactured goods (White 2009). Owing to the invention of steam technology in the 1700s, the availability of constant power supply made it possible to establish large-scale mills, factories and gas stations. A surplus of cheap agricultural labour from the colonies led to severe unemployment and poverty in the rural areas of the UK forcing them to migrate to these new port towns and cities in search of full-time employment, paving the way for a large-scale labour-intensive factory system. New technologies in road construction and building further facilitated the connectivity between the newly constructed factories, mines and cities. The introduction of these new urban typologies permanently altered the fabric of the city and marked the beginning of a new system of land use and ownership. Industrial housing (workshop dwellings) is perhaps one of the most appropriate examples to explain this change within the cities. While large-scale mills and factories were located near the river or the coast for easy access to goods, raw materials and other resources, several small-scale privately owned industries arose in dense neighbourhoods. Apart from the considerable privatisation of land, the introduction of railways began redefining the rural edges creating clear lines of segregation and connection at the same time.

An interesting development during this time was the evolution of the rural. The rural areas of England not only went through drastic changes in land use but also in land division and ownership. It evolved through two major forms of ownership, the open field system: this system allowed the arrangement of agricultural land into scattered strips that were communally regulated but privately owned. The scattering of strips of fields over 2–3 large, unfenced fields encouraged common grazing which consecutively needed common decisions on crop types, planting and harvesting schedules. The land, labour and capital were completely private only the regulations on land use and grazing were collective (McCloskey 1991). This system was superseded by 'The enclosures act' which was in existence since the twelfth century but only gained momentum during eighteenth-century Industrialisation. The act allowed the enclosure of open fields and common land creating legal property rights to land that was previously regulated collectively. This eventually led to the privatisation of arable land either by landlords or by rich farmers and completely annihilated small-scale farms. The insufficient compensation that these small farmers got in return forced them to leave the countryside and look for alternate job opportunities which worked perfectly for the industrial city that required a pool of cheap labour that could help in the functioning of the newly constructed factories and mills (Fairlie 2009).

> The enclosure of the 'commons' along with free trade and importing of food and commodities from its colonies via the North Sea played a very important role in creating a highly urbanized economy that dispossessed a large urban proletariat from the countryside and led to the decline of the small farmers
> Simon Fairlie, 2009

Meanwhile, the regulated control of arable land allowed private owners to make innovations that improved the yield of crops and create a surplus of food that was enough to feed the growing population. Weekly agricultural and livestock markets became more popular, and consumers not only had access to local goods but a variety of goods that were imported from the British colonies. Many of these imports originated in the expanding plantations in Africa, South America and Caribbean where merchants were heavily dependent on African and Indian slaves as their primary source of labour (White 2009).

The proximity to the North Sea not only facilitated decentralised production and manufacturing but also it completely altered the urban form of the city and created new social hierarchies within communities. The industrialisation of cities gave new meaning to both land and sea. The land was no longer only a space of production, it became a commodity and a means of progress and survival in the industrial era. The arbitrary privatisation of land could have been directly responsible for the depopulation of the rural and the decline of small farmers. The enclosure of the 'commons' along with free trade and importing of food and commodities from its colonies via the North Sea played a very important role in creating a highly urbanised economy that dispossessed a large urban proletariat from the countryside, concentrated landownerships and encouraged the creation and privatisation of farms far larger than any country in Europe (Fairlie 2009). Such a system not only disturbs social equity it also prioritises capital gain over sustenance. In the post-Brexit UK, this could prove to be a very unsustainable solution for a future that needs to be more equitable, responsive and most importantly self-sufficient.

33.3 Measuring the Sustainability of the UK Food System

33.3.1 UK Population Versus Self-Sufficiency

Leaving the EU ended the UK's membership of the Single Market and Customs Union, and that indicates a need for exclusive trade privileges. In the context of trade, two main issues are of utmost concern: (1) The British farming industry's dependence on the EU's common agricultural policy (CAP) subsidies and standards which after Brexit will necessitate major restructuring and reforms and (2) The British food industry's increasing dependence on its import-based market which will pave the way for major agricultural reforms post UK's exit from EU (Marshall 2022). Previously, UK had several large independently owned factory farms and estates that alone receive 500,000 pounds or more from the EU annually from 2016 to 2019 (Coe 2020). This is perhaps one of the reasons for UK's increasing dependence on its import market as the subsidy-driven farming industry favours a product that allows more monetary benefits without making any effort to ensure the maximum and efficient utilisation of available land. Furthermore, agricultural farming in the UK is not a lucrative profession as farmers currently earn more from the EU subsidies than from their farm business. The situation will only exacerbate in the coming years with UK's exit from EU and the increasing food demands that will come with the increasing population. Necessary reforms must be introduced in the near future to tackle farm subsidies, ensuring maximum per hectare yield and maintaining a balanced demand and supply.

UK's self-sufficiency rate has insidiously declined over the past 30 years from 78% to the current 60% (with just 18% self-sufficient in fruit and 55% in fresh veg—the latter declining 16% in the past two decades) (Department for Environment Food and Rural Affairs 2022) and it has been constantly trying to replace this steady erosion in the farming industry with food imports (Sandercock 2021). Over the years, this has had dangerous impacts not only on the farming industry in the UK but also on its biggest import markets because of the increasing competition for agricultural products, climatic events, land degradation and the disbalance in the demand versus supply ratio.

As discussed, the shift from the open field system to the enclosure system has had adverse impacts on small farmers and led to concentrated land ownership. The lack of a system to measure and/or reward efficiency in productivity and crop yields has allowed the large farms to be sold/rented for commercial use leading to a gross misuse of valuable arable land. Any reforms in the subsidies for large-scale individual landowners and factory farms by the EU have been met with strong opposition and lobbying. In many ways, the re-appropriation of land boundaries and the abolition of the more impartial open field system has directly resulted in years of unfavourable lobbying and gradually reduced the productivity due to excessive commercialisation and dependency on subsidies. The NFU has also predicted that at the current productivity rate the UK's self-sufficiency will drop to as low as 47.2% by 2080 (see Fig. 33.2). If necessary, reforms especially with respect to land re-distribution and productivity are not made soon the pressure on UK's

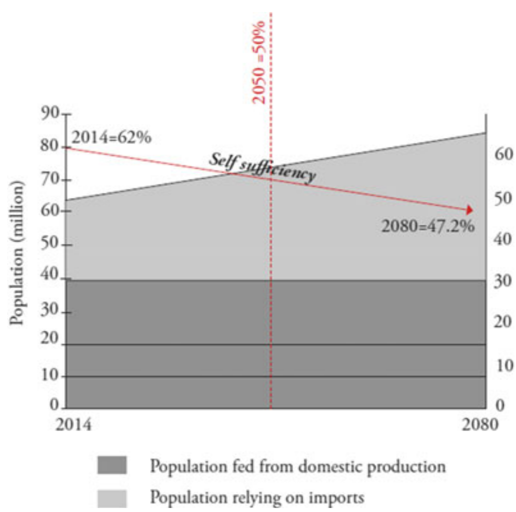


Fig. 33.2 UK population versus self-sufficiency. *Source* NFU 2021 report 'Levelling up rural Britain'

former colonies that till today are its biggest import markets to produce enough to meet its food demands will increase more.

In the meanwhile, with the population growth, a recent campaign to protect rural England (CPRE) report indicated that almost 55% of UK's rural countryside is at a risk of urbanisation (Burchardt et al. 2020). While most of this land has been earmarked for future housing, large developments and infrastructure projects have also been proposed. A majority of agricultural production and farming also happens within this rural countryside which means its newly imposed unprotected status could have direct implications on UK's food supply. For an industry that is anticipated to suffer from a shortage of investments due to the lack of sufficient subsidies post-Brexit, redevelopment of arable land will prove to be catastrophic.

33.3.2 Climate Risk and Land Availability of UK Suppliers

Since the food supply in the UK is heavily import dependent, the availability of food will be directly affected by both the loss of land and environmental risks in the UK as well as in its supplying countries. While the highest concentration of arable land in the UK lies in the eastern and south-eastern midlands, most of this land is also at risk of heavy fluvial and coastal flooding, presently many dense urban areas also lie within this zone (Sandercock 2021). Furthermore, as discussed in the previous section, the fact that this available rural land will also play a significant role in accommodating future housing makes flood risk assessment, management and rehabilitation a necessary prerequisite for continued productivity and any future large-scale planning.

The past several years have also seen a gradual decrease in domestic land used for food and feed within the UK. According to a recent study done on the impacts of UK food supply on the global croplands, the UK imports over 50% of its food and feed, whereas 70 and 64% of the associated cropland and greenhouse gas emissions (GHGE) are located abroad (de Ruiter et al. 2016). In many ways, the UK's food trade still has a colonial understructure as it continues to rely on the flow of goods and raw materials from its high-yielding import markets. In this context, while the UK makes significant contributions towards consumption-based CO_2 emissions, it simultaneously displaces the production-based emissions to its former colonies. This not only leads to the degradation of valuable productive land but also has significant impacts on the quality and accessibility of water resources within these countries. Another major factor to take into consideration is the projected population growth in UK's supplying countries. In many of these countries for example—India and Indonesia the population is expected to grow to an approximately 150% (UN 2020), so there is no promise that this reliance is sustainable (Table 33.1).

> The current ecological footprint analysis of the UK's supplying countries indicates that the projected population growth combined with the present food and lifestyle trends will result in almost 70% of the supplying countries to experience land deficits with 63% of the major suppliers facing cropland or pastureland deficit and 37% experiencing fishing ground deficit (See Table 01).
> UK Food Security Report, 2021

These given figures clearly reveal UK's continued dependency on its former colonies and can be seen as a result of several years of colonial trade. This modern-day version of globalised colonial trade has had significant impacts on the cropland availability and depletion of resources globally. While UK's industrialisation marked a clear shift from its agrarian economy to one based on manufacturing, the same cannot be said for its colonies. Its supplying countries had to struggle with rampant, uncontrolled industrialisation which was a result of their urgent need to participate in the global economy and recover from the loss of years of colonial exploitation, while ensuring the survival of their agrarian industry. Furthermore, presently laws are structured in such a way that it encourages the UK to

Table 33.1 UK suppliers land deficits/surplus, based on the UK Food Security Report, 2021

Supplier	Cropland	Pastureland	Fishing ground
Argentina	28	9	156
Australia	18	−52	203
China	−7	−28	63
India	−74	−24	69
Indonesia	−13	−30	127
Spain	−8	−5	−57
Thailand	0.3	−0.2	−11

import land and greenhouse gas emissions (GHGE) intensive commodities from its former colonies while importing on an average low resource intensive products. There is also a steady decrease in domestic land used for food and feed including the amount of domestic cropland within the UK used for exports, which suggests that the increase in food imports could be a result of the actual displacement of cropland and not because of an increase in food demands. Considering UK's decision to leave the EU market, the pressure on other non-EU countries including Britain's former colonies to meet UK's food demands will further increase (van Berkum et al. 2016). A recent data retrieved from the 2022 Key Economic Indicators has supported this claim, and it shows UK exports fell by 3.3% in cash terms over this period while imports further increased by 11.9% in the year of 2022 (Jozepa 2022). With the looming threat of the Ukraine war on the world's food supply, the UK may step back to 'The Hungry Empire' as Lizzie Collingham described in her book (Collingham 2017).

33.4 Utopian Ideas for Sustainable Food Cities

UK's shift from an agrarian economy combined with maritime logistics gave birth to a system of decentralised mass production that consequently changed the lifestyle of its people and continues to dictate their patterns of consumption till today. The era was especially crucial in allowing the creation of companies that acted as individual sovereigns protected by feudal law but generally free to act (Deamer 2015) which subsequently brought the rise of the urban (industrialised city). This shift could not have happened without two critical changes: (1) the progressive privatisation of productive land that authorised its repurposing and (2) the subsequent decline of the rural that was instrumental in providing competitive labour for the new industries. UK's food insufficiency cannot be solved only by increased productivity; the problem is manifold. This design thesis was not trying to tackle all aspects of this problem, instead, the authors believe creating a Utopian narrative and images that can offer a transformative power beyond apparent possibilities, and provoke alternative paths that might be worth pursuing (Ganjavie 2012; Sargisson 2012; Pinder 2013). In short, Utopias invite to rethink places to respond to wicked problems and tackle long-term crises.

For many years, architects, urbanists and theorists alike have tried to challenge the idea of this post-colonial city, either by creating their own versions of a new rural or by reimagining the existing urban (Deamer 2015). A crucial matter of contention in these projects has been that of individual choice and freedom. Many Utopian ideas for the new rural interpreted this choice via a democratic spatial rearrangement of the rural in the form of a systematic sprawl that can provide an abundance of choices that were otherwise absent or difficult to access in the city, for example—Wright's Broadacre City. In doing so, these exemplars were able to provide a more sustainable as well as economical alternative for the use and building of the various elements of the city (roads, pipes, housing, etc.) that allowed the system of individually owned low-density sprawl to be more affordable. By overlapping systems of production and living, these projects were also able to build a strong critique against private ownership, exploitation and unfairness, conspicuous consumption and accumulation of wealth (Waldheim 2010). In contemporary theory, similar concepts can be seen in Andrea Branzi's Agronica and reinterpreted through MVRDV's research on densities and reimagined cities. Both examples take the idea of the concept for a new city a step further by proposing what one calls 'weak urbanism' and the other calls 'lite urbanism' They talk about a system of flexible sprawl with its own logic and logistics, one that can accommodate change with such agility that parts of it can be completely redesigned with change in urbanistic goals and within a relatively short time (Maas et al. 2006).

As mentioned, the main aim of this research is to propose a new interpretation of self-sufficient city that will respond to the rapidly deteriorating food crisis, which is based on the previous research and adopted the theoretical knowledge gained from the various approaches to agrarianism. Before proceeding with the design aspect, the project has selected and investigated novel approaches to agrarian urbanism via three classic urban Utopian projects: Frank Llyod Wright's Broadacre City, Kisho Kurokawa's Agricultural City and MVRDV's Pig city (see Fig. 33.3).

Wright's vision for Broadacre City puts forward two main assumptions that are central to the discourse of agrarianism—(1) Cities will continue to be decentralised and (2) Landscape would become the primary medium of urban form (Waldheim 2010). Taking these assumptions into consideration Wright proposed a network of territorial urban infrastructures that would establish new relationships between the existing natural environment and the post-industrial landscape that is currently occupying the rural. Fundamental to the logic of the city was the concept of democracy.

The project visualises the new rural city with a physical and social arrangement that embodies and reinforces the ideals of a democratic city where each resident has an abundance of living and occupational choices. With the Jeffersonian Grid as its principal ordering system, the project was able to divide the unbound landscape of the rural into various private gardens, small farms, housing blocks, civic services, etc. Each resident was given the smallest available unit of land within the Broadacre grid which is 1 acre in this case to be built on and cultivated by the owner. (Waldheim 2010) The overall pattern of the city was also interspersed with several small- and large-scale industries and public services. Although the vision for a democratic city is such a needed and relevant matter of contention in the urbanism discourse till today, the implications of such a proposal might be questionable

Fig. 33.3 (Left) Broadacre City masterplan, Frank Lloyd Wright, 1935; (Middle) Agricultural City, Kisho Kurokawa, 1960; (Right) Pig City, MVRDV, 2001

considering that we are now moving towards a future where resources and land are becoming increasingly scarce and expensive.

The core of Kurokawa's design for the Agricultural City was to find a solution for the increasing flood risk in the town of Aichi after its destruction during the Ise Bay Typhoon (Kasahara et al. 2018). The key aspect of the design, therefore, was to create a system of the infrastructural grid that is raised above the ground leaving the land free for agriculture and flooding in the future. Taking a 500 × 500 m grid as the basic unit of a community, Kurokawa proposed that roads, water, services, electricity, monorails and other facilities be installed 4 m above the ground. Each 500 × 500 m block consists of twenty-five 100 × 100 m blocks to accommodate 200 people and acts as the basic unit of the proposed design. Once two or more such units combine, they become a village. (Fabrizi 2015).

While stressing the more technical aspects of design, Kurokawa's approach is also able to create a design that effortlessly embodies both a sense of community and habitat. As imagined by Kurokawa, eventually the grid multiplies spontaneously, without any hierarchies to almost recreate a traditional Japanese rural village settlement. Kurokawa believed that the increasing emphasis on designing 'cities' must be met with a counter-narrative where the urban design looks at rural communities as an extension of cities whose means of production in agriculture. His design emphasises on how each city type—rural, recreational, industrial, and consumption—has a distinct urban system. Thus, while the project states infrastructure as a basic framework for design, especially since the site was at an increased risk of flooding, the relationship with the land and the future vision for farming as the main mode of sustenance within the community is unclear.

MVRDV's Pig City project on designing a city for pigs took density and consumption as the key elements as their focus of research and development of the design. Considering the increasing pork consumption in the Netherlands, and the increasing dangers of the various livestock-based diseases, i.e. swine flu. It also puts forward two extreme visions for the future, with one looks at change in patterns of consumption and the other one focuses production methods. The result is a hybrid that tries to combine all the production activities involved in pig rearing and processing and transportation to concentrated high-density field towers. It further proposes concepts such as a communal slaughterhouse, fertiliser recycling and a central food core, all of which focus on reducing the physical footprint of animal farms and also reducing the risk of diseases (MVRDV 2001).

This project also shows how a complete transition towards bio-based farming is an unviable option since it would require more land than is currently available within the Netherlands. In comparison with Wright's vision for the rural city that deals with the social and political aspects of living and farming, MVRDV's approach to the future of food production and consumption is more advanced and direct. The project puts forward a bold vision where all non-land-based farming practices will be incorporated into higher densities and functions using technology.

33.5 A Spatial Narrative of the Self-Sufficient City in 2080

Building on the previous case studies for developing a democratic model of urban agrarianism, this proposed city structure is more concerned with various flows that shape the city, necessitating its need to be more adaptive and less individualised. It suggests a new form of weak urbanisation (like Wright's Broadacre City) that enables the city to remain flexible and open to change by embracing the drawbacks of an industrial economy.

The site is located in Port of Blyth Harbour in the Northeast of England, and its strategic North Sea location ensures it is well placed for supporting wind farm developments down the UK's east coast. With the existing clean energy, the design hypothesis promotes occupational diversity within the rural economy by incorporating a variety of land uses. The proposal is against the homogenous sprawl of productive urban typologies, e.g. factories, industries and mills, as these not only led to the devaluation of productive land but also exposed the vulnerability of an agrarian economy in the era. Instead, it argues that rural urbanisation needs to focus on creating occupational diversity and mixes of programmes not only for the economic resilience of the rural community but also to respond to the values of publicness and communal identity. To impose new forms of communal ownership and limit the commercialisation of food production, each 1-hectare plot is further subdivided to ensure clear lines of the mixed programmes of production, which includes (1) Communal farms and housing; (2) Service and commercial functions and (3) Institutional functions and services.

In this context, the proposed new rural city incorporates a strategy for the expected urban growth as well as efficient use of land for agricultural production. By using minimal elements for design, like the Agricultural City by Kisho Kurokawa, the new city allows a certain flexibility that can accommodate any future uncertainties. At the regional scale, the design interacts with the existing context through a series of interchanges, the first interchange between the proposed farm plots and the local port, as shown in Fig. 33.4, the port acts as the infrastructure terminal that essentially facilitates the exchange of services and goods between future rural cities. Just as the industries were fed by the rural, the new rural city is now fed by the city and its industries through organic and nutrient-based raw materials. Furthermore, by internalising the logistics of food distribution, the design also opens up the opportunity to redefine the port as a new productive space that can be used to introduce more advanced and sustainable farming techniques. For example, the port can be transformed into highly mechanised independent public–private farms that can continue to trade with the EU and help fill the gap in the food market that is expected to come after Brexit.

Unlike the industrial city, each element of the new rural city reinforces the importance of attaching the act of production to land, for example, green roofs and vertical greenery will be planned to absorb the heat and cool the building. The green waste from these areas can be recycled to make biofertilisers or animal fodders. Meanwhile, various plants will be planned and grown along the waterfront with the aim to improve the water retention ability of the site. These added plants will provide sheltering spaces for animals such as cows and pigs, sand pits are provided right on the sandy areas for chicken dust bathing… animals such as chickens are introduced to control the pests and reduce the use of pesticides, and cows can provide natural fertilisers to the soil and work as the natural mowers.

As shown in Fig. 33.5, the new city internalises all farms into highly dense, multi-level structures that can effectively combine both animal farming and commercial food production and will be heavily dependent on technology-based labour. Urban farms are highly automated (like MVRDV's Pig City), with multi-level tower complexes that require little to no manual monitoring, and there is less of the normal labour rivalry between commercial and non-commercial agricultural techniques. These strategies will help to reshape future farming and increase its labour-intensiveness by taking advantage of the chance to implement new agricultural reforms in the post-Brexit UK.

33.6 Conclusion

This research investigates the current food crisis in the UK, it argues the food supply system needs to be resilient to socioeconomic and geopolitical upheavals, as well as to natural phenomena like climate variability and weather-related disasters. Brexit has added to the UK's mounting food supply crisis, and it is unethical and unsustainable to rely on importing food from former colonies internationally like in the age of the British Empire. In order to increase the resilience and self-sufficiency for food, this project attempts to visualise a new conception of rural city development through the lens of Utopian thinking, in which new patterns of population and mixed programmes of land uses will be planned to create diversity and flexibility. The land

Fig. 33.4 Communal farms are planned on the urban periphery, adjacent to the Port of Blyth

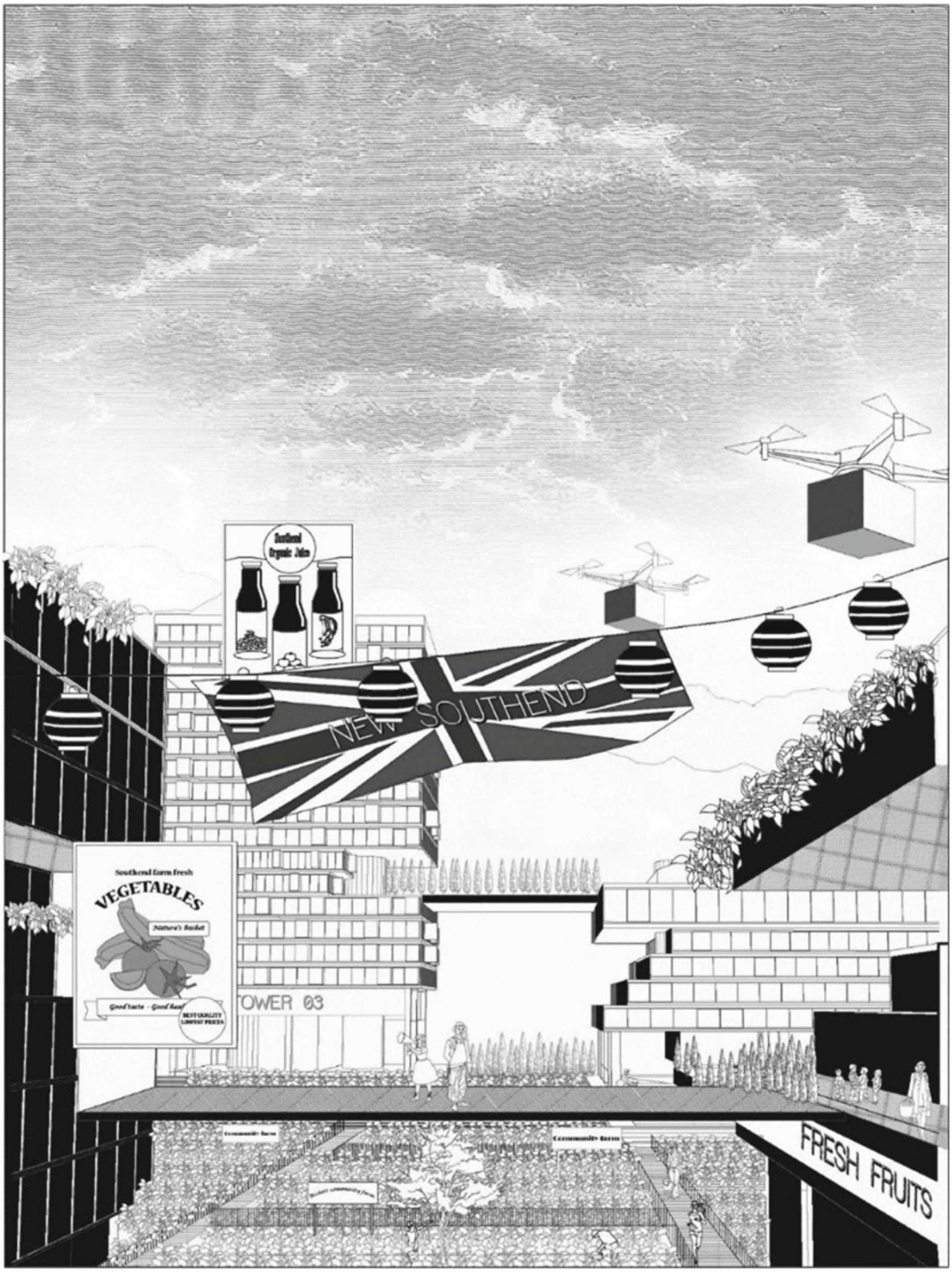


Fig. 33.5 The city is found based on a network of farms with highly dense, multi-level structures

becomes a crucial component of the project's story since food is a natural by-product of fertile soil, so the initiative seeks to internalise the logistics of food distribution, create new connections and an ecosystem between natural and artificial elements using the idea of land appropriation, which aims to initiate future sustainable living by putting up fresh ideas for using, owning, and inhabiting the land. In the meanwhile, the tactics of the project meet the present trend toward compact cities illustrated in three case studies. The design illustrates how a decentralised rural metropolis with cutting-edge farming systems may support its expanding population while being adaptable to embrace and respond to future uncertainties.

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Healthcare 2030. A Design Studio on the Future of a Distributed System in Singapore

34

Thomas Kong

Abstract

Taking Singapore as a laboratory for thinking and designing future healthcare spaces, services, and deliveries, architecture, and industrial design students worked together to develop innovative and scalable solutions for a distributed healthcare system in the year 2030. The projects are collaborative, multi-scalar, and multi-stakeholder in approach. They considered near-to-far-future scenarios for a distributed system across different sites, touchpoints, and experiences by harnessing digital technologies, deploying connected care platforms, and being supported by grassroots organisations, social agencies, and communities. The paper will share the critical reflections and outcomes from the studio led by an architect, experience, and industrial designers working in academia and the industry. The paper argues that designing a system-based healthcare future demands a re-tooling of current architecture education to one that is multidisciplinary, collaborative, and empathetic.

Keywords

Healthcare · Multidisciplinary · Collaborative · Empathetic · Care

34.1 Introduction

In January 2021, the Department of Architecture and Division of Industrial Design of the National University of Singapore, together with Philips ASEAN Pacific Centre Singapore (APAC), jointly ran a design studio focusing on the future of the city-state's healthcare system. Titled Healthcare 2030, the design studio tutors consisting of an architect, an industrial designer, and an experience designer co-conceived the design brief that encouraged architecture and industrial design students to develop innovative and scalable solutions for a distributed healthcare system in 2030. Working collaboratively in teams, students came up with multi-scalar projects comprising of multi-stakeholders and researched changing societal behaviours, cultural norms, and accessibility. They considered near-to-far-future scenarios for a distributed system at different sites, touchpoints, and experiences by harnessing digital technologies, deploying connected care platforms, and supported by grassroots organisations, social agencies, and communities. Through critical reflections on the design studio and the student projects, the paper

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argues that designing a system-based healthcare future demands a re-tooling of current architecture education to one that is multidisciplinary, collaborative, and empathetic.

34.2 Overview of Architectural Education

Architectural education occupies a unique place among other professional programmes in a university. Situated at the intersection of different fields and disciplines, learning to design a building requires the student to synthesise different knowledge, information, and skills to have a coherent concept, design process, and outcome. Central to architectural education is the design studio, and public critique as the primary mode of feedback. They form the cornerstone of teaching and learning in the curriculum. Over the years, architect educators and academics have critically examined the curriculum and offered ideas for its reform (Dutton 1987; Mitgang 1996; Buchanan 2012; Nicol and Pilling 2000; ARB 2021). Architectural education is set up to primarily support individual development. The studio professor's view and architectural expertise drive the design studio's focus. Not surprisingly, invited critics often share similar opinions and knowledge about architecture. Collaboration, if it happens, takes place among peers in the studio. Given the demands of imparting different skills and knowledge, the perception among faculty is that there is never enough time to adequately prepare a student for the profession. Increasing administrative responsibilities, curricular structures of different disciplines, timetables, and assessment criteria all impede collaborative teaching and learning that leads to a monoculture of thinking and making of architecture.

On the other hand, an overly formalistic or technical approach to architectural design can pose concerns. First, questions of form or technology usually take precedence over the primary goal of designing for people. Seldom does an architectural conversation revolve around the future occupants of the building. And if they do, the abstract, universal, and generic notion of the user become a poor substitute. It lacks the full complexities of the human experience and the range of emotions that an actual client or user can offer. Second, a building does not exist in isolation. It is part of a larger, complex system consisting of the social, political, cultural, ecological, economic, and technological contexts. Objects, buildings, and cities are progressively digitally networked to produce new experiences that enable seamless connectivity, performance, and service delivery. Current architectural curriculum rarely addresses the interconnected experiences of crossing multi-scalar realms, which the convergence of the material, digital, human, and natural worlds calls for.

34.3 Re-Tooling the Design Studio Experience

The Healthcare 2030 design studio differed from the previous studios at the National University of Singapore's Department of Architecture. It focused on the trinity of people, spaces, and services in forming a continuous, interconnected experiential journey. The design brief, schedule, and assignments were co-designed collectively. Over several Zoom meetings, the studio tutors decided that students needed to think and design systematically and across different scales, touchpoints, and empathise with the pain points of the patients and healthcare providers. The choice of transit, home, community, and healthcare facilities provided the contexts for their designs. On the other hand, Discover, Frame, Ideate, and Build divided the thirteen-week semester into four key phases. During the Discover phase, four teams (two architecture and two industrial design students) carried out contextual research based on a selected illness. Each team researched the behavioural, emotional, cultural, social, and economic contexts of the patient and the illness through observations, interviews, and literature reviews. The Framing phase called for identifying opportunities through insights gained from the Discover phase. The multidisciplinary teams co-created broad frameworks to organise their approaches and collectively discussed the possible sites that best showcased their designs. Each team also came up with a *What If?* question. It was the driving provocation, aspiration, and a call for imagination in designing new solutions. For example, *What if Every Neighbourhood Could be Dementia-Friendly?* For the Ideation phase, experience designers from Philips APAC conducted a one-day workshop to help the teams to visualise the entire experience journey for the patients, caregivers and healthcare providers (Fig. 34.1).

Finally, in the Build phase, students planned how to communicate their research and designs in the most visually compelling way. The teams pulled their respective knowledge and skills to deliver an integrated and cohesive final presentation. The industrial design students made videos of the patient's experience journey in the new distributed healthcare system and prototypes of the devices. On the other hand, the architecture students depicted the redesigned site, new building/s, and interior spaces in large-scale prints. Each student was responsible for a part of the verbal presentation, and everyone contributed to the question and answer portion of the final review. As mentioned earlier in the essay, architectural reviews are often insular. In the worst-case scenario, it is a means to reaffirm the professor's ideology. It can also become confrontational, which does not help the student to learn. In the case of the Healthcare 2030 studio, it was a platform for sharing, learning, and advancing good practices and knowledge in the field of healthcare design. Guests and students had only one common goal: how could we collectively design better spaces, services, and experiences for patients inflicted by the illnesses? In the following sections, the paper will

Fig. 34.1 Architecture and industrial design students mapping the experience journeys of the patients, caregivers and healthcare providers at the Philips APC studio

Fig. 34.2 Top: Diabetes Care Hub. Middle: Fysio. Bottom: Forget Us Not

introduce three projects that are emblematic of the re-tooled design studio experience where place and user-centric, as well as multi-scalar designs for a distributed healthcare system is integrated with technologies for the monitoring, caring, and healing process (Fig. 34.2).

34.4 Healthcare in Singapore

Singapore's healthcare system is ranked high in the world (Statista 2021; Bloomberg 2014; Straits Times 2014). The government makes efforts to ensure that healthcare remains affordable and accessible through financial subsidies, incentives to keep a healthy lifestyle, technological innovations, and careful management of costs. However, like many other countries, Singapore's healthcare system faces challenges on multiple fronts, such as an ageing population, the charge of chronic diseases like diabetes, workforce shortage, and rising costs. In 2012, the Ministry of Health set up a task force to develop a Healthy Living Master Plan (MOH 2014; Kok 2014). Based on feedback from Singaporeans, the task force identified the importance of a well-designed environment conducive to healthy living, that a healthy lifestyle excludes no one, and keeping costs affordable. Place, People, and Price were identified as driving forces to promote healthy living as a way of life.

For Place, the master plan envisaged a future where healthcare facilities and services will be close to and connected to parks, live and work spaces for better accessibility and seamless integration. To create a more physically inclusive environment and to encourage walking and cycling, universal and active design strategies were recommended. The Land Transport Authority is currently building an island-wide network of walkways to shelter commuters from inclement weather and encourage walking to the bus and train stations. On the other hand, residents could locate public exercise facilities and find activity programmes within two hundred metres of their homes through their mobile phones. For People, the master plan strived to promote mass participation in outdoor activities with rewards for achieving a personal target, attending health talks, and consuming healthy food. Equally important, the master plan aimed to harness the social energy of the community and sought to empower groups and individuals by training neighbourhood ambassadors and community coaches to assist professional healthcare workers. For Price, the government introduced several schemes to help low-income families and individuals access medical services. Food and beverage providers were also encouraged through incentives to offer healthier ingredients and affordable food options. As residents eat out often in the city-state, the goal was to ensure that twenty per cent of these meals will be healthier by 2020. The design studio was broadly based on the goals of the Healthy Living Master Plan, which was launched in 2014. It served as the framework for the students to conduct research and ideate near-to-far-future scenarios of healthcare service and delivery for their chosen contexts.

34.5 The Diabetes Care Hub

The Diabetes Care Hub team proposed a decentralised diabetic care system by introducing a distributed network of hubs and stations within Singapore's Park Connector Network (PCN). Consisting of six routes, the PCN is an island-wide network of walking and cycling paths formed by linking up the green spaces and water bodies. The new hubs and stations along the PCN created an island-wide interconnected healthcare ecosystem that seamlessly integrated preventive and care management of diabetic persons into their everyday lives. The plug-in model of the hubs and stations relieved the work of screening, consultation, and treatment from the hospitals and thereby allowing healthcare workers to focus on acute care. A person with diabetes could do a quick test at the station, housed with other exercise equipment in a specially designed pavilion. The hubs housed food outlets, community gardens, clinics, and facilities for apitherapy and leech therapy. An exciting feature was naturalised care, which the students defined as harnessing resources from Singapore's flora and fauna in diabetic treatment and management. The community gardens encouraged residents to cultivate herbs and vegetables, including the insulin plant Costus igneus. The project also incorporated AI and augmented reality technology in the integrated care experience. The digital interface informed, incentivised, and promoted active, healthy living and personal involvement in overall care management. The AR glasses and app helped persons with diabetes to monitor their meals and provided real-time tracking of their insulin levels.

34.6 Fysio

The Fysio team advocated shared responsibilities for a future healthcare system focusing on physiotherapy and promoting a healthy lifestyle. The students discovered that most residents were only a 5–10 min walk from a community park through their research. In their project, physiotherapy was taken from the hospital setting and embedded in a park. Instead of a cold and sterile environment for the physiotherapists and their patients, they enjoyed fresh air, greenery, and services to help in the recovery process. The project also incorporated biophilic design principles in the design of healthcare facilities. The architecture students took advantage of the park's terrain to insert some of the new spaces wholly and partially below ground, connected by ramps and staircases. For example, a hydrotherapy facility located partially below ground maintained a comfortable temperature for patients undergoing rehabilitation and recovery. Technologies like autonomous vehicles, AI, and mobile robots enhanced the delivery of healthcare services and cultivated a social support network among healthcare providers, patients, and their family members.

34.7 Forget Us not

The Forget Us Not team designed an integrated care system surrounding dementia. The project focused on detection, diagnosis, and the different stages of dementia care as it progresses. The care system enabled one to lead as normal a life as possible before the onset of late-stage dementia by addressing the multiple design scales and touch-points, from the interior of a public housing apartment to the surrounding public spaces. Like the two projects earlier, the goal was to shift the care focus from the hospital to the community for as long as possible. Through their research, the students discovered that being cared for at home was a preferred option. A neighbourhood in Singapore with a high population of senior residents was re-configured based on dementia-friendly design principles. The design of the new spaces considered materials, finishes, the geometry of footpaths, shapes of spaces, landmarks, lighting, views, colours, textures, and even smell. The project included the designing of an apartment. Flexibility, supervision, and memory-activating strategies was the overall design concept. Moreover, sensors and smart materials for detection and wayfinding added a digital infrastructural layer to the dementia-friendly neighbourhood.

34.8 Designing for Care in a Multi-Scalar and Distributed Healthcare System

Students in the Diabetes Care Hub team mapped the whole experience of a person with diabetes from management, screening, and resting to consultation and treatment. Each stage of the journey corresponded to design ideas across different scales (Fig. 34.3).

The Fysio team looked at an integrated service experience of different physiotherapy patients

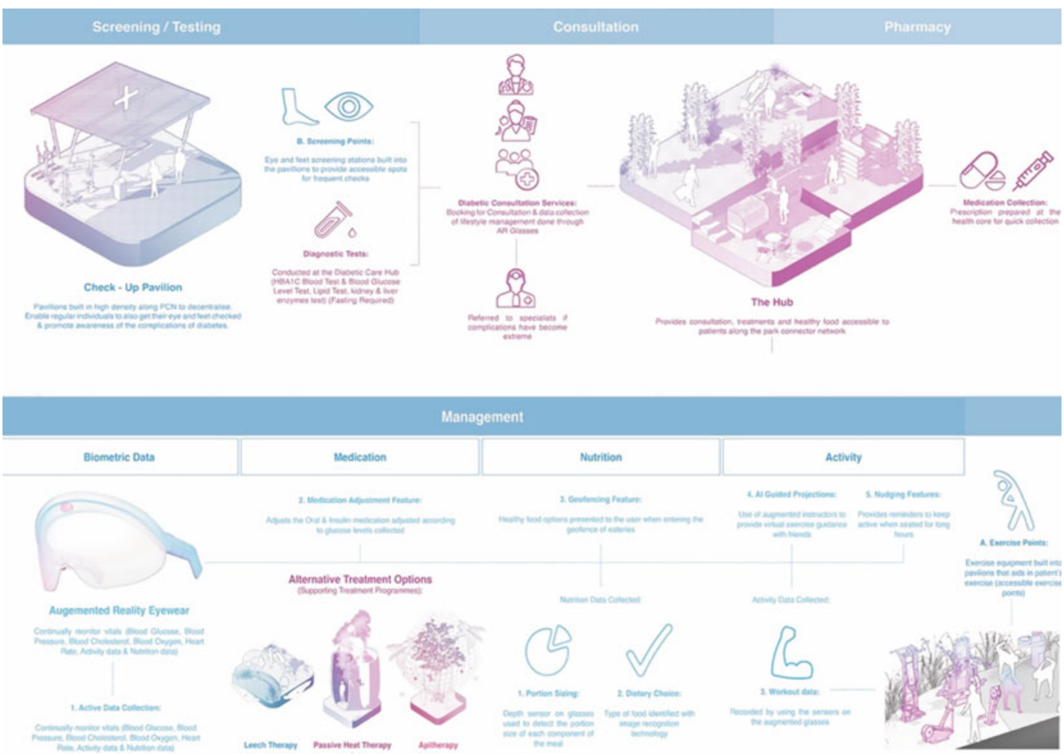

Fig. 34.3 Final experience journey mapping and design incorporating the entire user experience of a person with diabetes and the multi-scalar design solutions

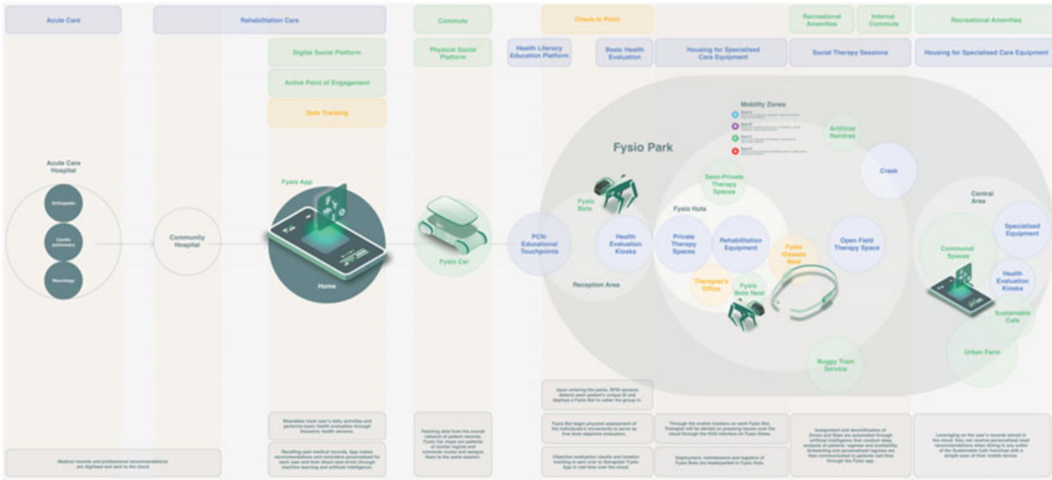

Fig. 34.4 Designing the different platforms and scales of engagement for a distributed physiotherapy experience in a park

based on their levels of mobility. It started with a new interface on the patient's smartphone to boarding a self-driving electric shuttle and bringing the patient to the nearby park. A community coach or a robot pet accompanied the patient throughout the different sessions depending on the level of need (Fig. 34.4).

For the Forget Us Not team working on the topic of dementia, the students created an experience journey consisting of detection, diagnosis, and three care stages from early to mid and late. Each stage of their experience map listed the challenges faced by the patients, their caregivers, and healthcare providers, together with the envisioned solutions from the home to the neighbourhood (Fig. 34.5).

Unlike most architecture studios where the design of the building and the site takes centre stage, all three projects had to design across the scales of the object, interior, building, and site. Another distinction was that the site was not assigned beforehand. The choice of possible sites was discussed and determined during the Framing phase when the teams had a clearer idea of their projects. In addition, each team came up with a service design strategy to accompany the spatial solutions.

During the semester, the students shared their ideas with healthcare practitioners, social workers, experience designers, architects, and industrial designers in several mini-presentations. The feedback was invaluable not only for the students but the guest reviewers as well. One social worker from a foundation helping elderly residents with their healthcare needs was impressed by the level of sensitivity, thoughtfulness, and comprehensiveness. Another healthcare practitioner found the idea of using insects to help manage diabetes unusual and provocative. She gave valuable suggestions on how her patients would respond to this unconventional treatment. The opportunities to present their ideas to various stakeholders helped the students to refine their initial thoughts and validated some of their design decisions. From the student's feedback, the mini-presentations gave them the sense of being part of a larger community of professionals confronting similar healthcare challenges. They felt the experience made their fledgling design contributions worthwhile and meaningful.

34.9 Designing for Care in Through Empathetic Design

An important goal in the Healthcare 2030 studio was the cultivation of empathy. The assignments enabled students to experience, interpret and

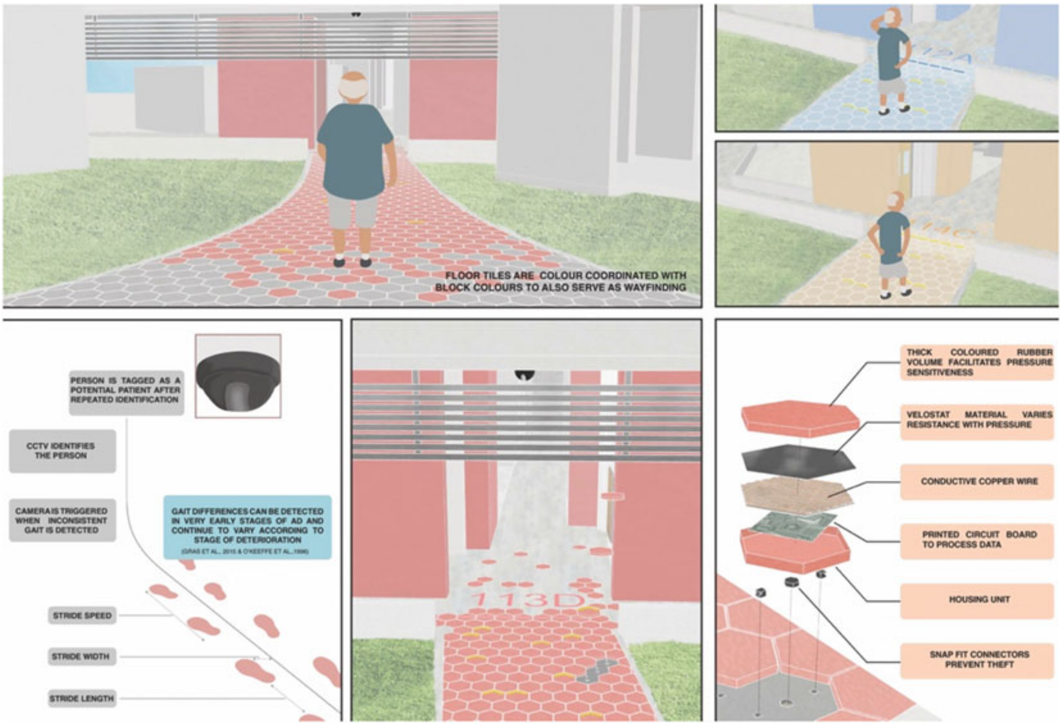

Fig. 34.5 Combination of digital monitoring and sensors embedded in the floor tiles for detection and assisting a person with dementia in wayfinding

assess their design proposals from the perspective of their future users. The industrial design students were familiar with experience journey maps, user interviews, and sensitising exercises. However, it was a new experience for the architecture students who were used to site, form, and programme. They initially struggled with the new approach but, over time, were able to see the benefits. Through examples in practice (Gensler 2017; Lau 2015) and studio conversations, the architecture students saw that the expanded process complemented and added value to their work as future architects.

In their essay What Happened to Empathic Design?, authors Mattelmaki, Vaajakallio, and Koskinen identified four layers of sensitivity in empathetic design (Mattelmäki et al. 2014). They are sensitivity to humans, design, technique, and collaboration. To encourage sensitivity to humans, students interviewed the patients, healthcare providers, and stakeholders at their homes, clinics, care centres, and offices. The Fysio team interviewed physiotherapists at their clinics and tried out the sessions and machines designed to identify, treat, and manage various injuries and chronic conditions. The experience allowed them to contextualise the difficulties faced, such as the cramped interiors, the lack of natural light, noise, and confusing appointment-making process. For sensitivity to design, the *What If?* question provided the students with an imaginative leap based on what they uncovered from their research in the discovery phase. For sensitivity to technique, students prototyped the experience as if they were patients using the product or services. In the case of the Diabetes Care Hub, they made a video of using the smart Goggle while cycling along the park connector. The video documented the entire experience of wearing the Google while cycling and finishing at a local eating outlet. It highlighted how the information from the goggle could help monitor the insulin level and recommend suitable food based on insulin sensitivity or blood sugar level.

Students in the Forget Us Not group researched the different colours and scents that flowering plants emit. Their new design for the pathways was based on colours and smell to help with the declining sense of orientation and spatial navigation of a person who has dementia. For collaboration, the mini-presentations turned a traditional architectural review experience of critique and defence into one where the students and the guests put their thinking hats together to refine the proposals. In this joint studio, we included the fifth layer of sensitivity, which is nature. To be sensitive to nature calls for a design to care for humans and our environment. In her book Designing Cultures of Care, Laurene Vaughan writes,

> Care needs to embrace the entire ecosystem that we inhabit and practice within.
> (Vaughan 2018, 8).

Vaughan further emphasises that,

From this perspective, it can be argued that design as practice of care would be a relational practice- that is, founded on the relationship between the designer and the contexts, within a range of proximities, of their practice (Vaughan 2018, 8).

One of the central framings of the Diabetes Care Hub team was the question, What does it mean to care? The students broke down care into three categories. First, as an action or the practice of care. Second, care as connected and engaged in shared experiences. Third, care as creating awareness to motivate actions of care. The students introduced community gardens in the care hub to bring the residents together. Medicinal plants for complementary diabetes therapy were proposed in the gardens and used in food preparation, while a digital interface nudged the user to be more involved in self-management. At the architectural level, the students introduced biophilic design principles. The form, materials, and programmes of the care hub reconnected the residents' everyday life to nature and improved the health and well-being of everyone in the community.

Similarly, the Fysio team used the new semi-underground and underground spaces to maintain a constant and comfortable temperature for physiotherapy sessions in hot and humid Singapore. Evaporative cooling through the therapy and reflective pools further aided the cooling process. These water bodies also fostered a multisensorial physiotherapy experience instead of a clean and sterile clinic.

34.10 Conclusion

The paper offers a re-tooled design studio experience by drawing ideas from the Healthcare 2030 studio grounded on a collaborative, multidisciplinary, multi-scalar, and multi-stakeholder approach. The goal of designing a connected care system across different scales, touchpoints, and sites compelled architecture and industrial design students to question their respective discipline's assumptions, work collaboratively, and find common grounds amidst the differences. After the semester, the Design Singapore Council co-sponsored a public exhibition of the projects at the National Design Centre. Students from three teams were also awarded internship opportunities in a global consultancy firm, and the Fysio team won an honourable mention in a healthcare design competition. On the other hand, a local architecture and design magazine featured the Diabetes Care Hub project for its innovative, multi-scalar, and comprehensive solutions. We were initially unsure how the studio will turn out due to the different approaches in teaching and learning design between architecture and industrial design. However, the numerous recognitions received by students affirmed that the decision to hold the joint design studio was the right one. It was a remarkable conclusion to the thirteen-week experiment to open up and re-imagine architecture education through the design of a distributed healthcare system in Singapore.

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