Advances in 21st Century Human Settlements

T. M. Vinod Kumar *Editor*

Smart Master Planning for Cities

Case Studies on Digital Innovations

Springer

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Smarter Master Planning

T. M. Vinod Kumar

Abstract This book explores the capabilities of Smart Master Planning as against legacy Master Planning of cities practised. Master Planning of cities exists because cities under change need uninterrupted integrated area development and urban regulation that benefits and protects the rights of all citizens under the constitution. Despite many shortcomings of Master Planning as discussed in this chapter, and which made some big-ticket national urban development projects replacing it with other short-lived plans with different names by the Union Government, it still exists in India and all countries being revised once every 20 years as per the constitution since no alternative has emerged to replace it. The 100 Smart City Programme and Jawaharlal Nehru Urban Renewal Mission (JNNURM) of India were two big-ticket National projects involving a larger amount of public investment ever received by Indian cities so far, were not using Master Plan and detailed town planning schemes for its implementation for integrated area development but is based on some other non-statutory limited time and limited scope plans which by design is short-lived and intend to die soon after the project is over with no continuity for integrated development of cities. The 100 Smart city project is strictly not even using local self-government institutional mechanism under the constitution but a special purpose vehicle to implement, unlike JNNURM. Despite all these circumstances, local self-governments continues to prepare and execute Master Plans as their constitutional responsibility despite some plan holidays years. One intend of this book is to evolve and not replace Master Planning of cities with Smart Master Planning which can broadly be classified as digital master Planning or based on innovations in some domains of Master Planning practices as alternatives keeping the intent of intention of Constitution of India respected and implemented. This book searches for an effective strengthening of Master Planning mentioned in the 74th constitutional amendment of India which we call Smart Master Planning. This can be digital or with domain-specific changes in master planning. This chapter assesses quantitatively the candidate cities for Master Planning in India based on the census 2011 and compares them with registered professional urban planners to plan it. Then discuss how the supply of candidates master Planning cities and demand of Planners can be balanced in India. This chapter explores the

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first scope and approach of past colonial legacy in Master Planning followed by a critique by many scholars and practising planners. This will be the basis of domain-specific master planning innovations. The Digital Master Plan which is emerging in a limited manner is then studied from practices of certain countries as an alternative for legacy master planning first with its architecture, followed by three international case studies Barcelona in Spain, Greater Spring fields in Brisbane Australia and Dublin in Ireland. Finally, it is followed by an introduction to the case study chapter by the author and his study team in one of two volumes entitled Smart Master Planning: domain innovation and digital innovation.

Keywords Smart and legacy Master Planning of Cities · Scope and approach of legacy Master Planning · Colonial British influence in Master Planning · Critique of legacy Master Planning · Candidate cities · Coverage of Master Planning in India and registered planners · Digital Master Planning as alternative · Architecture of digital Master Planning · Examples of digital Master Planning · Barcelona · Dublin and greater spring field · Authors approach to smart Master Planning of this book

1 Introduction

This book researches the Smart Master Planning of Cities discussing innovations using case studies. Cities are urban agglomeration the true representation of urbanised geographic space as per the census of India and UNHABITAT and not Municipal boundary, planning area or other towns administrative boundary fixed arbitrarily. Master Planning approach differs in countries as per the governing system followed whether it is a Communist, Capitalist, Secular, Theocratic or Democratic country, besides based on, emerging urban issues and long-range vision of the city. The Constitution determines the governing system and approach to the City Master Plan based on several regulatory legislation encompassing all aspects of city life. This differs from country to country and federal state to state. The constitution is a living document, an instrument that makes the government system work [1].

The adjective smart indicates a better, effective and responsive way of doing Master Planning than practised now but goes much beyond. Undoubtedly, there were several such attempts in the past in many countries and federal states to do that from time to time resulting in an ever-growing body of knowledge in planning theory and techniques. However, the concept of smart as applicable to Master Planning is a product of the twenty-first century, which is an emerging topic of great significance, largely unknown and not practised under many systems of Governance.

Smart can be understood easily if we understand the functioning of our smartphone or many IoT or smart devices [2] that are invading all houses. There is a competition to make smart devices to achieve an economy of scale in production. They are today an integral part of internet usage, cost cheaper by every day and spread all over the world dramatically encompassing end uses, irrespective of their income, age group, class and caste. We have a smartphone that converts our single function dumb

phone to a multifunctional capability of a powerful but tiny computer in your pocket that perform all tasks of communication more efficiently and creatively using all modes of communication and provides, you with many extras like video messaging, SMS/text messaging, email messaging, music player in the background, camera, word processing, spreadsheets, database management, meeting your bank transaction requirements electronically and shopping needs without going to Bank or Mall/shop, Government offices and so on. In other words, a smartphone for a smart citizen converts a physical city to a virtual cyberspace city where all transactions in cash and kind are possible using a smartphone. There are rapid up-gradation from 2 G, 3 G to 4 G with the introduction of cheaper phones, for example, Jio-Google 4 G smart phones within the purchasing capacity of the low-income group. It also makes the brick-and-mortar malls, banks, physical Newspapers, Cinema Theatre, Auditoriums and Government offices not strictly required for smartphone using populations. The transportation system usages also change consequently creating implications to the practice of urban land use and transportation systems Master planning.

Smart devices such as a smart plug or smart switch in a smart home is no more the dumb plug doing the assigned function but can be activated by Amazon Echo talk commands to switch on the TV attached to it or switch off even at a predetermined time and even without an echo voice command. The smart plug monitors the heat generated in the plug and can be programmed to cut off the power when the heat is generated to a certain unacceptable level. It can be programmed to switch on a certain time and switch off a certain time based on the ambient temperature and humidity that is comfortable to the occupant of the room. You can then add by design many more functions and scenes to the smart plug/switch and only your imagination limits the functional addition. In smart, two underlying principles are common in all these devices; the internet and wireless communications in their many forms and other technologies related to electronics. They are highly responsive and have superior communication for action. These smart devices in cities can make many of them work together in a group triggered by motion sensors, thermal and humidity sensors and light sensors and can trigger create scenes you want at certain times predetermined where some or many devices work together as per needs.

The concept of Smart Master Planning is an adaptation and extension of these ideas given above in city planning. The unacceptable delay in plan making, as well as its implementation, can be prevented by smart master planning. That means smart planning and its implementation can be fused in one so that there is no time loss in Master Planning and between planning and implementation which is never attempted before and undoubtedly a new concept conceived as part of the functioning of smart devices. Value addition to Master Planning results when smart is applied to Master Planning. It all indicates the automation of Master Planning with minimal human involvement. In a Government, the administrative staff is multiplying like a virus, increasing the cost of administration and creating more and more inefficiencies, delays, frustration, and anger among end-user of a city the citizens. This unwanted growth of administrative staff who invent and pursue complicated administrative procedures is financed by tax paid by the citizen. This smart transformation of Master Planning reduces the cost of delivering Municipal Services in a very smart, efficient,

cost-effective way without an increase in administrative staff. This book is all about discussing this innovation using a case study that makes it highly replicable to many cities. This task is taken up by the study teams of chapters of this book in the hope and intention that anyone can use the results freely.

Master Planning has two main functions regulatory and development. All existing legislation applicable to the city is termed as regulation and area or spatial development is called development. The book "Geographic Information System for Smart Cities" [3] defined smart cities as follows. "Smart city is a knowledge-based city that develops extraordinary capabilities to be self-aware, how it functions 24 h and 7 days a week and communicate, selectively, in real-time knowledge to citizen end users for a satisfactory way of life with easy public delivery of services, comfortable mobility, conserve energy, environment and other natural resources, and create energetic face to face communities and a vibrant urban economy even at a time there are National economic downturns" [1]. If you replace the word smart city/city in this definition with Smart Master Planning, you get the definition of Smart Master Planning.

The smart city and smart master planning are conceived around the concept of six components-systems smart people, smart mobility, smart economy, smart environment, smart government, and smart living working together in an integrated manner [4]. So Master Planning for integrated area development is all about long-range planning for these six systems. This way of working around these concepts transforms any city into a smart city. The level of the smart city is the level at which the six components have progressed in their working in these cities. There is no end or saturation in any of these six components if innovative practices are emerging from creative people in future. Every city has some level of achievement in these components in a very partial and non-integrated manner. The smart Master Planning task, therefore, looks at the level of development of the city as smart and make smart master plans. The smart city is not an end state of a city but constantly evolving as the creative and innovative inputs of the citizen evolve with the more innovative functionality of the city added to its six components as per the needs. These are realised through smart master planning. The six components system of the smart cities were discussed in many books of the smart city series which was edited by the author. These components are discussed here to place the smart master planning in the right perspective.

Although this book has case studies on Smart Master Planning from other countries, this chapter is India Centric, the largest democracy in the world with a federal structure; because the author is a citizen of India and is most familiar with the Master Planning of India. The credential to write this chapter derives from the fact that as a teacher I have taught Master Planning and its different constituents to Planning students for several decades and as a professional consultant worked on Master Plan of Kuantan in Malaysia as a Structure Planner for the World Bank, Project Manager of the first Master Plan of Lakshadweep group of islands and Adviser to Tata Consultancy Services for the Master Plan of Gandhi Nagar the Capital of Gujarat State and innumerable urban development project all over India.

This introductory chapter is divided into 10 parts.

Part 1 is this introduction which orients smart master planning in its full meaning.

The second part gives the most recent understanding of the scope of work of Master Planning practised in many parts of the world.

Part 3 deals with the evolution of Master Planning in India. The archaeological investigation on the prehistoric cities in Harappa and Mohan-Ja-dare shows the urban design of cities for common people planned with a high level of civil engineering skill and great care for the use of all showing a democratic master planning. The same is true in cities planned based on the Vedic planning period. However, we do not have abundant written pieces on the master planning of these cities and omitted in this chapter. In contrast, during the British Colonial period, we have considerable written pieces available and this chapter concentrate on that. This is despite we have an inferior sample of British Master Planning in comparison with Mohan Jab Daro and Harappa period and Vedic and Mughal period. The only justification to study this period is because the Master Plan being practised in several parts of India was evolved in the colonial period and continued in many states even very recently with no change despite its not so satisfying approach.

Part 4 looks at cities in the 2011 census and earlier for India, and Master Planning efforts in India. This is compared with available qualified city planners in India. With COVID 19, 2021 census will be delayed.

Part 5 is a summary of a literature survey that critically look at the past Master Planning effort in all aspects. I may warn here no one who wrote these papers do have a high opinion on the Master Planning effort in India. They are unanimous in not celebrating these efforts but accept that as a necessary evil in the absence of worthwhile alternatives. Can we find a legally valid alternative is the focus of this book?

The sixth part looks at the alternative to Master Planning and discusses the architecture of Digital master Planning.

The seventh part discusses the implementation of digital master planning in Barcelona (Brownfield),

The eighth part presents a new town planned and implemented as a case study of Greater Springfield's digital master plan: a New Town in Brisbane Australia (Greenfield).

The ninth part presents an attempt at making a digital Master plan as a Case Study Dublin. Ireland Digital Master Planning (Brownfield).

Part 10 briefly presents the approaches of Master planning suggested in this book as a city case study in Kozhikode Metropolitan Area. Finally, part 10 concludes this chapter with some definitive statements.

The Indian constitution believes in flexibility in implementing constitutional goals, in multi-levels of Governance of the nation [1], the states and Local self-governments like Municipal Corporation and Metropolitan planning committees, and others. The constitution exhibits adaptability as against dictatorial coercion on the other multilevel governance. Therefore, the constitution is updated with amendments as the needs arise and we are now on the 93rd amendment and in the 12th schedule of the Indian Constitution Article, 243 W gives 18 items the first is urban planning including town planning. The second is the regulation of land use and construction

of a building and the third being Planning for economic and social development. All these are the subject matter of the book.

The constitution of India in its flexibility and adaptability do not dictate how the Master Planning should be done and how urban regulation is to be achieved at different levels. It is left to us planners and academicians to design an approach acceptable and work within the legal framework of master Planning. This book is meant to achieve that through innovations and case studies detailing these innovations so that they can be used by those willing to use them.

So if you are a planner and I am a Mayor of a city empowered to appoint you as a planner as per the Indian Constitution, I shall ask you to give me a Master Plan of this city that double the GDP once every 2 years and demonstrate it. Is India producing such Mayors who ask these questions and planners confident to deliver what is asked convincingly and demonstrate in a sample area of the city? We will investigate the answer in the following paragraphs and all chapters of the book.

In this book for the hypothetical question posed, I want to consider cities as the worshipful Goddess of the wealth (Lakshmi of India) and planners of cities all smart people with or without a professional degree in planning who work for doubling of cities wealth in a premeditated limited time based on the knowledge including that is provided by the book. In the book, Smart Environment for Smart Cities [5], we discussed the rationale of how Indians in the Vedic period considered all elements of the environment in the universe as GOD so Lakshmi for Cities is acceptable for Indians.

Before answering this question raised by the hypothetical Mayor to hypothetical planner, we must critically understand what Master Planning of cities is all about.

2 Master Plan [6]

The master plan is the blueprint for the Long-Term Plan of a City generally 20 years, to guide the sustainable development of any city, formulating planning guidelines, policies, development codes and space requirements for various socio-economic activities and identifying infrastructure requirements. It is generally found to be executed for any city with local self-government such as a Municipality. Municipalities are constitutional entities in India. The constitutional body the election commission is assigned the responsibility to conduct periodic (5 years) election of local representatives in local government institutions like Municiaplaity by voting. The Central and State Finance Commission determines the share of taxes that provides grants in aid from the consolidated fund of Government to support its 12^{th} schedule functions. For local self-government, the state finance commission provides the standard of municipal services it should provide based on the quantum of grants available to the Municipality. It generally provides for municipal service which mostly is inadequate. Master Plan regulates the use of land and building by development control rules for environmental sustainability. Hence one view is that Master Plan is a Spatial Development Plan since regulation is meant to be undertaken in different areas of

the designated master plan of any city based on many states and central government legislation and the master plan postulates such as the use of land, and its intensity and many don't and dos related to that. 74th constitution amendments emphasise social justice and economic development and responsibility for Master planning are given to local bodies Master Plan. Master Plan focuses on social justice, by generally looks after the needs of people living in slums, economically weaker sections, and those under poverty and who sleeps every night with no roof over them in pavements. Hence Master Plan is for social justice and economic development. Economic development involves income generation as well as employment generation. World Bank emphasises the function of Master Plan as urban productivity increases, employment generation and poverty reduction, liveability, competitiveness in comparison to other cities as destinations for economic activities, sustainability, and bankability of urban government with a credit rating is also emphasised in some Master Plans. It may be emphasised that Master Plans always advocates the removal of poverty, foster economic development, environmental sustainability, better urban management and better urban finance. How far these are achieved by the Master Plan will be discussed later.

The Master Plan generally have many Components. They are

1. Spatial development plan generally called existing and proposed land use plan;
2. Resource mobilisation plan indicating the various source of financing plans such as state government grant in aid, house tax and other municipal taxes, grants for various government projects being implemented by municipality and others;
3. Institutional mechanism for plan implementation which may also involve collaboration with other government agencies and non-government agencies;
4. Comprehensive and easy to understand development management/promotion rules/regulations;
5. Participatory mechanism of the poor, women, NGO, Community and Socially Disadvantageous.

It may be noted all the above are not met satisfactorily in many Master Plans.

Generally, Master Planning follows a set procedure. A Master Plan must first conceptualise the city's future based on the existing land use plan and aspirations of the people, then cover all aspects of its planning, development, financing, phasing and management, along with institutional, financial, legal and administrative mechanisms for the realisation of this future. The outcome depends on the quality of the Master Plans. Development in the context of Master Planning means carrying out all or any of the works contemplated in a master plan and shall include building, engineering, or other operations in or over or under land, or any material change in the use of any building or land as proposed in the Proposed Master Plan. The Master Plan goal is to offer citizens a better quality of life; it is important to ensure in the master Planning that the growth and development of a city do not result in environmental degradation.

Let us look at concerning one sample state in India, the state of Kerala and the approach of Kerala Local Self Government Department for its 58 statutory towns. It states; "The present practice of annual planning based on the budgetary provision envisioning only short period implementation is inadequate and will hamper

the comprehensive mass-scale development of the town. Therefore, an integrated and coordinated planning strategy based on a comprehensive master scheme which effectively reflects the social, cultural, and heritage factors of every city is required". It is seen generally that these goals are never met adequately for various reasons.

Next, let us examine one city in Kerala and list out all Master Planning efforts statutory master Plans and non-statutory master Plans undertaken so far.

1. Non-Statutory Master Plan 1962 prepared by Shri. Rusi Khambatta at the request of Calicut Municipality.
2. Preparation of Statutory Regional Plan for Calicut city and 43 Panchayats. Surveys in 1964 and Interim Development Plan for Calicut Urban Complex (1967–1981) by Town and Country Planning Department Government of Kerala.
3. The second Statutory Master Plan was called the Development Plan for Calicut Urban Area (1981–2001). This was implemented through the number of Detailed Town Planning Schemes (DTP) by the Calicut Development Authority which now Government of Kerala has closed down most of the development Authorities in Kerala in their wisdom barring few such as Greater Kochi Development Authority, etc.
4. Non-Statutory Perspective Plan for Kozhikode 2003 (as part of UNDP-DST MATURE Project).
5. Non-Statutory Calicut Agglomeration Plan 2006 (Voluntary Effort of Indian Institute of Management, Centre for Water Resources Development and management, and others).
6. Non-Statutory Kerala Sustainable Urban Development Project Calicut Plan 2009.
7. Non-Statutory City Development Plan 2010 (for JNNURM Project but Calicut was not selected for this project by Central Government).
8. Statutory Master Plan of Kozhikode Area 2035.

A similar pattern exists all over India in master Planning

It can be seen that there were three statutory Master Plans with legal validity and five which were non-statutory with no legal validity but prepared for executing some project with very limited funds and limited period of the project allotted for project implementation. In between the second and third Master Plan of 20 years duration, there was a Master Plan holiday which gave great concern to real estate developers and other private builders whether what they are doing is legal or illegal that Can is demolished with new Master Plan legal land use and zonal plan.

There was a planned holiday in Kozhikode which was against the Government of Kerala Policy. The Plan holiday 2001 till June 2010 when the third Master Plan 2035 started and was completed in 2015 after considerable delays a part of Master Plan making all over India. There were many violations of the Master Plan 2001 during the plan period and plan holidays. There was then no new statutory Master Plan to conform. There was a complete, absence of proper development control and in Kozhikode and zonal development codes never existed, resulting in ad-hoc decisions.

Let us look at briefly Planning Issues Tackled in Master Plan 2001. They are

1. The decentralization of economic activities.
2. The rationalization of densities in the various parts of the urban area.
3. The streamlining of the transportation system.
4. The provision of easily accessible facilities such as education, health, recreation, shopping to all.
5. The provision of essential Urban Services.
6. Special consideration for the needs of the urban poor.
7. An implementation mechanism for balanced development including zoning and subdivision regulations suitable for local conditions.

I also enumerate here Planning Issues not generally tackled in statutory Master Plans

1. Local Economic development and social justice
2. Urban productivity, employment generation and poverty alleviation
3. Tourism Development
4. Urban Renewal
5. Solid Waste Management
6. Liveability, Competitiveness and Environment Sustainability
7. Urban Ecology and related Urban Form
8. Urban Governance.

The Objectives of the Perspective Plan prepared as part of the Department of Science and Technology MATURE project a non-statutory plan enumerated as above.

1. Rejuvenation of the trade and commerce sector in the city
2. Upliftment and up-gradation of Slums in the city
3. Better urban services including provision of drinking water
4. Better sanitation facilities
5. The decentralised and safe transportation system
6. Developing an institutional area near the city
7. Identifying the city as an educational centre and a tourism transit point
8. Solving environmental issues.

It may be noted that most of the Statutory and Non-statutory plans mentioned above incorporated most of the recommendations of the Perspective Plans or Urban Agglomeration Plan. The Plan holiday 2001 till June 2010 when the third Master Plan 2035 started and was completed in 2015 with considerable delays. There were many violations of the Master Plan 2001 during the plan period and plan holidays. There was then no new statutory Master Plan. There was a complete, absence of proper development control and development codes never existed, resulting in ad-hoc decisions as against the Government of Kerala's Policy is for "an integrated and coordinated planning strategy based on the comprehensive master scheme which effectively reflects the social, cultural, and heritage factors of every city are required".

It was during planning holidays the Calicut Development Authority which was entrusted to implement the second Master Plan and subsequent was closed down by the Government of Kerala as per their policy and Kozhikode Municipal Corporation

got the legal authority and power to plan Kozhikode, urban regulation and implement but there was inadequate technical manpower to do this work in the Municipal Corporation. There were no training opportunities created to do this new job to Municipal Corporation or augmentation of technical staff. There was no attempt to crate adequate technically qualified persons in the local self-government to discharge the planning functions. The planning function which is now with local bodies was incapable of technically translating policies of urban development of the Kerala Government or the local body had any policy of urban development which may be called their own. In many cases, there has been arbitrariness in permitting the maximum Floor Area Ratio (FAR). From the planning point of view, the FAR permissible for an area shall be based on the considerations of the infrastructure available in the area. High rise-high density developments can be permitted only in those parts of the towns where the available infrastructure is well developed and/or the infrastructure capacity could be augmented without creating an imbalance to the infrastructure system of the town. This was not followed during the Plan holidays. No new Town Planning Schemes were undertaken by Kozhikode Municipal Cooperation once the Master Plan 2035 came into being. Even before that the implementation of Town Planning Schemes by the Calicut Development Authority in comparison with other states in India was very poor.

Based on the above discussion let us Suggest the focus of the Master Plan for the future are

1. Spatial (Pragmatic urban space based on regional space, rationalising land use-transportation and infrastructure system)
2. Social (A caring city for the young, old, those below the poverty level and sick; extending even palliative care for terminally sick)
3. Economic (A city which is an engine of economic development by the promotion of income, employment and attracting investment)
4. Environmental (A city that protects the environment, conserving and enhancing the quality of air, water and land resources, and cultural and heritage resources)
5. Governance (A city with better citizen-municipal corporation interface and customer relationship management for all interaction and activities and better Urban Management and Finance)
6. Financial (A city that upgrades the Financial health of Municipal Corporation to attract more bankable loans).

The Master Plan shall have a Strategic Framework like a Regional Spatial Strategy (RSS) and a Local Development Framework (LDF). The regional framework comes out in the Planning area concept to a limited extent in which Master Plan is prepared along with adjoining Municipalities and village panchayat. It comes short of including all urban agglomeration of the census of India.

Local Development Document (say each panchayat and subdivision of city like Municipal ward) will include the policies and strategy for the area, site-specific allocations, and a proposals map. Supplementary Documents may elaborate upon policies and proposals and may include such areas as development briefs for specific areas. Development Control will change in the way it is operated in some key respects.

A Spatial Strategy may be postulated for Master Plan. Articulate a spatial vision of what the city will look like at the end of the period of the strategy and show how this will contribute to achieving sustainable development objectives. A blue-green city is articulated by many Kozhikode environmentalists. It provides a concise spatial strategy for achieving that vision, defining its main aims and objectives, illustrated by a key diagram, with the policies highlighted. It addresses regional or sub-regional issues that will take advantage of the range of development options that exist at that level.

The Regional Transport Strategy (RTS) will form an integral part of the RSS. Be locationally but not site-specific, while not going into the level of detail more appropriate to a development plan; be focused on delivery mechanisms that make clear what is to be done by whom and by when.

It minimises the need to travel and reduces car dependency; for example, through high-density mixed-use developments, good public transport and pedestrian and cycle-friendly design. It creates a sense of place, reflecting the local character and integrated with adjoining landscapes, with well-designed buildings and attractive green spaces.

It makes efficient use of energy and resources, including energy and water conservation measures and recycling facilities, siting buildings for energy efficiency, using sustainable construction processes and materials, and using renewable energy where possible. It takes account of community requirements, by involving the community in the development process and designing for all types of people, by including a mix of housing.

3 Indian Urban Planning in British Colonial days and Its Influence Later

The present-day Master planning in Kerala and many states in India is based mostly on legislation and planning techniques framed by colonial rulers. These rules are partial to colonial rulers in the sense it benefits more the East India Company that ruled India than Indians and were made to ease their ongoing colonial exploitation. Our legislators in parliament and assembly had never debated and reject or partially accept with modification, all these legislations which was made for Colonial rulers and not for native Indians whom they considered as slaves to be exploited. Even the imported competitive politics in India after the independence of India is an alien concept where traditionally Indian believes in consensus politics. The rationale is legislation is for all and why not make it the best pooling the intellectual resources of the opposition party. Unfortunately, there seems today some continuity with the British period than the best practices of Master Planning of prehistoric Harappa cities, Vedic period cities of Mughal period Cities which resulted in the archaeological a city for all than a present divided city giving more benefits to the colonial rulers of East India Company. So we study the Colonial influence in this section. I may

state here, the resulting master plan has not created any city similar to prehistoric Harappan cities, Vedic cities or Mughal cities all of which was the city for all. It cannot be in the British colony because past rich India was programmed by colonial rulers to be poor in a colonial day and the poor cannot sustain a city similar to what we had in Harappa. Ministry of External Affairs Government of India computed that British colonial rulers syphoned out to England from India a sum of $ 45 Trillian impoverishing India and most affected was Indian cities. This process had a maximum adverse impact on city development. The British influence in planning for Indian cities showed this attempt more. The issues the urban planning generally addressed was intended mainly for Britishers in India and not the Indian natives because colonial rulers were also living in Indian cities. By using design and control of city space; selective provision of water, sewerage, roads, street lighting; and police all of them for the British and not for the natives by dividing invariably cities into two parts was the result of Colonial Master Planning. However, luckily this was not spread all over India uniformly since the British whites in India were few and the spread of British whites in India was mainly in port cities where the wealth of India got syphoned from the Indian gateway of port cities to the gateway to England. The British introduced concepts of urban planning for themselves that is familiar to them and not Indians with no regard to the glories of the wealthy past of India but based largely on emerging European ideals of health and sanitation that was prevalent in the post-Industrial revolution in England such as improved roads, spaciousness, order and beautification to safeguard British populated part of India. This is applied in Indian cities where no industrial revolutions were allowed by the colonialists to take place since the colonial rulers prevented it to happen as part of making India poorer. The place they resided is called 'White Town' while in the areas inhabited by poor Indians, as 'Black Town', where they implemented no or less and cheaper infrastructure, with minimum taxation since poor Indians cannot afford and minimum recurring expenditure in Black Town. So, every city has two parts, for example, Lutyens Delhi and the rest of Delhi in pre-Independent India. As colonial Masters, it was easy to persuade their Indian subjects to accept these imported ideas of post-industrial city as their own, though never without opposition. Undoubtedly there was a conflict with local leaders, but Colonial subjugation helped the British manage and force their way in India. The physical and administrative legacies of colonial rule in Indian Cities then were more or less the same in British India and later independent India till 1991 but seem to continue even today in the implementation of urban projects in cities where central government direct with some money in project and state government follow it. If Central Government says City Development Plan for JNNURM is to be used than the Master Plan under State Government, the latter followed it since money was there in the project. Even after independence, more power was given to appointed bureaucrats than to elected officials; along with subordination of city governments to state and national authorities; use of eminent domain especially for slum removal; a policy of low taxes regardless of civic needs; a pattern of patronage in contracting out urban service even if it is public sector undertakings; and more emphasis on impressive design and architecture for government and the elites than on the basic needs of the ever-increasing immigrant and poor urban masses. This exists

even today as a legacy of colonial rule and India could not overcome these legacies. This was the same in other colonies of the British such as in Africa where the British colonised. India's ancient legacy from the Republics of India of 2500 years ago which was based on consultations with beneficiaries and consensus being practised as in the sangha of Buddhism all over the world were disregarded by bureaucracy who from time to time produced government orders and encouraged competitive politics as against consensus politics to divide communities and rule.

As stated, Indian colonial cities have always been an area dominated, designed and occupied by the British, which was fortified to protect them like Forts named for St. George in Bombay and Madras, and for King William III in Calcutta (Figs. 1 and 2). Sometimes these areas were called the civil lines. Here the Colonial Masters built their homes not traditional Indian homes but British homes, shops, and churches as well as their commercial and administrative headquarters, with some variations since Fort William had few residential settlements while Fort St. George was a veritable city. The army was accommodated in a nearby area called the cantonment or camp. The much larger Indian area of the city was usually referred to as the native, or black town. As British control extended across India, such patterns of racial separation were repeated, although they never amounted to a system of apartheid. These were the main concepts of Indian cities under colonial rule.

Any official plan that emphasised this segregation was however short-lived, Indians overwhelmingly outnumbered the British in the Fort area in later years which made the colonialists lament that they do not have adequate legislation to separate

Fig. 1 St. George Madras eighteenth century sketch. An eighteenth-century sketch of Fort St. George, Madras by Jan Van Ryne. *Source* http://en.wikipedia.org/wiki/File:Fort_St._George,_Chennai.jpg

Fig. 2 Fort William 18 Calcutta century sketch. 2. Fort William, Calcutta. *Source* http://en.wikipedia.org/wiki/File:Fortwilliam_1760.jpg

Indians from this area. Out of a total population of 10,801 listed as dwelling in the Fort, 250 were English, 5464 Parses, 4061 Hindus, 775 'Moors', 146 Portuguese and 105 Armenians [7]. These groups, however, tended to be separated even within the Fort, with Churchgate Street functioning as an intangible line of demarcation that separated the British settlement to the south, characterised by 'whitewashed English homes with covered piazzas', from the 'brightly painted and carved ethnic Indian houses to the north' [8].

Later, suburbs began to develop outside the fort walls, the resulting suburbs were even less racially exclusive than the fort areas [9, 10]. European officials and merchants as well as wealthy Indians found themselves forming new elite neighbourhoods together as 'many Indian magnates began to move out of their wadis and Mohalla's to European dominated areas such as Malabar and Cumballa Hills, Breach Candy and Mahalaxmi.'

This mixing of rich Indians with British areas was gradually replaced by poorer Indians and the British start living together in white towns since they had better civic amenities. The existing laws were not sufficient to keep up their original intent but the British used every pretext to practice their intent.

For instance, after the revolt of 1857, the British saw their supremacy and rule under attack, they could retaliate with devastating, uncompromising and cruel power. The entire Indian population of Delhi was evacuated and allowed to return only in groups, like for instance Hindus in January 1858. Muslims not till the end of that year. Muslims who wanted their property back had to pay for it' (as cited [11]). The British break up the close-knit residential neighbourhoods where rebels could hide and escape British forces and create roads along which troops could be deployed quickly.

New sanitation measures included not only water supply and sewerage, but also extended to regulation and health examinations of the Indian women who serviced the British troops sexually. The British also introduced new taxes and collected them more efficiently to make the city pay for the new construction, services, and police [12]. This was mainly to fund infrastructure like roads which was not for people instead of for the army to navigate and suppress the rebellion. While before that people freely shared part of their land to create access to their homes and roads but the ruling British found that such things will never happen to roads and railway land solely to take away wealth in kind to Britain and it mainly served the British interest in India. So, there was a land acquisition act and the British forcefully acquired land in the name of eminent domain and executed the colonial infrastructure for the benefit of Brittan. Surprisingly, a state like Kerala which is relatively poorer than other south Indian states because of less industrialisation and survival trend from Money order economy and non-productive household investment pattern from Gulf countries followed land acquisition than traditional land-sharing mechanism practised for thousands of years in India for city development. This is a good example of the lasting impact of British legacy through Indian Administrative service as if there exists a psychological barrier to overcome and cities in Kerala is a living example of lack of urban development because of inadequate land management. The same bureaucracy that implements the land acquisition forcefully was used to suppress potential wealth creators of cities by bureaucratic means and red tapes if not physical force to have any industrial and commercial activities by the native Indians so that the native become more impoverished and less strong. This continued in some form after independence. The confronting approach with strikes and bands to wealth creators like industrialists or big farmers by Marxist-led government in Kerala never allowed any industrialisation to take place in Kerala which affected adversely the economic base of Kerala cities. I feel this trend is there in Kerala even today in the name of socialism and communist party rules but with different slogans akin to environmental terrorism.

It was felt more legislation for urban governance was required to meet the emerging issues. The East India Company passed the Improvement in Towns Act (Act 26 of 1850) 30, which called for more contributions to support Municipal Commissions that would introduce urban improvements. Ahmedabad adopted the act in 1856, as did some towns in the Bengal presidency, also in the 1850s, and some in Punjab in the 1860s. By 1860, a new regime of municipal record-keeping and control over building activity in towns and cities was inaugurated through the new Municipal Committees [13], which focused largely on providing urban facilities and services and enforcing building bye-laws [14]. Initially, persons nominated by the British rulers governed these municipalities. This continued in the post-independence period as if it is the only way while other options were there more beneficial. This is another instance of an unsatisfactory psychological barrier I mentioned. This marked the beginning of urban governance in India during the British Colonial period not accounting for the earlier experiences of India probably from the prehistoric times onwards. Later, especially after 1882, the municipalities

were opened to more members elected from the city's Indian population as well as restricting their powers by Municipal Commissioners the bureaucrat.

Viceroy Lord Ripon in 1982 extended the principles of local self-government to all municipalities under British rule, but under the strict administrative control of the British under the chairmanship of the municipal commissioner, usually a white. Civic improvement although part of the agenda, the burden of tax collection moved from the British to Indians. Most citizens did not want to pay the taxes, especially when they perceived no benefit for themselves and more benefit flowed to the British populated area or for Britain to syphon out money from India to Britain. This was perceived as the reason for white administered Municipality. Many have noted the shortage of municipal funds and the almost total lack of concern for parts of the city into which poor immigrants moved.

The plague that broke out in Bombay in 1896, following the first Improvement Trust In 1898, was initiated in Bombay [14]. The trust the answer to the poor sanitation in Bombay threatened the city's which was called then a 'cholera nest, [7] and threatened to close their ports to ships passing through Bombay. The threat became a reality in 1896 as the 'plague initially closed the ports of Europe to ships from Bombay, disrupting the city's export trade and virtually paralysing its commercial life' [8]. The Trust was to bring Bombay into compliance with international health standards. The Trust was to save lives through improving housing standards. 'The establishment of the Bombay Improvement Trust in 1898 was the outcome of a firmly entrenched belief that plague was, in the first instance, the direct result of overcrowding in poorly ventilated and filth-ridden dwellings' [15]. Mortality rates, 1896–1900, reached 65.4 per thousand and remained at 64.1 per thousand, in 1901–05. This was more than double its rate in the previous decades and [16] Workers fled. The population of the city which had been 821,764 in 1891 [16] plummeted to 400,000 in 1897–98 [7], although, the city recouped its losses by 1911. Ira Klein points out the absence of building code in most of Bombay, and the census 1901 discuss the grim housing conditions of the period. There were 100,000 homeless, [15] and tremendous disparities in wealth, and urban blight. The Bombay Improvement Trust was therefore charged with invoking the power of eminent domain to destroy slums and improve the living conditions of the poor. The Trust focused on physical planning: creating new streets, decongesting crowded localities, reclaiming land for urban expansion and constructing housing for low-income residents. These improvements were also intended to enhance the city's image as a centre of imperial and commercial power but nothing was done to help the majority of the poor and here is an instance of physical planning as if no human existed in the physical space.

The Trust was not a democratic institution where a citizen has a say but controlled by appointed officials, who could proceed 'unencumbered by accountability to namesake representatives of local self-governing institutions.' [15]. Subsequently, these Improvement Trusts were extended to other large cities across India—Agra, Kanpur, Nagpur, Delhi, Calcutta and so on. Undoubtedly there was always frictions between the elected municipal governments and the appointed and controlling government servants concerning the division of functions and responsibilities and as a rule, the appointed won. This initiated the process of the multiplicity of authorities that became

a major issue of governance after independence' [17]. For improving slums and for access to better living conditions for the poor, the Bombay Improvement Trust was a failure which I may call under mindless cruel physical planning. In the name of slum improvement, many houses were destroyed without providing any alternatives. The Municipal Corporation had rooms inside houses destroyed to create interior *chowks* through administrative coercion. To create needed urban space, some residents were displaced. Residents compensated for the loss by them build many storeys, resulting in overcrowding. There was also a rise in house prices, so the poor could not afford them eventually. They left or they cramped even more tightly into the remaining space. The Trust was unable to provide adequate new housing on the city's outskirts. Poor residents also could not pay the systematic collection of rent demanded by the Trust; they often preferred private owners with whom they could negotiate or delay payments. There was acute conflict over land and the planning efforts were marginalised and vested interests determined incremental growth in the island city. The state power over land was never dominant to ensure that planning initiatives were implemented.

The condition of Calcutta was unlike Bombay. Richards, the first chairman of the Calcutta Improvement Trust, wrote a report 'On the Condition, Improvement and Town Planning of the City of Calcutta and Contiguous Areas.' revealing his frustration in dealing with the lack of planning. He noted that the city possesses no streets. There are but two small areas in Calcutta having a normal street system. About 2,500 acres are provided only with highly irregular lanes and passages. It would require the creation of 110 miles of ordinary 30–40 Ft streets to bring Calcutta into line with even the old built-up sections of European cities [18]; for a fuller discussion of Richards' report [19]. There was little vacant land to sell off for development. The CIT saw its mission mostly as destroying slums or at least opening them up to circulation of traffic and ventilation of air.

The British Town Planning Act of 1909 began to influence Indian planning, but the context of Britain and India was different. This legislation called for purchasing land on the outskirts of cities and developing it for the "respectable" poor with a steady wage; they would then abandon their inner-city homes for the next generation of the poor. 'It was an idea based on the possibility of rising real incomes for the poor, orderly and controlled administration, and the efficacy of private initiative. …Conditions in Indian cities could not have been more different' [20].

Industrialisation in India was minimal through most of the nineteenth century. The industrial revolution was allowed to bypass India by British colonialists so that they can suppress India and rule an economically weak Indian colony. Town planning in the late 1880s and 1890s was more 'a matter of asserting the Imperial presence by the construction of impressive buildings for colonial rulers and their officers,' mimicking the buildings the native kings made [20]. In municipalities, extraordinarily little professional expertise existed for drafting and implementing town planning [20]. The key personnel in India were sanitary and civil engineers, who cleared slums or built straight roads through them disregarding dwellings there; filled up tanks to get rid of mosquitoes with no understanding of the ecology of lakes and ponds, and made sure civil lines were well taken care of with water and sewerage services paid

for by taxes on the entire city population a form of exploitative urban development and municipal administration and social planning (not socialist or communist) was virtually non-existent to take care of the majority urban dwellers.

The Bombay Town Planning Act of 1915, the first town planning legislation in India, gave the Bombay Municipal Corporation powers to prepare Town Planning Schemes for urban development or redevelopment and present them to the Governor in Council of the City of Bombay. It called for zoning, building regulations, acquisition of land for public purposes, and the collection of funds for local improvements. The need was felt especially strongly because of the chaotic growth of Bombay's textile mills and the workers' housing that surrounded them. The initiative is vested in the local authorities, although the State Government could in special cases direct the local authorities to undertake Town Planning Schemes [14, 21]. Other provinces followed, UP in 1919, Madras in 1920. All the plans were physical in orientation and had no mention of economic development or social change. The plan implementation got divided into local governments and Improvement Trusts. The local governments were empowered to draw up planning acts that called for the use of eminent domain; compensation for the land acquired would be negotiated, but the government had the final say as per the land acquisition act.

The Bombay legislation (*Vide Bombay, Government of India, (1925) Bombay Town Planning Act, No. 1 of 1915. Town Planning Scheme: Ahmedabad No. 1 (Jamalpur) (Final) (Poona: Yeravda Prison Press)*) for the first time in India called for land pooling made possible. Each landowner to be affected by the acquisition of public facilities would surrender a part of his land to the government and keep other parts. The land remaining after the government's acquisition would be re-parcelled out in proportion to the value of each person's land to the whole. It was presumed that landowners would approve of this process because the value of their land, even though reduced in size, would nevertheless increase under the new road or other facility introduced into the area. No one was completely dispossessed; the value of the land increased; the government did not purchase land or become a landlord. In the short run, this method was time-consuming, requiring a great deal of consultation with the landowners, but, in the long run, it created less resentment and fewer protests. Nevertheless, after some time, the process of land pooling gave way to the use of the eminent domain, even in Bombay Province. Eminent domain appeared so much easier to use. In the last decade, however, Gujarat has returned to using land pooling [21].

The town planning schemes improved the site plan and got more access to electricity and water supply and sewage lines to Jamalpur and Kankaria, areas just adjacent to and outside the walls of the old city, were generally popular and passed easily. On the west bank of the Sabarmati River, however, farmers objected to new development plans that took away their land. Vallabhbhai Patel, who felt that the city had to expand, persuaded them to comply. On the other hand, Patel felt that the plans for pulling down the city walls and replacing them with a ring road and an electric tram line were too expensive. Besides, he appreciated the symbolic importance to the Muslim community of retaining the walls, which had been built in the time of the Gujarat Sultanate, and of preserving the Muslim cemeteries at their base. This

project languished for two decades before it was implemented, without the tram line. Later, Patel also opposed plans for a road through the walled city, on grounds that Indians had not been consulted; road construction was, therefore, put off until 1933. Social and political considerations were also part of the agenda of the Indian National Congress and in 1924 the INC presided over the election to the Ahmedabad Municipality of Kacharabhai Bhagat and two other Dalits, its first 'untouchable' mill worker representatives [22].

In 1915, Patrick Geddes arrived in India, to bring to India his innovative Cities and Town Planning Exhibition. Geddes stayed on in India until 1924, the last six years as a professor of Civics and Sociology at Bombay University. He managed to get the Madras Government in 1915 to appoint the first official town planner in India, H.V. Lanchester, architect and editor of The Builder [23]. Geddes' ideas were rooted in planning for the community rather than in the physical planning of buildings and roads by professional engineers. Geddes saw British planning as the problem, not the solution with unrealistic activities of the British engineers and sanitarians with their belief in wide, open thoroughfares, the wholesale destruction of slum areas, flushed sewers, etc.; whilst Improvement Trusts rarely had the powers to make a comprehensive impact on the total environment of the city' [23, 24]. Geddes proposed cheap and ameliorative solutions.

A few of the princes invited Geddes to make new plans for their capital cities, and some did establish Improvement Trusts. Geddes' ideas endured, but they had to wait for a time and place in which community, rather than zoning, would be the focus of planning. A few European trained urban planners came to India after Geddes. Linton Bogle, a graduate of the first British university department of civic design at Liverpool, came and wrote a treatise on Town Planning in India in 1929, following his experience as Chief Engineer of the Lucknow Improvement Trust. Bogle wrote of the need to address the appalling conditions in the slums. He used public health indices—a death rate of 501/ 1000 infants under one year of age in Bombay; 464 in Cawnpore; 330 in Calcutta—to emphasise the need for immediate action. He cited the dense overcrowding in the large cities, the lack of space for recreation and play, the need for larger residences. Bogle was an engineer, and most of the remedies he proposed took the form of physical planning, including zoning and increased room for wider roads [23]. In his introduction to Bogle's manual, Radhakamal Mookerjee, of the University of Lucknow, proclaimed the need for social planning as well as engineering, in part because all of the industrial cities had enormous surpluses of the male population who might be seduced by 'the thought of running away to liquor shops and brothels where there is more room space, more light, and more company' [24].

Depression in the 1930s and then World War II brought about a pause in Indian planning, as elsewhere. The construction of New Delhi as a new national capital, which continued even through the depression, was a major exception.

The publication of a report in 1946 by the Health Survey and Development Committee under the Chairmanship of Sir Joseph Bhore recommended the creation of a Ministry of Housing and Town Planning in every Province, well equipped Provincial Directorates of Town Planning, the appointment of an expert in the Central

Ministry of Health to advise on and scrutinise Town Planning Schemes in different provinces seeking financial support from the centre, and creation of Improvement Trusts in all large cities.

After independence in 1947: the shortage of professionals, the non-existence of comprehensive town planning legislation in almost all the States, and lack of organisation of town planning department were keenly felt. In 1951, the Institute of Town Planners, India, was created with 19 founding members now with more than 5000 members. It is now the most-wealthy professional body in India with the establishment of Institute Buildings in most of the states which was based on clever use of town planning principles of self-generating institutions growth. The central and state governments began establishing planning legislation and town planning departments at the state level. The preparation of Master Plans for major Indian cities began in the 1950s as a coordinated set of proposals for the physical development of the whole city rather than for parts of it—as the Town Planning Schemes had been—and going beyond problems of crisis management into consideration of future as well as present needs.

Town planning emerged in England as a response to the problems posed by the industrial city in the nineteenth century. In India, the town planning and urban development were for reasons of governance, and to reduce threats posed by epidemics, was more piecemeal and partial, hampered by indifference to the problems of indigenous zones of the city, inadequate finances, and ineffective legal measures. By the twentieth century, the influence of professional town planners, the growing nationalist interest in municipal politics, and the interventions of indigenous elites altered the scenario. Many Indian cities, however, continued to bear the marks of a legacy of cities divided on racial and class lines and planned (or not planned) accordingly.

4 Cities, Master Planning and Planners in India

The first Indian Town Planner in the British Colony India was a British citizen, a civil engineer cum editor of a journal appointed in 1915. He is not the first Indian Planner of India. The first and the earliest Harappan cities in the prehistoric era are planned by someone who may be the first planner in India. City planning in the Vedic period is considered a respectable profession meant for people with extraordinary accomplishments, as discussed in Manasara the Vedic treatise on city planning.

In the British colony of India, there existed a demand for urban planners which dramatically increased after independence, but a great shortage is felt in recent decades than any time before. The planning is changing in the digital age and the planners must be re-educated and be made worthy of this digital age. Further, they need to update their professional knowledge base continuously. City Planning was multidisciplinary from the very inception with economists, Sociologists, and other related social sciences and lawyers participate along with Architects and Civil engineers. The current scenario suggests computer scientists, IT professionals, Electronic engineers and manufacturing engineers shall be part of the planning team of a city

that aspires to be a digital city of the twenty-first century. As indicated elsewhere the need of Urban planners were met by the Government Departments or those working in Urban Improvement Trusts, Town Planning Departments, Municipalities and later Urban Development Authorities. The state Government decides on all planning activities often not even consulting the stakeholders as if it is like the civil engineering profession. Planners are also required at the state level and district level since state urban development policies, urbanisation strategies and legislations are framed at the state level and district planning work are undertaken at the district level and Metropolitan Planning is conducted at metropolitan areas and Master Planning cities of all sizes where Municipality is constituted. Further specialised planners like Transportation Planners, urban Conservation Specialists, Housing specialists, Urban designers, Environment and ecology Planners are all required at the state, district, and metropolitan level or above. Planners are also required at the National Level in the Ministry of Urban Development and organisations like Town and Country Planning Organisations.

The state and union government domination in urban planning as a departmental work changed after the enactment of the 74th constitutional amendment which stated the responsibility of Urban Planning and Regulation goes to local self-government with constitutional statuses such, for example, Municipalities and Municipal Corporations. They are independent of the State Government urban Planning department and can ask in principle any consultant to do the job if money is allocated by the finance commission for that task in reasonable quantity and at their description and local bodies are encouraged with less of bureaucracy at the state level.

Many Municipalities turned to private consultants for their planning needs and there was a growth of consultant planners ever since. Many international and Indian companies started Planning firms in India. These companies also utilised the academic resources for planning projects much easier than the Government department with their many sets of rules and regulations and hierarchy of sanctioning authorities and so on which constraints open collaborations of academics in Planning projects in Government departments with outside professionals. Instead of leaving academic institutions to make their own rules of consultant practices, the Government is trying to make these institutions more and more bureaucrats that do not allow free availability for the private sector the academicians for planning projects. This is at a time when India has more planning opportunities and fewer planners.

As of now, there are about 5000 registered Planners which means one planner for every 75,000-urban population. while the urban agglomerations are more than planners available as can be seen in the statistics given below. The statistics are presented below so that one can make an informed judgement of how planners may be deployed for the growing demand for Master Planning in India in the twenty-first century.

The demand pattern of Master Planning in India is based on the supply of candidate's cities by size for Master Planning which requires an analysis of cities size distribution. Constitution envisages urban regulation for all cities and how this can be met? Smaller the cities, it is possible for one town planner to meet the professional demand but class 1 cities with population 100,000 + and metropolises with

one million population, megacities with 10 million population and meta cities with 20 million population and above requires more number of planners as well as planners with specialisation per city. Being multidisciplinary work in nature, he may have to get other disciplines for his work as discussed. First, it is important to study the phenomenon of urbanisation in India as its magnitude in the absolute number of cities to decide on Planner manpower. Then assess the demand for Planners professionally trained and how they should be instituted and deployed to meet the supply of urban centres with demand for planners in a market economy of India with a past of strong socialist orientation under a disproportionately large bureaucracy and red-tapism. Then we must assess how a multidisciplinary team can be easily assembled, mobilised or instituted. Then we must assess how far city planning professionals can be privatised and what is the ideal mix of private consultancy firms and public government departments.

Along with professional inputs for planning discussed, the local resources in colleges, schools and other institutions can be mobilised for participatory planning. This call for planners as professional leader of this work as a person suited to work as a mobiliser and organiser for community action. Do we impart such capabilities in planning schools in India? Are Government planners doing or capable or allowed for such orientation of planning which is the needs of the country in the twenty-first century.

The population as per the last 2011 census of India: is 1210.2 million, the level of urbanisation: about 31% and the urban population in the absolute term is 377.10 million. Although the per cent in comparison with the western nations looks small, the size of the urban population is comparable to the total population of the United States and many more countries combined in the world.

The rural–urban split of the population in the last few censuses namely 1951 to 2011 is given below. In recent decades there has been an acceleration in the number of urban habitats as well as in urban population in comparison to those in rural areas.

The growth pattern of the urban population from 1901 to 2011 is tabulated below (Table 1). Although annual exponential growth does not show appreciable change the percentage of the urban population is increasing steadily. It can be concluded that the growth of urban population is above population growth and normal but the percentage of urban is rapidly increasing necessitating more urban, Master planning.

Additional details of cities are given in Table 2.

In the process of urbanisation in India, the number of cities got multiplied faster. Within 110 years the number of cities with 100,000 population and above-called class 1 cities grew from 24 to 468 and the number of urban agglomerations 1827 to 7935. All of which needs a Master Plan which is not provided for. In the 2011 Census, 475 places with 981 OGs have been identified as Urban Agglomerations as against 384 UAs with 962 OGs in the 2001 Census. Can the planning demand required be met with 5000 registered planners?

Table 3 illustrates the growth of the urban population in terms of size and number of urban agglomerations from 2001 to 2011.

The urban population shows a spurt from 1971 to 2001 and 2011 while rural population growth is slowing down in growth.

Table 1 Urban population in India, 1901–2011

Number of towns in each category							
Census year	Class I	Class II	Class III	Class IV	Class V	Class VI	Total
1901	24	43	130	391	744	479	1811
1911	23	40	135	364	707	485	1754
1921	29	45	145	370	734	571	1894
1931	35	56	183	434	800	509	2017
1941	49	74	343	498	920	509	2190
1951	76	91	327	608	1124	569	2795
1961	102	129	417	719	711	172	2270
1971	148	173	558	827	623	147	2476
1981	218	270	743	1059	758	253	3301
1991	218	270	743	1059	758	197	3696
2001	393	401	1151	1344	888	191	4368
2011	468 (53 Metros)	546	1321	1091	474	133	4041

Source [24, 25]
Note:
Metro = Metropolitan cities
Class 1 100,000 and above, and Metropolitan cities 1 million and above
Class II 50,000 to 99,999
Class III 20,000 to 49,999
Class IV 10,000 to 19,999
Class V 5,000 to 9,999
Class VI less than 5,000

The class-wise distribution of statutory towns/cities as per Census 2011 is as follows (Table 4).

Most of the urban settlements experienced haphazard and unplanned growth, non-conforming land uses, mushrooming unauthorised colonies and land conversion from agriculture to urban resulting in environmental degradation and resulting in a poor quality of life. The main reason for all is many of these towns have no Master Plans or the Master Plan executed so far has not given the city a better outcome desired by the city population. The major issue is how can these demands be met. If planners services can be imported from outside the country can they make Master Plans which satisfy the ways of life and work of the citizen who follows Indian culture? Are the imported planners' experts in Indian culture?

Table 5 studies in detail how different categories of towns changes during the 2001 and 2011 census.

In the Tables 4 and 5, the class size distribution of towns from 1901 to 2011 shows the number of urban agglomeration which can be defined as city as against municipal boundary itself is rapidly increasing over the last two censuses of India. Many UAs/Towns and Out Growths (OGs) merged during this period.

Table 2 Details of Towns in India 1991 to 2011

Census years	Number of towns/UAs	Cities with a population of 1 lakh and above	Urban population (in millions)	% Urban population	Urban annual exponential growth rate
1901	1827	24	26	10.8	–
1911	1815	21	26	10.3	0.03
1921	1949	27	28	11.2	0.79
1931	2072	33	34	12.0	1.75
1941	2250	47	44	13.9	2.77
1951	2843	71	62	17.3	3.47
1961	2365	95	79	18.0	2,34
1971	2590	139	109	19.9	3.23
1981	3378	204	159	23.3	3.79
1991	4689	273	217	25.7	3.11
2001	5161	350	285	27.8	2.74
2011	7935	468	377	31.2	2.76

Source (1) Computed from Census of India Part II A (ii) Towns and Urban Agglomerations classified by population in 1991 with variation since 1901
(2) Census of India 2011, Final Population Totals, Registrar General of India, New Delhi

The decadal growth of the total urban and rural population is tabulated in Table 5. It can be seen that the decadal growth of rural population percentage is reducing but the urban population decadal growth is only +0.3%. This calls that Master Planners need to care for integrated urban and rural areas in the immediate future.

Population statistics of urban and rural and decadal growth and 20 years growth is given in the above table. The last decade 2001–11 showed greater urban growth and the rate of growth of rural population growth declined considerably.

Table 6 shows classes of Towns in 2001 and 2011. For Master planning Statutory Towns and Class 1 Towns are most important and they are tabulated below for 2001 and 2011. Can we meet the master Planning demands of these towns by 5000 registered planners in India and what about future candidate towns?

The Census 2011 enumerates, 7,935 towns in the country. The number of towns has increased by 2,774 since the last Census. Many of these towns are part of UAs and the rest are independent towns. The total number of Urban Agglomerations/Towns, which constitutes the urban frame, is 6166 in the country.

The population of UAs/Towns can be summarised as follows:

1. The total urban population in the country as per Census 2011 is more than 377 million constituting 31.16% of the total population and every urban citizen requires the services of a professional planner.
2. Class I UAs/Towns: The UAs/Towns are grouped based on their population in Census. The UAs/Towns which have at least 1,00,000 persons as a population are categorised as Class I UA/Town. At the Census 2011, there are 468 such

Table 3 Urban Population in India 1901 to 2011

Census year	No. of towns/UA	Total population in million	Urban population in million	Rural population in million	Urban population as a percentage of total population
1901	1830	238	213	26	10.8
1911	1815	252	226	26	10.3
1921	1914	291	223	28	11.2
1931	2066	279	246	34	12.0
1941	2253	319	275	44	13.9
1951	2.822	361	299	62	17.3
1961	2.334	439	360	79	18.0
1971	3.567	548	439	109	19.9
1981	3,347	683	524	160	23.3
1991	3,769	846	629	218	25.7
2001	4,374	1,027	742	285	27.8
2011	4041	1211	873	377	31.6

Source Census
Note
1. Urban Agglomeration is treated as one unit
2. The total population in 2001 includes an estimated population of Gujarat and Himachal Pradesh where census could not be undertaken
3. The total 1991 population of India includes an interpolated population of Jammu and Kashmir
4. The total population of 1981 also includes an interpolated population of Assam where the census could not be conducted

Table 4 Type of towns/UAs/OGs number of towns

S no	Towns agglomerations and outgrowths	Number of towns	
		2011 Census	2001 Census
1	Statutory towns	4,041	3,799
2	Census towns	3,894	1,362
3	Urban agglomerations	475	384
4	Out growths	981	962

Source [26]

UAs/Towns. The corresponding number in Census 2001 was 394 which requires the services of a professional planner.

3. 264.9 million persons, constituting 70% of the total urban population, live in these Class I UAs/Towns. The proportion has increased considerably over the last Census. In the remaining classes of towns, the growth has been nominal and requires the services of a professional planner.

Table 5 Population census 2001 to 2011 and decadal growth rural, urban and total

	The person in million nos		Decadal growth in a population (%)	
Year	2001	2011	1991–2001	2001–2011
Total	1029	1210	21.5	17.6
Rural	743	833	18.1	12.2
Urban	286 (27.81%)	377 (31.16%)	31.5	31.8 (+0.3%)

Source http://mohua.gov.in/cms/number-of-cities--towns-by-city-size-class.php

Table 6 Cities and towns by city class size

	Population size	Number of UAs and towns 2001	Number of UAs and towns 2011
Class 1 towns	100,000 above	333	465
	Out of above more than10,000,000	35	53
Total towns all classes		5161	7935
Statutory towns		3799	4041
Census towns		1362	3894

Source [27]

4. Million Plus UAs/Towns: Out of 468 UAs/Towns belonging to the Class I category, 52 UAs/Towns each has a population of one million or above each. Known as Million Plus UAs/Cities, these are the major urban centres in the country. 160.7 million persons (or 42.6% of the urban population) live in these Million Plus UAs/Cities.18 new UAs/Towns have been added to this list since the last Census.
5. Meta and Mega-Cities: Among the Million Plus UAs/Cities, there are two exceptionally large UAs with more than 20 million persons now in the country, known as Meta-Cities. These are Greater Mumbai UA (18.4 million), and Delhi UA (16.3 million). The largest UA in the country is Greater Mumbai UA followed by Delhi UA.. which held the second rank in Census 2001 has been replaced by Delhi UA. The growth in population in the Mega Cities has slowed down considerably during the last decade. Greater Mumbai UA, which had witnessed 30.47% growth in population during 1991–2001 has recorded 12.05% during 2001–2011. Similarly, Delhi UA (from 52.24% to 26.69% in 2001–2011) and Kolkata UA (from 19.60% to 6.87% in 2001–2011) have also slowed down considerably. All major statics given is mapped in t = figure below.

Figure 3 gives the spatial distribution of urban settlement in 1991 and metropolitan and megacities in 2011. The western half of India is having more mega and metro cities than the eastern part.

Break up of class 1 cities in India which include mega cities Delhi, Mumbai and Kolkata and remaining metro cities is given in Fig. 3.

Table 7 Growth of metropolises in India 1901–2011

Census years	Number of metropolises	Population in millions	Decadal increase (%)	The population of metropolises as a percentage of India's total population	The population of metropolises as a percentage of India's total urban population
1901	1	23		0.6	5.8
1911	2	2.8	82.8	1.1	10.7
1921	2	3.1	13.4	1.3	11.1
1931	2	3.4	8.9	1.2	10.2
1941	2	5.3	5.7	1.7	12.0
1951	5	11.8	21.3	3.3	18.8
1961	7	18.1	54.0	4.1	22.9
1971	9	27.8	53.8	5.1	25.5
1981	12	42.1	51.3	6.2	26.4
1991	23	70.7	67.8	8.4	32.5
2001	35	107.8	52.8	10.5	37.0
2011	52	159.6	48.9	13.2	42.3

Source (1) Computed from Census of India 1991, Part-II A (ii)-Towns and Urban Agglomerations classified by population in 1991 with variation since 1991
(2) Census of India, 2011 Final Population Totals, Registrar of India, Census

Among the urban population, the largest per cent of people in India live in megacities. Table 8 computes these figures for states. With an extremely high share of the metropolitan population of urban Kerala, it is important to concentrate on metropolitan development in Kerala to reap the harvest of rapid economic development.

Table 8 tabulates the metropolitan areas by states in 2011.

Figure 4 represents the towns and cities in 1951 and the number of metropolitan areas in 2011. It can be seen unlike China the western part of India has more megacities and metropolitan cities than the eastern part. There is also near equitable distribution of mega and metro cities all around the Indian Union, unlike China.

The rapid pace of urbanisation poses an unprecedented managerial and policy challenge for sustainability calling for more able Master Planners of cities better equipped and better trained.

Minister of State for Urban Development Babul Supriyo said in a written reply in 2020. Planners in India have one urban planner for 75,000 urban people. There are about 5,000 registered urban planners in the country or one per every 75,000-urban population. Though this ratio may be low compared to that of developed countries, the

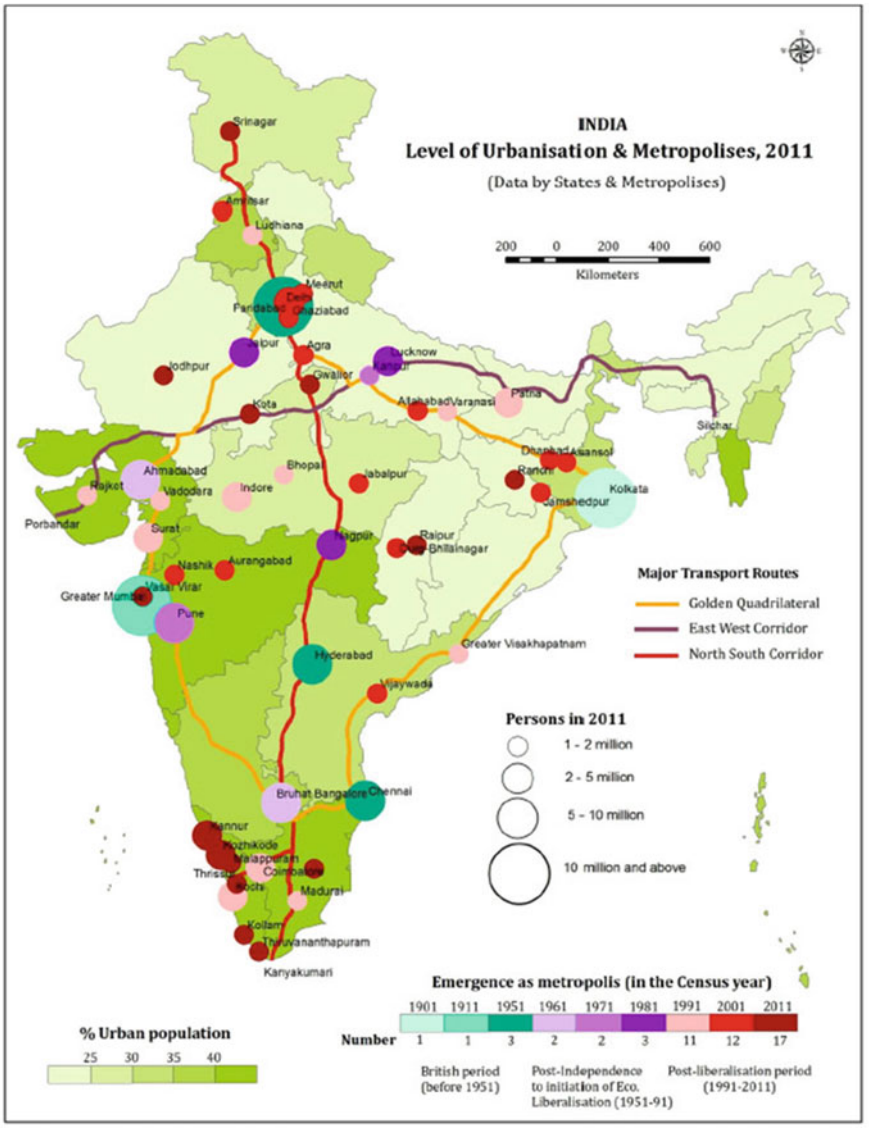


Fig. 3 Levels of Urbanisation and Metropolises in India 2011. *Source* [28]

adequacy of urban planners needs to be seen in the context of the scale of urbanisation in India,

In summary, we enumerate the following.

1. Total Number of Cities and Towns: 7933
2. Total Number of Master Plans: 2738 (34%)
3. Total Number of Statutory Towns: 4041

Table 8 Configuration of metropolises in 2011

State/Union territory	Metropolises	No. of metropolises	Population of metropolises	State urban population	State % urban population	% Share of metropolises
Kerala	Kochi UA, Kozhikode UA, Thrissur UA, Malappuram UA, Thiruvananthapuram UA, Kannur UA, Kollam UA	7	12,139,860	15,934,926	47.7	76.2
Uttar Pradesh	Kanpur UA, Lucknow UA, Ghaziabad UA, Agra UA, Varanasi UA, Meerut UA, Allahabad UA	7	14,025,098	44,495,063	22.3	31.5
Maharashtra	Greater Mumbai UA, Pune UA, Nagpur UA, Nashik UA, Vasai Virar (Mun.Corp.), Aurangabad UA	6	29,927,857	50,818,259	45.2	58.9
Gujarat	Ahmedabad UA, Surat UA, Vadodara UA, Rajkot UA	4	29,927,857	50,818,259	45.2	55.0
Madhya Pradesh	Indore UA, Bhopal UA, Jabalpur UA, Gwalior UA	4	6,428,127	25,745,083	42.6	55.0
Tamil Nadu	Chennai UA, Coimbatore UA, Madurai UA, Tiruchirappalli UA	4	13,278,580	34,917,440	48.4	38.0

(continued)

Table 8 (continued)

State/Union territory	Metropolises	No. of metropolises	Population of metropolises	State urban population	State % urban population	% Share of metropolises
Andhra Pradesh	Hyderabad UA, Vishakhapatnam (M.Corp.), Vijayawada UA	3	3,662,372	28,219,075	33.4	38.6
Jharkhand	Jamshedpur UA, Dhanbad UA, Ranchi UA	3	3,662,372	7,933,061	24.0	46.2
Rajasthan	Jaipur (M.Corp.), Jodhpur UA, Kota (M.Corp.)	3	5,186,157	17,048,085	24.9	30.4
Chhattisgarh	Raipur UA, Raipur UA, Bhilainagar UA	2	2,187,780	5,937,237	23.2	36.8
Punjab	Ludhiana (M. Corp), Ludhiana (M. Corp) Amritsar UA	2	2,802,428	103,991,346,375	37.5	26.9
West Bengal	Kolkata UA, Asansol UA	2	1,530,140	29,093,002	31.9	52.6
Bihar	Patna UA	1	2,049,156	11,758,016	11.3	17.4
Haryana	Faridabad (M.Corp.)	1	1,412,050	8,842,103	34.9	16.0

M Corp-Municipal Corporation
Source [25]

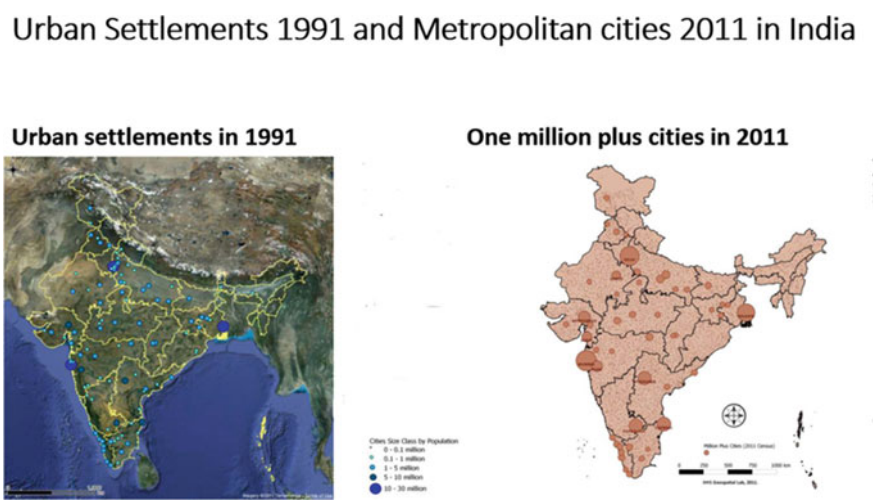


Fig. 4 Urban Areas in 1951 and Million Plus Urban Agglomeration in 2011 in India

4. Total Number of Statutory Towns having Master Plan: 1938 (48%)
5. Total Number of Census Towns: 3892
6. Total Number of Census Towns having Master Plan: 800 (20%)
7. Percentage of Urban Population in Statuary Towns 85%
8. Percentage of Urban Population in Census Towns 15%.

The governing terms of reference of the 12th schedule 74th constitution amendment call for all Municipal local bodies to prepare Master Plans and Govern urban regulations based on that. The above facts show they are not doing that because of several constraints enumerated, but they cannot ignore it. Now, what can be done?

1. Planning departments in every state are not expanding. to meet this gap in manpower for Master Planning. Do we want it to expand the Government planning department or privatise planning?
2. The Municipalities need not use Government departments to prepared Master Plans and so the case for expanding planning departments to meet this task is not tenable.
3. Although few national and international consultancies are active in India, they are not able to adequately meet the demand for planning.
4. The budget available for consultants to plan to adopt the current Institute of Town Planners Professional fee document is not provided for in many municipalities.
5. The Government planning support system of urban mapping which started in the 8th five year plan period has not yet covered all cities with the lapse of many decades in between mainly due to less objective achievements of a total government-run project and not involving private companies. The output came generally very late. Why not use the private agency for urban mapping as well as cadastral survey mapping.

6. While Master planning is transiting to digital planning many more disciplines like computer science for E-Governance support and urban information system, electronics engineers specialising in IoTs, Mechanical engineers for Industry 4 applications in Master Planning along with conventional collaborators like Economist, Sociologist, ecologist, law and geographers shall be part of the Planning service company.
7. State and central government finance commissions are not giving sufficient budget to local bodies to hire the best talents from within or outside India to execute their constitutional responsibilities.
8. Municipal administrations seem less autonomous even though they are constitutional bodies to be more under state government and it should change for independence in Master Planning.
9. The only way out is summarised below

    a. Reduce the Government Planners to 10% present strength and post all of them to the state headquarter to manage the legal process of planning and prepare Urban Planning policies.
    b. Research set up like Niti Aayog may be instituted at state levels to support urban and regional planning in respective states and give research-based direction.
    c. Form at the national level, a public–private Planning Services Company like the successful model of Kochi International Airport company to perform all planning services starting with digital cadastral maps and ending up with E-Governance and all types of digital planning with the remaining 4500 registered planners under virtual office system to give e-serving of Master Planning to all cities.
    d. The equity participation for the above company is less than 49% shall be from Central and state and local self-government levels. The remaining equity shall be from private individuals or organizations including planners themselves.
    e. Institute of Planners India and all planning schools shall be represented in the technical and executive board of the company.
    f. The company shall not have a large brick and mortar office, but a digital virtual office shall replace them and service can be digital.
    g. The state-level branch of the Planning Service Company shall operate in virtual offices at the state level using the network of consultants largely on a job basis scattered all over India.
    h. The details of this company need to be worked out by a competent group of professionals drawn from the Institute of Town Planners India, State and Central Government Planning Officers and leading Planning Schools in India.

5 Critique of Master Planning

The Master Plan is available as a report generally found on the website of a Municipality freely downloadable and consists of content like what is discussed earlier in the chapter. It generally has two maps of colour coded, one of existing land use and the other the proposed with its rationale and underlying concepts explained in the report. It further elaborates the regulation of urban development in different parts of the city as zonal plans regulations; in some cases, as colour coded and annotated maps or left as the directive statement in some cases.

It further deals with local economic development, demography, slums, housing, poverty, physical infrastructure and social infrastructure in addition to all that is discussed in previous sections. The earlier preoccupations of British Colonial days discussed earlier in the Chapter seem to be extended in the Master Plans. Statistics of Downloads and views of the readers are not kept on the website and the website, by and large, is not meant to discuss the Master Plan. It is not a report read by all citizens but used by concerned Government officials, planners, architects and engineers and other stakeholders. People generally consult it with the help of a Town Planner when they must build for a certain purpose such as houses, shops and industries. The preparation of the plan is generally done by a team of experts led by Urban Planners in consultation with Government officers dealing with the subject matter and elected members of the Municipality. Public meetings and mass media coverage of Master Planning opens the process to public consultations. Earlier experience of preparation of Master Plan did not consult people but was solely a Government office activity directed by State Head Quarter office. In the recent time after the 74th Constitutional Amendment, planners try to involve stakeholders with consultations which are mandatory to record officially for plan sanction.

Many studies [29–58] are there enumerating the shortcoming of the Master Plan and it is summarised in this section. Most of them are written based on urban planner's own experience of preparing a Master Plan and watching its various process by experienced authors but there are also academicians looking at these aspects in the references given. Sometimes the same conclusions are reached by many authors.

Therefore, I have summarised their conclusions of these papers in a summary form below without presenting statistics of opinion by authors with some exceptions. This will form the basis for one of two volumes for the book for Smart Master Planning focusing mainly on selected domain studies.

1. Master Plan as a guide for planned development ultimately become a sort of document which was less amenable/accommodative to the **unforeseeable changes** in the city requirements such as flood or COVID 19 pandemic.
2. **Disaster management** is not given importance in Master Planning.
3. Master planning methods adopted over the last few decades in India have not produced a satisfactory physical environment [35] and have not been **effective** in the outputs as well as outcomes [56].
4. The planning process in the past has been **unduly long** mostly five years some more than 10 years and largely confined to the detailing of land use aspects.

5. Functionally, master plans paid inadequate attention to the provision of city-specific major infrastructure like metros rails. Once it is implemented the structure of the city as envisaged in the Master Plan is no more valid.
6. Environmental conservation was neglected and there was no ecosystem planning.
7. Financing issues and commitment did not figure in Master Plan including strategies to circumvent any related issues and made Master Plan unrealistic proposals without the budgetary commitment from State and Central Government and stakeholders in private sectors [56].
8. The master planning approach did not exhibit a holistic view of urban development that integrates city economic development, social change and cultural development and did not deal with interconnecting all these aspects spatially. For example, master plans cannot be translated into socio-economic development plans creating cultural change and integrated development.
9. The physical planning exercises in Master Plan generally were restricted to core urban areas without much integration with the peripheral areas and rural hinterlands.
10. Attempts to adopt an integrated development plan approach, based on national, state and regional strategies and recognition of the spatial and functional linkages between settlements of different orders have not been made in Master Plans.
11. In the process of plan-making and plan implementation, no adequate attention to the integration of land use and transport, planning has been made. The fact that transport is a key determinant of land use and "leads" development is sometimes ignored.
12. The shortcomings of the Master Plan approach are in the resulting design, conceptual issues and procedures that are resulting in unacceptable delays and the evil of delays are not questioned by the public.
13. The Master Plans are too static incapable of addressing emerging issues from time to time as it appears, and they take an exceptionally long time to prepare and are too infrequently updated.
14. Master Plan is subservient to vested interest and there have been case-by-case relaxations in the plan to serve vested interests.
15. Proposals/estimates have not kept pace with the unprecedented growth and future requirement of cities.
16. Master Plans are generally silent on costing and financial management for infrastructure provisioning.
17. No specific set of incentives were outlined in terms of financial assistance to implement the Master Plan.
18. Master Plan instead of becoming a tool for regulated development has become a platform for stakeholder dissent (as experienced in Master Plan of Delhi).
19. Zoning and Development Regulations are cumbersome to follow, vaguely stated to call for controversies and long court cases and result in weak enforcement.
20. Master plans rarely provide guidelines on the techniques of implementation

21. Master plans are often based on the unrealistic appraisal of the economic potential of the planning areas and, in some cases, on the needs.
22. Master plans seldom provide detailed land use and elaborate and unambiguous land use regulation or suggests control by Community or elected representatives and NGOs, Academics and the Business community are not involved in the planning process meaningfully [58].
23. The Master plan details out the urbanised and urbanising areas under its jurisdiction and suggests land use up to the neighbourhood level. This minute detail for 20 years has resulted in a lack of flexibility and has hindered individual self-expression.
24. The plan projects and 'end state' scenario for 20 years is not realistic for short and medium-term actions.
25. The plan is mostly static and not amendable to quick mid-course corrections.
26. Inordinate delays in Master Plan preparation and approval of zonal plans and urban land management schemes and, besides, difficulty in obtaining possession of land sought to be acquired for the purpose is the main hindrances to a speedy and successful implementation of the Master Plan.
27. The efficacy of the master Plan is adversely affected by the divergence between the presentation of urban growth envisaged 20 years ago and emerging urban growth reality.
28. The mechanism for public participation is ineffective in the process of development planning, in both its preparation and implementation. It is more top-down than a bottom-up approach.
29. Master Plan preparation is undertaken with a very weak information base especially on socio-economic parameters, housing and environment.
30. The plans prescribe impractical densities and layout high standards to improve the quality of life in a city. These are generally higher than what the city population, particularly the poor, can afford.
31. Estimates of financial outlay do not match the development works envisaged in the Master Plan. The strategies for raising resources required for plan implementations are never an integral part of the plan.
32. Urban planning in India has been overshadowed by its spatial content instead of the realisation of social and economic objectives. Town planning exercises tended to concentrate on the physical order and environmental quality of the city and were isolated from the mainstream development planning, decision-making and implementation strategies.
33. The absence of machinery for systematic and continuous collection of data on the movement of land and tenement prices undermines the implementation of the Master Plan.
34. Through a significant portion of the development is due to the initiative of the private sector, this factor is not recognised in the Plan.
35. The regulatory mechanisms in the Master Plan are to enable better management of the city. but too restrictive controls are costly enough to provide incentives for breach rather than compliance.

36. The root cause of the urban maladies has been the divorcing of the plan preparation from plan implementation, and Ineffective plan Monitoring:
37. An institutional and information system does not, generally, exist for plan monitoring. Since the budgetary system does not explicitly consider the requirement of plan implementation, the problem of resources is not periodically highlighted.
38. Master plans or Development plans have been taken as given from the past colonial system prevalent before the independence without enshrining the good features after independence especially after 1991 such as the market economy. The result of this traditional planning approach in the form of master plans is turning out to be frustrating.
39. Urban planning in the past was primarily influenced by central planning principles of the post-independence era and the characteristics of the communist planning of the now-defunct Soviet model. The idea was everything on City Planning is decided by Planning Commission for the Nation and Planning Board for State and Master Plan of the city is expected to follow that in the way it is to be implemented as suggested by these Planning bodies. Now the Planning Commission is no more, and the Planning Board have doubtful life, but no alternate approach is suggested. What was left at local self-government was arithmetic of central planning for allocation of central funds at city level by some formula which will not make comprehensive city development. This, unfortunately, do not allow local initiative and innovation by local stakeholders. The negative empowerment of bureaucracy over municipality by communist planning act as a retardation mechanism for urban development.
40. In the liberalised era and globalised world, the planning processes must serve the economic and social objectives of the global society through the creation of a growth enabling physical spaces and infrastructure in cities. This changing context itself calls for identifying alternative approaches and strengthening existing planning mechanisms and institutions at the city level.
41. There are no efforts to link the short term or investment plans with the existing Master Plan. For example, every state has an annual budget and plan but there is no connection between the annual plan and Master Plan. One of the reasons for this disjuncture between the Master Plan, investment plans and governance structure is that the first one is a very long-term plan and the medium-term zonal plan is never given due importance and flexibility.
42. Land use designations are usually determined or justified on one of the three principles in the Master Plan: as responsive to existing conditions, to enable smooth traffic flows, or as a part of some larger conceptual plan for the city [34]. The distribution of various land uses has been made even to reduce traffic congestion inside the old city and to reduce the number of commuting trips in the peripheral areas. The local level conceptual plan, i.e. micro-level land use planning is completely lacking in the Master Plan. The land-use plan is responsive rather than act as the location of many of the land uses are determined by the existing condition or character of the land. For example, the illegal growth of residences near the industrial area land surrounding the industrial area has

been declared for mix residential and commercial development. Likewise, the location of transportation nodes, private bus stands, and the truck terminus is also compromised in the Master Plan.

43. The master plan is highly bureaucratic in its processing and also design-oriented as it is prepared by the planners, engineers and architects of the Town Planning Department who are very much interested in sketching out aesthetic layout plans of the city and have little concerns of differing socio-economic needs or its changing character from one part of the city to another. For instance, delimitation of planning zones seems to be arbitrarily done because the basis of delimitation is not clear and erroneous. There lies a considerable difference regarding socio-economic structure and level of development of existing land use in each zone. For example, the old city zone covers the oldest part of the city at one hand are highly dense and in contrast, the sparsely developed areas are the newly developing areas. These differ from each other in many aspects and have their own needs and problems which require different approaches and methods of planning to tackle the planning issues and strategies. The approaches and methods applied for the old city cannot apply to sparsely developed areas. Hence, putting together two heterogeneous areas to form a planning zone is erroneous as well as unscientific for urban development. The story is the same for the rest of the planning zones except the peripheral zone which is entirely rural. Therefore, the planning standards adopted cannot be uniform but change realistically from one part of the city to another.
44. A planning zone has been defined as an area where the community is self-contained in terms of employment, housing, and other community facilities. This is a highly unpractical approach to land use planning in which coordinated and integrated land uses and functions of the city has been completely overlooked. Further, the urban society of a specific area cannot be made fully contained in terms of employment, schooling, and health care facilities particularly in Indian cities
45. The short-term measures to bring about improvement in existing conditions particularly in the old city area is ambiguously mentioned with refraining phrases of relocation, provision of community facility, conservation, reconstruction and redevelopment. Such measures need a huge amount of money and people's active participation about which the Master Plan is silent.
46. One Master Plan in India took an Inordinate time of sixteen years (from 1973 to 1989) in preparation and approval of the Master Plan and, in obtaining possession of land sought to be acquired for the very purpose. All these while, several changes, i.e. increase in population and economic activities, growth of socio-economic facilities, a boom in the service sector of the economy, decline in manufacturing activities due to shifting and dislocation of road alignment away from the city, change inward boundary and so on occurred in the city. Consequently, the city's development has been taking place without proper implementation of the Master Plan.
47. Lack of public awareness and public participation in preparing and implementation of Master Plan has negatively influenced the realisation of its objectives

and goals. Hence, the Master Plan is more top-down than a bottom-up approach to planning

48. Master Plan has been prepared for a projected population and in many cases, the projection was not correct when plans are reviewed.

The master planning approach in urban planning has received little success and so there is a case for smart master planning. Major causes and factors attributing to partial fulfilment of objectives of the master plan include excessive time consumption in plan preparation, approval, sanctioning of financial resources and acquisition of land with outmoded Land acquisition legislation, lack of trained staff and other requisite planning support resources, appropriate legislations, lack of coordination between government institutions and accountability, poor governance, widespread corruption, lack of will and responsibility and above lack of public cooperation and participation. The timely solution of the above impediments is essential for the preparation of a good plan and its successful implementation. Further, the top-down approach of master planning must be reverting to a bottom-up approach ensuring active public participation in planning and decision-making processes. Here, the role of government institutions should be as a facilitator in urban development. The partial success of the master plan indicates that it needs much more positive and concerted efforts for full implementation rather than questioning the relevance of this approach as some academicians do. Further, short, or medium-term action plans must be formulated attuned to the long-term master plan for the avoidance of failure and increasing its effectiveness. As far as Master Plan is concerned, it has been implemented with partial or minimal success. It is because a few proposals lacking in ground realities and coherence. It also indicates lacunas in plan preparation processes and administrative hindrances in the implementation of the plan. These shortcomings need to be eliminated through concerted efforts to avoid failure of the master plan in future.

6 Towards Digital Master Planning of Cities

We have discussed the past Master Planning efforts and their shortcomings, which is under great disruption today and now it is time to discuss the future of Master Planning. The outcome of the Master Planning during the colonial period as well as the post-independence period has been largely disappointing. There is nothing to showcase to the world about its achievement. We are unable to find through Master Planning how cities are made into engines of economic development and for rapid social and cultural changes. Instead, what we see there is the ugly hydra of bureaucracy that makes citizens and entrepreneurs immobilised depleting their all initiatives. Bureaucracy is there in its full force as discussed during the plan-making and its implementation is mostly self-serving but not for the citizen or city. Cities cannot function without urban regulations and Master Plan act as the legal instrument for urban regulation and therefore you cannot remove Master Planning however

imperfect it may be, but bureaucracy can be minimised and partially eliminated which saves money to Government in terms of their salary and upkeep if the citizen can own Master planning and do self-regulation using science and technology using a bottom-up process.

There are two approaches in front of us. One is tweaking all the shortcomings reported in the previous section one by one. The author feels it is impossible because our past largely British made legislations for the benefit of Britain used by present-day Urban Planning in India as the land acquisition act cannot be reformed in the past by Parliament. The alternative suggested by parliamentarians was more bureaucratic and complicated and counterproductive. It is likely the past will continue and instead of Master plan preparation taking 13 years to complete will take 23 years for a 20-year plan and implementation perhaps 230 years or there can be planning holidays. This is all because the framers of legislation in parliament and assemblies have not researched the subject matter adequately and come out with a rational means.

The Amrut project of the Ministry of Urban Development GOI insists on Master Planning based on GIS and remote sensing which can overcome some part of delays in Master Planning if well organised with private sector participation. When the use of remote sensing for accurate maps and application of GIS as a tool to making land use and zonal plans the disruption was mild. GIS was used in the past wrongly to substitute cartography. This is not the appropriate use of GIS in Master Planning which is to visualise descriptive and predictive land use and transportation models and other innumerable routine functions. This is not much of disruption since Remote sensing maps were used in the past also in some cities.

Cloud computing, ubiquitous connectivity, the internet of things, artificial intelligence/machine learning/deep learning, blockchain, augmented reality, virtual reality, and wearables, is the future of digital Master Planning. This I call great disruption. Here the disruption is total.

The Master Plan for cities and regions is practised around the world, such as the design of new towns, metropolises, or residential development—the Master Plan guides the development project from concept and design, through to implementation. Even as further details of the design and construction emerge, the Master Plan is a baseline that is updated and improved upon but less prevalent in the digital realm.

Digital master Planning is all about using ICT infrastructure, science and digital technologies, to translate the urban vision of the Master Plan into a coherent design and implementation framework to help Municipalities achieve their constitutional responsibilities.

For Akira Consulting the Digital Master Plan consists of 10 core components [59–63] as outlined below (Fig. 5).

1. Vision: Outlines an aspirational description of the target state the Master Plan of a future date, together with specific goals and success metrics.
2. Digital Experience Mapping: Describes the expected experiences of staff, customers, partners and other stakeholders, as well as the digital touchpoints that enable and support each of these experiences.

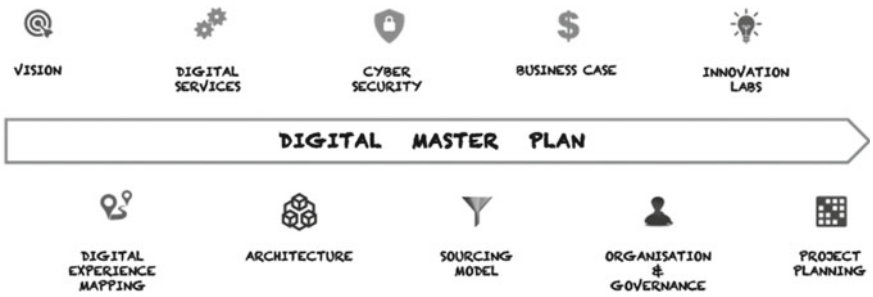


Fig. 5 Digital master plan. *Source* [63]

3. Digital Services: Describes the individual services to be delivered as part of the target design. They may include telecommunications and networks, computing infrastructure, enterprise and business applications, integration technologies, analytics, cybersecurity and data protection, etc. Services are clarified in terms of priority, business ownership, required levels of service and where they sit on the scale of must-have to nice-to-have. These services represent the translation of the vision into a scope that can be implemented.
4. Architecture: Details the key principles and application-, infrastructure-, integration- and data architecture needed to implement and support the Digital Services.
5. Cyber Security: The reference framework, standards and policies, tools, and operational model to protect the ICT infrastructure, systems, and data. It also addresses the resiliency of the architecture and its ability to support business continuity.
6. Sourcing Model: Designates what should be implemented and managed externally vs in-house? What are the main categories of technology products and services that need to be sourced? What is the landscape of possible providers for each category? What are the responsibilities between providers and customers? The sourcing model provides a strategy for who does what during planning, implementation and ongoing support.
7. Business Case: Based on the Digital Services and Sourcing Model, what will it cost? What are the potential sources of revenue/monetisation? How does the cost model change between build and operate?
8. Organisation and Governance: This describes the target organisation model, roles and responsibilities and skills development needed. It also details the governance model internally and with providers and partners.
9. Innovation Labs: Ongoing innovation, throughout the programme and beyond is essential to avoid stagnation. Establishing an innovation lab provides the capability to run accelerated proofs-of-concept for emerging technologies or targeted solutions. For example, an IoT scenario or AI use case. Potential technology providers should be involved at this stage to demonstrate POC scenarios and use cases on their technology platforms.

10. Project Planning: A detailed project plan which describes the tasks and key project milestones to achieve the goal. What are the possible risks and challenges? How will quality be assured across the programme?

Where is it applicable?

The Digital Master Plan works well with greenfield projects that do not have the burden of legacy systems, infrastructure and provider agreements. The Digital Master Plan can be a stand-alone scope or integrated with the physical master plan, representing the digital layer. For example, Sidewalk Labs [61] has integrated the physical and digital layers into an "urban innovation platform" as part of their proposal for the Toronto Quayside neighbourhood development project.

However, it can be even more powerful to drive a Digital Transformation initiative by first designing the target state, unencumbered by existing constraints, just as a start-up would do. The transition from the current state to the future design can then be built into the master plan.

Applications of the Digital Master Plan may include

- New site or district design
- Mega and major events
- City-wide initiatives
- Stadiums and entertainment venues
- Digital transformation.

The digital master plan is a Living Plan. The need to continually update and improve the Digital Master Plan accepts the fact that technologies are changing rapidly and business priorities shifting. New uses for blockchain, analytics and artificial intelligence may need to be incorporated. Emerging technologies that were initially not considered should be evaluated and tested as the plan evolves. Business priorities, organisation structures, stakeholders or external dependencies may have changed. These changes and improvements may impact budget, timelines, sourcing models or organisation while remaining true to achieving the desired vision and goals.

The digital Master Plan integrates all the elements needed to achieve a seamless and inspirational digital experience. It backs up the vision with a robust design and implementation plan. It enables key architectural principles to be agreed upon, infrastructure and systems to be prioritised, and the most appropriate sourcing model and provider landscape to be established. Most importantly, it lays out a clear plan of execution to reach the destination, while minimising the risk of going off-track or stagnating mid-way.

The digital master plan is not static but dynamic, unlike the existing Master Planning practice. The digital Master plan evolves on user experience. The better the newer user experience the old digital approach to a component of the master plan is forsaken. Innovations drive the digital master plan. It is difficult to borrow digital master planning from one country to another or one city to another since a digital master plan is to be designed concerning an individual country, federal state or city.

Three examples of digital Master planning from three countries are presented below before we elaborate briefly on the author's approach to digital master planning with a case study of the Kozhikode Metropolitan area in one of the case studies of this book.

7 Digital Master Planning Case Study Barcelona

Barcelona is the second-largest city in Spain with a population of 1.6 million in the city and 5 million in the Barcelona metropolitan area. The city's experience in digital master planning is based on its involvement in many information technology-based projects such as

1. Open data initiative that is designed to offer all of the city's data (or at least of all of it that can be provided legally) to anyone that can use it to make a product or service [64].
2. Many e-Governance projects.
3. Many projects facilitate citizen participation in planning.
4. Initiation of special projects on ICT to transform an economically depressed neighbourhood in the city centre.

The Municipal Institute for Informatics (IMI), a department of the city government, gave leadership to all the above activities. The city has ten districts, and a similar number of service departments. IMI is a part of the central administration, and its services are available to all ten districts and service departments. The IMI owns Barcelona's citywide fibre network, which includes 500 wireless access points and the city's servers. The district and service department managers are driven by efficiency and cost savings. Early estimates have suggested that the city has saved 20–30% on telecoms Opex and Capex, while savings of up to 25% have been made on the cost of introducing new city services. A common platform to execute these projects than decentralised to different districts gave more efficiency and less cost per district. For example, transportation problems that call for control traffic congestion and pollution by reducing the use of private cars utilised a network of CCTV cameras and sensors and have connected them through its unified network. This has proved to be far cheaper than connecting through a public provider.

Barcelona has its fibre and Wi-Fi network and its Wi-Fi network available to citizens.

Currently, each service department has its platform, but there are plans for a common platform to be rolled out across the whole city. The model for the platform has been based on Apple's App Store, and the city will provide software development kits so that developers can create their apps for the platform. The private companies also participated. For example, logistics companies have been given access to parking metre data (both real-time and historical), which has enabled them to plan their routes better. There was no unnecessary sensitivity to the misuse of data in democracy.

The platform includes the mechanical sensors and actuators (remote controls), which already exist in public escalators, moveable bollards, and air quality and traffic monitor was integrated to a larger platform that will manage and control all of these functions, allowing the city to automate some of its processes such as cycling down the local power station on days when air quality and local weather conditions demand it.

Two underlying concepts related to the Digital Master Planning of Barcelona are strategic digital cities based on strategic decision-making in the utilisation of ICT and digital planning of the city. ICT the basis of the strategic digital city was available and accessible to most of its citizens, incorporating services based on technology to improve city management and the relationship with citizens who benefit from this "digital phenomenon".

The strategic digital city provides tools that improve the internal processes and public services provided to society (such as connectivity, information availability, technology, monitoring, infrastructure) that promote the participation of the population [63, 64] and reports that "despite obstacles and implementation difficulties, digital city projects have started an inexorable process of municipal modernisation with positive effects on the quality of services and access to ICTs".

The concept of the strategic digital city had many objectives. It deliberately gave access to the Internet to all, easily sorting out the issues of social digital inclusion. Further, the citizen was involved and motivated in the processes of Municipal government that arouse their interest and motivation of citizen to actively participate in the strategic digital city of Barcelona.

Relationship between the digital planning of the city of Barcelona and the strategic digital city

The urban planning of Barcelona relates to the needs of the population and the uses of digital city tools gave efficiency in service delivery that paved the way for better relations with Municipal Government. The relationships between strategy and information technology help to provide individuals with tools for improvement in cities. Barcelona is identified by intelligent management, able to respond quickly or even anticipated the needs presented by its citizens [66, 67].

"The term 'digital cities' has been used as a contemporary expression of an urban ideal that adds a better quality of life, information, communication and efficient management of services and public spaces. Thus, the use of strategies and information technologies serves as a platform to facilitate information and communication. Therefore, the digital city addresses the possibility of providing public services and information to citizens in broader virtual realities" [68].

The "Barcelona City Digital 2017–2020" plan, presented in October 2016, is a municipal road map to promote the urban innovation of intelligent management, to improve the quality of life of citizens, and promote a more pluralistic digital economy. "It is based on the transformation and digital innovation of the public sector and companies, government, universities, communities and organisation of people with clear public leadership and citizen".

The digital planning of the city of Barcelona and its relations with the strategic digital city is diagrammatically presented below.

Barcelona City Digital is based on four pillars, as shown in Fig. 6,

1. Barcelona city in common, which deals with social transformation and public innovation through technology, for a more open and efficient city.
2. Barcelona is a democratic city that focuses on technology as a facilitator for a more participatory, collaborative, and transparent city, that is, for a more democratic city.
3. Barcelona circular city, which raises the questions about sharing common resources for a more sustainable city and
4. Barcelona creative city, which points the questions about the arts, science, and technology to productive co-creation.

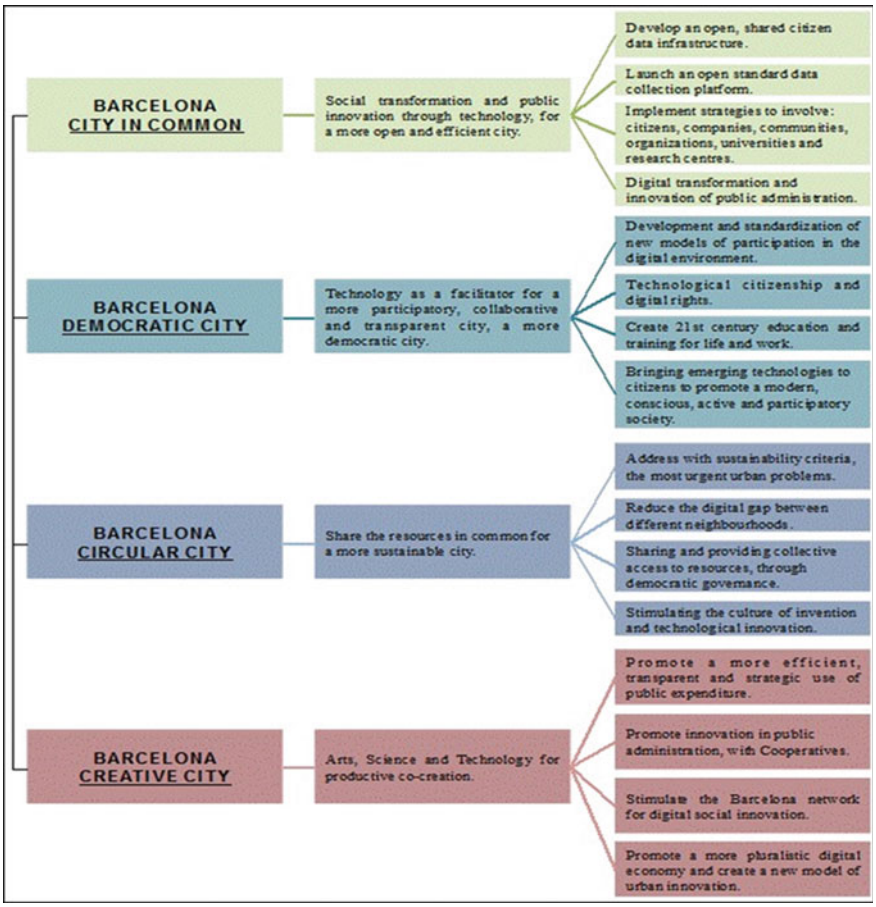


Fig. 6 Scheme of the Barcelona City Digital Plan 2017–2020. *Source* [67]

Information technology, information, strategy, and public services, which are the pillars of this concept. It provides tools that improve internal processes and public services provided to the society, such as connectivity, availability of information, technology, monitoring, infrastructure, and the promotion of population participation.

This series of benefits to the population results in the increase in the quality of life with the provision of services through the internet, through the participation of the citizen in the management of the city and the consequent contribution in the administration of the rulers [68, 69].

Analysis of information technology

The Barcelona Digital City 2017–2020 plan utilise technology for social change and public service delivery innovation. This allows users to interact and communicate [70]. Barcelona Digital City intends to develop a data infrastructure of the city that is open and possible to be shared, as well as develop a strategy involving citizens, companies, communities and universities, with some well-defined policy lines democratisation. Also, the government promoted citizen debates to discuss and submit proposals on the city's technological strategy.

Analysis of strategies

The strategy of the Barcelona City Digital Plan was to improve the government and city; companies and social organizations; and citizenship. This plan aims at "transformation in the public administration." This digital transformation is a strategic objective of the Municipal Communication Institute, to improve and streamline management processes and services for citizens, using information technology to benefit Barcelona. This is facilitated by defining open standards for digital services, and the regulation of digitization of the public sector.

The Barcelona Digital City Plan aims to provide, strategically and progressively, all neighbourhoods of the city infrastructure, resources, incentives and programs by providing each community or neighbourhood resources to enable citizens of all ages and conditions to make technology a means for improving public services and for more equitable and sustainable economic and social development [71].

The relationship between digital city strategies using information technology gives citizens innovative tools for city improvements, and the ability for enhanced interaction between citizens and government since the city is now physically and digitally integrated with digital inclusion to benefit all.

"Barcelona aims at the digital transformation of the city by using the technology of information through strategic projects, which aim to improve and streamline management processes and services to citizens, using information technology and strategy to benefit the inhabitants of Barcelona. Thus, information technology and, consequently, a strategy is increasingly present in the lives of the people of this city."

8 Greater Springfield's Digital Master Plan for a New Town Near Brisbane Australia [72–76]

The Greater Springfield in Brisbane Australia is a New Town. This is the first city conceived, designed and built and then a Digital Master Plan is superimposed. This is meant to make the city smart in a systematic and integrated manner. From the very inception of conception, design and planning, Information Technology is considered as the key pillars of Greater Springfield and forms an important component of the emerging city's master plan. Currently, the most significant driver for smart city development is improving city infrastructures such as energy, water, and transportation systems. Some smart city project has been initiated to the above elements, but overall smart city development is still largely in various degrees of planning. The physical infrastructure now in place in Greater Springfield is first class, with the road, rail, schools, a hospital and retail all in place. Based on the physical infrastructure, the virtual infrastructure can now evolve quickly and provide the fusion between "the physical world and the online world". This connectivity and intelligence, based upon real-time data about interactions, will create opportunities for improved liveability and creation of new value."By building a digital platform, other businesses can easily connect their business, build products and services on top of it, and thereby co-create value. In such a networked eco-system, digital governance is required to establish the conditions that those parts of the community can come to create and consume value. Few developments globally other than Greater Springfield can say that it has its digital master plan. A plan which ensures that adaption, creation and adoption of digital technologies and processes are considered exponentially as Greater Springfield grows into an efficient and cost-effective destination to live, learn, work or play".

"The focus of the plan is to facilitate further innovation in Greater Springfield, long-term sustainability, enhanced citizen-focussed governance and job creation. In doing so, it will improve the functioning of the city, making it a better place to live, work learn and play as well as to visit. It will advance the attractiveness of the city and amenity for homeowners and businesses who can see the benefits of being at the leading edge in an environment suited to tech companies and digital start-ups" (Fig. 7).

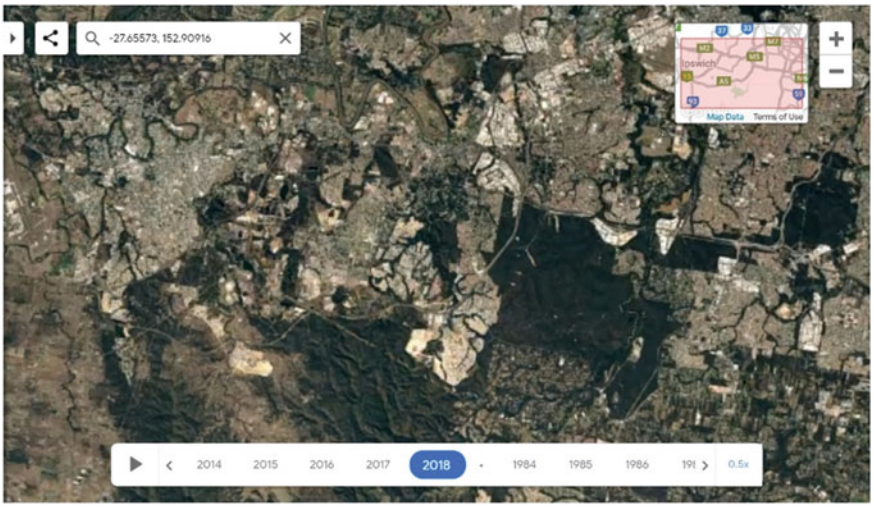
Greater Springfield's digital master plan seeks to bring together the best of human imagination and radical efficiency in information transmission, to enable greater creativity and community centred value. The digital master plan is designed to position Greater Springfield as a leader in cutting-edge technology infrastructure. The building blocks of a digital infrastructure include an interconnected network of infrastructure and services. This network provides the connectivity and capability to integrate services for the citizens and businesses in Greater Springfield. The digital network is an enabler for the Internet of Things or digital technologies. As the city becomes entirely powered by digital technologies, it can begin to be a platform of virtual interaction between people and things; allowing culture and code to connect, collaborate and collide. Greater Springfield can evolve quickly and provide the fusion

Source: [73]

Fig. 7 Concept plan of greater spring field digital master plan. *Source* [72]

of both the physical and digital worlds. This connectivity and intelligence, based upon real-time data about everyday interactions, will create new value opportunities and improving the liveability of the city. Greater Springfield community will have access to more intelligent platforms to assist their lifestyle, with access to data for personal health, business performance, self-improvement, and education. This interconnectivity is at the very heart of Springfield—a living, breathing ecosystem of data. 360-data can feedback into products and services—allowing a personal offering like never (Fig. 8).

1. Health: Digital health records will support the new economic zone and provide researchers with richer health and activity data for their studies.
2. Digital: Today, co-working spaces provide the city with a physical location in terms of adaption and adoption of digital technologies and processes.
3. Education: An educated, motivated and inspired workforce understands the benefits of living in a master-planned, digitally connected community.
4. Governance: "Policies and frameworks will support various stakeholders to interact and extract value while complying with important legal requirements" [72].



Source: [73]

Fig. 8 Aerial photo of greater spring field in 2018. *Source* [72]

9 Case Study Dublin Digital Master Planning Dublin Ireland

"The Digital Masterplan for Dublin is designed as a journey towards the ultimate Digital City," said Lord Mayor of Dublin, in June 2013. The Digital Master Plan-Formulation and Structure was executed by Mayor through Digital Dublin Leadership Forum. This Digital Leadership Forum chaired by the Lord Mayor of Dublin was established to undertake the following

- **Develop** further a Dublin Innovation Eco System and incentivise innovation
- **Build** an International and European Innovation system through City collaboration
- **Act** primarily through the Quadruple Helix (Citizen, Business, Education, Government)
- **Make** Adoption the key to realising innovation
- **Promote** intersectional Innovation using Dublin City as Testbed **Promote** Innovators and Entrepreneurs as Heroes.

The Digital Dublin will be built by and around "Digi Dubs". The "Digi Dub" is the digitally active and engaged citizen who uses digital technologies in daily life—at home, at work and school.

Digital Masterplan Structure

The Digital Masterplan is structured with a few key components:

(1) **A vision**, as a mission statement and a set of guiding principles that inform and underpin all digital activities.

(2) **Two innovative toolsets** are combined to deliver an approach to planning and execution of digital initiatives:

   a. **A Digital Maturity Scorecard** (DMS)—developed by Dublin City Council in conjunction with Intel Labs Europe, NUI Maynooth (the Innovation Value Institute) and Dublin City University. The DMS will be used to benchmark Dublin's digital standing internationally.
   b. **The Dublin City Council Beta Project** mechanism to continually prioritise, prototype and evaluate innovative ideas.

(3) Actions to be pursued to achieve digital excellence in the Dublin region are grouped into 7 logical action blocks for ease of understanding and implementation.

   These Actions include

   a. Big Ticket Actions identified through the Digital Leadership Forum, of critical and high impact.
   b. Enabling other actions that will be implemented for the delivery of the Masterplan.

This document is a summary of the key elements of the Masterplan—full details of the Masterplan published on [77].

Digital Vision, Mission Statement and Principles

The Digital Masterplan for Dublin guides the city for the adaption, creation of digital technologies and processes for the efficient management of the city, its resources, and activities. The deliverable of the Masterplan is further innovation, long-term sustainability, enhanced governance and job creation.

Vision

"To co-create Dublin as a global leader in innovation where technology is harnessed, adopted, adapted and created to develop economic competitiveness and cohesive and sustainable society."

Two Innovative Toolsets for Digital Dublin

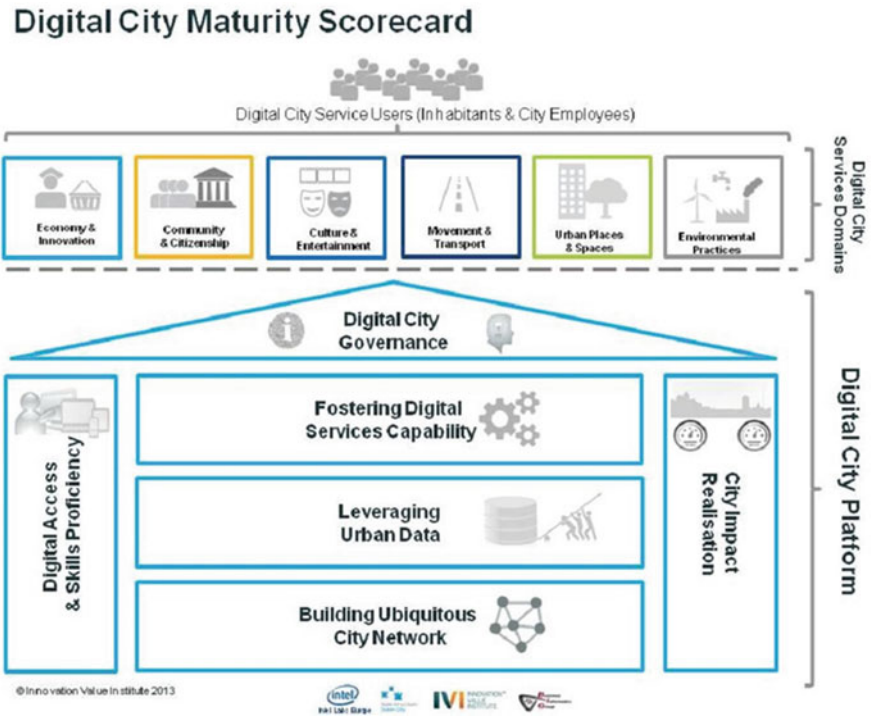
The Digital Maturity Scorecard

The Digital Maturity Scorecard (DMS) is an analytical tool to benchmark internationally to help deploy resources. The DMS defines six layers of digital activity that the city must build up to international and best-practice standards to become a truly Digital City as follows:

Actions pursued as part of the Digital Masterplan will relate to one or more of six digital city service domains which impact the quality of life in the city region:

It is essential to match technological solutions to the challenges of modern urban living, job creation and retention, maintaining a globally competitive and attractive business environment, enhancing civil society, enhancing the potential of new creative and smart economy industries, addressing infrastructural and social problems, improving the quality of the environment and the physical and virtual connectivity of citizens and business.

The impact of actions carried out under the Masterplan will be evaluated against the DMS. The DMS essentially looks at Dublin's level of digital maturity on a scale of 1-5. The goal is to transform the city and thus move up this scale. The Scorecard will be refined and developed through the application (Fig. 9).



Source: [78]

Fig. 9 Maturity scoreboard. *Source* [77]

Only through collaboration between citizens, business, research and academia and local government can the city arrive at its destination as a global Digital City. That collaboration works along with a roadmap of change and Innovation as represented in Fig. 10.

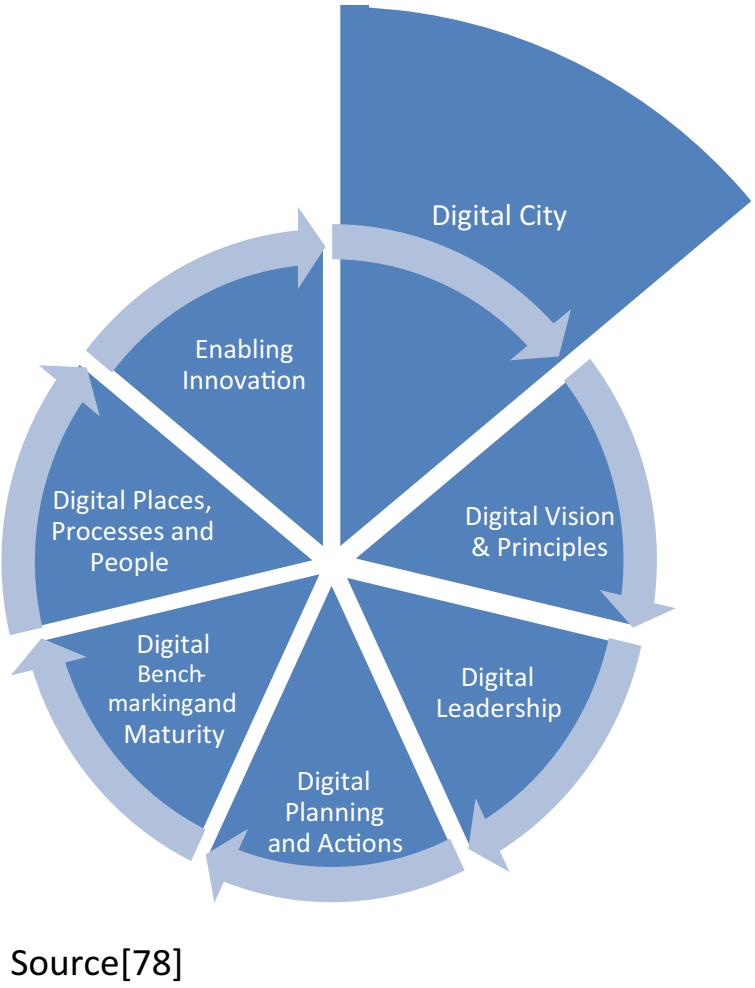


Fig. 10 Road map to digital excellence in Dublin Ireland. *Source* [77]

Source [77]

Action details

This section is organised as follows:

(1) The Big Ticket Actions
(2) The second part describes actions under each Action Block.

Big Ticket #1—Fibre to Every Home

Fast, reliable and cost-competitive broadband infrastructure is critical for all Dublin homes for remote/home-working. Broadband enables higher overall growth by allowing firms to cast their net wider when looking for suppliers or seeking new market opportunities to increase their customer base or looking to more effectively link business functions, e.g. sales, design, manufacturing, supply chain, stock control and accounts—particularly across many geographical locations. The only broadband delivery technology sufficiently developed to provide room for the likely bandwidth growth patterns in the region is fibre. Fibre rollout should be prioritised within the City Region. The market must be incentivised to invest in Dublin to guarantee full fibre optic coverage. This plan proposes that a minimum of 100 Mb symmetrical broadband be delivered into every home in the Dublin region using Fibre. Until now the key challenge with fibre deployment has been what is known as the "last mile"—the cost of the infrastructural work associated with getting the fibre over the final part of the journey from a shared local supply point to the home. The Telco industry estimates that there is an average unit cost of €1,500 per dwelling involved in delivering this "last mile".

The state investment would be delivered via a tax credit to be set against the new Local Property Tax and would cost up to €117m a year over three years to be divided between local and central government. This would, in turn, create opportunities for telecom operators to partner together to deliver fibre in the most efficient way possible.

The companies delivering Fibre under the initiative will have to sign up to a Public Service Obligation (PSO) to ensure that delivery would include the provision in disadvantaged areas and to individuals who are under age, circumstances or health cannot participate in the shared cost model outlined above. This will involve a commitment to deliver for every five connections under the shared cost model one connection for free.

The Digital Agenda for Europe acknowledges the socio-economic benefits of broadband and highlights its importance for competitiveness, social inclusion and employment. This proposal would ensure comprehensive Fibre to every home coverage in the Dublin region; it would futureproof the region's residential data network for years to come and it would generate a substantial number of civil/construction jobs in the short term.

Other points for consideration:

- Symmetrical 100 MB fibre capacity should be provisioned as soon as possible in one pilot residential area which is currently a broadband "black spot" within the city. The delivery of eHealth and education services should be then piloted in this area
- Carrier-neutral ducting should be installed during all significant public infrastructure works in the Region such as roads, water, and sewerage and that all current and future ducting are recorded and mapped
- In line with national policy State-owned infrastructure should be explored and leveraged for fibre provision in line with national policy

- Planning regulations should be reviewed immediately and updated to ensure comprehensive provision for fibre within all new builds.

Big Ticket #2—Digital Accelerator District

Innovation is key for progression to a digital future as it encompasses the facilitation of research, collaboration across the triple helix, open data share, idea creation and commercialization, smart cities and creative citizens.

While there are excellent incubators around the City it is fair to say that Dublin lacks a single 'go-to' point for Digital Acceleration that is of a large enough scale for a city with such a tech profile.

To this effect, a new Digital Accelerator District (DAD) was proposed which will be of the appropriate scale to localise and link ideas, innovation, skills, talent, mentoring capabilities and finance.

This will complement existing companies, spaces, and initiatives like Launchbox, i.e. Dogpatch Labs; the NDRC; the Centres for Science Engineering and Technology (CSE); The Digital Hub; and the Guinness Enterprise Centre that have filled this space to date. Dublin hopes to partner with one or more of the above entities in the development and operation of the DAD. Further DADs will be developed as demand and opportunity arise.

To incentivise the accelerated growth of viable digital businesses is proposed to break the space within the DAD into three zones and to provide a rates structure as follows:

– Zone 1—Year 1 of start-up—0 rates
– Zone 2—Year 2 of start-up—50% rates discount
– Zone 3—Year 3 of start-up—25% rates discount.

This will require the Central Government to provide the necessary flexibility in local business rate schemes to permit the Local Government to financially incentivise targeted locations in accelerator districts.

Fledgeling businesses will be actively expected to move through the DAD zones, or they will lose their discounts and ultimately their place in the DAD. Dublin will also work with other infrastructure providers (electricity, water, broadband) to seek the provision of a similar discount mechanism.

Big Ticket #3—Maximising Local Supply Chains to Multinational Corporations (MNCs)

The Digital Leadership Forum pledges to push the agenda of Irish indigenous companies in developing their relationships with MNCs based in the Dublin region. The proper fiscal and regulatory environment must be created for indigenous SMEs to thrive and trade and as part of this process to enter the high-end (R&D, IP-intensive activities) supply chain and consciousness of large MNCs. Provision of high-end activities is an "import substitution" for locally based MNCs.

MNCs in Ireland source about €80bn in goods and services globally of which €11bn comes from Irish businesses. The joint IDA/Enterprise Ireland team is

targeting an increase in this figure in 2013 by identifying 65 multinationals that offer the potential for Irish companies and through increased participation by Enterprise Ireland clients on inward investment itineraries of IDA companies. It is estimated by DJEI that if multinational companies based in Ireland included more Irish companies in their global supply chains then just a 5pc increase in spending locally by multinationals would generate €500 m in the local economy in Ireland in 2013.

Dublin city is proposing to partner with SME representative organisations (e.g. ISME, IIA, SFA, Chamber of Commerce), to develop a web-based portal for Dublin-based multi-nationals to auction packages of digital/innovation/R&D work to the local SME market.

This Action should deliver:

(1) Greater access to local MNC supply chains for SMEs and a corresponding growth in business
(2) An innovation supply route for the local MNC community
(3) Enhanced MNC links for the SME representative organisations.

To complement the big-ticket item to **Maximise Indigenous Supply Chains,** it is proposed that a minimum spend of 30% on new local government ICT and digital services should be directed to SMEs.

Strengthening the use of digital by the SME base is an important part of going digital on a mass scale.

Big Ticket #4—The Dublin Storefront and Shop Window

The objective is to support and expand the work being undertaken by different organisations in developing the use of digital systems and an online business presence by Dublin and Irish Business. The Irish Internet Association and the City/County Enterprise Boards have been active for some years in this area. Recent work under the "Activating Dublin" initiative of the Chamber of Commerce will provide a toolkit that could become a standard for getting Dublin/Irish SMEs trading successfully online or expanding their current online presence. A key challenge, however, is to devise a shared basis for future expansion of these initiatives and a means by which success and ongoing business challenges of expansion and continued usage can be monitored, supported and evaluated beyond the initial web presence or adoption of digital technologies and processes.

There is a need to build on this work and to create an eCommerce and digital adoption support platform that will particularly target businesses in the non-ICT sector such as Food and Accommodation, Construction, and small start-ups. These are businesses that just need to plug in and get going. They are also businesses that could reduce cost and improve efficiency by developing digital back-office driven processes, e-procurement and the use of digital technology in terms of customer and financial management. The Forum is cognisant of the fact that the platform should not become an innovation blocker that is, directing high potential concepts and businesses away from their bespoke e-commerce propositions. The Platform, however, should provide a means of ongoing support and monitoring of business success and digital expansion.

There is also an opportunity to build such a platform in a way that provides opportunities for the skill enhancement and experience building of young unemployed individuals across a range of disciplines. This could be achieved by a redefined Job Bridge initiative that provides for a longer period and direct opportunities for linked experience with participating in small business.

Considering an ESRI estimate that over 70% of exports will be traded services by 2025, without intervention there is a risk of Ireland and Dublin falling behind and losing global competitiveness and attractiveness. The UPC Digital Business Index shows that 3 in 10 Irish businesses are 'Digital Leaders', while 1 in 7 is 'Digital Laggards': with the balance falling into the category of 'Digital Followers'.

CSO Information Society statistics show that from 2009 to 2012 there has been notable uptake in internet usage and website development across the main sectors of the Irish economy. Nonetheless, there are shortfalls. For example, in the accommodation and food service sector internet usage and website ownership was relatively low in 2012 with only 66 per cent of enterprises having a website or homepage, though this was an increase of 12 per cent on 2009 figures.

Moreover, CSO Information Society statistics from 2012 show that only 23% of Irish SMEs are selling online with just over half using eCommerce to make some purchases.

Dublin city anticipates that a coordinated drive involving local and central government with a reliance on extensive private sector involvement will deliver a substantial update of e-commerce trading particularly in the SME sector in the Dublin region.

The Dublin Storefront will also facilitate the development of a 'Created in Dublin' brand that can be opened to all Dublin firms trading online and not just those trading via the Dublin Storefront. The Dublin Storefront will ideally be built and operated through a business-based organisation or association (e.g. Chamber of Commerce, Irish Internet Association) with funding support from the Government (local and national), staff resources to include internships, and funding from the businesses who become members by way of annual fees.

Big Ticket #5—Digital Sister Cities Virtual Network

This will involve a redesign and remodelling of the website www.citieslinked.com. Targeted at Sister Cities committed to International collaboration around digital society, economy and innovation it will provide a means to connect civic government, businesses, education and innovators globally. It will be a portal that combines web and social media tools with events/information and project partner search across the participating cities. It will help cities co-create the digital future by way of common actions in business, education, and city test-bedding of new services and products. Participating cities will be required to allocate a dedicated Digital Co-operation Manager to ensure participation.

The Network of Digital Co-operation Managers will meet bi-annually. The Digital Co-operation Managers will be responsible for the promotion of the Virtual Network, recruitment of companies, departments of government, education institutions and

innovators to active membership of the Network and support for member engagement. This will involve developing the beta project approach, research and business co-operation matching and networking seminars locally among members.

Dublin will internationalise, through this web-based portal, the Beta Project concept in its sister cities so that testing ideas can be shared, and testing realised across like-minded sister cities. This will also allow the innovators who designed the innovations to expand the potential "reference proof of concept" and hasten the route for successful innovations to market.

The Digital Maturity Scorecard (DMS) will be shared with sister cities and will be a first step in the standardisation of international digital benchmarking. This, in turn, will allow cities to put in place realistic targets and adopt processes and technologies borrowed from each other. The portal will be used to refine, record and share this benchmarking.

Big Ticket #6—Available as Digital

Available as Digital is a commitment by Dublin City Council to ensure that all services are available in digital format. City Council will lead by example and will encourage other public sector bodies to sign up to an Available as Digital Charter with targeted commitments and deadlines to develop digital versions of all public services, engagement and information. All public services and business should provide their services as digital.

The Masterplan is seeking to fill digital services gaps, working on best practice models to digitise all services. This action complements the "Knowledge is Power" Action Block, seeking to achieve higher levels of digital literacy and actions to increase access to high-quality broadband.

The interoperability of services and the concepts of big data and the internet of things are core facilitators of going digital. How? Big data allows evidence-based decision-making and the creation of new digital services. The internet of things is part of creating a digital mesh where all types of daily actions and interactions, places and things are linked through sensors, devices, and continual streams of communication.

As part of this initiative to go digital by default and as part of the drive to create a Digital Commonage the Masterplan will develop and adopt a set of 'Digital Design Principles.' These will be similar to the Government Digital Services UK (GDS) design principles (https://www.gov.uk/designprinciples). It is intended that these will, in time, be adopted by all Government agencies in the city resulting in standardised government digital/web access for all.

Big Ticket #7—Co-Creating Future

This will involve the commitment by Local and National Government complemented by Business Corporate Social Responsibility (CSR) to establish programmes to support the development of cocreation skills in communities, government organisations, young people and adults.

To facilitate skill development particularly among communities and groups, a dedicated fund to support voluntary organisations delivering coding and advanced digital skills would be established from public and private funds. This would be

administered through the Digital City Team to fund and support targeted skills development in areas such as programming, coding, computer science, information technology, gaming, data mining, creative media and social media.

To develop an experience for graduates to enable market entry into jobs, it is proposed to seek a special extended Job Bridge internship to train and employ recent graduates as Enhanced Digital Skills facilitators. An initial team of 10 such facilitators (interns), for 18 months, will be recruited and supported by delivery, management, and training at a cost of approximately €200,000. They will develop a programme and work with schools, youth groups and senior citizen groups within communities. This initiative will be delivered and managed by an appropriate Education/Youth/ business agency (e.g. VEC, Foróige, CYC, IIA).

Other Actions

Action Block 1: "Organising for Action"

This is a critical enabling action that requires resourcing commitment from Dublin City Council to enable Masterplan actions to be pursued and realised.

Establishment of a digital city team	To match skills in Dublin City Council and across the leadership forum with the digital needs of the city and the Masterplan actions and to establish a digital city team to execute the masterplan and deliver actions To identify technical skills within the existing City Council resource pool which can be harnessed to deliver the Masterplan
Business accelerator team	To cluster innovation initiatives and support technology business start-ups and expansion
Digital funding	Seed funding for key actions and resources must be allocated by the Local and National Governments. The region will also seek external means to develop solutions to its urban challenges. This will involve working closely with research institutions, SME's and MNE's to develop research proposals that will benefit citizens and businesses alike
Unified city region portal	The redesign and use of www.Dublin.ie as a one-stop portal for information about events, digital developments and organisations across the Dublin region
Supporting a repository of digital events and digital mapping	To build an interactive digital repository for all digital events that are happening in the city region Mapping digital activity and organisations that promote and enhance digital. This would include a digital mapping of international connections that support digital development. This should be an element of Dublin, i.e. portal

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Research programme	A programme of research and events in partnership with business, statutory agencies and education designed to highlight by evidence and research critical issues of infrastructure, legislation/regulation, policy and investment that must be addressed to ensure the future development of digital, technology and media businesses in Ireland
Support for digital and creative initiatives	Funding and resource support to digital initiatives that have global and local value in developing new business, opportunities and profiles for Dublin. The recent Fusion initiative led by the Irish Times is one such example

Action Block 2: Creating Awareness and Building Participation

Innovation Dublin festival	The Innovation Dublin Festival is ongoing and will further incorporate and showcase enterprise on digital innovation across the city. This action will develop the festival, extend its international promotion and branding, and brand-related events throughout the year. The festival website will develop a directory of innovation leaders and initiatives
Digital champions—leaders who inspire	Identify Digital Champions who inspire across the six urban domains of the Dublin City Development Plan and the Digital Masterplan Work with business and EU institutions to hold an annual Innovation Luminary Award event in Dublin
Develop citizen participation and digital governance	To further democratise decision-making through extending the Your Dublin, Your Voice citizen panel and to evolve new digital methods to engage citizens. To extend information and knowledge and engagement with the democratic and administrative decision-making systems throughout City stakeholder organisations
Deploy social media tools and strategies to engage citizens	A social media roll-out programme will be delivered by the Digital City Team to engage further with citizens on topical issues, events and opportunities

Action Block 3: Building the Digital Commonage

Explore new infrastructure, e.g. spectrum playgrounds—including white space	The spectrum playground (wireless transmission frequencies) may lead to the testing and trialling of new infrastructure and equipment that will enable the communication systems of the future. However, it is the services and applications that sit on these systems that will make them successful. The aim is to accompany the spectrum playground activities with a series of open workshops for rapid prototyping of new services and applications that might exploit the new infrastructures
City Watch App and Sensors—trial and evaluation	This App allows citizens to instantaneously report faults or problems in their area; issues of public safety or concern; to take pictures or file reports. Citizens will receive points for engagement. Further sensor networks will be rolled out, and initiatives around data analytics developed, in conjunction with business and education
Expand and develop open data through Dublin ked	To make public and commercial datasets open for public consumption, research and commercialisation. To bring more data online with a focus on real-time data Agree to actions to secure future data centre provision by way of ensuring power supply while also building data and analytics through sensors and software development
Expand the digital laboratory to be a city-wide beta	Prioritising, trialling and validating new and existing ideas which have a strong digital genome in test locations and virtual space across the city. It will be built from the top down by policy, the middle out by the ideas and projects of the City and the bottom-up by citizens and businesses through trialling
Dublin public wireless broadband—Mesh the City	To provide good-quality, free public Wi-Fi/ 4G in core city areas
Expand the sensor networks in the city landscape	Harness the data potential of sensors by locating sensors within the landscape and buildings of the city

Action Block 4: Expanding and Innovating the Economy.

Digital business city	Promotion and awareness of the advantages of going digital in business supported by research and identification of market opportunities in different economic sectors
Internships to build experience	An Internship programme to provide experience to graduates that will enhance their capacity to obtain jobs in the technology sector
Start-Up CEO support group	A Start-Up CEO/Founders group to support and assist new business start-ups to grow and access funding. A dedicated Technology Business mentor panel will be established with the help of businesses to support start-ups in the sector. The Panel will be managed by the LEO
Establishment of a Dublin regional enterprise forum	The formation of a Dublin Enterprise Forum in respect of the small firms' sector would have as one focus using ICT to drive competitiveness and realise this through a Finance Digital Dublin sub-forum chaired by the LEOs in the Region and consisting of micro lenders, banks and representative organisations as appropriate This Forum would match those with capital, experience, networks and other resources with small companies with long-term potential
Annual start-up Dublin declaration	A survey of start-up activity in Dublin and identification of opportunities annually
Dublin as an investment and start-up location programme	A programme of trade/promotion events to encourage international start-ups, entrepreneurs, venture capitalists and companies looking for a European access location to consider Dublin
Single portal for investors, companies, and mobile talent	A single portal and support service networking Innovation hubs/nodes, enterprise support services, property and infrastructure information, schools/facilities/housing options and education services aimed at overseas companies and individuals
Critical infrastructure charters	The development and agreement of critical infrastructure charters for priority delivery based on research and industry or agency identification that can cluster economic development in niche technology industries and geographical areas of the region. These charters would have targets and deliverables and would be agreed with utility and transport companies and endorsed by the national government. One key area for immediate attention is electricity distribution to support the attraction of data centres

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Global media and awareness campaign	A global media and awareness campaign would be developed in partnership with business and statutory economic national agencies. Using social and traditional media and harnessing meetings, events and activities of the city
	Stakeholders internationally it would promote Dublin as the "Place to be Innovative", the by-line being Innovate in Dublin

Action Block 5: Shaping a Better City

Trialling of digital technologies and services in communities, homes, and businesses	A series of new technologies will be trialled across the housing stock of DCC and within Dublin businesses. The city will look to pilot new initiatives across its housing stock in the areas of energy (for example, Glenn Dimplex Quantum home heating trial in Dublin City and Fingal), delivery of education and health services, access and so forth. The Beta Project mechanism will be used to realise innovative new ideas for this action
Digital adventure carnivals and streetscapes	A proposal for a travelling 'Digital Carnival' that will visit Dublin City schools, community centres and libraries on a year-round basis to foster curiosity and confidence in new emerging technologies and boost digital participation and understanding in local Dublin communities Build on the Digital Carnival to create phase by phase a digital and interactive "adventure" landscape in Dublin streets and public spaces. Augmented Reality, Wi-Fi zone-based messaging, digital interactive signage and gaming models to support interaction could be deployed
Signing up to the green digital charter	Actions to be selected and trialled as Beta Projects
Digital safe cities	Using technologies to make our city a safer place as part of the UN Women Safe Cities Global Programme
Digital water—D_2O	Innovative technologies to manage all aspects of the water system

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Deliver hackathons and creative data events	To run hackathon events to address city and organisational challenges. This action will maximise the use of skills within the city and provide the focus for the informal gatherings of developers and designers already happening within Dublin. It is furthermore proposed to develop and validate the concept of a Code Café(s) using Beta Projects

Action Block 6: Global Positioning

Global city benchmarking	To measure impact and assess performance compared to competitor cities. To identify best practices within each domain to set targets and establish international standards. To extend the use and application of the Digital Maturity Scorecard
Using the DMS to evaluate the ongoing success	The Digital Maturity Scorecard (DMS) will be applied in sister cities and will see a first step taken in the standardisation of international benchmarking. This, in turn, will allow cities to put in place realistic targets and adopt processes and technologies borrowed from each other
Attracting events and cconferences and leading missions	Attract technology events and conferences and ensure that technology and digital business is central to all overseas missions from the City

Action Block 7: Knowledge is Power—Skills and Co-Creation.

Getting our people coding	Develop and roll out a programme of Dublin CoderDojo events at Dublin City Council libraries
Digital Dublin day	Holding an Annual Digital Dublin Day with centres in each area of the City
Computer loan scheme	Developing and testing through libraries an equipment rental scheme to support access
Develop entrepreneurial skills among young people	Support initiatives designed to develop enterprise skills among young people including Biz Kids in the Dublin region

9.1 Smart Master Planning: Innovations and Case Studies Kozhikode Metropolitan Area Study: Current Influence on Cities

Digital Master Planning efforts are socio-cultural and local economic constructs and hence unique. Therefore, what we discussed in the last few sections for Dublin or Barcelona or Springfield cannot be copied to another city. Once copied rest assured it will never work. However, it was worthwhile to discuss so that one can postulate workable models of digital master planning based on local resources including human resources. So, it is important to build it based on the endowment of the city and the socio-cultural and technological possibilities currently available. The author and his team tried to build their method of executing digital master planning and is discussed in this book. What follows is an introduction to these four chapters.

Taking into consideration all aspects discussed above, metropolitan cities are ideal places where digital master planning can be initiated in India which does not exist as of today. There were 53 metropolitan cities in the 2011 census with one million and above population in India. There is also a constitutional body called the Metropolitan Committee who has got a legitimate share of the consolidated fund of the Government of India and the respective State Government under which this effort can function. This number 53 is likely to increase. Out of 53 cities, seven of them were in a relatively small populated state, Kerala. In Kerala, once census 2011 data is mapped based on the definition of urban agglomeration given in the Indian Census, five out of seven metropolitan agglomerations is merged to form a Kochi-Kannur megacity of near 10 million population. This megacity is internationally well connected by three international airports and one seaport in Kochi along with few minor ports like Beypore in Kozhikode and many other fisheries harbours. A case study presented in this book is from this megacity. Kochi Kannur focusing on Kozhikode Metropolitan Area.

With a majority, Kerala population including low income-daily wage earners like unskilled labour, carpenters, coconut harvester, electrician and plumbers, domestic servants and hawkers like those market vegetable and fish at the household level are smartphone owners and uses extensively internet-based cash payments by unified direct bank transfers. During the COVID days, students from primary school to higher secondary school use smartphones for online teaching in Kerala although internet coverage is not satisfactory. There is an emerging trend of small and medium enterprises seamless integration of digital information technology throughout the built and manufactured environment in Kerala befitting a likely heralding of industry 4 through digital master planning. The diffusion of computing power available to the ordinary citizen of Kerala and ubiquitous computing with the people of Kerala are ready for digital master planning while institutions like Municipality and providers of Master Planning skills seems not ready yet ready unless they get trained rigorously on digital master planning and other related disciplines like computer sciences and electronica and information technology jointly execute digital master planning. Our

chapter in this book will showcase an approach not known before and suitable for the Kochi-Kannur megacity.

The Marxist-led Left Democratic Front LDF Governments and the opposition UDF the united democratic front in Kerala was always confronting wealth creators whether it is a large farmer or industrialist under socialism or communism. This is achieved through the high level of political mobilisation that jacks up labour wages in comparison with other states in India by strikes and bandh against any entrepreneurship. The politicians were supported by a colonial ruler-type British legacy bureaucracy with a high level of corruption in which politicians are a party. There are many court cases some criminal and others civil pending against them and in a democracy court case takes many decades to settle and these corrupted are free until final judgement is made by courts after many decades.

All these made Kerala the most backward state in industrialisation in South India in particular and whole to India in general. Kerala missed the first, second and third industrial revolutions because of several reasons including colonial rule and the only way out is the digital master planning and digitally powered fourth industrial revolution by the smart community. The rampant educated unemployment in Kerala made educated and skilled people of Kerala migrate under distress to many counties for gainful employment. Go to any country and you may find a Kerala migrant there sending money home which is the backbone consumption-based and not production-based money order economy of Kerala in the absence of industrialisation. The limited number of Kerala entrepreneurs do not consider Kerala as a favourable destination for establishing their industries and established industries in the neighbouring Tamil Nadu and Karnataka away from Kerala's trade unions and almost daily strikes and bandh supported by local political parties. This can only change when Kerala Governments honour the wealth generators and give entrepreneurs an environment to usher in the digital economy in Kerala. Average people are ready but not the ruling dispensations. The case study we present shows how a smart economy can be empowered at the community level to overcome the genetic defects of the Kerala economy and Governance. The digital Master Plan under smart community and the smart economy is the goal of our case study. We present some insight into the case study in this part.

The "digital master plans" are attempts to mobilise the local community including all stakeholders around common visions, goals, and road maps to digitally adapt to the economic pressures, within local social, economic and political constraints. Digital industrialization like Industry 4 at a community level is well ushered in a digital master planning regime than conventional 19th-century master planning under the 1920 Malabar Town Planning Act of Kerala practised in Kerala until recently.

Minimal Government at near-zero administrative cost and maximum Governance through E-Governance and E-Democracy can usher in the digital revolution and fast pace industrialisation in Kerala and this means vast changes in political ideologies now existing in Kerala. Multitudes of TV channels and Newspapers are divided among the political parties as their paid or unpaid spokesmen and it is difficult for a citizen to make up their mind on emerging environmental, developmental and

social issues. Replacing Representative Democracy with direct democracy using E-Democracy for Master Planning is a worthwhile approach to embark on digital master planning when the truth is difficult to understand about emerging issues.

Creating least cost and easy access to high bandwidth fibre to home internet to all (i.e. above and below poverty level) is already underway nationally and at the state level. Extensive use of IoT for urban surveys eliminating humans will bring down survey costs and undue delays in Master Plan surveys considerably and create speedy production of results of surveys and mapping for master planning. Further Model-based cloud computing treating data and models in an equal way and march towards artificial intelligence and the use of Blockchain. All these are explored in the case study. What are the goals of digital Master Plans?

9.2 Digital Master Planning Goals

1. Minimal Government at near-zero administrative cost and maximum Governance through E-Governance and E-Democracy
2. Replacing Representative democracy with direct democracy in local self-government using E-Democracy for Master Planning for items where Indian constitutions provide households to decide under the 12th schedule of 74th constitutional amendments.
3. Creating least cost easy access to high bandwidth fibre to home internet to all (i.e. above and below poverty level)
4. Extensive use of IoT for urban surveys and also urban interventions eliminating humans
5. Machine to Machine system to execute 12th scheduled items.
6. Model-based cloud computing treating data and models in an equal way and march towards artificial intelligence and the use of Blockchain

9.3 Domains of Digital Master Planning

1. Scenario driven Spatial Decision supports for E-Governance and E-Democracy for 18 tasks given in the 74th constitutional amendment.
2. Making these 18 tasks smart with the use of assistive technologies and systems of IoTs and ICTs the list is given below.

Table list of 18 items in 12th schedule.

	List of 18 items in 12th schedule	Scope of work to make it smart
1	Regulation of land use and construction of land buildings	Smart Zonal Plan based on the sample Test case Katangal Smart Global Economic Community and other one Smart Economic Community Mukkam

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2	Urban planning including the town planning	Smart Master Plan Process and Content
3	Planning for economic and social development	Smart Work area Plan
4	Urban poverty alleviation	E-Urban Land Management (E-ULM) (E-ULM) and Poverty alleviation
5	Water supply for domestic, industrial and commercial purposes	Smart Water
6	Fire services	Smart Fire service
7	Public health sanitation, conservancy and solid waste management	Smart Public Health
8	Slum improvement and up-gradation	Smart Slum up-gradation
9	Safeguarding the interests of the weaker sections of society, including the physically handicapped and mentally unsound	Smart safeguard
10	Urban forestry, protection of environment and promotion of ecological aspects	Smart Urban Forestry
11	Construction of roads and bridges	Smart Mobility
12	Provision of urban amenities and facilities such as parks, gardens, and playgrounds	Smart Infrastructure
13	Promotion of cultural, educational and aesthetic aspects	Smart cultural and Educational facilities
14	Burials and burials grounds, cremation and cremation grounds, and electric crematoriums	ICT enabling and facility Management
15	Cattle ponds, prevention of cruelty to animals	Smart animal Facilities
16	Regulation of slaughterhouses and tanneries	Smart slaughterhouse facilities
17	Public amenities including street lighting, parking spaces, bus stops and public conveniences	Smart Public Amenities
18	Vital statistics including registration of births and deaths	Smart Urban Information System

3. Further Digitisation of Surekha the annual planning software used in Kerala using GIS for participatory decision support. Screenshots of website explains the Sulekha (Figs. 11, 12, 13).

4. Digitisation of Master Plan and not map
5. Digitisation of zonal Plans and not maps
6. Digitisation of Urban Land management in process management. The process is discussed in Smart Economy in Smart Cities book and few screenshots of the website that interrupt in the process is given in Figs. 14 and 15.

Fig. 11 Sulekha website

Fig. 12 Login page for Sulekha website

Fig. 13 Scope of Surekha in decentralised planning

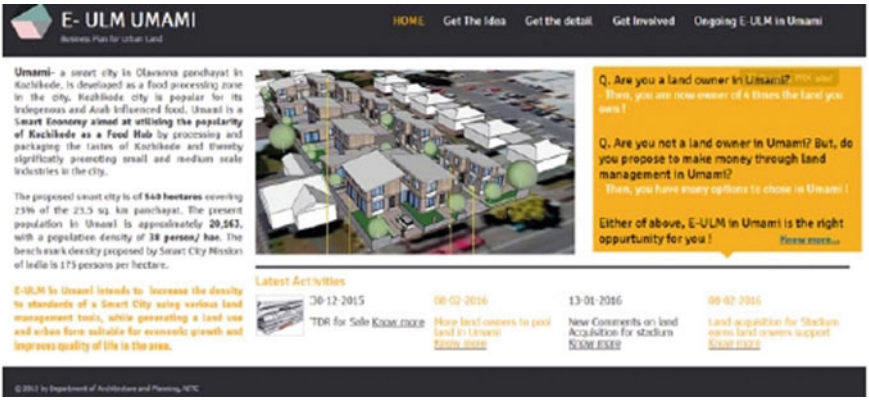

Fig. 14 Home Page-E-ULM Umami business plan for urban land

9.4 Constitutional Urban Areas Receiving Grants from Consolidated Accounts to the Following Areas

They are enumerated below. In the Master Planning, these are allowed to be implemented based on Smart Master Planning while preparation of Master Plans is a joint effort of smart community locally and all the above institutions. The smart community will use their resources to implement economically productive activities.

1. Wards under ward committee
2. Cantonment under Cantonment Board

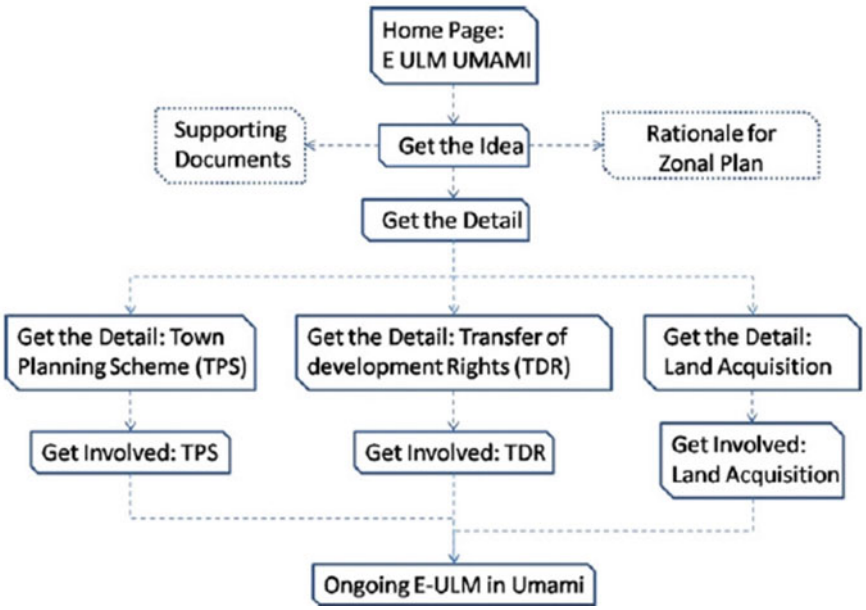

Fig. 15 Structure of E-ULM interactive website

3. Towns under Municipality/Town Committee
4. Cities under Municipal Corporation
5. Metropolitan Areas under Metropolitan Committees
6. The district under the district Planning Committee.

9.5 Smart Master Planning Objectives

(a) Smart Master Plan Objective:

1. Ways and means for the fulfilment of 12th schedule using ICT, IoT, E-Governance and E-Democracy and Machine to Machine system of implementation.

(b) Approaches:

1. Delivery at least cost by reducing administrative cost and simplification of procedures to access municipal service through digital means
2. Consumer access delivery at least cost and effort
3. Integration of smart planning, governance and implementation
4. Use of ICT, IoT, E-Democracy and E-Governance.

9.6 The Summary of Smart Master Planning for Kozhikode Metropolitan Area

The three official Master Plans of Kozhikode were prepared in the past namely Master Plans (1962–)1981, 2021 and 2035 were based on the Malabar Town and Country Planning Legislation 1920, borrowed from the Madras Town Planning Act being practised then by British Colonial rulers of India. The present Town and Country Planning Act 2016 came into being later. There was no intention in the legislation to make Kozhikode a bigger global economic superpower than it was before British rule, and incorporation of Master Plan related technologies and innovating approaches available then.

The approach followed in the Smart Master Planning of Kozhikode Metropolitan Area case study is a digital Master Planning that differs from the earlier approaches of the three official plans.

The earlier three official Master Plans were never prepared solely for one Municipality or Municipal Corporation like Kozhikode but for planning, the area comprises adjacent municipalities and village panchayats keeping in mind city is part of a region. No census in India recognises this planning area. For the Master planning of Kozhikode in this exercise, we adopted the Kozhikode Metropolitan Area 2011 census which is accepted by the census of India, the Indian Constitution, Election Commission and Finance Commission for the sharing of Tax from state and central revenue. This approach ensures that urban development of metropolitan areas is regional planning incorporating many census towns in an integrated fashion and is based on the Indian Constitution, the concept of Multilevel planning and the concept of integrated regional development of cities.

The strength of Kerala historically lies in the strength of people as a community for the common cause and the ability for community action which Britishers were afraid of and therefore absent in Master Planning based on 1920 legislation. The social and community actions last few hundred years on temple entry movement of the lower caste, education and health care development initiated by Christian priests like Chavara Achan (and many who all later became saints ordained by Rome;) advocated wherever there is a palli or church there should be a pallikudam or school. There was no end to such social movements in Kerala spearheaded from time to time by Narayana Guru, Chattambi swami and many more like Muslim Educational Society, SNDP, Nair Service Society and Kerala Shastra Parishad. The full literacy movement planned family movement and land reforms all are the product of community action. Based on all that Master Plan was conceived as a mass movement involving community and institutions mostly local. The high Human Development Index, low infant mortality rate and global mobility of people of Kerala are all by-products of this community action and initiative in the past.

The adjective smart for these communities in recent times is legitimate and based on the fact Kerala is the first state who declared fully computer literate and smartphone ownership is more than 100%.

The Master Plan in practice and our proposed master plan differs. The Master Plan practised in Kerala essentially is a land-use proposal to be implemented in the plan period of 20 years through regulation and development. Our approach to Master Plan states that Master Plan is a development and regulation of an aggregate of communities which we call smart communities in Kozhikode Metropolitan Areas. For regulation, we require an unambiguous physical zonal plan map and for development for these communities a clear action program. For this to happen we seek the initiative of local communities with the help of authorities in multi-level as discussed who works parallel.

These smart communities have a geographic space that is easy to identify. This is centred around a nucleated road junction where you will see many shops, cinema theatre, banks, schools, offices, bus stops and so on. The same is repeated in the next junction. The community can be delineated by the perpendicular bisector of all such junctions. Here it is found people use all the nucleated facilities in the junction daily or periodically. Where one community ends the other neighbouring community starts.

The Kozhikode Metropolitan Area is having many smart communities. They can be classified into three broad categories and can be innumerable and diverse types within these three categories.

Smart Economic Community example case study Mukkam. This is the most common type of smart community which develops as per the development of local economic activities.

Smart Global Economic Community example case study Kattangal. Here the economy is global as well as local. The smart community collaborate with the institution locally who have the potential to be an entrepreneur to produce and market global products and services in a participatory fashion.

Special Economic Community example junction near the proposed Railway station of semi high-speed railway station in Kozhikode. This is not studied but is easy to implement.

Many of these smart communities have privately owned land and the publicly owned land are an exceedingly small and insignificant part. Even the publicly owned land like the road is voluntarily given away by local inhabitants for roads that are maintained by Government. This is the same as all built-up areas in the community. So, we do not advocate Government acquisition of land and government build development in the community, but other non-cash-based land management approaches are used based on E-ULM discussed above.

The study believes in community-based area development of the smart community. Here the community include all households and all institutions who will collaborate voluntarily to plan, manage, and govern the development.

An analysis of the Master Plan 2035 of the Kozhikode area shows it is a **Proactive Area Development Plan** for Kozhikode Planning area potential and committed or investigated projects. Based on that a land-use plan proposal for 20 years is made and it is regulated by zonal regulations. No one including the Government of Kerala or Municipality can guarantee that this development will take place in the next

20 years with committed finances since such commitments are beyond the Municipal Corporation.

Instead of a **Reactive Area Development Plan** for Smart Community who are committed to implementing the proposal with limited help from Government is adopted. In this only committed and financed government projects will be included and the duration of the plan will be 5 years or less and thereafter revised.

Besides, the study proposes that broad land use and infrastructure plans may be prepared for Kozhikode Metropolitan Areas based on all committed and proposed projects by state and central governments indicated. Since sufficient expertise exists it is not attempted in this study.

The study recommends preparing an approach to implement the constitutional obligation of implementing the 12th Schedule by Metropolitan Area Committees and other Municipalities and Panchayats.

The smart community plan will have a Concept Plan, Zonal Plan and Alphanumeric Zonal Code GIS.E-Urban Land Management Solutions for the smart communities.

We would like to reduce the time to plan, manage and implement to near zero for all 12th schedule items and so advocate Machine to Machine (M2M) Communication system. M2M Automatic Communication system for 12th schedule implementation will be demonstrated by innovative total System design for planning, managing and implementing of 18 items of 12th schedule for Mukkam and Kattangal.

The existing Master Plan Administrative Process of Kozhikode will be studied to find the delays and a web-based Smart Master Planning administrative process will be proposed for transparency.

Automated Data City, Cloud Computing System and Model-Based Management to integrate the M2M communications will be proposed.

The Design of User-friendly Interactive Web design for master Planning 12th Schedule that gives the total solution to all citizens will be developed. This is detailed out in four chapters.

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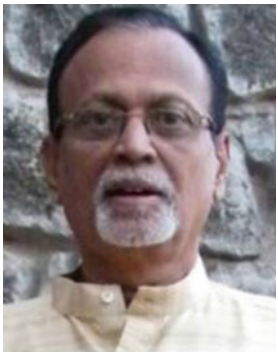

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Bhopal

Application of Artificial Neural Network in Master Planning—A Case of Simulating the Land Use and Land Cover Changes in Bhopal

Vidhulekha Tiwari and Amit Chatterjee

Abstract An urban ecosystem is intricate, and several factors collaborate to produce what we see as a city. While the dynamics of urban areas are functioning in complex ways, the conventional planning methods are generally linear and rational. This leads to an incongruity between the actual structure and the methods used to solve the resulting issues. Moreover, the accuracy and efficiency of plans prepared by conventional methods are often very less and they are not flexible. These plans do not properly respond to changes that may occur in the future. These challenges create a need to develop better planning methods for planning cities and machine learning methods can help us solve the issues. Artificial Neural Network (ANN) is one of the Machine Learning (ML) algorithms which consider various intangible, complex and nonlinear agents affecting any urban fabric. Artificial neural networks represent biological neurons and their networks. It is a black-box model, which means that the programme gets executed but the equations governing it cannot be extracted and examined. Using ANN can help in simulating various factors that are required for the preparation of a Master plan, thus improving its accuracy, time efficiency and flexibility. Using such tools can also help in better monitoring of the plans, which is otherwise time-consuming and challenging. In this study, Bhopal was selected as a case study. Even though Bhopal is the capital of the state of Madhya Pradesh, it is lagging in development as compared to several other state capitals in the country. The last master plan of the city was published in 1992, and afterwards, several attempts to make a plan have failed due to various objections arising from the side of the city's citizens. The recent Draft Development Plan 2031, also a GIS-based Master Plan (Directorate of Town and Country Planning, Madhya Pradesh, Bhopal Development Plan-2031, (Draft) Volume-I, Existing conditions, studies & analysis, 2020), is amid controversies regarding its ecological impacts and inaccurate mapping. In this study, ANN was used to simulate land use and land cover changes for the city of Bhopal. Using the ANN algorithm, the programme was trained with data for changes in land

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use and land cover from 2005 to 2018. The datasets were classified, and the algorithm was trained to check the desired accuracy. The same parameters were simulated for the year 2031 and the results were compared with the recently proposed draft development plan of the Bhopal city. The study was demonstrated how ANN could produce results that can directly be utilised as a crucial component while preparing subsequent master plans.

Keywords Artificial neural network · Bhopal · Master planning · Land use and land cover · Simulation

1 Introduction

The description of cities in normative models has been defined as cosmic models, machines and organisms. The cosmic model defines capitals and centres and says their objective is to satisfy inner and outer needs. The models which define cities as machines talk specifically about towns and conclude that the objective of towns is to simplify complexities for speedy outcomes. The model which defines cities as biological organisms talks about urban metabolism. Over time, as experts realised that cities are highly complex, chaos theory has also been used for explaining them.

The interaction between inanimate infrastructure with the animate ecosystem through governance and management governs how the urban form develops. The fact that the cities are the centres for economy and administration adds to the complicacy of the urban fabric. What is difficult is trying to define the correlations between the numerous factors which create the complexity. Experts have been trying to decode this intricacy for decades, but it is impossible to consider and analyse all the factors involved manually.

At the same time, urban planning is considered art as well as science, but traditional urban planners have relied too much on the art side until now. Post-independence, preparation of master plans happened in Indian cities with the objective of managing urban growth and planned development. These plans were mostly proposed for a timeline of 20 years.

While the technical advancements are happening at a logarithmic rate, their application in urban planning in India is relatively low. In the twenty-first century, when several schemes for urban development are under action in the country, the rate of development of cities increases multi-fold.

In this era, making the master plans for 20 years with a review period of 5 years will not serve the purpose. The speed of plan preparation, monitoring and review needs to increase. The rate of development demands novel technologies for better planning to ensure better management.

Machine learning methods can help us tackle these challenges. Artificial Neural Network (ANN) is a Machine Learning (ML) tool that considers various intangible, complex and nonlinear agents affecting any urban fabric. Using ANN can help simulate various factors required to prepare a master plan, thus improving its accuracy,

time efficiency, and flexibility. Using such tools can also help better monitor the plans, which is otherwise time consuming and challenging.

2 Urban Systems and Complexity

I think the next century will be the century of complexity.

Stephen Hawking (2000)

Complexity is emerging as a post-Newtonian paradigm for approaching from a unifying point of view a large body of phenomena occurring in systems constituted by several subunits, at the crossroads of physical, engineering, environmental, life and human sciences [1]. A complex system is literally one in which there are multiple interactions between many different components [2]. Cities have been treated as systems for 50 years but only in the last two decades has the focus changed from aggregate equilibrium systems to more evolving systems whose structure merges from the bottom up [3].

The chaos theory can be treated as a subset of complexity theory at the outset. The term complex means a system consisting of interwoven parts, and thus complexity theory is meant to analyse such systems. The term chaos, on the other hand, means irregular, unpredictable or non-deterministic. Instead of the common notion that chaos is unorganised, complex systems are studied using chaos theory in mathematics.

Deterministic nonlinear processes are analysed using complexity theory. As urban environments are similar, many experts have been integrating these theories in urban and regional planning. Numerous urban studies and analyses have been done using complex systems analysis techniques such as fractal analysis and agent-based modeling.

A research-based on the application of fractal geometry in urban growth prediction [4] suggests that the existing methods based on concepts like rationalism, reductionism and comprehensive long-term planning have been inadequate. Studies have proved again and again how urban systems act as complex organisations, and thus the paper studies it with the help of fractal analysis. The factors considered in the study were urban growth, density distribution and distribution of land cover. This study assumes that the city growth follows fractal-shaped developments and takes the shape of a fractal shape of Sierpinski Carpet. After the analysis, it was found that the assumptions were correct. This paper showed an alternative approach to urban growth modelling and verified how the various simulations agree with the actual on-ground scenarios.

On the other hand, techniques such as cellular automata have helped study and analyse the urban frameworks. The CA as a tool was developed in the 1940s to replicate a given set of algorithms systematically. It has been extensively used in studying urban growth and land-use change determination.

Unlike widely used growth models based on cellular automata, there are two main advantages of using the proposed machine learning-based framework. Firstly, it does not define rules a priori as the model learns the dynamics of growth directly from the historical data. Secondly, it is very easy to train new machine learning models using different explanatory input variables to assess their impact [5].

However, few on-ground implementations of studies based on these concepts can be seen worldwide. The prime reason is the gap between the academicians studying these phenomena and those working to implement the urban plans. The experts working on mathematical theories and machine learning are far from urban planners, and thus it is required to fill this gap to ensure advancement in the subject.

3 Artificial Intelligence and Machine Learning

The ability of any machine or computer to display intelligence, which is otherwise a characteristic of humans or animals, can be called artificial intelligence. It includes perceiving the environments, cognitive functions, learning, problem-solving and many other aspects. These functions may also be beyond the capacity of human intelligence, and that precisely is the function for which Artificial Intelligence is used.

Artificial Intelligence is now being used in a wide range of fields. Many such AI tools are being used in several aspects of urban planning. Research describes how various AI-based techniques have been directly imported to urban studies or developed for urban analysis [6]. They have classified artificial intelligence solutions for urban land dynamics in mainly four parts, namely,

- Artificial Life: focused on the micro-simulation environment while mimicking the dynamics of natural life forms. Examples are Cellular Automata (CA), Agent-Based Modelling (ABM) and Swarm Intelligence.
- Intelligent Stochastic Optimisation Process: relies on mathematical algorithms and data-mining processes. Examples are Genetic Algorithm (GA) and Simulation Annealing (SA).
- Evolution Computing and Spatial DNA: explains algorithms that are a result of local conditions and behaviours. Examples are Artificial Neural Networks (ANN) and Spatial DNA.
- Knowledge-Based Intelligent Systems: relies more on language-alike environments than mathematical or statistical formulations. Examples are Fuzzy Logic, Heuristic Search and Reasoning Systems.

The same paper also nicely lists out the applications of various AI and Hybrid-AI systems. It mentions how these methods have been applied to study pedestrian dynamics, traffic flow simulation, urban growth prediction, modelling of transportation networks, and landscape transition simulation. Several researchers have attempted to model various aspects like population distribution, binary urban footprint, and urban footprint with the help of ML [5].

As stated by Wu and Silva [6], the critical issue in this whole scenario is "despite a large number of AI applications in urban planning, approaches for integrating AI techniques into a framework that includes spatial and non-spatial dynamics are scarce in the literature". Moreover, it is required to find ways to make the technologies work together for better results.

Machine Learning is a subset of Artificial Intelligence (AI) that imitates the process in which humans learn through machines, increasing its efficiency over iterations. A process in which a system learns patterns based on input and output data fed to it is defined as Machine Learning (ML). ML is a branch of Artificial Intelligence (AI). In the system, an algorithm is constructed, which reads and learns from a dataset and keeps improving with constant testing and verification. The advantages of ML are as follows:

- No repeated human interference is required,
- The system develops itself over time,
- Highly complex problems can be solved without human bias,
- Time efficiency is obtained.

The ML algorithms can be classified in four ways based on their learning pattern. Both input and output data are provided in supervised learning, and the system learns the pattern; in semi-supervised learning, only a partial fraction of data is provided. Unsupervised learning is entirely independent, and reinforced learning learns by reacting to rewards and punishments on each output it gives. One of the most diverse algorithms applicable to all types is Artificial Neural Network (ANN) (Fig. 1).

As time demands, Machine Learning has also found its applications in urban planning. Various algorithms such as support vector machines, decision tree, and random forest have been extensively used in urban growth modelling, behaviour choice modelling and many other fields, but ANN seems to be one of the most commonly used algorithms.

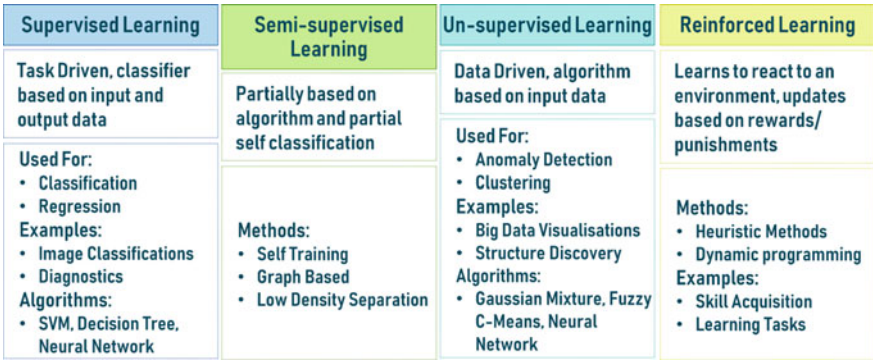


Fig. 1 Classification of ML algorithms

4 Application of ANN in Urban Planning

Artificial neural networks are a type of machine learning algorithms which represent biological neurons and their networks. The nodes represent the cell body of neurons, the axons represent the connections between the neurons, and the outputs represent the cell axon terminals. Each neuron can process the received signals and transmit them to several other neurons. Having a function similar to the biological neurons, they need to be trained with certain kinds of data, and over time the system learns it (Fig. 2).

There is an input layer in a fundamental ANN architecture, one or more hidden layers, and an output layer. Each axon has weight derived during training, and based on this; the output value is processed. It also has a defined threshold value, and an output is produced only when the processed value is higher than the threshold value.

Due to the ability of ANN to work with nonlinear systems, it has found its applications in many disciplines. As stated earlier, it is one of the most versatile algorithms and can be extensively used for pattern recognition, classification, prediction, etc. Urban planning has found applications in Urban Growth Modelling, Land Cover Classification, mapping land cover changes, and in fields such as governance.

ANN is classified as a black-box model because what happens inside it is unknown. The ANN provides outputs for a given set of inputs based on its training algorithms, and hence it is suitable for situations where understanding the mechanism is not required (Fig. 3).

Among various data-mining techniques, the advantages of using ANN are many such as

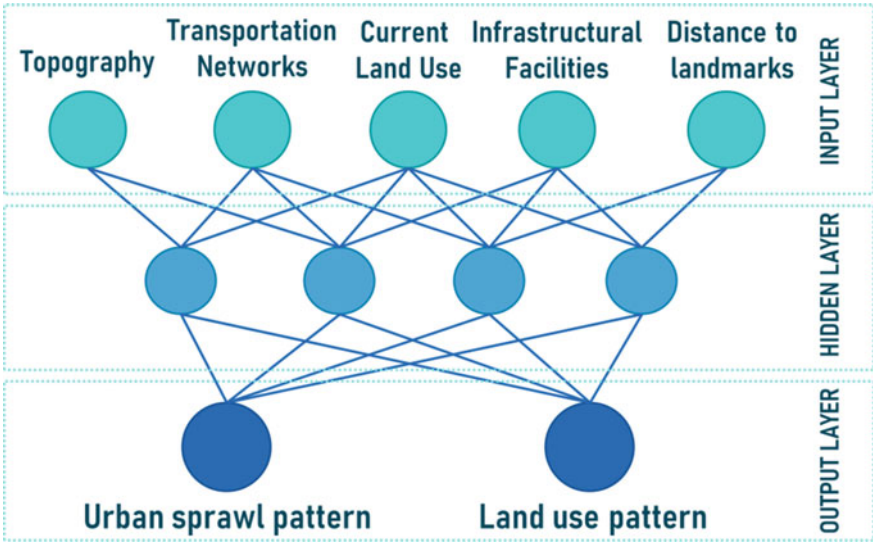


Fig. 2 The input and output layers to be used in the programme

Fig. 3 Types of mathematical models of complex dynamic systems

- ANN is relatively more straightforward and faster,
- Defining transfer function is not required in ANN,
- ANN is relatively easy and flexible to be implemented in hardware,
- The ANN can learn various problems using the same transfer function,
- ANN is better for large datasets.

ANN has been extensively used to study land Use and land cover changes in urban areas. A study by Riccioli et al. [7] uses four factors, namely, distance from roads, distance from inhabited centres, slope and altitude, to study land-use changes in the Chianti Area, located in the province of Florence, in Italy. The paper focuses on how these factors affect the changes in LU of the area and explains how they can be further applied for further studies.

Another study by Maithani [8] is done to predict the urban sprawl in the city of Saharanpur. The steps in the study are as follows:

- Generation of maps corresponding to factors driving urban growth in the study area,
- Generation of maps depicting actual urban growth in the study area,
- Generation of training and testing dataset from the data created in previous steps,
- Design of ANN with different network architectures,
- Training and evaluation of ANN,
- Selection of optimal ANN architecture,
- Masking of exclusionary areas,
- Simulation of urban growth using the optimal ANN architecture.

They have used five layers in their study, which are Euclidian Distance of each cell from the nearest major road, Euclidian Distance of each cell from the nearest minor road, Euclidean Distance of a cell from the nearest builtup, Euclidian Distance of each cell from the city core and Amount of built-up in the neighbourhood (500 m). These layers were kept as input layers to predict whether a piece of land would be built up or not. The simulation was done using MLP architecture with various layer combinations. The accuracies achieved were from the range of 64–87%.

In one of the studies urban growth modelling of Sanandaj city was done from 2000 to 2006 [9]. The results were reasonably good; the PCM and FoM values were 90.10% and 43.75%, respectively.

Besides the application in land change prediction, ANN has found several roles in other kinds of studies. A study by Abdullah [10] predicts the numbers of families,

students and cars using the education data, number of houses, number of families, number of vehicles and number of patients to answer how a city is expanding. The results show the trend of expansion of these factors with Mean squared normalised error performance function values as 0.0146, 0.0812 and 0.0947, respectively, for all three factors.

5 Methodology

Bhopal was selected as a case study for this research. A proposed development plan for 2005 was published in 1992, and afterwards no new plan has been accepted in the city. The Draft Development Plan 2031 [11], even though it is a GIS-based Master Plan, is among controversies due to expected negative ecological impacts. The postponement in preparations of master plans hinders the growth of a city.

The use of ML tools which can help in future land use prediction can help in avoiding the delay in Master plan preparations. Data availability plays a critical role in such studies, and an ideal set of data was available for the city of Bhopal. The data for various aspects of input and output layers to be used for the study was available for 2005 and 2018, with 13 years of gap. The development plan for Bhopal has been proposed for 2031, with 13 years of gap between 2018 and 2031; this helped better analyse simulations for land use data.

Land use and land cover act as the base for further developments in any area. Predicting these two factors with better accuracy will solve many underlying issues. Ensuring a minute increase in the accuracy will lead to a much accurate outcomes. Thus, land use and land cover were considered at output variables for the ANN programme for simulating the urban growth.

Using the ANN algorithm, the programme was trained with data for changes in Land Use and Land Cover from 2005 to 2018 using the Multi-layer Perceptron (MLP) architecture. The MLP is a class of feed-forward artificial neural network which contains more than one hidden layer. The datasets were classified, and the algorithm was trained to check the desired accuracy. The same parameters were simulated for the year 2031, and the results were compared with the recently proposed draft development plan of Bhopal city.

Although certain limitations arise in such studies due to the quantity and quality of data available, the scope for advanced studies after collecting a better data set is always available.

6 Bhopal Case Study

The city of Bhopal is the capital of Madhya Pradesh. It is a city of historical importance fenced with beautiful natural landscapes. The city has a rich historical background and is considered one of the critical centres of the Dravidian civilisation.

Bhopal is the basic territorial unit of administration in the state and is located in the centre of India.

Bhopal was found by the Raja Bhoj of the Paramara Dynasty in the eleventh century. The city was initially known as Bhojpal, named after king Bhoj and the dam ('pal') he had constructed. The upper lake of Bhopal, which still provides for around 25% of the city's water supply, resulted from this dam. The city developed around this lake and is now known as 'Bhopal'.

Geographically the city is located in Malwa plateau, which generally has an undulating topography. The Vindhyan hill range occupies the eastern part of the Phanda block of the Bhopal district, including a significant part of Bhopal city. Almost three-fourths area of the district is covered with black cotton soils formed by the weathering of basaltic rocks. The rest of the district area is covered with yellowish-red, mixed soils derived from sandstone and shale.

River Betwa drains the district with its main tributaries like Kaliasot, Kerwa, Ajnal, Bah, Halali and Kolans. River Parwati forms the north-western boundary of the district, and its main tributaries Mawal and Ulti, drain the area.

Bhopal was an independent state of eighteenth century India, a princely state of India from 1818 to 1947 and an Indian state on May 1, 1949. The city has architectural bases in Hindu and Islamic culture and lifestyles, which can be perceived through its heritage structures and layouts.

The first Municipal Body Majlis-e-Intezamia was formed in 1907 in the erstwhile state of Bhopal. The first survey was conducted in 1916 after the enactment of the municipal act. The first municipal board was instituted in the year 1952. In 1956, Madhya Bharat, Vindhya Pradesh and Bhopal were merged, and Bhopal became the capital city of Madhya Pradesh. In 1983, Bhopal got the status of Municipal Corporation with 56 wards. In 1975, the total Municipal area was 71.23 km^2; in 1999 it was 285 km^2 with a stable political environment, it serves as a hotspot for trade and commerce. This position is also bolstered by high literacy.

In terms of population, Bhopal is the second largest city of Madhya Pradesh with population of 1,886,100 as per census 2011. According to the Draft Bhopal Development Plan 2031, the current population of Bhopal is approximately 2,333,106. Since 2015, a growth rate of 2.5% in the population has been observed. This estimation includes the suburban areas of the city.

There are five railway stations in the city out of which the three namely Bhopal Junction railway station, Habibganj railway station and Sant Hirdaram Nagar railway station are the important ones. There are three important bus terminals, namely, ISBT, Halalpur and Nadra, of which ISBT provides services for interstate buses, and Halalpur & Nadra for providing services for intercity buses.

Several public transport services which include BRTS, Standard Buses, Intermediate Public Transport (Mini-Buses), and Para Transit (Vans and Shared Autos) are available in the city. The total length of the BRTS corridor is 28 km, which stretches from Bairagarh to Misrod, and is available on eight routes. The bus routes witness high density commercial development [12]. Most of the arterial and sub-arterial roads are connected by other modes of transport.

Bhopal Metro Rail Project has been launched in the city, out of which the approved phase 1 will contain two corridors with a combined length of 27.87 km. The first corridor will be approximately connected Karond Circle to AIIMS, and the second corridor will connect Bhadbhada Square to Ratnagiri Tiraha.

Bhopal is a part of smart city mission and AMRUT Mission and also has historical importance. Out of the 100 cities chosen in the first round of the Smart City Mission, Bhopal was also included. The city occupies a strategic location if the road connectivity of the state and country is considered. Since Bhopal is also the capital city of Madhya Pradesh, its efficient management is a necessity.

The city can be grossly divided into two areas: Old (north) Bhopal and New (south) Bhopal. The Old Bhopal area is mainly residential, and people rely upon small-scale retail businesses based on electrical goods, automobile repair, cotton, chemicals, handicrafts and jewellery. The new Bhopal area is administrative and commercial. The base map of Bhopal is shown in Map 1. The district has several lakes, and thus the city is also known as the city of lakes. A national park is also situated in the centre of the city (Map 2).

M. P. Nagar is the most prominent commercial area of the city. The industrial suburb of Bhopal is Mandideep. Bharat Heavy Electricals Limited (BHEL) has its offices in Bhopal. It has a significant suburb named after it, located in the eastern part of the city. The city has evolved into discreet townships with sparse outgrowth between the old city, BHEL Township, Capital Project (TT Nagar), Mandideep Industrial Area, Bairagarh and Kolar Nagar Palika. The urban sprawl has followed significant roads such as Chhola, Hoshangabad and Kolar Roads.

A vivid urban development past the late 70s has been in the southeast direction along Hoshangabad Road due to the availability of land and the presence of Habibganj Station, an important transport node. Also, the undulating terrain, a primary railway line in the north of the city, and the upper lake in the west restrict the city's growth in the respective directions.

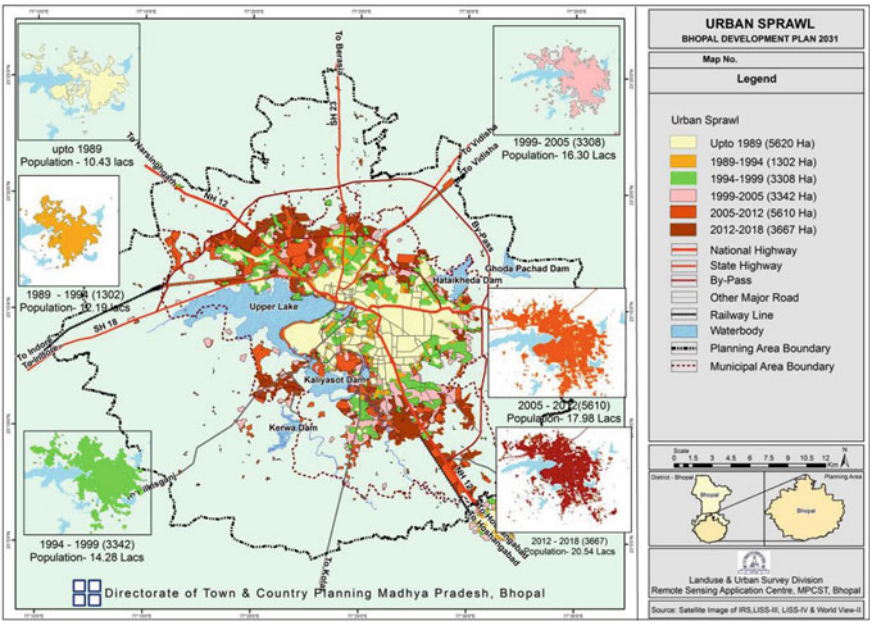
The map shows that the city has expanded towards the southern region due to the cheap availability of land during the initial phase of development and the proximity of Habibganj Railway Station. The industrial town of Mandideep and the BRTS corridor have also influenced the city's growth towards the south.

The first development plan for Capital Project Township in Bhopal was passed in 1959, based on which the capital area got developed. Another interim development plan was launched in 1963 for the whole city of Bhopal.

Next, the existing land use map was published in 1971 under the Madhya Pradesh Town Planning (Amendment) Act 1968. This plan was adopted after discussions, and thus Bhopal became one of the very few cities in India where an interim development plan was implemented.

The plan considered a population of 10 Lakhs and was to be implemented till the year 1991. The following master plan was published in the year 1994 for the year 2005. It got approved under Section 19 of the Nagar Tatha Gram Nivesh Adhiniyam 1973 [14]. Until this time, planning was happening smoothly, which led to a good base for future developments in the city.

Map 1 Bhopal Municipal Corporation and Bhopal Planning Area Jurisdiction. *Source* [13]

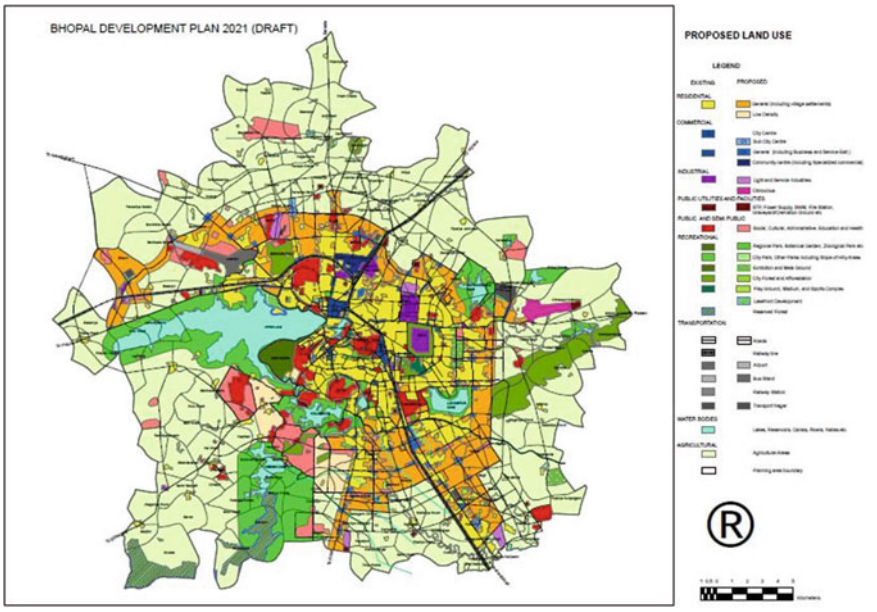


Map 2 The sprawl in the city of Bhopal. *Source* [11]

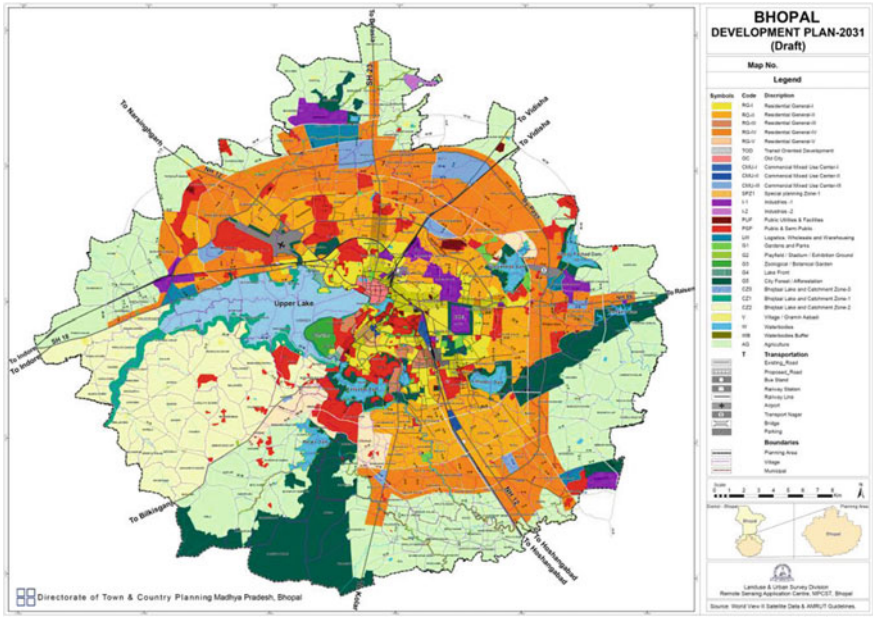
In Bhopal Development Plan 2005, the planning area was 601.06 km^2, which was extended to 813.92 km^2 in Bhopal Draft Development Plan 2021 (not approved), and to 1016.90 km^2 in Bhopal Draft Development Plan 2031. Spatially, there is an average increase of approximately 200 km^2 in the last two decades in the city of Bhopal (Maps 3 and 4; Fig. 4).

The graph above shows the share of various land uses in different Development plans for the city of Bhopal. As the planning area has been increased in the Draft BDP 2031, we can see a high deviation in the area allotted for the various land uses in Draft BDP 2031. One interesting point to be noted in these trends is that the land percentage allotted to various uses in different development plans varies significantly for the actual land use share in 2018; this creates the need for planners to adapt according to the actual needs of a city and its organic development. Although the recent proposal for 2031 is a GIS-based Master Plan, the errors are still there. ANN may help here in avoiding similar scenarios in the future.

Bhopal has transformed from being Nawabi Bhopal to the state capital of Madhya Pradesh, and then knowledge hub from nineteenth to twentieth Century. Due to the farsightedness of previous plans, Bhopal seems to be functioning better than many other cities across India. While this scenario makes the residents appreciate the expertise of the planners, it also gives us the responsibility to ensure that better and timely plan preparations are done in the future.



Map 3 Proposed draft development plan of Bhopal—2021. *Source* [15]



Map 4 Proposed draft development plan of Bhopal—2031. *Source* [16]

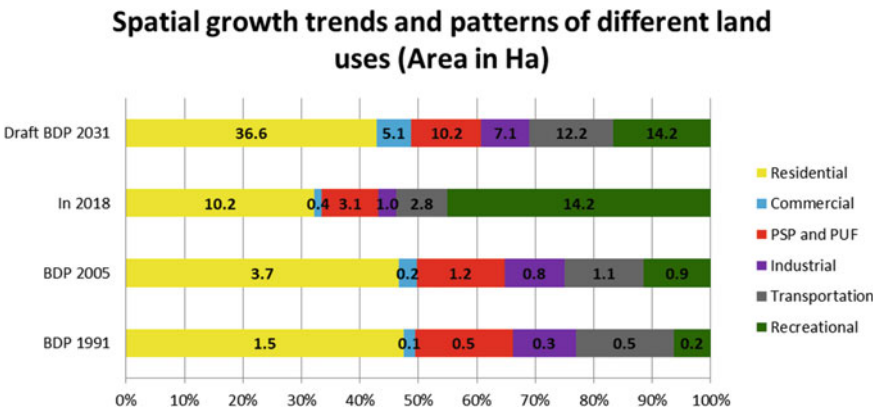


Fig. 4 Share of various land use in different plans

7 Simulation and Analysis

Various factors affect land use and land cover changes, which are respectively less dependent and more tangible. In this study, five factors, namely, Topography, Transportation Networks, Current Land use, Infrastructure facilities and Distance from landmarks were taken into consideration detailed analysis.

These factors were put in the input layers of the ANN framework to simulate land cover and land-use changes. The data for the analysis was taken from USGS, Bhopal Municipal Corporation and Town and Country Planning Department, as shown in Table 1.

All the data were processed using the software *ArcGIS*. The *Euclidean Distance* of each cell from the nearest arterial, sub-arterial, collector and local roads, railway stations, and major city landmarks were defined. The slope and contour map was generated using DEM of 2005 and 2018 from *Landsat* data. The slope was taken in percentage in continuous scale, and contour (height from mean sea level) was taken in classes of 5 m intervals. For infrastructural facilities, the data for water supply and sewerage availability were taken from Bhopal Municipal Corporation.

7.1 Land Use Simulation

The simulations for land use in 2018 and 2031 are shown in Maps 5 and 6. As mentioned earlier, the accuracies of the simulations were very low for land use, and it can be seen in the maps. Here the neural network has overlooked the minor inconsistencies. The patches of various land uses are small, and hence more errors are produced.

Table 1 Description of data used along with its sources

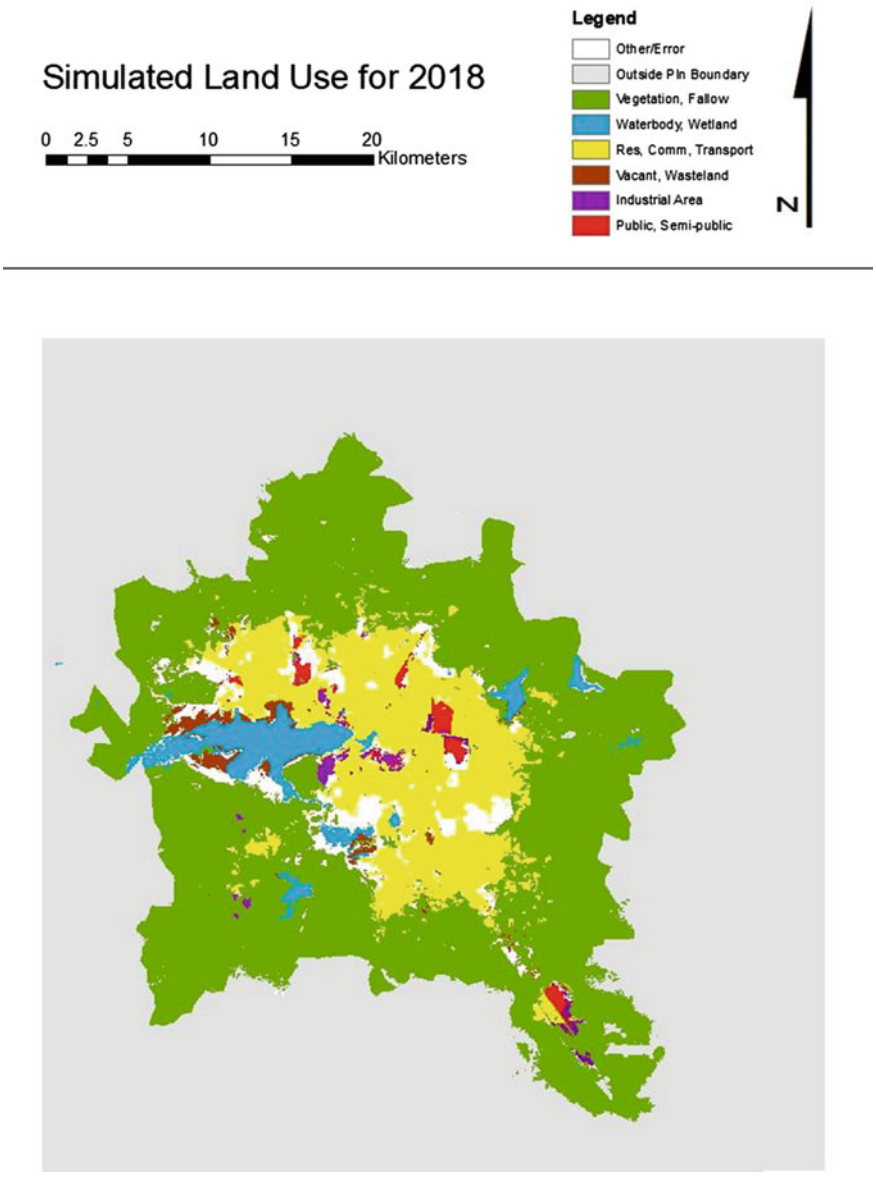
Data description			
Description	Type of data	Source	Classes
Euclidean distance from roads	Continuous	Satellite imagery, Google Earth	Absolute value (in metres)
Slope	Continuous	USGS, DEM	Absolute value (in percentages)
Contour	Classified	USGS, DEM	5 m interval
Water supply availability	Binary	Bhopal Municipal Corporation	Yes/No
Sewerage availability	Binary	Bhopal Municipal Corporation	Yes/No
Existing land use	Nominal	T&CP Bhopal	Outer, vegetation or fallow, vacant or waste, residential or commercial or transport or mixed, PSP, water or wetland, recreational or open spaces, restricted, industrial
Land cover	Nominal	USGS, LandSat imagery	Water, barren, vegetation and built up
Euclidean distance from landmarks	Continuous	Satellite imagery, Google Earth	Absolute value (in metres)

Various error values arising in these simulations are at the boundaries of two different land uses; this is primarily because of a few minor faults in the programme, which can be rectified with the helped advanced methods.

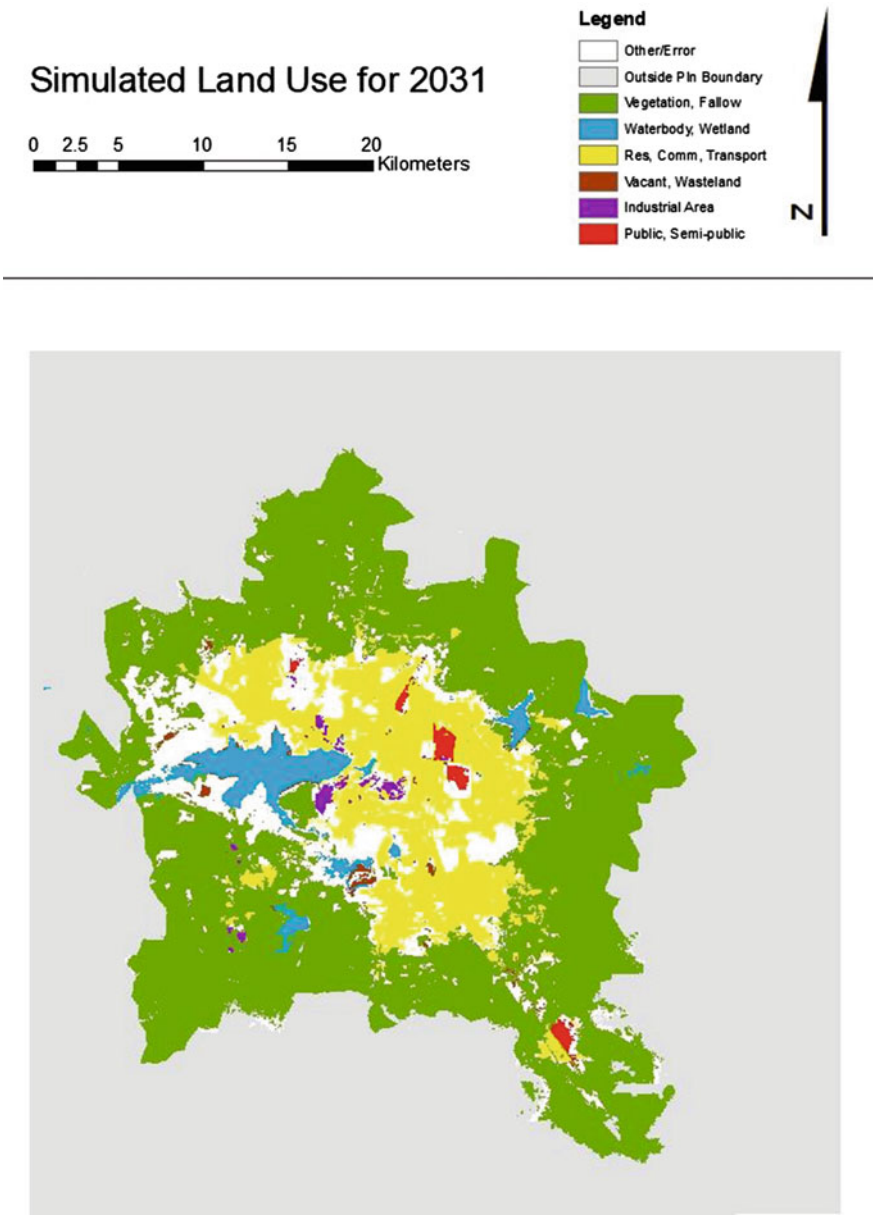
One of the main shortcomings of simulating land uses is that it cannot simply work with mixed land uses until they are more specified. We can conclude that for simulating land uses, we need more accurate and recent data. The comparison of various land uses, and their trends are shown in Fig. 5.

The area outside the planning boundary had decreased from 2005 to 2018 as the boundary was extended. The vegetation and fallow land increased from 2015 to 2018, but the simulations show reverse trends in 2018 and 2031. While the green cover in the area has increased in this period due to the success of schemes like Joint Forest Management (JFM), the green cover of Bhopal city has been decreasing.

The area under residential, commercial and transportation land uses has increased from 2005 to 2018, which is obvious. The trend in simulations also shows the same, but the errors can be observed in the simulated values. Vacant and wasteland have decreased in the input layers, and the same pattern is also followed in the simulations. The area of water bodies and wetland is also decreasing in reality as well as in the simulations. The area under public & semi-public land-use and industrial land-use show a slightly increasing trend from 2005 to 2018, but it is the other way round in



Map 5 Simulated land use for 2018



Map 6 Simulated land use for 2031

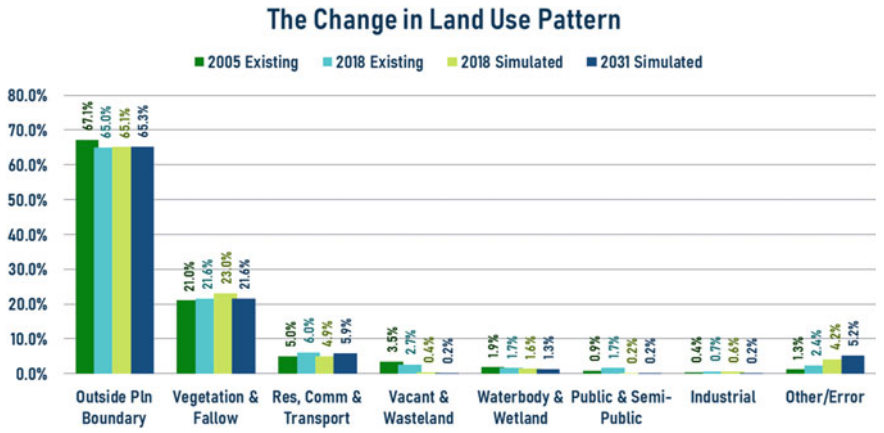


Fig. 5 The change in land use from 2005 to 2031

simulations. We can assume that the error values, if they would not have occurred, then would compensate for the errors caused in other datasets.

7.2 Land Cover Simulation

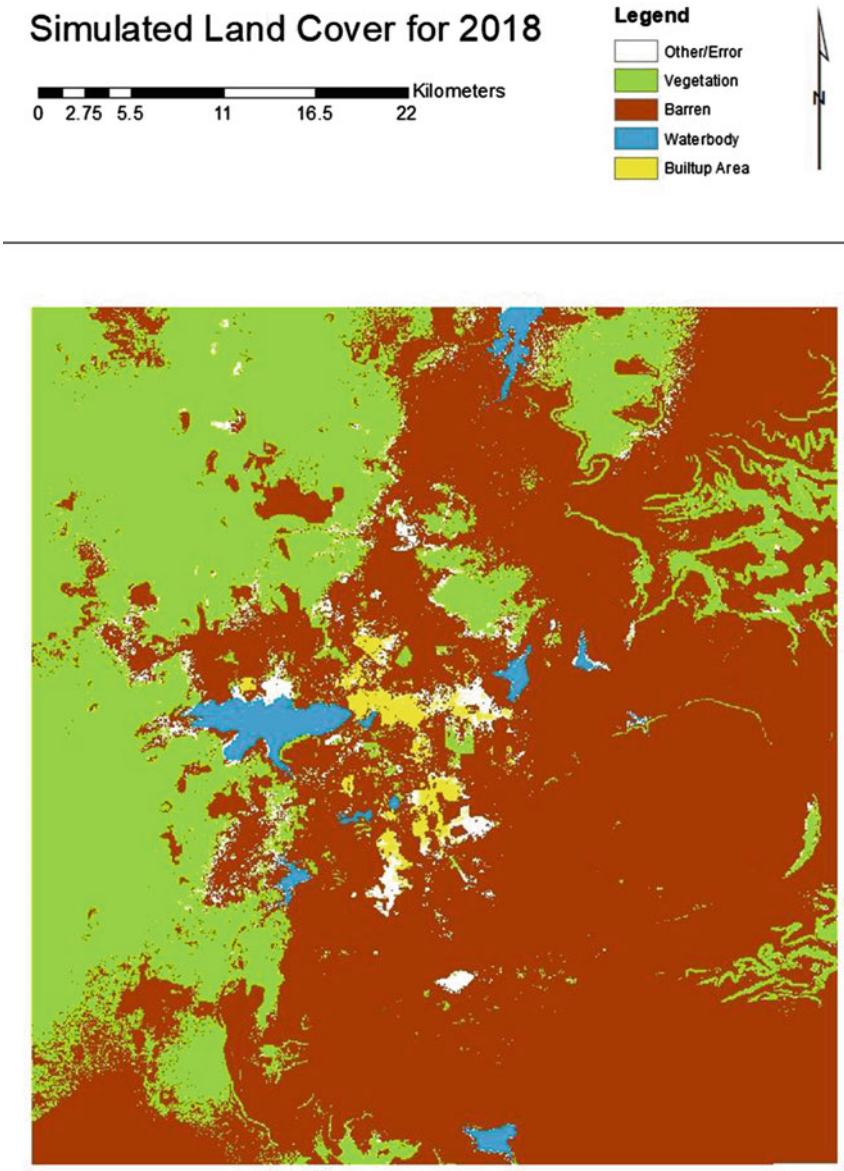
The simulations of land cover for 2018 and 2031 are shown in Map 7 and Map 8, respectively.

The trends and deviations of various land covers are shown in Fig. 6. While barren land is decreasing from 2015 to 2018 in the actual data, it shows the increasing trend in simulations of 2018 and 2031. Contrarily, the vegetation is increasing from 2015 to 2018, but the simulations show reverse trends in the simulations of 2018 and 2031.

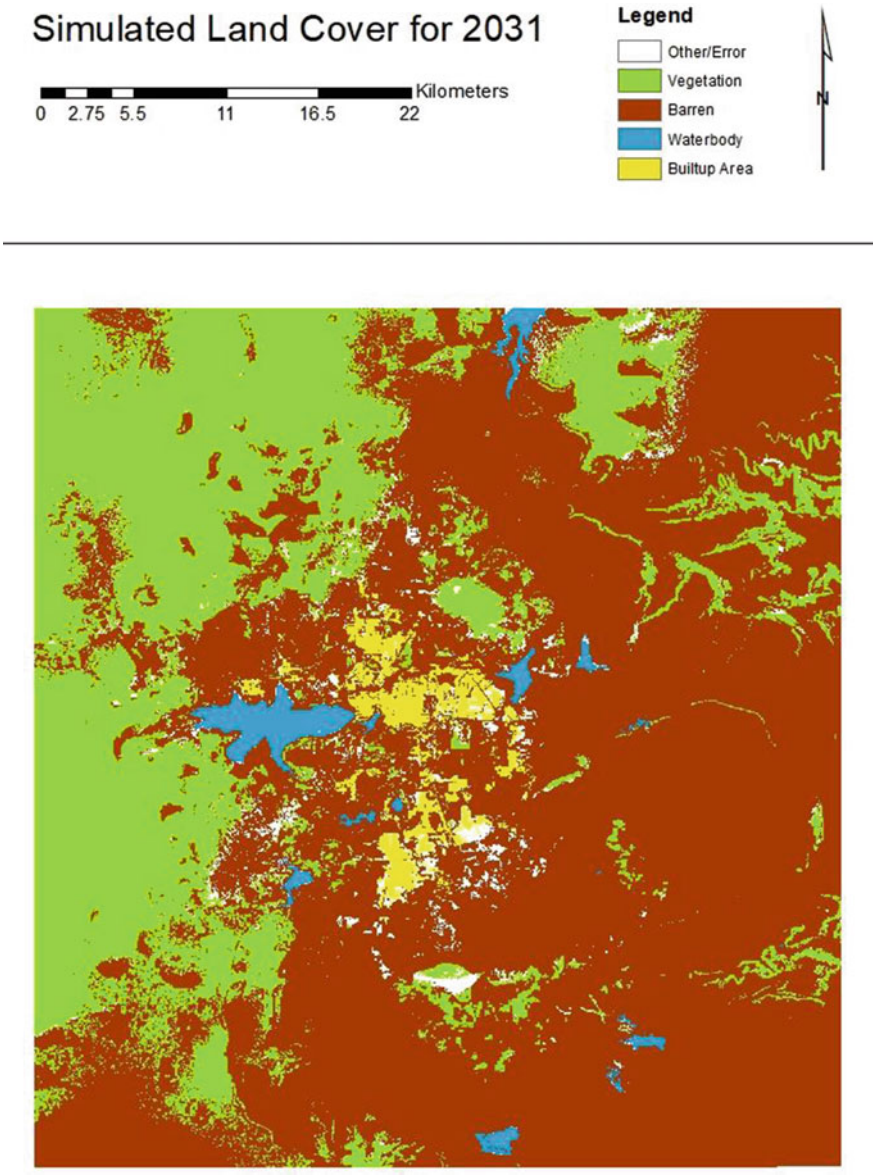
While the area covered by water bodies has decreased from 2015 to 2018, it seems to be constant in the simulations. The built-up area has a high error in the simulations, but the increasing trend has been the same. The error in the value of the built-up area in the simulations can be explained if we see the other/error values. The other/error values, if added to the built-up area, the other/error values seem to be compensating for the high errors in the simulations.

The outputs with other (error) values in the final simulations were obtained due to a few errors in the programme and data points, which can be modified in actual applications.

As the system's accuracy increases with more training, if we keep retraining the algorithm at defined intervals, it will give better results; this will also include updating the system with the changes happening on the ground with time. The data for updating the system can be acquired using ground verifications, satellite imageries, and new urban local bodies and government policies.



Map 7 Simulated land cover for 2018



Map 8 Simulated land cover for 2031

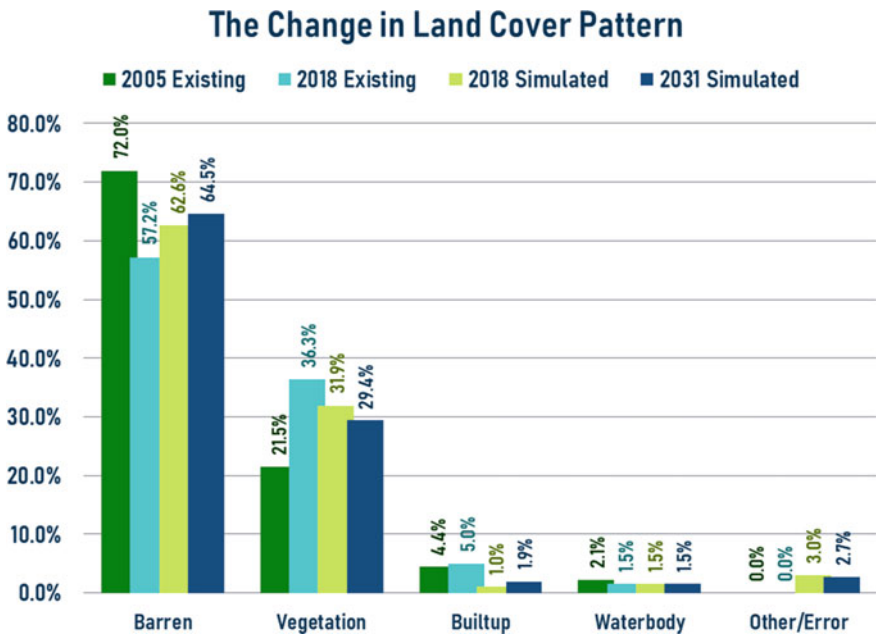


Fig. 6 The change in land cover from 2005 to 2031

8 Assessing Informality in Urban Development

Identifying current and future informal regions within cities remains a crucial issue for policymakers and governments in developing countries. The delineation process of identifying such regions in cities requires vast resources. There are various studies that identify informal settlements based on satellite image classification, which rely on both supervised or unsupervised machine learning approaches. In the absence of these datasets, the analysis becomes difficult. The predictSLUMS is one such model which uses spatial statistics and Artificial Neural Networks (ANN) to define informal settlements based on two ubiquitous characteristics of informal settlements. The model shows high validity and accuracy for identifying and predicting informality within the same city the model was trained on or in different ones of a similar context [17]. This verifies that the scope of application of ANN is extremely versatile.

A survey-based slum mapping programme was conducted by the Indonesian government to reach the national target of "cities without slums" by 2019. It shows that several mapping inconsistencies happened due to several reasons, such as the dependency on the surveyor's experiences and the complexity of the slum indicators set. To reduce such inconsistencies, Leonita et al. [18] show how the machine learning algorithms like support vector machine (SVM) and random forest (RF) can be used effectively in slum mapping.

As per Census 2011, 26.68% population of Bhopal city, with 102,803 households is living in informal housing. Many of these settlements are in government owned lands and critical drainage basin along the lakes shores, river banks and nallahs. Upon detailed analysis, it becomes observable that the slums are located in the areas close to the work centres in the city. While from outside it may appear that the slum dwellers are far from the effects of any smart interference, the new generation in slums is actually quite techno-savvy. The residents often prefer to deposit electricity and other bills online. Use of mobile apps, sharing information with family and friends, getting awareness on various issues through smart communication sources are revolutionary practices, which are changing complete interface and life style of slum inhabitants [12].

Slums are not the only kind on informalities which occur in urban areas. Any kind on unauthorised development can be termed as 'informal'. While the current research has been limited to recognition of slums through image classification of satellite imageries, much more detailed information can be achieved through applications of ML.

It can be observed that the urban sprawl in Bhopal is taking place in the south-east direction along Hoshangabad road towards the Mandideep Industrial Area. The industries and residential plots have already developed there; this is evident in the simulations, but no corresponding provision exists in the development plan. Moreover, let us look at the land cover simulations. To protect the green cover, the city should be developed more towards the eastern and southern direction, but no such consideration has been taken in the plan; this leads to the conclusion that using ANN for simulations can help avoid such conflicts and may help make a plan that is more realistic and aligned with the needs of the people (Fig. 7).

While there is a high chance of over-fitting in this case, the results were still satisfactory. Despite the errors, the simulations still gave a much better idea of the future patterns of development. Thus it can be concluded that ANN with MLP architecture can be successfully used to simulate land use and land cover changes in any urban area. This simulation can be used in the stage of plan preparation to foretell the growth patterns and plan accordingly correctly.

9 Conclusion and Way Forward

At the end of this chapter, it can be concluded that ANN can be integrated with the contemporary planning techniques in India to get faster and more efficient results. ANN can be used in plan preparation as well in monitoring stages to ensure efficiency in urban management. The model in the study chose a very simplistic method for analysis, which can further be developed to get better results.

As ANN can successfully help the planners to predict the future land developments, the frequency of review of master plans can be increased considerably. The conventional Master Plans are generally prepared for a duration of 20 years and reviewed at 10 years, but the current rate of urban development requires that

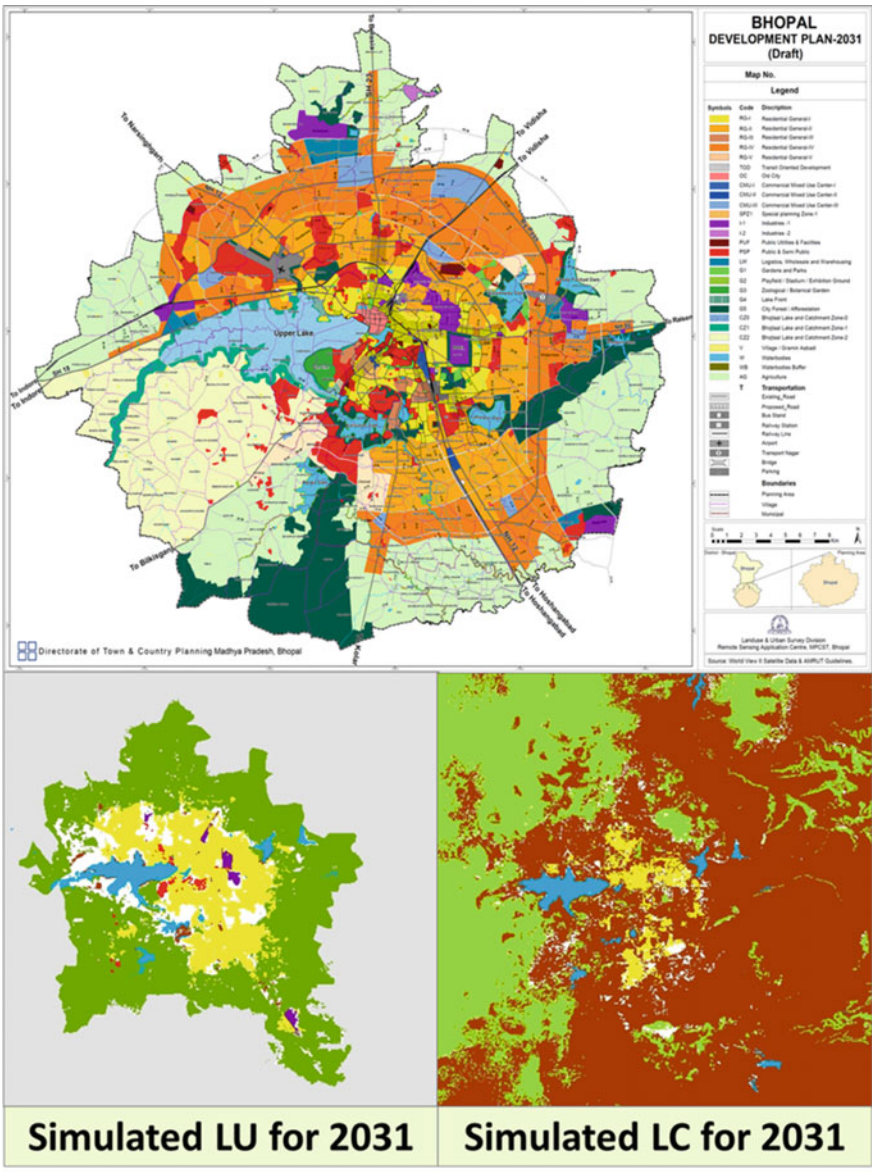


Fig. 7 Comparison of the Draft Bhopal Development Plan 2031 and simulations were made for the year 2031

the review frequency is increased on the basis of requirement of a particular city. The time periods are an extremely subjective matter which will depend on the size, planning, policies, infrastructure and population of the city.

Moreover, not everything can be handled by technology and hence the role of manual interventions must not be forgotten. Several uncertain events occur, and they cannot be incorporated into the ML systems without considering the irregularities.

Various unprecedented developments still occur in urban areas. The emergence of street vendors and restaurants around residential areas and informal settlements around industrial areas are commonly observed examples. Such developments act as catalysts for the growth of other formalities. These uncertain effects of plans and policies can be studied with ML tools.

The application of ML tools is not only limited to simulating results for merely land use and land cover changes but also delves into several factors like plan implementation, monitoring, decision-making and governance. ML has seen its application in economics, governance and management as well.

The applications of AI and ML in urban studies have been detailed previously, but the gap lies between researchers and conventional planners. For the application of such techniques, we need more interdisciplinary research. Development of the required infrastructure and data capturing methods plays a crucial role in further advancements. The administration can use this data, service providers, enterprises and citizens for various activities such as urban planning, disaster management, service provision, risk reduction, environment protection, traffic management and many other fields.

Simulation of the policies before implementation becomes possible with AI and ML. Simulated cities are being used for advanced urban studies, and this presents us with a broad scope for such studies soon.

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Chennai

Smart Master Plan and 3D GIS Planning Support system—A Case of Chennai City, Tamil Nadu, India

Kusum Lata, Faiz Ahmed Chundeli, and Adinarayanane Ramamurthy

Abstract As 3D modeling tools and methodologies become more widespread, urban planners are beginning to think three dimensionally to address the ever-growing urban concerns, particularly in dealing with the built environment. In this chapter, the viability and necessity of using 3D GIS as a planning support system for smart master plan are examined. The interactive, dynamic, and information-rich 3D model used in this research provides an innovative method for sharing urban planning data with both urban planners and the general public. This study's methodological approach shows how 3D models can be employed as a smart master plan tool in regular urban planning activities. Every city has its planning procedure, and industry standards must be followed when integrating 3D models and 3D volumetric evaluation methodologies. More research into customization in the integration of 3D models is needed, from data collecting tactics through analysis and display. The research described in this chapter has aided in the expansion of 3D city model applications in urban planning toward a smart master plan approach. Although 3D city models improve analytical powers, adopting them into daily planning procedures necessitates more study in terms of greater analytical capabilities and adaptability. For the assessment and monitoring of growth and development, 3D technologies are an unavoidable prerequisite. Tools that are easy to use and free to download, as well as those that integrate spatial and non-spatial data more extensively. By combining 3D volumetric studies into day-to-day operations and planning processes to understand the threshold limits for growth and development, urban planners, city administrators, and lawmakers will be able to plan more efficiently.

Keywords 3D GIS · 3D city models · Urban planning · Decision support tool

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1 Introduction

Numerous processes, techniques, and studies go into the planning of a metropolitan area. It necessitates a thorough awareness of issues in both horizontal and vertical dimensions. The failure to consider the vertical dimension of a city is currently one of the fundamental shortcomings in urban studies. Urbanization is increasingly taking place on a vertical scale, notably in Asian countries with significant vertical urbanization. The evaluation of the availability of (physical) infrastructural facilities for such an area is limited by a two-dimensional (2D) layout of a city center with skyscrapers. In actuality, 2D drawings rarely reveal an area's vertical volume and therefore put planners' imaginations to the test when imagining a "mental map" of a particular region. Traditional 2D plans limit planners' analytical perspective, and the limits of these designs become more apparent as cities get larger and more complex [1]. In general, urban analysis is limited to two dimensions, making it impossible to study a city's growth and development in three dimensions [2, 3]. Because of the complexity of data integration and modeling, as well as the absence of relevant skills for incorporating 3D models into everyday planning processes, urban planners are hesitant to employ 3D tools, affecting the efficiency and efficacy of the plans generated. This antiquated approach to urban planning and administration must be updated with technological breakthroughs that facilitate efficient planning (Xu et al. 2009). The use of 3D models in urban planning and design is a recent development in which "digital information is transformed into common graphical information," however most applications are limited to representations of the urban environment [4]. This graphical data allows urban researchers to depict and investigate urban characteristics in a variety of ways, including 2D (maps), 3D (built form), and four-dimensional (temporal) forms [5]. For urban planners, it is an opportunity to become familiar with and to integrate these tools for efficient analysis, planning, and designing of urban spaces.

3D models and visualizations are now thought to be more dependable than other traditional representations for gaining a better grasp of spatial data [6]. One of the key advantages of a 3D model is that it realistically depicts the world. Decision-makers and urban planners may get a good picture of how a city will look in terms of its spread and profile by employing 3D city models, which is not achievable with 2D map data. In actuality, 3D city modeling's applications are primarily limited to data visualization and communication. This study aims to include 3D models into everyday urban planning processes to improve urban analysis and planning. Urban planners use geographic information systems (GIS) extensively for planning and analysis utilizing 2D maps. They allow users to overlay data geographically and use it for effective analysis and management of urban space [5, 7]. A variety of analyses can be done using 3D city models created with ArcMap and ArcScene, including attribute and geographic queries, view-shed analysis, shadow analysis, and others [8]. 3D volumetric analysis as a smart city decision support tool for planning, analysis, and decision-making is discussed in this chapter. Furthermore, it has been discovered that the current plan development, implementation, and review mechanism does not

meet the legislative criteria. To attain the required goals and objectives, the system also detects a strong requirement for an effective planning support system. This study intends to create such a planning support system, and it's important since it'll provide a methodological foundation for incorporating 3D models into everyday urban planning procedures for better analysis, planning, and decision-making. The potentials of 3D volumetric analyses, as well as their visualization benefits, will be revealed and demonstrated in this chapter.

2 City Planning and Development—An Overview

2.1 Urban Dynamics and Its Complexity

When compared to developed countries, the rate at which Asian cities are developing and the tremendous rate of urbanization are phenomenal. In these quickly rising countries, urban planners face a huge task in addressing the issues produced by fast growth. In places like Chennai, India, urban development plans are traditionally prepared and implemented by hand, utilizing traditional equipment and procedures. The application of CAD and GIS is restricted to mapping. In many urban centers, the inadequacies of traditional methodologies are visible in real development, which has a temporal and geographic irregularity or a temporal and spatial excess of planning. The traditional planning process has several flaws, including a shaky database for plan creation, a plan that isn't comprehensive or holistic, insufficient public participation, and a lack of monitoring and implementation mechanisms [9]. Urban planners are under increasing pressure to solve these difficulties and incorporate new tools and technologies into their daily work. Any technology designed to aid urban planners must be spatially contextualized. In these situations, the most often used applications by urban planners are CAD and GIS. While CAD and GIS systems can provide geographical qualities that aid planners in understanding development pressures, trends, and hotspots, their applicability is primarily limited by 2D designs. In recent years, Asian metropolitan areas have experienced more vertical expansion than horizontal development, necessitating the creation of tools and procedures to aid in the assessment of urban growth in the vertical dimension. When it comes to the provision of physical and social infrastructure, this becomes unavoidable [10]. Concentrated vertical developments imply difficult planning characteristics because voluminous activities must occur within a smaller spatial context.

2.2 City Planning and Development in India: A Glance

In managing growing urbanization, India is facing significant urban planning and development challenges. India's population is predicted to overtake China's by 2025, with more than 1.2 billion people. Existing megacities would account for a large amount of this increase, providing the greatest challenges to India's urban future [9]. The Ministry of Urban Development, the Ministry of Housing and Urban Poverty Alleviation, and the Planning Commission of India are all responsible for urban planning and development in India. These are the key agencies in charge of establishing policies, legislation, and development initiatives, among other things. Town planning departments are in charge of preparing master plans and development plans at the state level [11]. In India, the development plan directs city planning and defines land-use zones for residential, commercial, institutional, and industrial applications, among others [12]. The urban planning process is more or less the same throughout the country following the guidelines stipulated in Urban Development Plan Formulation and Implementation [13].

3 Conventional Plan-Making and Regulatory Mechanism

3.1 Conventional Plan Formulation Process and Regulatory Mechanism

In India, the traditional plan formulation process is represented in Fig. 1. The designation of the plan's goal, which is usually a policy note by the decision-maker based on people's desires, is the first step in plan formulation. The techniques and means of reaching the goal of the strategy are spelled out in objectives. The identification of expected requirements for various activities is the next significant step in plan formulation. Traditionally, the nodal body for collecting and compiling important information from other departments on their plans has been the Town Planning Department. This approach has been ineffective due to the lack of participation and cooperation across the departments [13]. To prepare a plan, urban planners seek information from numerous agencies, which makes the planner's function critical. Plan formulation considers planning theories and principles, planning tools and procedures, norms and standards, and evaluation processes, in addition to the preceding information. In Chennai, a similar plan creation procedure is used, and the booming metropolis is unable to keep up with improvements in the supply of long-term infrastructure to its residents. The advent of new economy bases necessitates a departure from traditional master planning tools and techniques to ensure Chennai's long-term and equitable growth. Though the previous master plan initiatives were successful in providing a strategic direction for the city's expansion, the new Master Plan must be examined for higher floor space index and density to meet the city's expanding demands. The conventional plan-making process has many shortcomings such as a weak database

Fig. 1 Conventional plan formulation processes in practice, UDPFI-1996. (*Source* [13])

for plan preparation, the non-comprehensive and non-holistic nature of the plan, inadequate public participation, and lack of monitoring and implementation mechanism [9].

Zoning is a fundamental planning method used in Indian cities to manage urban development, with a set of restrictions affecting land use, density, form, and volume [14]. It's one of the legal tools for regulating urban development. Zoning improves city order [15], serves as an effective design control tool [16], and serves as a legal framework for guiding land use and protecting public health, welfare, and safety [13]. As a result, zoning is a set of requirements [17] that are utilized to implement master plans or development plans, and it is frequently regarded as a regulatory measure held by a city development agency. Zoning is determined by factors such as land use, bulk, height, and building shape [16]. However, traditional methods for developing zoning regulations, such as two-dimensional maps, fail to provide a platform for analyzing existing development and infrastructure. Zoning is the key planning strategy in cities

like Chennai. As a result, urban planners must have a thorough understanding of the impact of zoning restrictions on city development. With today's tools and processes, which are mostly based on conventional 2D blueprints, planning for a better future is nearly difficult.

3.2 Overlapping Competencies and Clash of Authorities

The participation of state government agencies in the management of urban issues is a defining feature of Chennai's governance. Public Work Departments (PWD), Tamil Nadu Housing Board (TNHB), Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB), Chennai Metropolitan Development Authority (CMDA), and other organizations are involved in the planning and management of urban services. Due to overlapping abilities and authority conflicts, effective planning and management of urban services are almost impossible. Furthermore, to prevent cities from becoming increasingly unserviceable and unsustainable, India's urban planning and development authorities must embrace advances in planning tools and processes. One of the crucial tasks indicated in this study is the construction of an information-rich city database with dynamic and static city models, as well as cities' critical data that need daily updating. By applying dynamic information systems to existing planning processes that focus on urban-related concerns, urban planners will be able to plan more effectively. To develop such a digital database, Delhi adopted the Geospatial Data Infrastructure Act (2011). This 3D-built environment is included in the database, as well as the full physical infrastructure such as roads, water supply, wastewater, electrical lines, and so on. For cities like Chennai, an authoritative database of this type is critical, since it will prevent overlapping competencies and authority clashes over decision-making, as well as provide up-to-date information on city development.

4 Data Analytics and 3D GIS as Decision Support Tool

4.1 Planning and Decision Support Tool

Assessment of current conditions, generation of alternatives for future developments, and community participation are all frequent components of planning (Abdullah et al. 2005). Existing circumstances must be assessed not just for current development, but also for projecting future requirements, planning, and managing future developments [18]. The Indian planning system is traditionally based on experience and trend analysis rather than scientific planning tools and techniques,as a result, this traditional technique must be reassessed to fulfill modern planning demands with improved and efficient planning processes. Planners require a suitable instrument that can match

the scale of their vision, which they have yet to find, for enhanced and efficient planning of urban spaces, which requires complicated processes and procedures [19]. Any decision that has a long-term impact on the built environment, according to Pullar and Tidey [20], must be rigorously assessed before implementation, and computer simulation is one such instrument for assessing the impact of such decisions. Planners rely on the availability, quality, and breadth of information to understand current events and make informed judgments. The final decision-makers in India are not usually urban planners, but urban planners may provide them with complete information in the form of a 3D information-rich city model to help them make better judgments [21]. The development of planning tools and procedures has opened up a world of possibilities for urban planners in terms of analyzing, planning, making decisions, and presenting geographically related data [18]. These advanced tools and methodologies will improve land-use planning decision-making and hence the social and economic elements of planning.

4.2 2D and 3D GIS for Planning

In planning processes that utilize spatial data for analysis, planning, and decision-making, GIS plays an important role [22]. Planners prefer GIS because it can analyze both spatial and non-spatial data [23]. GIS considerably improves the handling of geographical data in planning and management, and it also serves as a useful tool for data sharing across departments. GIS is primarily utilized in India for the creation of maps. A GIS database comprises both spatial and non-spatial attribute data, such as land, buildings, roads, rivers, utilities, social amenities, and transportation. Since the 1960s, GIS has progressed from a 2D to a 3D depiction [24]. With limited analytical capabilities, the third dimension currently serves only as an add-on attribute to 2D designs. 3D GIS is frequently seen as a technical subject including 3D data organization, processing, and display [25]. Many researchers still regard 3D GIS as an extension of 2D drawings, and the traditional 2D database is one of the primary drawbacks of employing 3D city models in urban planning processes. For urban planners, effectively visualizing complex 3D constructed environments remains a difficulty. With the recent breakthroughs in GIS technology on quantitative urban planning and analysis [23], there is a large demand for effective and efficient 3D GIS integration for urban planning objectives for increased analysis, planning, and decision-making [26]. The ability to construct scenarios based on analyses and generate what-if scenarios is a significant aspect of 3D GIS [27, 28]. The data storage and retrieval capabilities of 3D GIS help spatial analysis, planning, and decision-making in two ways: first, they provide rapid and efficient data retrieval and sharing to support planning decisions. Second, it has a built-in 3D urban analytical capability that allows different options to be analyzed [28]. There are several approaches for creating 3D city models, all of which rely heavily on GIS data [29]. Traditional geometric modeling software, such as CAD, which is widely used in Indian planning, is incapable of visualizing big urban environments [30]. For generating volumetric blocks, extrusion techniques

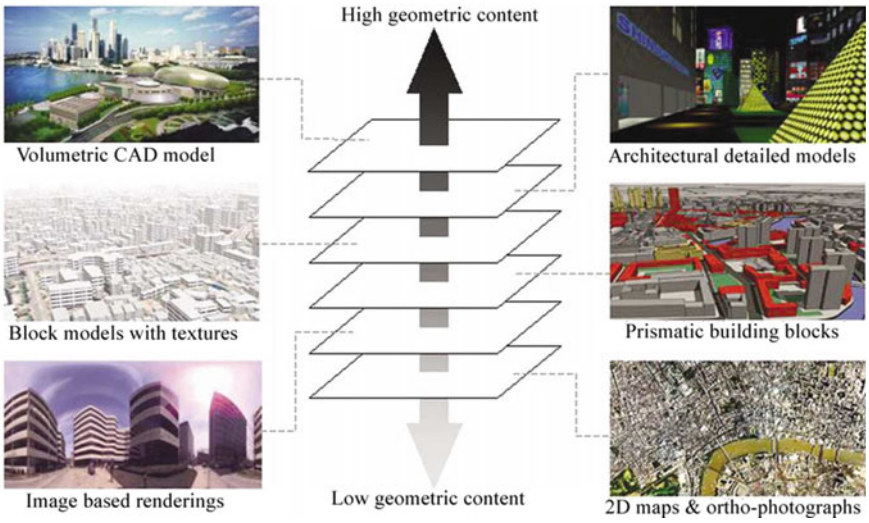

Fig. 2 Shinde's 3D city model typology, based on the degree of reality. (*Source* [28])

within GIS are the most popular approach of geometric modeling of the metropolis [31]. Combining 2D GIS and 3D visualization tools can make urban planning more effective and powerful as shown in Fig. 2.

4.3 Visualization Method for Linking Master Plan and Smartness

The use of 3D GIS has begun to have an impact on the planning profession [23, 32]. 3D GIS is now being used to model urban landscapes and investigate development scenarios, as well as illustrate alternative land-use plans and their influence on cities. 3D GIS models can connect past, present, and potential future developments in the built environment, closely resembling reality [33]. Yin and Hastings [23] demonstrated the use of 3D GIS in visibility analysis, and the model they created was used to evaluate zoning regulations in New York City concerning building height restrictions. Shiode and Yin [34] employed 3D GIS to analyze the built environment of cities from 1927 to 2000. By including zoning restrictions into the simulation model, development agencies all around the world have constructed virtual city models for controlling and managing urban development [35]. With its visual and analytical capabilities, a 3D GIS model will enable urban planners to effectively explain future development plans [28, 33]. 2D GIS maps provide for a wide range of geographical analyses [36]. GIS models are coupled with rich attribute data that can be utilized for spatial query and analysis. The application of geographic data in the form of 3D GIS has expanded as a result of the use of 3D data. Building height data is generally used

to create 3D GIS models, which are normally created by 2D extrusions of the GIS dataset in the vertical direction [37]. Since 3D GIS is built on a 2D GIS database, a wide range of spatial analysis is made possible, such as view-shed analysis, spatial query, and 2D, 3D simulations [23].

4.4 Demands for 3D City Modeling and Types of 3D City Models

Urban planning entails several complicated processes and procedures. Planning involves assessing existing conditions, developing development plan concepts, and including the public in the planning process. Forecasting future development necessitates a review of current facilities and services to make plans. The methods and approaches used by Indian planners are still traditional, with several restrictions. Urban growth is a dynamic process, and city planners need better decision-making tools to keep track of current events and estimate the future [38]. Planners need an appropriate tool for analysis, planning, and decision-making to improve planning processes that entail complicated processes, procedures, and analyses [19]. Although the urban environment is 3D, human perceptions of it are either 2.5D or 3D, hence any examination of the built environment must be done in 3D [39]. 3D models and visualizations are now thought to be more dependable than other traditional representations for gaining a better grasp of spatial data [6]. One of the key advantages of a 3D model is that it realistically depicts the world. Decision-makers and urban planners may get a good picture of how a city will look in terms of its spread and profile by employing 3D city models, which is not achievable with 2D map data. According to Marr [39], the reasons for not using 3D city models in urban planning processes are either conceptual or technical. By conceptual, he means that 3D city models are not entirely necessary for explaining complex-built environments, and by technical, he means that there is a lack of data, data structure, and inadequate tools for integration. With advances in planning tools and techniques, one can say that there would be no more technical issues in nearby future and the only reason for not opting for 3D city models is conceptual in nature [25].

4.5 Applications of 3D City Models in Urban Planning

There has been a significant increase in the use of 3D city models over the last two decades [40]. Currently, 3D city models are used extensively in various fields of urban studies, for example, in the visualization of the urban setting [41, 42, 43, 44], urban land-use planning [45], 3D cadastral mapping [46, 47, 48], environmental planning and simulation [49, 50], and in studies of transportation [3], emergency response [1, 51], and the built environment [28, 52]. Although the application of 3D

models to urban planning is not new, their application to the analysis of micro-level urban problems is a novel topic of research [45, 53]. A well-designed 3D city model improves the planning process, and with technological advancements, the 3D model appears to be more advantageous than 2D blueprints [54]. The use of a 3D city model allows for a more thorough investigation of the data. When compared to 2D layouts, the display of the current condition and predictions is easier and more instructive [54]. Cities can currently be modeled in 3D using a variety of techniques [55].

4.6 Current Research in Applications 3D City Models

While developing a 3D city model, the objectives of making such a model are very crucial. 3D models can be generated with distinct "levels of detail" (LOD) as required by the application and the users [43]. The concept of LOD is crucial in 3D city modeling,it indicates the real world and the data acquired for modeling [56]. An appropriate 3D city model should be chosen based on the purpose of a project. According to Shiode [28], the degree of reality is used as the important factor in creating a typology of 3D city models. Shiode [28] classifies 3D city models into six categories based on the degree of detailing, Fig. 3, which are as follows: (i) 2D digital maps and ortho-photographs,(ii) image-based renderings, (iii) prismatic building blocks, (iv) block models with textures, (v) architectural detailed models, and (vi) volumetric CAD models. Shiode [28] also classifies 3D city models into four categories based on their analytical capabilities, which are (i) aesthetic models are intended for illustration and aesthetic appreciations of development projects for authorities and the general public. Though aesthetic models are of the highest degree

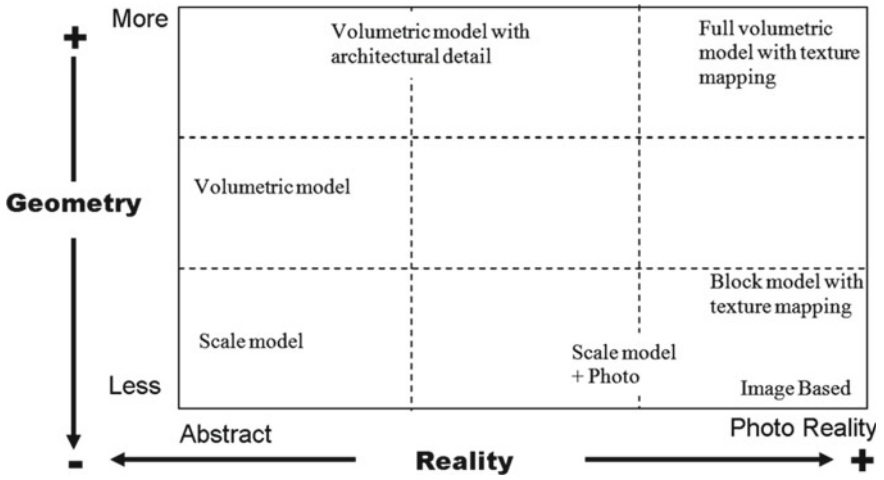

Fig. 3 Summary of types of 3D city models. (*Source* [57])

of reality, their analytical functions are very limited. (ii) Property models are models equipped with one or more analytical functions, for instance, the view-shed analysis, dynamic building blocks, and some basic querying functions. (iii) Full analytical feature models are the ones equipped with more multiple analytical functions, such as view-shed analysis, shadow analysis, scenario-based simulations, etc. (iv) Hybrid models are the combination of physical models and virtual reality models used for project appraisals.

As illustrated in Fig. 3, divides simulated 3D city models into three categories: volumetric model, image-based rendering, and hybrid model. The detailing of a volumetric model can range from simple geometric block models to intricate architectural detailing. Shiode [28] defined image-based rendering as "panoramic image-based modeling," in which a sequence of images is wrapped to form a viewpoint. Even though image-based modeling is less expensive and produces a more realistic depiction of the world, this model lacks 3D geometry. Hybrid models combine volumetric and image-based modeling approaches to generate realistic 3D city models, with a volumetric model covered with my texture mapping techniques. Based on the project's specifications, an appropriate 3D model with the required level of detailing is selected.

5 Application of 3D GIS and City Model for Smart Planning

5.1 3D Data Analytics and Simulation

There is a significant rise in the use of 3D city models in urban planning processes [33]. 3D models can be incorporated in several planning process stages, such as data collection and checking, analysis, prediction, and presentations, for superior understanding of real-world development. The modeling and visualization of different information and data at each stage of the planning process make modeling complicated and time-consuming. The application of 3D city models in the urban planning context varies from concept generation to decision-making and public participation. [36] explains the applications of 3D city models in 12 arenas such as (i) emergency services, (ii) urban planning, (iii) telecommunication, (iv) architecture, (v) facility and utility managements, (vi) marketing and economic development, (vii) property analysis, (viii) tourism and entertainment, (ix) E-commerce, (x) environment, (xi) education and learning, and (xii) city portals. Shiode [28] classifies the application of 3D city models into four broad groups, such as (i) planning and design, (ii) infrastructure and facility services, (iii) commercial sector and marketing, and (iv) promotion and learning of information on cities. The application of 3D city models in planning and design varies from site location analysis, community planning, and public participation. 3D city models are the best way for communicating with the general public, analyzing the data available for planning and design.

The provision of urban infrastructure services such as road network, water supply, sewerage, and other physical and social infrastructure facilities can be improved by applying 3D city models for planning, design, and maintenance [58]. 3D city models are also used for commercial purposes, such as to locate commercial and tourism spots, etc., and also in real estate businesses for selling and buying properties. 3D city models create a platform for people from different walks of life, to learn about cities. Kim [57] broadly categorizes the applications of 3D city models in urban planning and design into seven. (i) Public participation, 3D city models act as a communication tool to facilitate public participation in planning processes. 3D city models create a better platform for sharing information with the general public, on concepts, and design proposals. A better feedback mechanism for effective decision-making is made possible with the help of 3D city models. (ii) Visual impact analysis is another application of 3D city models, where it can facilitate the evaluation of design alternatives and attain the best solutions based on context and aesthetics. (iii) Development control, 3D city models have been used for controlling and monitoring development using visualization. (iv) Time-dependent phenomena, iconographic study, changes in the growth pattern of cities, shadows study, and distribution of population density are visualized using 3D city models for a better understanding of cities' growth. (v) Historic preservation, 3D city models are also used in historic preservation by adopting comparative analysis using visualization techniques of the proposed development and the existing historic sites. (vi) Dispute resolution, 3D city models can produce accurate visualization of a given development proposal to facilitate informed decision-making. This gives the user an accurate understanding of the size of the projects and their context and it helps in solving various disputes that arise. (vii) Environmental study, 3D city models can be used extensively for analyzing microclimates in built environment, in areas such as wind tunnel effects, humidity, sunlight, temperature variations, etc. It will also help in understanding the concept of the comfort factor in urban environments. However, most of these models can perform only limited analysis, despite being photo-realistic in nature and these models cannot provide additional spatial queries and analyses [28, 33].

5.2 3D City Models in Urban Planning

Non-specialists and the general public find conventional 2D plans difficult to understand, hence elaborate interpretations by professionals are required to comprehend the system [24]. According to current research, these restrictions can be overcome by incorporating advanced 3D city models into urban planning procedures [24, 59]. The use of advanced 3D city models for quantitative assessment improves comprehension of the complex urban system, as well as resolving urban planning difficulties and producing better planning outcomes [24]. According to the results of the tests, the visual preferences of designers and non-designers are similar since they both read 3D models in the same way. Planners and the general public can use a 3D city model to better understand complicated urban environments and the effects of anticipated

future projects [23]. "A 3D city model speaks in common visual language, that people can understand" [23], as compared to conventional 2D maps [23, 59]. Indian cities need an efficient planning system that deals with rapid current and future urban developments [58]. There is a strong need to develop a planning support tool, to achieve desired goals and objectives, generate alternatives, and manage urban development. 3D city models with inherent visual and analytical capabilities are essential in today's planning practices for a better understanding of urban environments and enhanced decision-making [37, 60, 61]. 3D city model can contribute to bringing efficiency and effectiveness in everyday planning processes, by enabling urban planners to understand the present urban environment and envision an appropriate future [37]. 3D city model for spatial–temporal analysis that will support planning and design of urban environment has been recently developed [37]. 3D spatial–temporal model acts as a tool for representing urban growth change and performing spatial queries. Static models are interpreted by Yin and Shiode [37] as a single news chapter picture of the subject, representing a single point of view on the urban environment, whereas dynamic 3D cities are modeled as continuous television news feeds. Building a 3D city model that reflects the past, present, and future urban environment by giving information on built-environment intensity change [37] and information on physical and social infrastructure carrying capacity requires more research [58]. Such 3D models not only assist urban planners in performing enhanced analysis, planning, and decision-making but also aid in bringing planning transparency to the general public through effective dissemination of planning information. More research into the integration of data on population change in 3D databases will aid in the dynamic assessment of the relationship between population change and urban development [37]. This research attempts to integrate population data in a 3D city model for the quantification of physical infrastructure that will enhance urban planning processes.

Planners have always used visual media to communicate with diverse persons involved in planning processes [36], and visualization has a long history in urban planning. There is a lot of use of city models in urban planning processes [62, 63]. Visualization has evolved as one of the most powerful decision support tools, thanks to recent improvements in digital computation techniques [24]. According to Langendorf [64], visualization has three purposes: first, to aid in the generation of alternatives,second, to aid in the understanding of complex urban systems,and third, to facilitate communication processes. 3D city models are useful for connecting with the real world [65]. Cities are thought of as living entities that alter and evolve [66]. The development of 3D city models is unavoidable, given its analytical capabilities in spatial analysis, planning, and decision-making [63, 65]. Expertise in the use of 3D city models for quantitative assessments of the built environment is required for improved analysis, planning, and decision-making [24, 58, 63]. This study is based on the preceding literature and aims to learn how to use 3D city models as a tool for quantitative assessments in urban planning procedures inside the Indian planning system. Today, many cities are actively involved in developing virtual city models for addressing various urban issues [24], and it is also anticipated that soon, there will be a further increase in the use of virtual city models in urban planning processes. The digital 3D city models in planning are expected to improve the planning processes,

by making spatial and non-spatial data more accessible and easier to understand and engage by various stakeholders, including the general public [24]. The social applicability of 3D city models in urban planning processes is the essence of 3D visualization.

6 Dynamics of Chennai City Study Region

6.1 History of Urban Planning in Chennai

The Chennai Metropolitan Area (CMA) includes the Chennai Corporation's territory, as well as 16 municipalities, 20 town panchayats, and 214 villages [67]. As seen in Fig. 4, the CMA or Chennai District consists of the Chennai Corporation as well as portions of the Kancheepuram and Tiruvallur Districts. The Chennai Metropolitan Area (CMA) has a total administrative area of 1192 km^2, with a City Corporation area of 426 km^2 [67]. Before this, The Madras Town Planning Act was enacted in 1920, and it was used to plan the city of Chennai. Although the town planning legislation was passed in 1920, the first master plan for Chennai was not completed until 1975, and only a few Town Planning Schemes were developed (CMDA, Draft Master Plan-II for Chennai Metropolitan Area-2026, 2007).

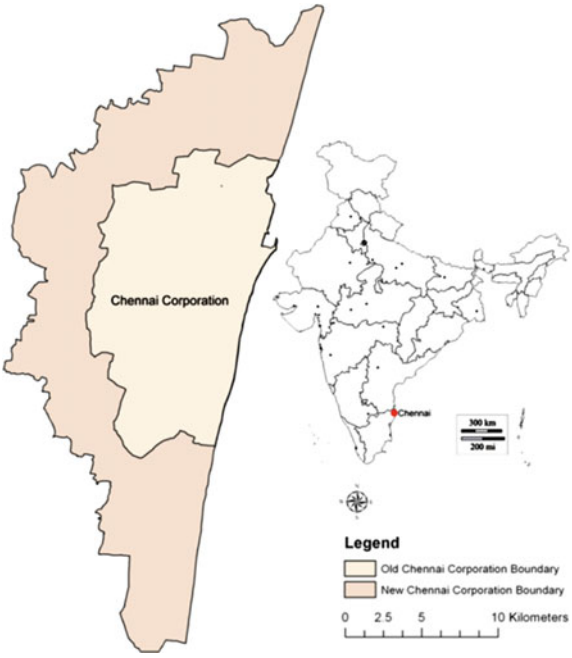

Fig. 4 Study area location map. *Source* [67]

6.2 Critical Review of Urban Planning in Chennai

Chennai has a long and illustrious history of planning. In Chennai, zoning and building by-laws are still two of the most important tools for modern city planning [14]. In addition, master plans aim to create a physical pattern of land use and transit routes for the city and the surrounding metropolitan area. As a result, master plans serve as a template for other government bodies to create sector-specific plans [67]. The city of Chennai's second master plan was completed in 2008 and is currently being implemented. By 2026, the second master plan aims to make Chennai one of India's most livable cities, with a high quality of life and a sustainable environment. However, the rules and master plans for planning do not address how to achieve this aim. The master plan also fails to consider how Chennai's urban shape is changing. It also doesn't address how climate, landform, established urban fabric, existing physical and social infrastructure services, and other factors were considered when master plans were created. Various planning schemes, policies, two master plans, and development laws developed by the Development Authority over the past 53 years are understood to have governed the evolution of Chennai City. Chennai City planning began in 1957 with a basic town planning scheme and ended in 2008 with the second master plan, which included land-use zoning and development restrictions as a regulatory mechanism for the city's expansion. With two-dimensional plans, the master plan's spatial strategy and land-use planning adhere to zoning and development restrictions that apply to various zones. Urban planning and development were based on two-dimensional zoning and master plans.

6.3 Study Area Location and Selection

Chennai is one of India's major metropolises. It is the country's fourth largest metropolitan metropolis and is located on the Bay of Bengal's coast. The Chennai Metropolitan Territory (CMA) has a total administrative area of 1192 km^2, with a new Chennai corporation area of 426 km^2, as indicated in Fig. 5. In 2011, Chennai City Corporation had a population of 7.8 million people [68]. Chennai is South India's most important cultural, commercial, educational, and industrial center.

6.4 Profile and Land-use Classification

Kannadasan Nagar is one of Chennai Corporation's planning units [67]. As indicated in Fig. 5, it makes up the southeast corner of Chennai's Theagaraya Nagar (T. Nagar). T. Nagar is said to be India's largest retail district. Kannadasan Nagar is a residential activity facilitator. Commercial activities are restricted to the study area's outskirts. The planning units cover a total area of 0.69 km^2. The Kannadasan Nagar area's

Fig. 5 Chennai metropolitan area—administrative boundary

Detailed Development Plan (DDP) was completed in 1980. According to the current field survey, the study area's population is around 77,270 people, with 917 various types of buildings. The research area is defined by two roads: South Boag Road on the east and Venkatanarayana Road on the southwest. There is also a neighborhood park called "Natesan Park" in the study area. As indicated in Fig. 6, the overall study area is 0.69 km^2, with 53% of plots being residential, 0.17% commercial, 18% mixed use, 8% institutional, and 2% parks and playgrounds [67]. Road and street networks take approximately 19% of the overall study area.

6.5 Data Collection Techniques

Plot and building-level data are two types of attribute data connected with 3D information-rich base models. The plot border, area, frontage, land uses, acceptable floor space index (FSI), maximum permissible building height, road connectivity, utilities (water supply and wastewater network data), and so on are all included in plot-level data. As indicated in Fig. 7, plot-level data for the research region was acquired from secondary sources in the Chennai master plans [67]. The footprint of the building, the number of levels, and the purpose of each floor are all included in the building-level data. As illustrated in Fig. 7, the footprint data was gathered

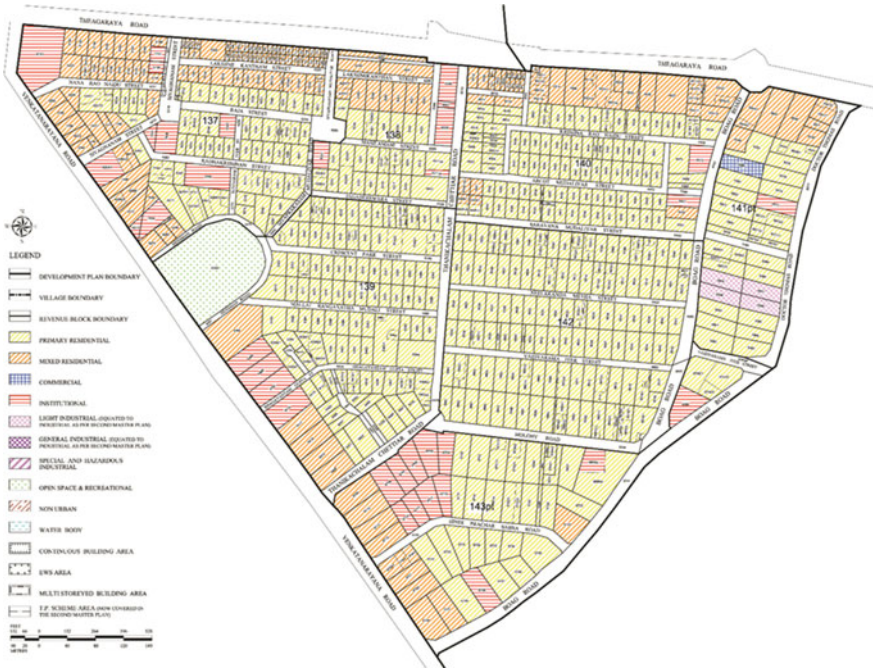

Fig. 6 Kannadasan Nagar area, DDP. *Source* [67]

using Google Images (2013 data), and the number of floors and uses at each level were estimated using primary survey data. To reduce the errors when representing the realistic built environment, complete enumeration of the study area is carried out. Table 1 shows the total residential, commercial, and institutional built-up area at each floor level, which was obtained from a primary survey and was also used to quantify the water supply and wastewater.

7 Area-Specific Analysis of the Study Region

7.1 Building Footprint Analysis

Using 1980 and 2013 datasets, a similar technique as depicted in Fig. 7 was adopted to create a 3D information-rich model of the study region, Kannadasan Nagar. To assess the intensity of developments and their impact on the carrying capacity of the physical infrastructure (water supply and wastewater) network in place, a status analysis of both the 1980 and 2013 datasets was conducted. The goal of this research's conceptual framework is to create a model that evaluates the relationship between physical development and all other physical and social infrastructure needs in the

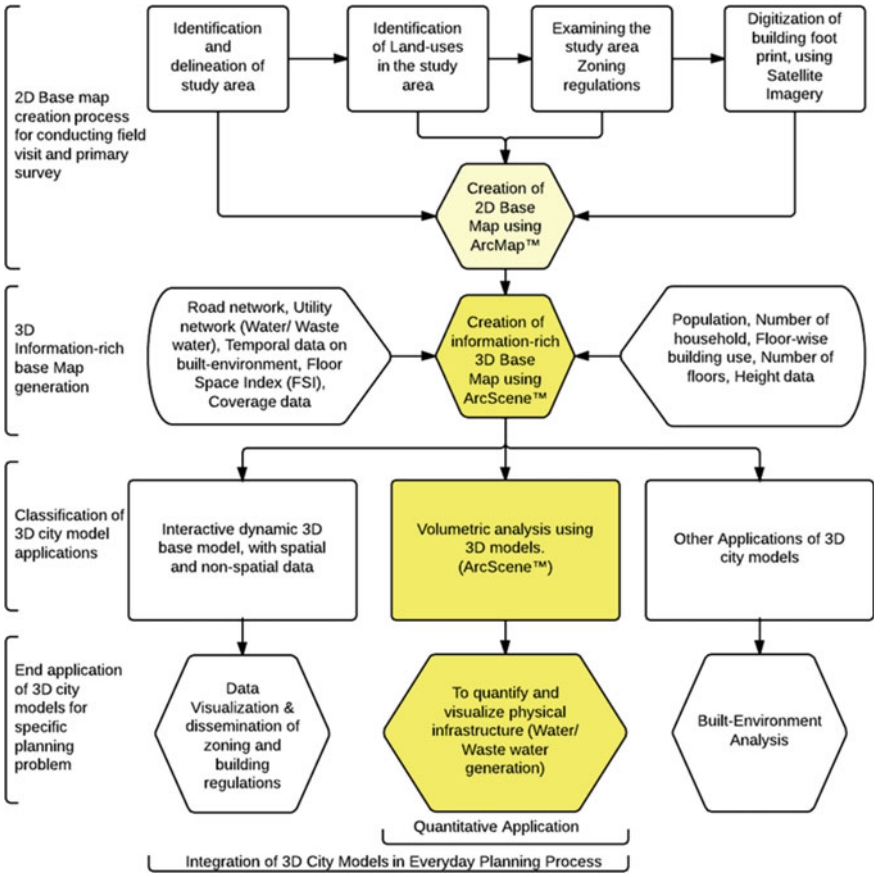

Fig. 7 Conceptual frameworks for creating 3D information-rich models and for performing the volumetric analysis

studied area. As indicated in Fig. 6, the total study area is 0.69 km^2, with 53% of plots being residential, 0.17% commercial, 18% mixed use, 8% institutional, and 2% parks and playgrounds [67]. Road and street networks take approximately 19% of the overall study area. The DDP for the Kannadasan Nagar region was prepared in 1980, and since then, there has been a substantial change in building activity and intensity throughout Chennai and inside the study area. An old aerial photograph (1980) of the research area was received from the Institute of Remote Sensing (IRS), Chennai, to measure the change in intensity of developments over three decades. The footprints of the study region in 1980 were digitized and confirmed using DDP supplied by CMDA for structures and land uses. For the current year (2013) status on the intensity of development, a primary survey was carried out using a digitized base map prepared using the current year Google Images.

Table 1 Floor-wise area statement of the study area, 2013

Floors	R-count	R-area (m^2)	C-count	C-area (m^2)	I-count	I-area (m^2)	Total count	Total area (m^2)
I	713	188,580	169	65,742	35	16,866	917	271,188
II	675	184,844	153	60,664	25	13,343	853	258,852
III	279	105,411	66	32,850	8	5847	353	144,107
IV	136	58,836	33	20,461	2	1613	171	80,910
V	36	18,962	22	14,705	1	1070	59	34,738
VI	11	6724	12	9565	0	0	23	16,288
VII	4	3648	4	4240	0	0	8	7888
VIII	3	3018	4	4240	0	0	7	7258
IX	3	3018	2	1974	0	0	5	4992
X	1	1360	0	0	0	0	1	1360
		574,401		214,440		38,740		827,580
		69%		26%		5%		

Source Primary survey by the author

7.2 Quantification of Development Intensity

In 1980, the study area's footprint was marked in yellow, blue, and red, with road networks, residential, commercial, and institutional building footprints indicated in yellow, blue, and red, respectively. The 1980 planned open space is also depicted in Fig. 8. Outside the research area, gray footprints have been noted. According to 1980 data, the total available land for development is around 0.55 km^2, with a building footprint size of approximately 0.13 km^2. There are 709 structures in the study area, with residential usage accounting for 80% of the footprint and commercial and institutional use accounting for 10% each. The study's net footprint coverage (excluding road and street networks, parks, and playgrounds) is around 24%, with a gross coverage of 19%. In other words, in 1980, approximately three-quarters (76%) of land was available as net open space, while around 81% was available as gross open space. In 1980, Fig. 8 depicts the total intensity of development in the study area, which includes residential, commercial, and institutional growth. With 709 buildings, the overall volume of the built environment is 911555 cubic meters, with residential activities shaping 71% of the intensity, 15% commercial, and 14% institutional. Figure 8 depicts the intensity of development in 1980 for specific uses such as residential development, commercial development, and institutional development.

A single-story building makes up 30% of the study area, while two-story buildings make up 26%, three-story buildings make up 32%, and four-story buildings make up 12%. Level I (ground floor) accounts for 57% of total activity volume, followed by 26% on level II (first floor), 14% on level III (second floor), and 3% on level IV (fourth floor). On the level I floors, residential activities account for 80% of the activity,

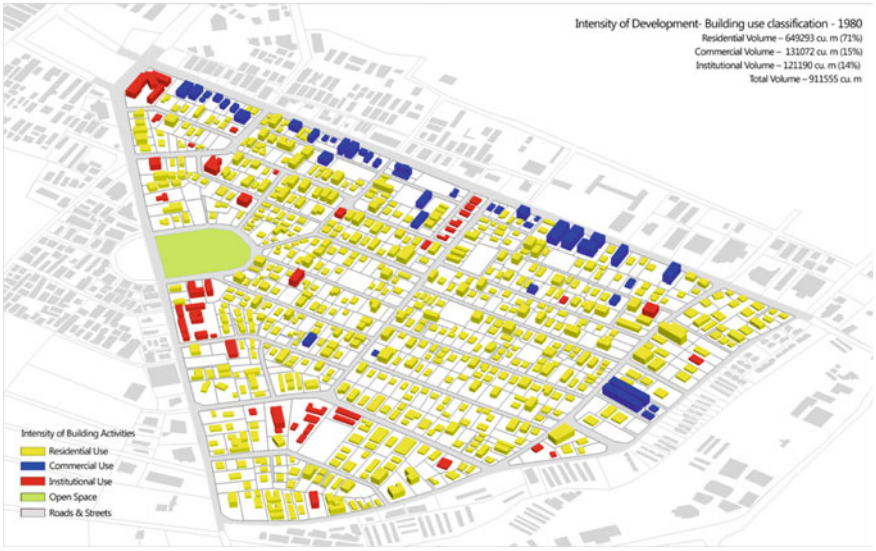

Fig. 8 The intensity of development—building use classification of the study area in 1980

with commercial and institutional activities accounting for 10% each. Residential activities account for 69% of activity on level II floors, followed by commercial activities (13%) and institutional activities (18%). In level III, residential activities account for 53%, commercial activities for 18%, and institutional activities for 29%. 90% of the activities in level IV are commercial and 10% are residential, Fig. 9.

7.3 Land Use and Functional Dynamism

All 675 plots in the research region are divided into three categories based on development regulations. (i) Plots on which conventional buildings may be constructed. (ii) Plots on which exceptional structures are permitted to be built. (iii) Plots where multi-story buildings are allowed to be built. The criteria for plot classification are listed in Table 2.

This is as per the rules outlined in the city of Chennai's second master plan [67]. The image depicts the classification of 1980 plots according to the development standards outlined in the Chennai master plan [67]. According to the classification, 75% of the total plots available in the study region in 1980 were acceptable for conventional building constructions, 23% for special buildings, and 2% for multi-story buildings, as shown in Fig. 10. Based on secondary information from IRS and CMDA, Fig. 10 depicts the real development that occurred in 1980. Except for a few buildings shown in red, which are not compatible with the proposed land uses, the bulk of the buildings is consistent with the proposed land uses. According to available

Fig. 9 The intensity of development—building use classification of the study area in 2013

data, 97% of structures built in 1980 fit into the categories of regular buildings, 1% special buildings, and 2% multi-story buildings, as illustrated in Fig. 10.

7.4 Volumetric Assessment and Built Form

An FSI audit was conducted based on the available data. The study area's net FSI, which excludes roads and street networks as well as parks and playgrounds, is around 0.42, with a gross FSI of 0.33. For the city of Chennai, the general FSI is 1.5 [67]. FSI is one of the most important planning instruments utilized in Chennai for current and future development planning and design, as well as the supply of related infrastructure services. The graphic depicts the FSI audit of the study area's buildings. Buildings are divided into three categories: those with an FSI of less than 1.5, those with an FSI of 1.5–1.75, and those with an FSI of more than 1.75.

Table 2 Criteria used for classification of plots

Classification of plots	Road width	Plot size
Ordinary buildings (G + 1 building)	Less than 9 m	Less than 200 m^2
Special buildings (G + 3/Stilt + 4 building)	9–12 m	200–1199 m^2
Multi-storied buildings (above G + 3/Stilt + 4 building)	12 m and above	1200 m^2 and above

Source [67]

Fig. 10 The actual intensity of development in 1980

8 Results and Discussion

8.1 Comparison of Developments Intensity Between 1980 and 2013

In 1980, the study region's overall net footprint coverage was nearly a quarter (24%) of the whole study area. In other words, as indicated in Fig. 11, about three-quarters of the land was available as net open space in 1980, and about 81% was available as gross open space. By 2013, a fifth of the study area had been added as built fabric over a three-decade period. The entire footprint coverage for 2013 is 50% of the total study area, and the intensity of development has doubled in terms of footprints throughout this period. The footprints of the 1980 and 2013 datasets are compared in Fig. 11. The footprints of buildings in 1980 are represented in yellow, and the footprints of buildings in 2013 are overlapped on the 1980 dataset and shown in red. It also shows that 26% of the study area is eaten away by the building fabric in a span of three decades.

8.2 Comparative Building Footprint Analysis

Between 1980 and 2013, there was a minor rise in the number of new buildings added to the study region, according to the volumetric intensity of development. In

Fig. 11 Footprint comparison 1980–2013

1980, there were 709 structures in the study area; in 2013, there were 917 buildings, a 28% increase. This increase in the number of buildings represents the addition of a new structure during a three-decade period. Buildings that are reconstructed on the same plots are not included. On the other hand, the study area's footprint has nearly doubled from 129418 m^2 to 271188 m^2, a 110% increase in footprint area since 1980. However, a staggering 263% increase in the amount of intensity is discovered. In 1980, the total volume of buildings was 911548 cu.m, and in 2013, it had increased by 263% to 3310320 cu.m, as shown in Fig. 12. According to the findings, the research area has experienced extraordinary vertical growth. This is also obvious from the literature, which shows that most Asian cities have expanded vertically rather than horizontally, with a similar pattern in Indian cities. Figure 12 depicts the 1980 building volume overlapping with the 2013 building volume, which is colored yellow and red, respectively.

8.3 Comparative of Volumetric Intensity on Development

The outcomes of a comparison of 1980 and 2013 activity studies suggest that residential activities have increased by 254%, while commercial activity has increased by a staggering 449%. The use of institutions has increased by 46%. The physical infrastructure requirements are greatly influenced by changes in activities or building usage. The 1980 activity analysis, such as residential, commercial, and institutional, overlapped with the 2013 dataset, as seen in Fig. 13. Between 1980 and 2013, an

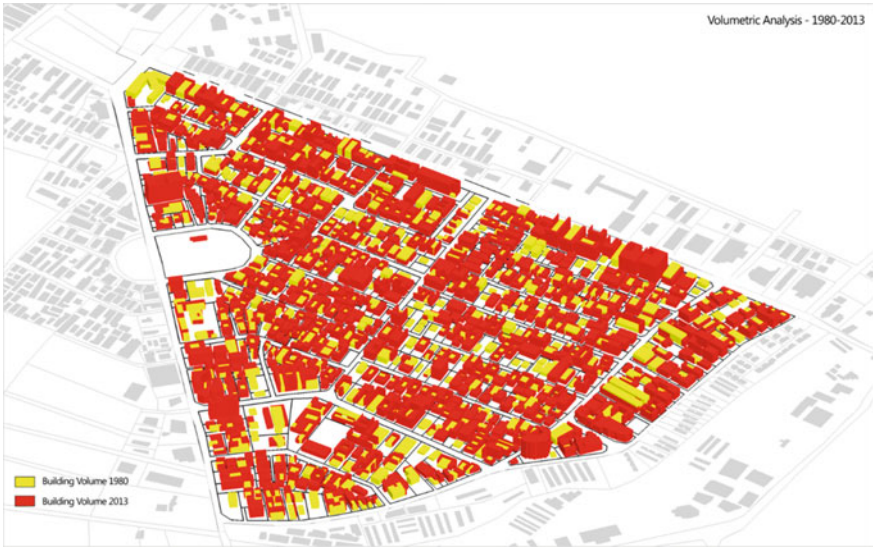

Fig. 12 Comparision of building volume 1980–2013

FSI audit was conducted, and the findings revealed that no new buildings with FSI 0-1.5 were built; however, there was a 716% increase in various buildings with FSI 1.5–2.5, and a remarkable 2400% increase in new buildings with FSI 2.5 and beyond. The findings suggest that there is a strong desire to create multi-story buildings in the research area.

Fig. 13 Comparision of residential activity 1980–2013

The findings also suggest that the FSI was around 0.42 (net FSI) and 0.33 (gross FSI) in 1980, and is now 1.52 (net FSI) and 1.20 (gross FSI) in 2013. Even though the intensity of development has increased dramatically, the FSI for the entire study region has just recently surpassed the commonly adopted FSI of 1.5 in Chennai City. As a result, the impact of increased development intensity on physical infrastructure services has been established. The infrastructure services supplied and the intensity of development are clearly out of sync. The results of the 3D volumetric analysis are critical in places like Chennai, where there is an insufficient and inefficient supply and demand of physical infrastructure services, particularly water supply and wastewater generation. Densification of urban centers occurs without first measuring the intended intensity of development concerning the infrastructure services available, resulting in unsustainable urban development. For example, according to the findings, the study area's overall FSI in 1980 was around 0.42, but it was 1.52 in 2013. FSI, on the other hand, has climbed by 266% in the last three decades, Fig. 14. Contrary to popular assumption, the overall FSI has slightly crossed its upper limitations of 1.5 FSI, although most of Chennai's planned areas have exceeded their FSI restrictions. The city becomes chaotic and deformed due to infrastructure failure that is not strengthened to match the increasing intensity of development. Furthermore, utilizing traditional tools and methodologies, proactive, dynamic quantification, and visualization in everyday planning and decision-making is almost difficult. Before making judgments about increasing the density of development or proposing new developments, urban planners must analyze the infrastructure services available. Based on the carrying capacity of the infrastructure services in place, such analyses will assist identify zones where the intensity of growth can be raised or restrained.

Fig. 14 Comparison of FSI 1980–2013

The findings of this study are restricted to an examination of key physical infrastructure factors including water supply and wastewater generation. Other physical and social infrastructure criteria must be incorporated in volumetric evaluations, in addition to the parameters listed above, for more informed decision-making.

9 Recommendation and Conclusion

Urban planners are beginning to think three dimensionally to address the ever-growing urban problems, particularly in dealing with the built environment, as 3D modeling tools and approaches become more popular. The possibility and need for incorporating 3D GIS as a planning support system for smart master plan are discussed in this chapter. This study's interactive, dynamic, information-rich 3D model demonstrates a novel technique for disseminating urban planning data for the benefit of both urban planners and the general public. Planners can use this 3D information-rich model to get up-to-date information on city development for better analysis, planning, and decision-making. Sharing 3D information-rich models in the public realm improves transparency in planning processes. One of the most significant benefits of having a 3D city model is the capacity to quantify the activities that occur in a specific location, not only in two dimensions but also in three dimensions. Planners can use volumetric data to quantify and assess activities in terms of volume against infrastructure services available.

This study also demonstrates the usage of 3D models to compare envisioned growth plans to present development trends. When there is an increase in built-environment intensity without a simultaneous enhancement of existing infrastructure services, certain zones within the study area critically overshoot the network's designed carrying capacity. The methodological framework created in this study demonstrates how 3D models can be used as a smart master plan tool in everyday urban planning operations. The main critical planning factors (physical infrastructure) that can be obtained using 3D city models have also been found in this study. Apart from zoning restrictions, all physical and social infrastructure elements must be analyzed holistically for informed planning and decision-making. 3D volumetric analysis is one such technology that can integrate all of these parameters into daily urban planning operations, allowing for improved analysis, planning, and decision-making. Furthermore, 3D volumetric assessments that are within the designed carrying capacity of the entire in situ infrastructure can be used to determine the study area's appropriate development intensity.

The process of 3D modeling and analysis is time-consuming. Integrating 3D models into urban planning processes necessitates substantial study into a variety of topics, including modeling approach simplification, data integration, and enhanced and simplified analytical techniques, among others. Furthermore, the 3D volumetric analysis used in this study is based on static 3D models created with ArcScene. The dynamic nature of the urban planning process necessitates dynamic 3D volumetric analyses. More study into 3D dynamic volumetric measurements is needed. Every

city has its plan-making process, and integrating 3D models and 3D volumetric evaluation methodologies must be done by industry standards. From data collection strategies to analysis and presentation, more study on customization in the integration of 3D models is required.

The research presented in the chapter has helped to broaden the applications of 3D city models in urban planning toward a smart master plan approach. Although 3D city models provide enhanced analytical capabilities, incorporating them into everyday planning processes requires additional research in terms of superior analytical capabilities and flexibility. There is an inevitable requirement of 3D tools for the assessment and monitoring of growth and development. Tools that are simple to use and freely available, and that integrate spatial and non-spatial data more thoroughly. Urban planners, city administrators, and policymakers will be able to plan more efficiently by incorporating 3D volumetric analyses into day-to-day affairs and planning processes to understand the threshold limits for growth and development.

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Faiz Ahmed Chundeli is a researcher and built-environment analyst, with a specialization in modeling and simulation of built-environment. After obtaining a Bachelor's degree in Architecture and a Master's degree in Planning, he went on to pursue M.S. (Research) degree at Polytech Tours, France. He holds a Ph.D. in simulation and modeling of built-environment for quantitative urban analysis. Dr. Faiz teaches at the School of Planning and Architecture, Vijayawada, India (An institute of national importance under the Ministry of Education, Government of India). He has authored several peer-reviewed research articles, book chapters, and presented papers at national and international conferences. Dr. Faiz is currently developing a high-resolution micro-scale meteorological simulation of the urban environment for measuring and modeling the wind environment, heat and carbon fluxes, daylight availability, heat island effect etc.

Adinarayanane Ramamurthy acquired Ph.D., a degree in Urban Studies and Planning from the School of Architecture and Planning, Anna University, Chennai. He holds Ph.D., in simulation and modeling of Energy Efficient Sustainable Development of Metropolitan cities for quantitative urban analysis through System Dynamics. He completed post-graduation in Urban and Rural Planning from the Indian Institute of Technology Roorkee (IITR), Uttarakhand State. He received his Bachelor's Degree in Civil Engineering from Annamalai University, Tamil Nadu State. He has experience of over 27 years in the academic, research, and professional field of Planning and Architecture. He has published a book authored over twenty peer-reviewed journal research papers and has presented in several international conferences. Dr. Adinarayanane is currently heading the Department of Planning and He is also holding the position of Dean (Planning and Development) at the School of Planning and Architecture Vijayawada (An institute of national importance under the Ministry of Education, Government of India).

Kozhikode

Spatial Planning of Kattangal Smart Global Economic Community

T. M. Vinod Kumar, Bimal Puthuvayi, and Riya Robi

1 Introduction

A master plan is a dynamic long-term document to guide the future growth and development of an area. It is multidisciplinary considering all the aspects that affect the quality of life of people and the interrelationships between them. It encompasses various disciplines of studies like social aspects, economics, environment, culture, etc. The master plan focuses on the rational use of land and resources to meet the present and future requirements of citizens and to develop control rules for sustainability. The 74th Constitutional Amendment Act of 1992, aiming at strengthening democracy at the grass-root level through local bodies, emphasizes social justice and economic development and responsibility for master planning and development control are given to local bodies.

Smart master planning concept integrates information and communication technology (ICT) and various physical devices connected to the IoT network to optimize the efficiency of operations and services in the planning area and connect to citizens. ICT and IoTs allow officials to interact directly with both community and city infrastructure and to monitor and help in decision-making through E-Democracy and E-Governance. An illustration of smart infrastructure is shown in Fig. 1.

In the world of growing computing power and increasing IT-based industry where everything is getting automated, our cities and towns should also be automated and work smartly.

This chapter looks at the traditional master planning process and finds opportunities to automate the processes as much as possible It would explore the concepts of smart master planning with ICTs and IoTs.

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T. M. Vinod Kumar (ed.), *Smart Master Planning for Cities*, Advances in 21st Century Human Settlements, https://doi.org/10.1007/978-981-19-2564-1_4

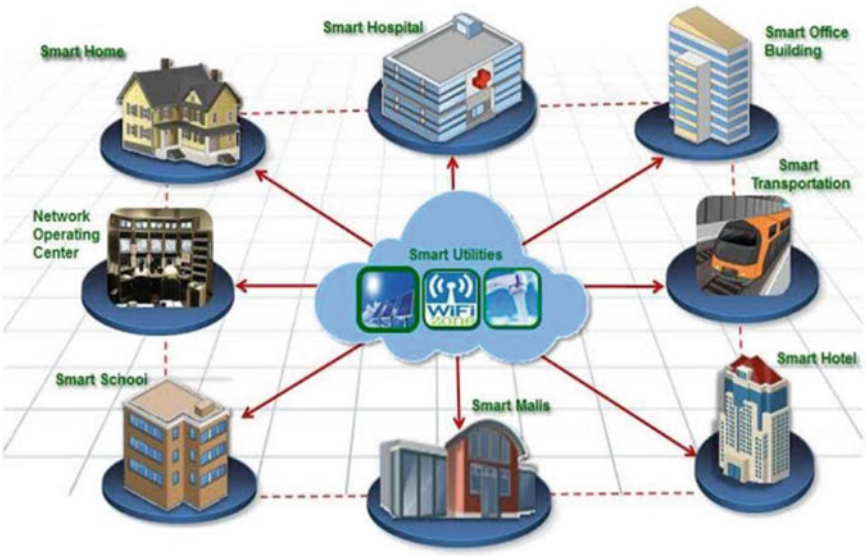


Fig. 1 Smart infrastructure planning. *Source* [1]

2 Kattangal as a Smart Global Economic Community

Kattangal is a small town in Kerala, which developed in the middle of rural settlement along with the development of the National Institute of Technology Calicut at its centre and taking energy from the rural–urban continuum of Kerala. The presence of a technological university and the high level of digital literacy of its population gives its intellectual capital, which is the most essential potential needed to be a smart global economic community. A master plan was proposed to develop the area into a Smart Global Economic community. This chapter attempts to relook the master plan process to utilize the ICT framework to automate the master planning process and also to make it dynamic.

The study area considered is Kattangal junction which comprises 14 square kilometres. Kattangal junction community is a part of the SGEC cluster of Chathamangalam, identified in a previous study [1]. Kattangal was recognized as a global economic community as a result of a survey and analysis conducted in 2018, which involved household survey, interview with ward members and aspiration survey of shop owners, employees and students from the National Institute of Technology Calicut. The given Fig. 2 shows the regional context and location of the study area (Fig. 2).

There exists immense scope for the Kattangal Global Economic Community to be developed as a Smart Global Economic Community. This chapter explores the potential and facilities required to actively participate in global market with an opportunity to transform Kattangal community into an SGEC being already identified and

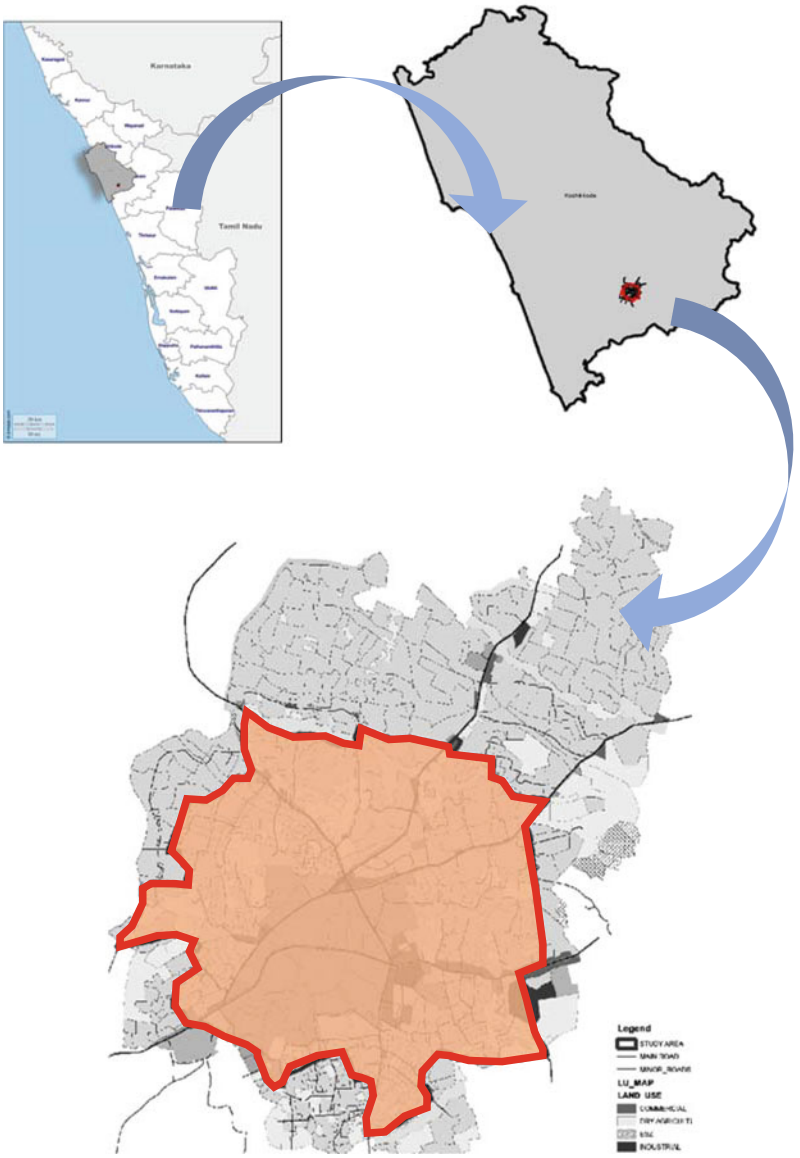


Fig. 2 Context and location of Kattangal, study area. *Source* [1]

existed. The aim is to provide smart planning strategies to make the community an industry producing knowledge-based products which can be traded in the global market competing with the industrial giants. The major investment will be intellectual capital and focus areas that involve education, research and development centres.

2.1 Smart Global Economic Strategy

The potential smart workforce of Kattangal is characterized by the willingness to work and remarkable academic abilities. The prime strategy used to develop Kattangal junction community into an SGEC involves the development of workforce based on the skill set available and providing ways for acquiring more skills, by exploring the existing organizational set-up.

The interest of existing working class could be used as potential skills and manpower needed for the proposed smart community. A survey conducted in 2018 reveals that, in Kattangal, 20% working people show willingness to work alternatively which can be attributed to the fact that 21% are marginal workers as shown in Fig. 3. Also, 45% are willing to switch to community-generated local employment. The workspace requirement at home and community level could be achieved by land pooling.

Figure 4 shows the percentage of households in Kattangal associated with different organizations. Kudumbasree is a poverty eradication and women empowerment programme implemented by the State Poverty Eradication Mission (SPEM) of the

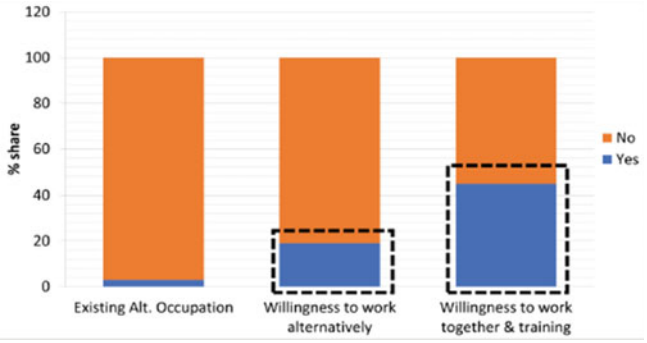


Fig. 3 Alternate occupation and willingness to word alternatively and get trained. *Source* [1]

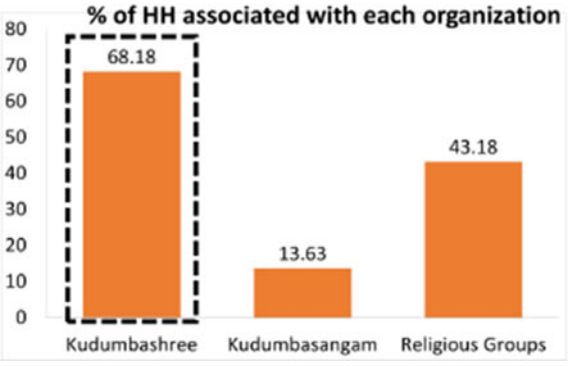


Fig. 4 Percentage of households associated with each organization. *Source* [1]

Government of Kerala which has active involvement from 68.18% of households. The membership with Kudumbashree can be extended to 100% and workspace sharing, training and cultural inclusion can be proposed through Kudumbashree. E-governance can be achieved through extensive use of smartphones, by developing smartphone applications by the community which would serve the community as well.

2.2 Analysis of Existing Land Use

The existing land use is dominated by residential and dry agriculture mixed use, comprising up to 65.89% of the total study area, followed by public use. The land use pattern of the study area and its surroundings is depicted in Fig. 6. The proportion of area under each land use category computed is shown in Fig. 5.

The percentage of land area under different land use categories is computed and given in Table 1.

A closer look at the temporal shift in the land use pattern, as depicted in Fig. 7 between 2004 and 2019 reveals drastic changes.

The number of individual residential plots without any other land uses is very low. The residential area is more covered with dry agriculture as coconut being the major crop in the region. The area covered by dry agriculture is high, and the spread of well-maintained agricultural land is lower as most of the land being turned into vacant lands. The low-lying lands are mainly covered with wet agriculture with paddy as

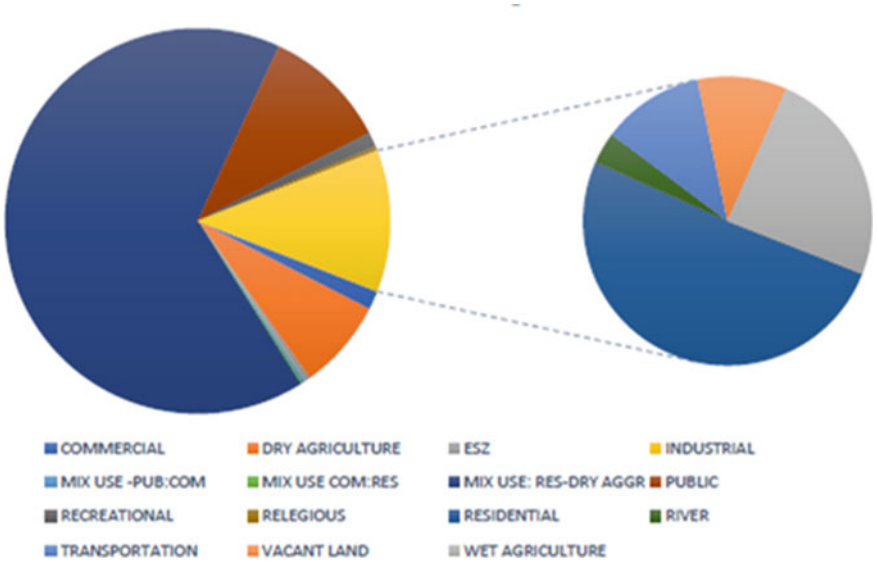


Fig. 5 Proportion of area under different land uses, Kattangal. *Source* [1]

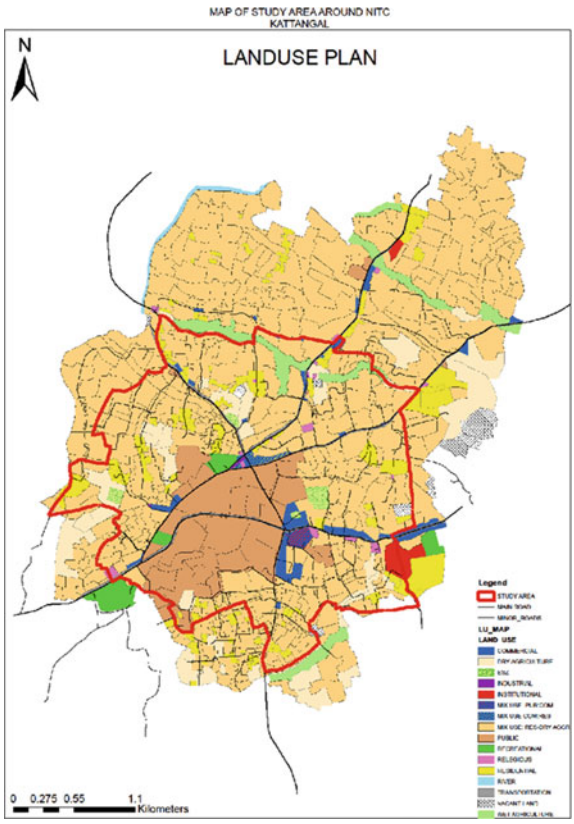


Fig. 6 Existing land use map of kattangal. *Source* [1]

the major crop. These wet agricultural lands are merging with dry agricultural land as water availability is becoming a major issue for maintaining the wet agricultural land.

The community is well served with a very well laid social infrastructure facility. It consists of several educational institutions, healthcare institutions, commercial developments, religious institutions and public amenities. The Panchayat office is also located at Kattangal is very well accessible from all the areas in the region. The major social infrastructure includes educational institutions such as NITC, NIELT, MES Raja College, MES School, DR School, Spring Valley School, Govt. School REC, etc. Religious institutions such as churches, mosques and temples are present in different places to serve the community within the area. Other public facilities include NIT Health centre, Panchayat office and public library.

Table 1 Percentage area under different land use categories. *Source* [1]

Land use	Area (%)
Commercial	1.60
Dry agriculture	7.58
Eco sensitive zone	0.46
Industrial	0.04
MX: public–commercial	0.24
MX: commercial–residential	0.16
MX: residential–dry agriculture	65.89
Public	10.53
Recreational	1.23
Religious	0.36
Residential	6.04
River	0.42
Transportation	1.36
Vacant land	1.19
Wet agriculture	2.89
14.13 m^2	100

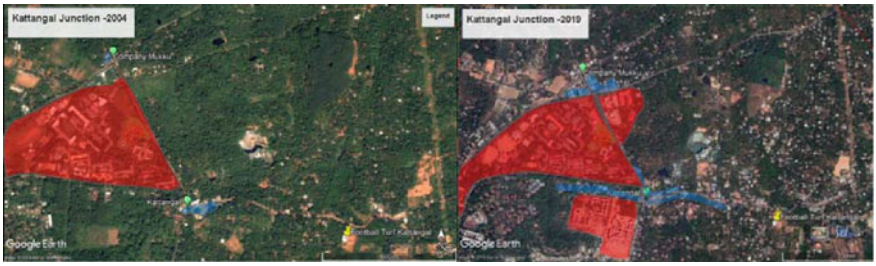


Fig. 7 Shift in land cover/land use from 2004 to 2019, Kattangal. *Source* [1]

2.3 SWOT Analysis

A careful observation and analysis of the study region has proven the availability of well-connected road infrastructure and availability of communication infrastructure as well, which will support the implementation of plans towards developing into SGEC. The concentrated development around nodes is also a strength. However, the study area lacks proper safety measures to improve walkability and availability of public open spaces. The absence of street lights was also observed. The opportunities in the study area include the available network for advanced technology, power grid line proximity, land availability for workspaces and open spaces, area availability for PV system installation and slope towards natural watersheds. The existence of many inaccessible land parcels, the presence of ecologically fragile areas. Poorly

maintained agricultural land and flood proneness in low-lying lands are the major threats to development, observed in the study area. Figure 8 shows the SWOT analysis in brief. A few photographs are also included to supplement the background study as given in Figs. 9 and 10.

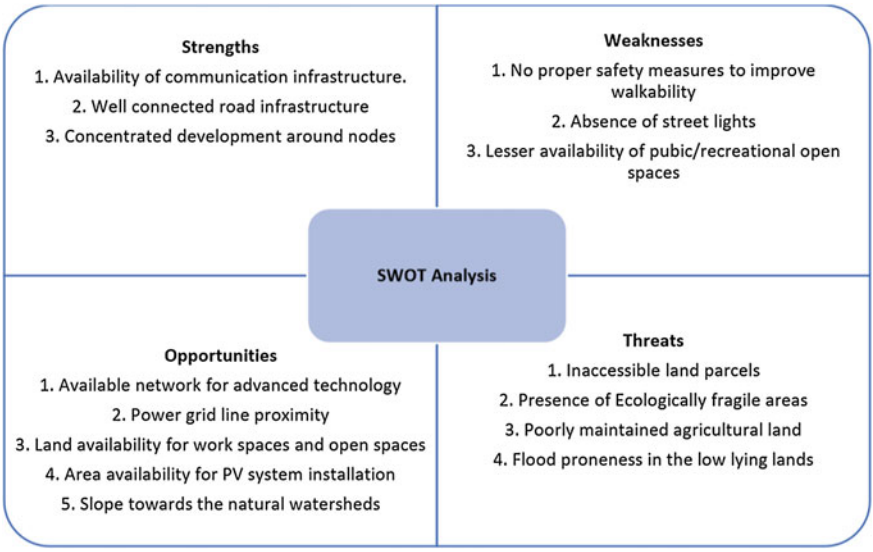


Fig. 8 SWOT analysis of the study area. *Source* [1]

Fig. 9 Captures from the study area—Kattangal

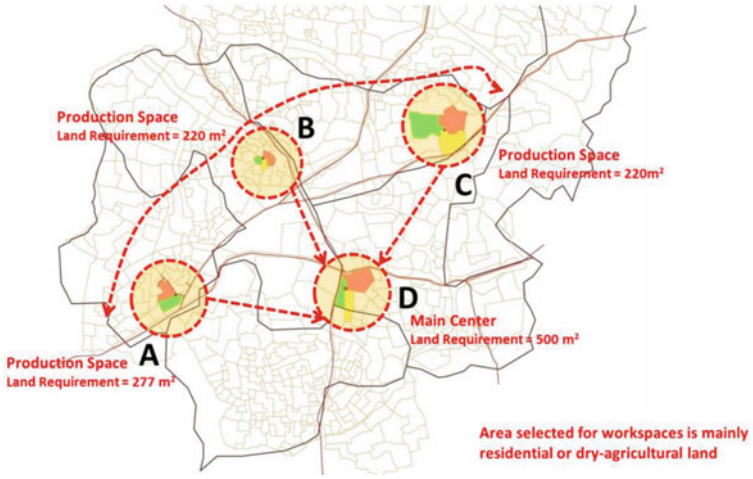


Fig. 10 Identified locations for workspaces and rooftop availability around. *Source* [1]

3 Zonal Plan Goals

Goals are proposed for each of the six elements and their corresponding interventions are grouped under M2M, IoT and spatial interventions (Fig. 11). This includes.

- **Smart Mobility**
- **Smart Economy**
- **Smart Living**
- **Smart Governance**
- **Smart Environment**
- **Smart People**.

3.1 Methodology for the Preparation of Zonal Plans

The preparation of zonal plan requires a thorough study of already prepared proposals for developing Kattangal SEGC. The proposals are then aligned with items listed in the 12th Schedule of the 74th Constitutional Amendment. New proposals are added to bridge the gap, incorporating machine-to-machine connections, integrating ICT/IOT and land management techniques. A web-based interactive GIS SGEC Zonal Plan for Kattangal is the end product made by employing e-governance and GIS-based plan consolidation (Fig. 12).

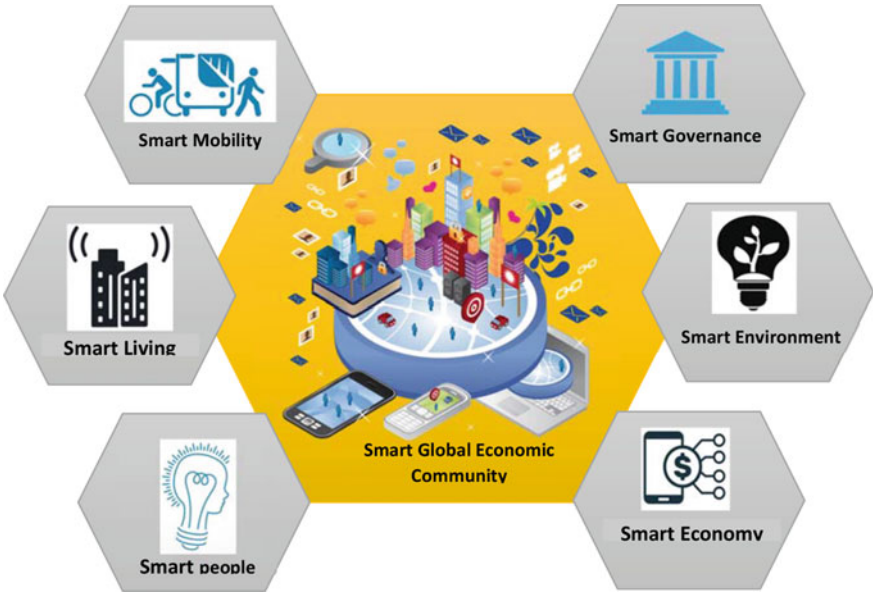


Fig. 11 Zonal plan goals for Kattangal SGEC

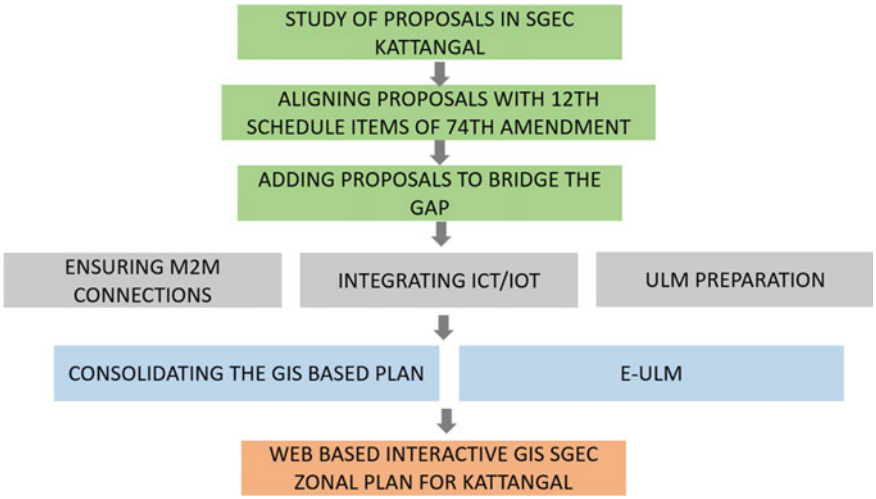


Fig. 12 Methodology for the preparation of Zonal Plan, Kattangal

3.2 Smart Zonal Plan-Strategies for Kattangal Sgec

- **Area-based development for a Smart Global Economic Community**: Area-based development for the area for a Smart Global Economic Community will revive the existing area for transaction of facilities or goods on a global market. Therefore, 18 items covered under the 12th Schedule of the Indian Constitution will be delved into and solutions will be proposed to improve their functioning thereby improving the liveability of the whole community.
- **Items of 12th schedule of Indian Constitutions**: Eighteen items are covered under the 12th Schedule of the Indian Constitution. The municipalities were established for the administration of the towns and smaller cities. There are many other names of the municipalities like municipal corporations/council, municipal committee, municipal board, city municipality and others.
- **M2M connectivity** refers to the interaction of two or more devices/machines that are connected to each other. In simple word, Kattangal zonal plan will contrivance the interaction between real-world objects using a simple access to a network. Items under the 12th schedule should be dealt with the provision of M2M connectivity.
- **Internet of Things or IoT** can be introduced in the Kattangal in a different way such as implementation and operation. Even though M2M or MtoM and the IoT are often confused, these two expressions do not represent exactly the same thing. Technologies such as sensor monitoring of sanitation and waste management, telematics and telemetry of urban amenities and facilities, remote monitoring of agro-forestry production and safety measures of the agro-products and so on.
- On the other hand, IoT is a system of devices with unique identifiers (known as UID) capable of transmitting information over a network. The basic difference between M2M and IoT is, IoT requires no human-to-human or human-to-machine interaction. While M2M enables device-to-device communication, the IoT allows multiple machines to design a connected data network.
- IoT-based existing platforms like SULEKHA can be utilized in the implementation of the zonal plan in Kattangal area.

3.3 SGEC: Goals and Objectives

The goals and the corresponding objectives to achieve the goal for accomplishing the smart zonal plan for Kattangal SGEC is as given below.

3.3.1 Smart Economy-for Global Market

GOAL 1: **To furnish the area as a Smart Global Economic Centre that can make transactions on a global market thereby catering to the requirements of local community**

- **Objective 1** – To create a knowledge-based economy—with a 3D printing manufacturing line.
- **Objective 2** – To make urban Farms/ local food shed using modern technologies.
- **Objective 3** – To boost the production of agriculture based and ayurvedic products.
- **Objective 4** – To generate a rental economy—with short-term renting of commercial spaces—such as stores, storage spaces, homes.

3.3.2 Smart Living-on a Global Level

GOAL 2: **To improve the quality of life of the people in the area, to equip them physically, mentally and socially to contribute to the advancement of the area into a Smart Global Economic Community**

- **Objective 1** – To provide ample open spaces and cultural avenues equipped with ICT/ Iot based facilities for the community to use.
- **Objective 2** – To ensure 24 x 7 monitoring of the spaces and thereby to ensure safety and security.
- **Objective 3** – To promote social inclusion of people from all communities.
- **Objective 4** – To provide groups and communities. Safe environment for communities to live in and also improve the healthcare systems to cater to individuals of all age group and communities.
- **Objective 5** – To alleviate the impacts of poverty-stricken areas.

3.3.3 Smart Environment-Global Standards

GOAL 3: **To protect the environmental quality of Kattangal for a sustainable development of the area**

- **Objective 1** – To ensure proper centralized water recharge, collection and distribution systems for the area to tackle water shortage.
- **Objective 2** – To introduce Iot based systems to check water shortage during summer season.
- **Objective 3** – To formulate measures to battle the water logging issues of the area.
- **Objective 4** – To improve the waste management system of the area.
- **Objective 5** – To employ sustainable use of the agricultural lands for the benefit of the agricultural agriculture-based community.

3.3.4 Smart Mobility-for Global Connectivity

GOAL 4: **To provide a secured and seamless connectivity for the Smart Global Economic Community that will provide an uninterrupted transactional activity of the resources and produces with the domestic and global market and to provide a secure environment for the users**

- **Objective 1** – To perform IoT Based Traffic Monitoring & Status Communication Systems.
- **Objective 2** – To form measures to ensure safety of pedestrians.
- **Objective 3** – To increase the connectivity of interior points.
- **Objective 4** – To encourage the use of low cost and green transportation.

IoT-based systems are incorporated into the transportation system of the area for smooth movement of goods to domestic and international markets.

3.3.5 Smart People-Globally Inclusive Community

GOAL 5: **To enhance the community as a whole and in an inclusive manner where people from all communities including people from the weaker community can also avail the smart facilities provided and can be exposed to a global market where their skills can be of great benefit to the same**

- **Objective 1** – To enable quick and easy access for people to different facilities provided through digital platforms.
- **Objective 2** – To induce cultural inclusivity through digital platforms and also cultural spaces.
- **Objective 3** – To avail aids and training facilities provided from different organizations for people from economically weaker sections of the community.
- **Objective 4** – To provide digital platforms for people to employ the facilities of education, training and employment in the Smart Global Economic Centre.

3.3.6 Smart Governance-for Guidance on Global Level

GOAL 6: **To frame a smart administrative system that will be more efficient, accessible, deliberative and consumes less time**

- **Objective 1** – To provide IoT/ICT Based solutions for day to day needs of the residents.
- **Objective 2** – To provide all civic services through cloud and internet-based technologies.
- **Objective 3** – To strive for paperless service mode in all official/governmental and commercial services.

- **Objective 4** – To create policies and regulations to ensure a cordial understanding between the transactors (domestic and global market).

4 Concepts

This section discusses the concepts that serve as the backbone for the proposals for achieving zonal plan goals.

4.1 Boosting Local Economies

In order to identify and mobilize the skilled workforce, the existing work participation trends of the population are analysed as given below. The economy is dominated by tertiary sector (91%) as shown in Fig. 14. The study area has 66% of non-working population as depicted in Fig. 15. The overall female work participation ratio is low as much as 7.37% (Figs. 16 and 17).

The share of marginal jobs is 21% as observed in Fig. 17. The employable non-working population is identified from the figures discussed. A survey was also carried out to check the willingness of home makers to work and get trained, which resulted

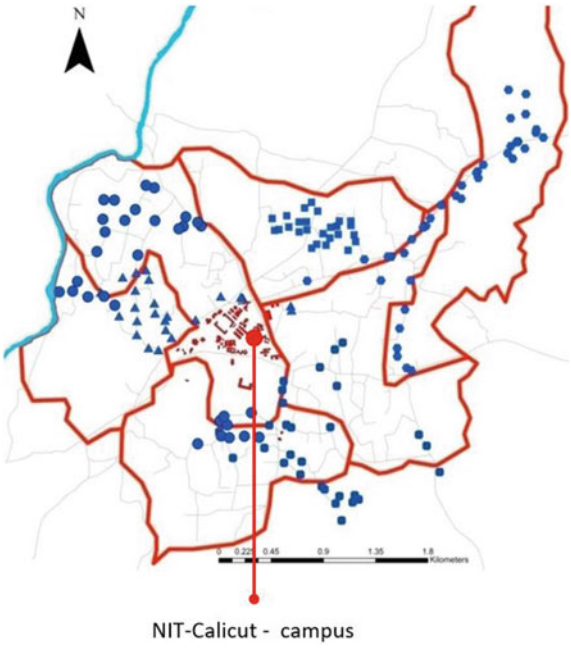


Fig. 13 Location of NITC in the study area. *Source* [1]

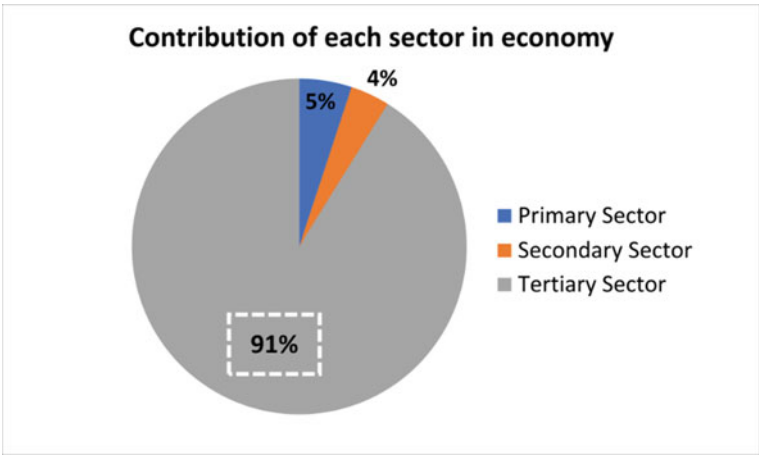


Fig. 14 Contribution of primary, secondary and tertiary sectors to the economy. *Source* [1]

Fig. 15 Percentage share of non-working population. *Source* [1]

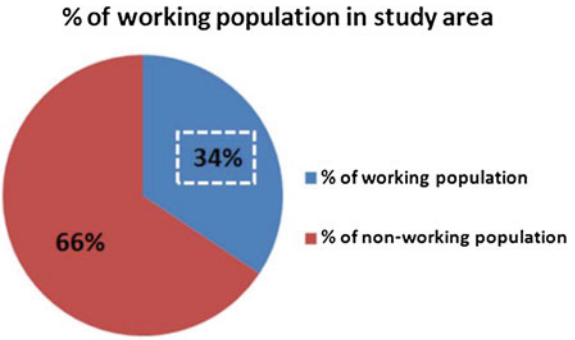
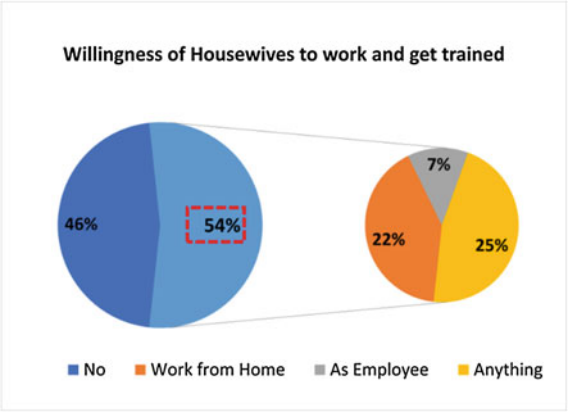


Fig. 16 Percentage share of homemakers to work and get trained. *Source* [1]



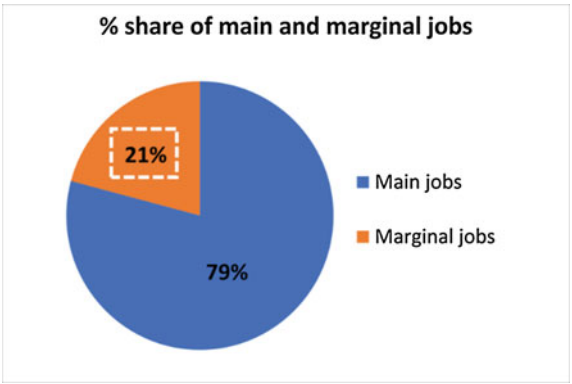


Fig. 17 Percentage share of marginal jobs. *Source* [1]

in a share of 54% giving positive responses. A further observation was also carried out on their choice on mode of work as shown in Fig. 16. Thus, the potential work force is generated. The proximity to NITC is also visible in Fig. 13

4.1.1 Working Population and Land Use

The distribution of working population based on gender and age group as depicted in Fig. 6 and Table 1 clearly shows that the female working population , especially in the young employable age group is low, which need to be addressed and also could be used as an opportunity to create a new work force base.

4.1.2 Strategy

In the industrial economy, place matters to companies because it gave them control over the means of production—,capital, labour and materials—,and access to transportation centres that minimized the cost of moving products from one location to another.

In the global information economy, however, power comes not from location per se but rather from the ability to command one of the intangible assets that make customers loyal. These assets are concepts, competence and connections. Today, a place has value if it can provide companies with at least one of these resources.

The Fig. 20 draws the components under different strategies for economic development which will be utilized ahead.

Concepts are leading-edge ideas, designs or formulations for products or services that create value for customers.

Competence is the ability to translate ideas into applications for customers, execute to the highest standards.

Connections are alliances among businesses to leverage core capabilities, create more value for customers or simply open doors and widen horizons [2].

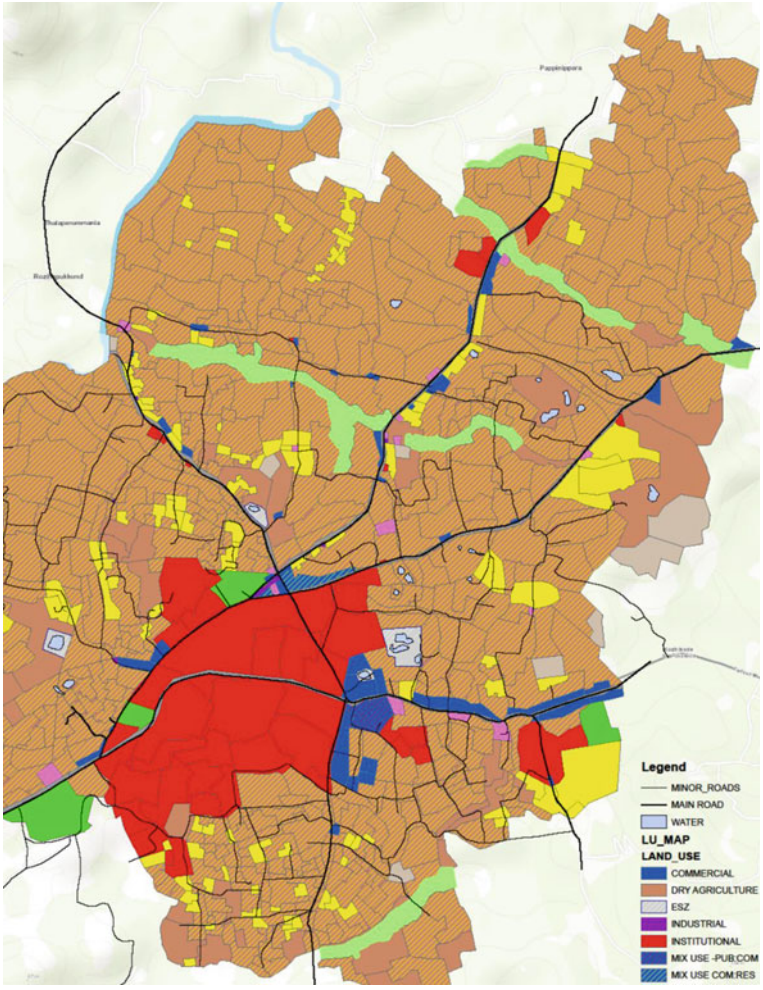


Fig. 18 Existing land use. *Source* [1]

4.1.3 Transportation and Logistics Cost

The total cost involves logistics cost, quality costs, procurement costs and inventory costs. The share of transportation in the total logistics cost is as high as 50.3% as shown in Fig. 21.

The proximity of Kattangal to airports is as depicted in Fig. 22 and Table 4. Calicut Airport is the nearest airport, whilst majority of trade and freight movement occurs through primarily Cochin Airport and then Kannur Airport.

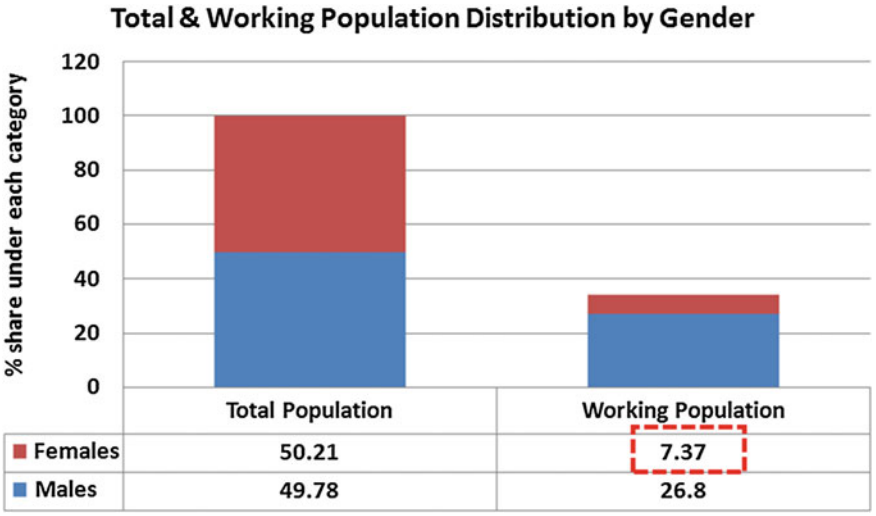


Fig. 19 Working population and gender. *Source* [1]

Table 2 Percentage share of area under different land use. *Source* [1]

Land use	Area (%)
Commercial	1.60
Dry Agriculture	7.58
Eco Sensitive Zone	0.46
Industrial	0.04
MX: Public - Commercial	0.24
MX: Commercial - Residential	0.16
MX: Residential – Dry Agriculture	65.89
Public	10.53
Recreational	1.23
Religious	0.36
Residential	6.04
River	0.42
Transportation	1.36
Vacant Land	1.19
Wet Agriculture	2.89
14.13 Sq.m.	100%

Table 3 Working population by age group. *Source* [1]

	Male (%)	Female (%)
Total population	49.78	50.21
Working population	26.8	7.37
Population in age group 23–49	56.5	57
Working population in age group 23–49	100	33

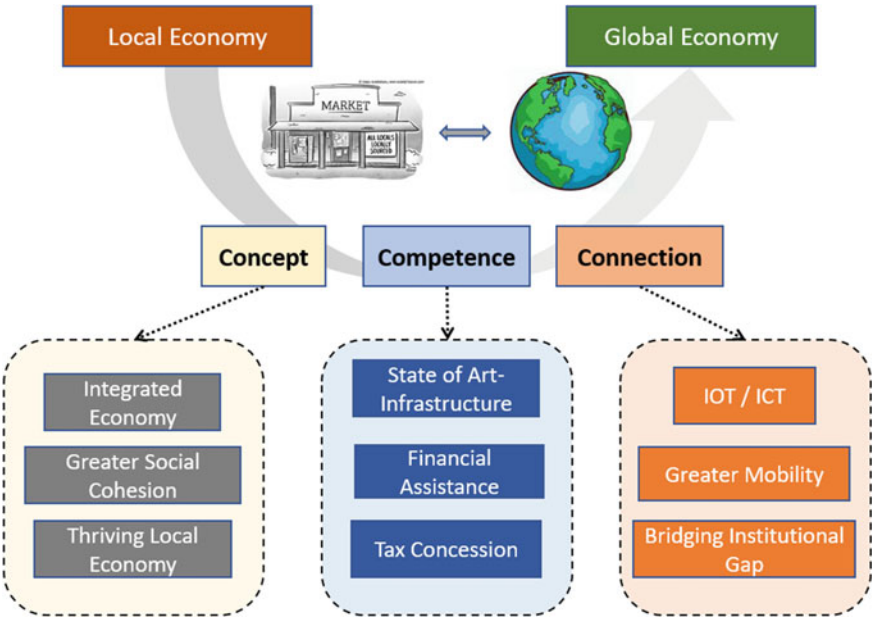


Fig. 20 Strategies for development.

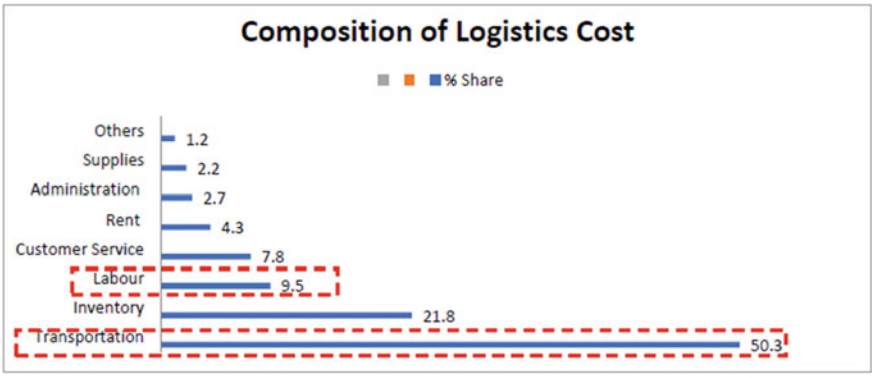


Fig. 21 Composition of logistics cost. *Source* [1]

Fig. 22 Proximity to airports. *Source* [1]

Table 4 Connectivity to airports. *Source* Author

Calicut airport	Via Anthiyurkunnu Road	1 h (29.3 km)
	Via Areekode Road	1 h 4 min (29.3 km)
	Via Edavannapara Road	1 h 2 min (31.3 km)
Cochin airport	Via NH 66	5 h 15 min (183 km)
	Via NH 544	5 h 7 min (177 km)
	Via Malappuram–Palakkad Road	5 h 24 min (192 km)
Kannur airport	Via NH 66	2 h 53 min (107 km)
	Via Koothuparambu–Chovva bypass	3 h 11 min (108 km)

Strategies for optimizing Logistics Cost

- Market Development:
  Addition of services to new countries, where each country act as a new market and establishing new online retail websites for the new country.
- Market Penetration:
  Generation of more revenue from the currently operating markets which will be possible due to lower costs and prices.
- Product Development:
  Diversifying the products offered.
  Investing as well as investing on R&D for rapid product development.

- Diversification:
  Growing E-commerce based on acquisition strategy.
- CRM strategy:
  Maintaining sophisticated communication that automates the process of creating value for the customer.

4.2 Economic Cost Development

The Fig. 23 gives a direction of economic cost development for a smart economy. A series of products are identified for the community development. The manufacturing processes of theses products are studied. The energy and workspace requirements are calculated simultaneously. The next step is the design of workspace and development of grid. A stable export market is created for the products using suitable marketing strategies. The entire process is ICT enabled and also due focus is given to the reduction of marginal cost by optimising land, energy, conveyance and labour costs.

4.2.1 Issues, Potentials and Strategies

The identified issues, potentials and strategies in boosting local economies is as listed in the Tables 5 and 6.

Strategy-Economic Development

In the first phase, during the design of supply chain, the final packaging of the product may be performed by those employed shopkeepers with spare time in the first phase

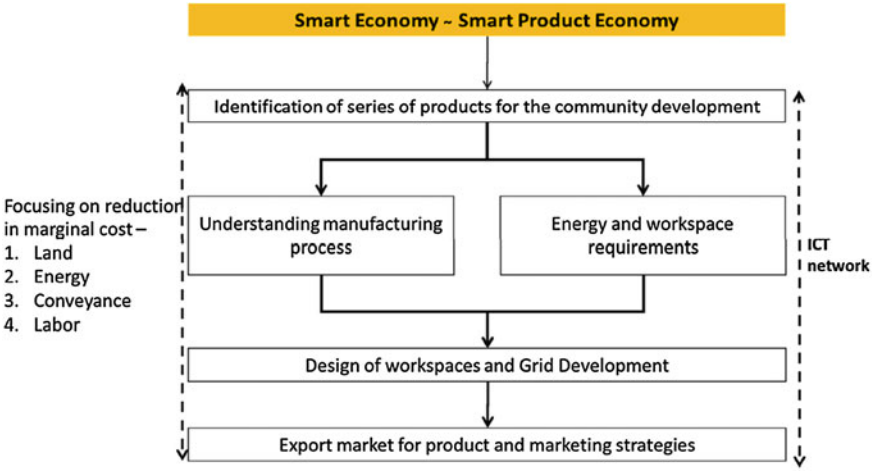


Fig. 23 Proposal for smart economy. *Source* [1]

Table 5 Issues, potentials and strategies for boosting local economy. *Source* [1]

	ISSUES	POTENTIALS	STRATEGIES
Demographic & Economic	1. 67%women in working age group are unemployed	2. 53% HH have housewives willing to work 3. 41%women in age group 23-49 are graduates or above	1. Development of product focusing on women employment and skills
	1. 21% of working population are marginal workers hence not employed throughout the year	2. Around 20% HH have people willing to work alternatively 3. 45% HH have people willing to share workspace and get trained	1. Mainstream job generation for marginal workers within the community
		1. 100% HH ownership	1. Land pooling for community level workspaces
Social Inclusion	1. 40% HH are not associated with any organization	2. 68% HH are associated with Kudumbashree & 62% incur benefits from it.	1. 100% HH Membership with Kudumbashree
		98% HH own smart phones & 96% use it for social connectivity, entertainment, etc.	1. Digital know-how of people to be used as potential for development of e-governance, smart phone apps
Facilities	1. 55% HH face water scarcity mostly in summer months 2. Only 33% HH have KWA/Panchayat water supply	3. 5% HH have RwH Systems incurring benefits	4. Community& HH level RwH systems 5. Decentralized percolation tanks to recharge groundwater
	1. 55%& 25%HH dump/burn plastic and kitchen waste respectively	2. 95% HH have septic tanks & 90% HH do not face flooding issues	3. Ensuring 100% plastic waste collection
		1. 67% HH are willing to install PV at subsidized rates	2. Installing community PV systems in a phased manner
	1. Lack of neighbourhood level recreational facilities		1. Movie theatres as community assets 2. Off season use of percolation tanks as recreational spaces 3. Decentralized parks, libraries, etc.

of execution to increase direct income. By the second phase, wherein the direct income of the population has seen an increment, the commercial establishments can focus on improvement of income through indirect economy. Thus, spatial planning must take into account the growth of commercial spaces in the projected phase. In the second phase, IOTS that facilitate smart shopping such as easy payment options such

Table 6 Issues, Potentials and Strategies in Strategic economic development. *Source* [1]

ISSUES	POTENTIALS	STRATEGIES
•74 % of those unwilling to participate in the smart economy earn less than 10 thousand rupees per month •70 % of those unwilling to participate in the smart economy are educated upto 10th standard	•71 % of those employed in the commercial establishments are willing to participate in the smart economy •The skillset of those employed in commercial establishments are primarily in marketing, handyman jobs and basic software	• Improve direst income by being part of the supply chain and then indirect income in the second phase • Spatial planning must take into account the growth of commercial spaces in the projected phase II • Smart inventory management • Local delivery app
	• 68% live within a distance of 1km and 83% live within a distance of 3km	Shops can utilize roof space for PV energy generation, to utilize for own requirement, or set up charge stands for transportation requirements
• Lack of parking • Lack of public toilets • Poor sidewalks		• Geofencing • Real time location of public vehicles • Establish form based coding
• Middling quality of transportation		

as cart POS, information kiosk that provide information on goods, discounts, etc., digital showcases can aid in increasing customer spending. Service site for customer service could also be employed. Smart inventory management will aid the smart community in sharing information across warehouse, production (manufacturing, assembly, packaging, etc.) and distribution centres in the supply chain.

4.2.2 Special Economic Zone—Concept

Indian SEZs are primarily set up with the objectives of attracting FDI, promoting export, generating employment and infusing new technologies. Indian SEZs can leverage the factor advantages, and also the comparative cost advantages, in various industry sectors to capture a share of these investments. Also, the rising cost of manufacturing and service operations in several Asian economies offers an opportunity for Indian SEZs to gain a share of the relocating investments. Domestic investment in export-oriented activities is also a distinct market opportunity for the SEZs. SEZ includes four interdependent operational and policy making components—industry product and process value chains to accommodate for the competitive markets, connecting technologies (information and logistics), resource management and knowledge creation and the global integration of the region in which the

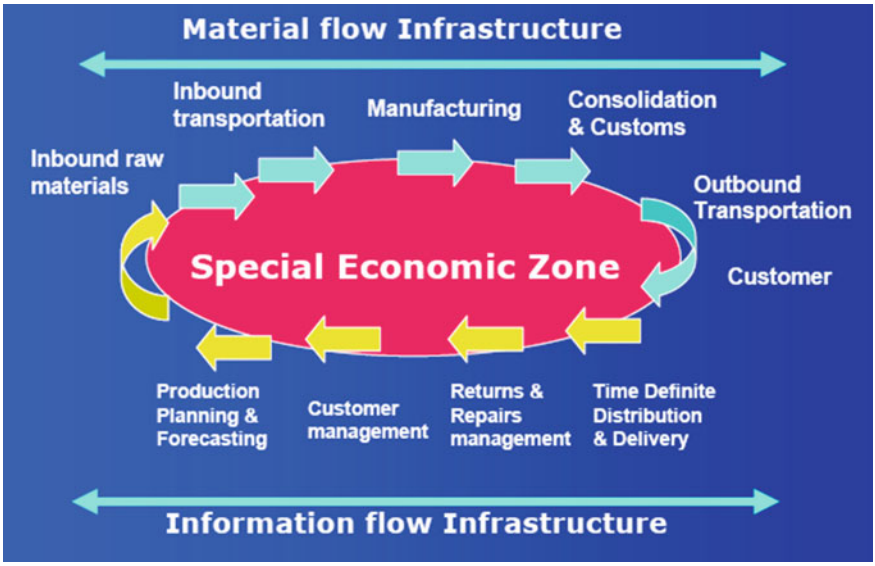


Fig. 24 Connecting Technologies in a SEZ [3]

SEZ is located in to economic world. One way in which the competitiveness of the SEZ and its performance can be improved is by identifying the various factors that could possibly influence the above stated four components of the SEZ as shown in Fig. 25 and espousing an integrated approach in fostering all of them. [3] As shown in Fig. 24, a good logistics and transportation infrastructure is the basis for a world-class logistics industry. Real-time information systems and decision-support tools are the key to improved supply chain productivity and efficiency [3].

4.2.3 Urban Enterprise Zone at Kattangal

Urban Enterprise Zone (UEZ) is an area in which policies to encourage economic growth and development are implemented. Their policies offer tax concession, infrastructure incentives, and reduced regulations to attract investments and private companies into the zones. UEZs are place where companies can locate free of certain local, state, and federal taxes and restrictions. They are intended to encourage development in blighted sites through tax and regulatory relief to entrepreneurs and investors who launch businesses in the area. UEZ provide necessary and attractive state of art infrastructure to the businesses registered. UEZ could also contain recreational and leisure infrastructure sidelined parallelly to business infrastructure facilities in the region.

Urban Enterprise zones under the Special Economic Zonal Act are framed apt for regions inhabiting a small area of less than 50 * hectares. But with infrastructure facilities promoting exports and resource management support at local markets, this idea could be projected towards global market within these minute accolades.

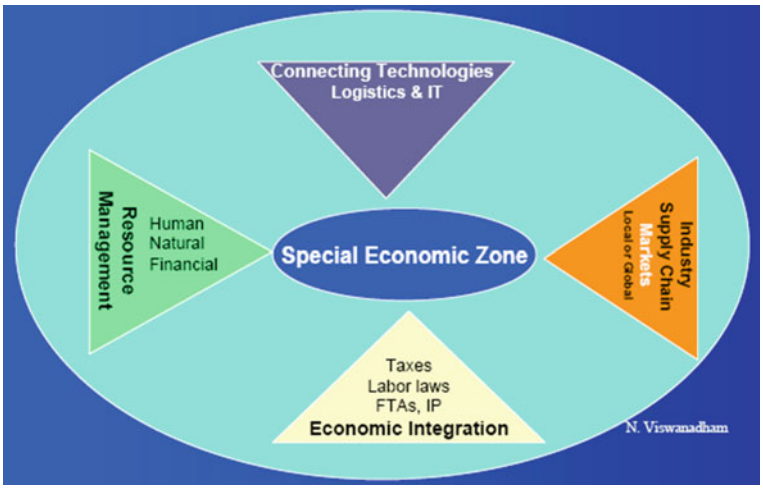


Fig. 25 Design Components of SEZs [3]

Kattangal could be made into an Urban Enterprise zone in that regard under the class were factors relating to the availability and quality of the resources: natural resources such as raw materials, water, industrial inputs such as power, human resources and their productivity, management skills for global sourcing, global marketing and global human resource management and availability financial inputs such as venture capital firms and so on The objectives of creating a UEZ in Kattangal for ultimately boosting the local economy is as shown in (Fig. 26).

Fig. 26 Objectives of urban enterprise zone in Kattangal. *Source* Author

4.3 Kattangal SGEC: Population Projection

Kattangal area is very rural in characteristics, but with more dense population. The development and the urban character as much it shows are because of the presence of the National Institute of Technology in its precinct. Chathamangalam Gramapanchayath is the village administration and this village is a major educational hub in Kerala.

The six wards included in the study area are the following:

1. Kattangal,
2. Poolakode,
3. Chenoth,
4. Pullavoor,
5. Malayamma and
6. East Malayamma.

Chathamangalam Grampanchayath has a population of 48,790 according to Census 2011. Density of the population is 1219.7. Population data for 1991 and 2001 is taken from the District Urbanization Report Kozhikode (TNCP). The population projection details is as given in (Fig. 27 and Table 7).

Kattangal SGEC is having a area of 14 sq km and the total Projected Population of Study Area in 2031 will be **20846**. The time frame for a zonal plan of Smart Global economic Community is 3–7 years and it should be reviewed every 3 years (URDPFI guideline). Census data is available till 2011. Population for 2021 and 2031 is projected. The time frame for Kattangal SGEC is till 2031. All the proposals are made to meet the requirement of this projected population.

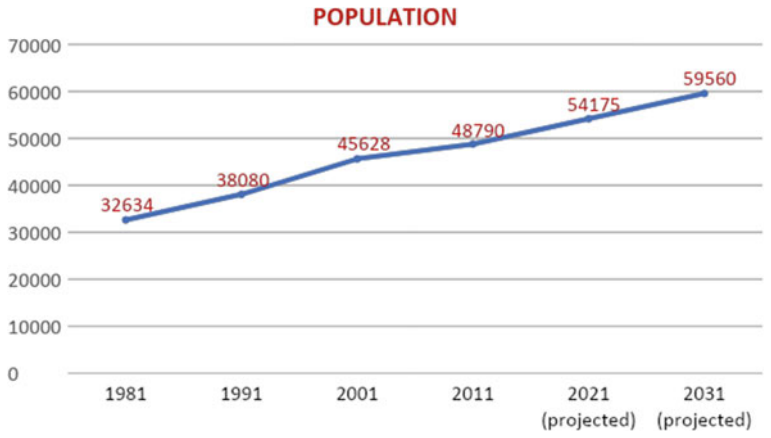


Fig. 27 Population projection of Chathamangalam Panchayat. *Source* [1]

Table 7 Population projection of Chathamangalam Panchayat. *Source* [1]

Year	Population	Area (Km^2)	Density	Increment
1981	32,634	40	815	
1991	38,080	40	952	5446
2001	45,628	40	1140.7	7548
2011	48,790	40	1219.75	3162
2021 (projected)	54,175	40	1354.37	5385
2031 (projected)	59,560	40	1489	5385

Fig. 28 SWOT of socio-economic development. *Source* [1]

5 Proposals

5.1 SWOT Analysis of Socio-Economic Development

The SWOT Analysis for the Socio-Economic Development of Kattangal SGEC is as shown in Fig. 28.

5.2 Smart Economy

Smart economy refers to the sustainable, innovative, technologically advanced, and attractive ways of investment and henceforth boosting up the economy of a community. The local economic development of the people is facilitated through the

Fig. 29 Line of business generated in smart economy [1]

community members only. Adequate training and skills are imparted to people to increase their production, managerial, entrepreneurial capabilities [4]. Based on the SWOT analysis conducted the following proposals are put forward to create a smart economy:

- Knowledge-based economy—3D printing manufacturing line
- Urban farming
- Agri-based product manufacturing
- Shared economy/short term renting.

5.2.1 Knowledge-Based Economy—3D Printing Manufacturing Line

3D printing enables additive manufacturing. It allows sharing of digital design files. The product selection will be based on market demand and profit per product. 3D printers are differentiated based on market demand and profit per product. The selection of 3D printing process and company will be based on costs, products and complexity achieved.

Line of Business Generated

The line of business generated through 3D printing manufacturing line is shown in Fig. 29.

Proposed products

The products proposed for the community are mainly high-value products like IoT based devices, circuit boards, electronic items, etc. These products are financially viable and have a wide-open market in India and globally. With the advent of Smart-cities, these are the most advisable products having a manufacturing cost less than the market price in the community. [1] A representative image for the proposed products is shown in Fig. 30.

Fig. 30 Proposed products for smart economy [1]

Location Criteria

In order to allocate spaces for the manufacturing line, certain criteria were followed as depicted in Fig. 31. The main factors taken into account was the availability of open spaces, accessibility by women as the identified workforce mainly constitute of unemployed women. The total land required for production spaces and workspaces was decentralized into four strategic locations based on accessibility to the main road, walkability from nearby households, and rooftop availability for PV cells [1] (See Fig. 10). The total built-up requirement was added with open spaces around to allow for a sustainable working environment.

5.2.2 Urban Farms

The mission is to 'To create a circular, self-sufficient community with sustainable and accessible greenspace within the city, that brings fresh farm produce to the city neighborhoods, supporting the local economy and fostering environmental resilience'.

Land Suitability Analysis for Urban Farms

The Table 7 and Fig. 32 shows areas under different land use category in Kattangal SGEC to check the land suitability for urban farms. In addition, the maximum permissible coverage is 65 for residential areas. High ground coverage may affect land supply for farms in future.

High Ground coverage may affect land supply for farms in future (Table 8).

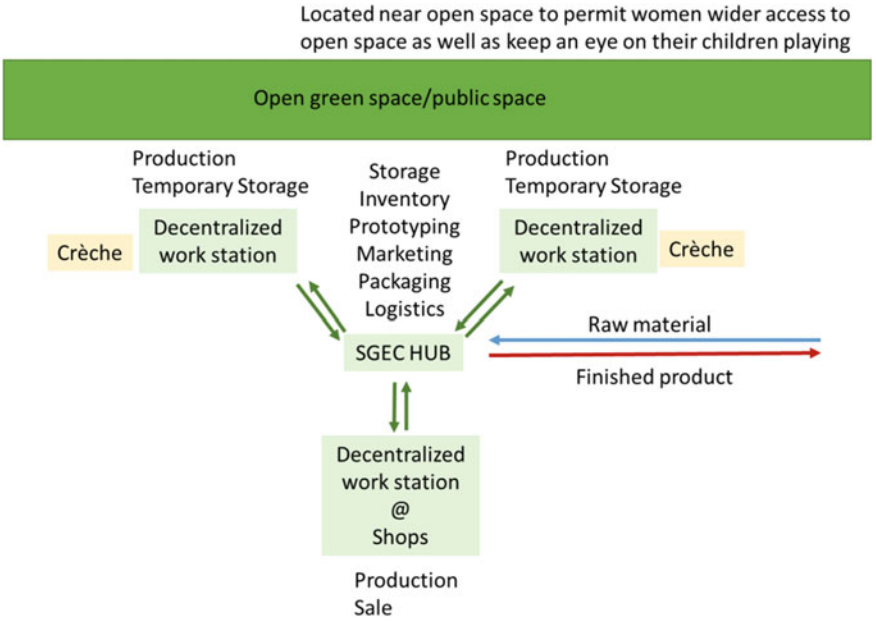


Fig. 31 Location of work stations for better accessibility to women and workflow of production. [1]

Development Rules and Strategies

Strategies to provide greenery and communal spaces and maintain the land availability for urban farming and encourage vertical expansion:

- Reduction in ground coverage.
- Providing overall green area limit.
- Horizontal surface area of the softscape,

An example is permanent planting beds.

These are permanent, sunken planting areas which shall be designed with sufficient soil depth to accommodate a variety of plant types. A minimum soil depth of 1000 mm shall be provided for trees and palms, 500 mm for shrubs and climbers and 300 mm for ground covers. As an alternative, building owners can provide well-landscaped, raised planting beds at maximum 300 mm high, planted with trees or shrubs.

- Horizontal surface area of the hardscape,

An example is communal facilities, urban farm.

Vertical surface area of green walls and extensive green roofs as either softscape or hardscape requirements could be provided (Table 9).

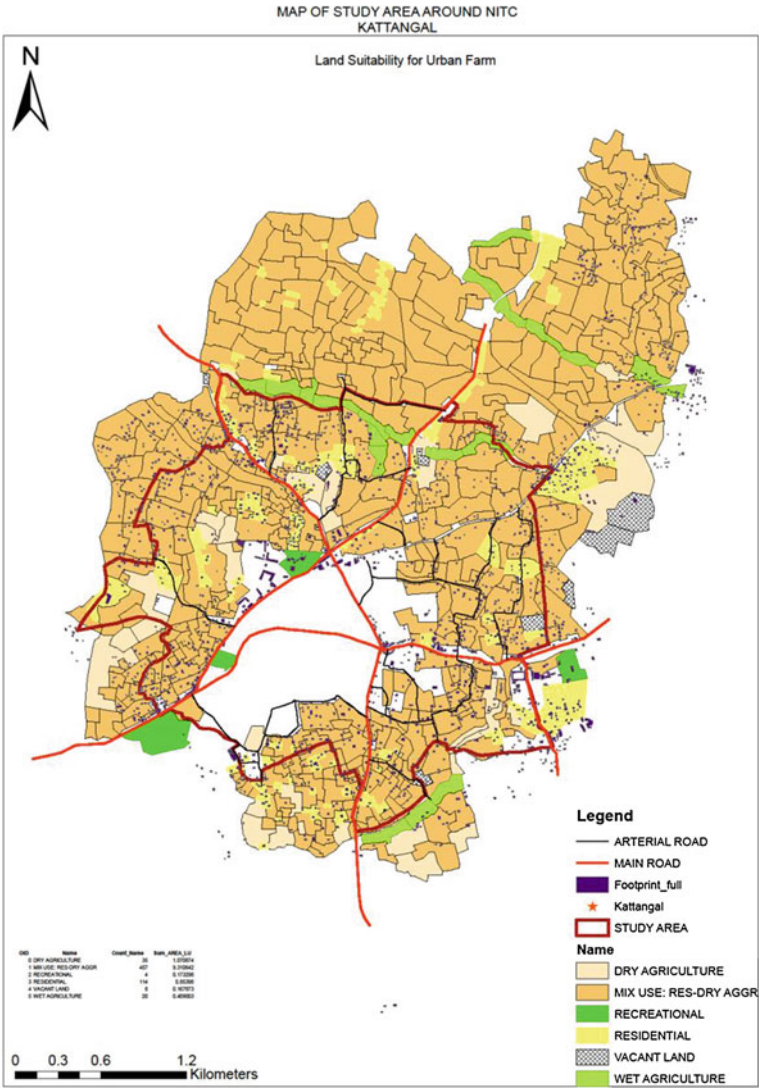


Fig. 32 Land use map-suitability analysis for urban farms

Proposed Classification

The classification of urban farms is carried out based on the land use analysis and ownership of land. The classification is depicted in Table 10 and Figs. 33, 34 and 35.

Table 8 Areas under existing land use

Existing land use category	Area (Km^2)	Area%
• Dry agriculture	1.070874	8
• Mix us: res-dry agriculture	9.310642	66
• Recreational	0.173298	1
• Residential	0.85398	6
• Vacant land	0.167873	1
• Wet agriculture	0.409003	3

Table 9 Area requirement for the proposed facilities. *Source* Author

Existing FSI	Proposed Ground Coverage	Overall Greenery Provision (as % of site area)	Minimum softscape requirement (as a % of site area)
4	40%	70%	40%
<4	40%	50%	40%
Example:			
FSI=	4		
	acres	Sq ft	
Site Area=	0.25	10890	
	Ground coverage	4356	
	Remaining Area	6534	
	Total Built up	43560	
	No. of floors	10	
	Overall Greenery Provision	7623	
	Softscape	4356	
	Hardscape	3267	

Table 10 Classification of urban farms. *Source* Author

Existing land use	Farm category	Area (Km^2)	Area%	Farm type
Mix us: res–dry Agriculture, wet agriculture	Commercial–private	9.719645	69%	Commercial large scale (plots area $\geq$ 15 cents) private garden
Recreational, vacant land	Public	0.341171	2%	Community garden/public landscape
Dry agriculture	Commercial	1.070874	8%	Commercial large scale (plots area $\geq$ 15 cents)
Residential	Personal–private	0.85398	6%	Private garden Personal use: restaurant/home
	Total	11.98567	85%	

Supply chain

The products of the urban farms could be sold in the local market or business which can form the supply chain as depicted in Fig. 38.

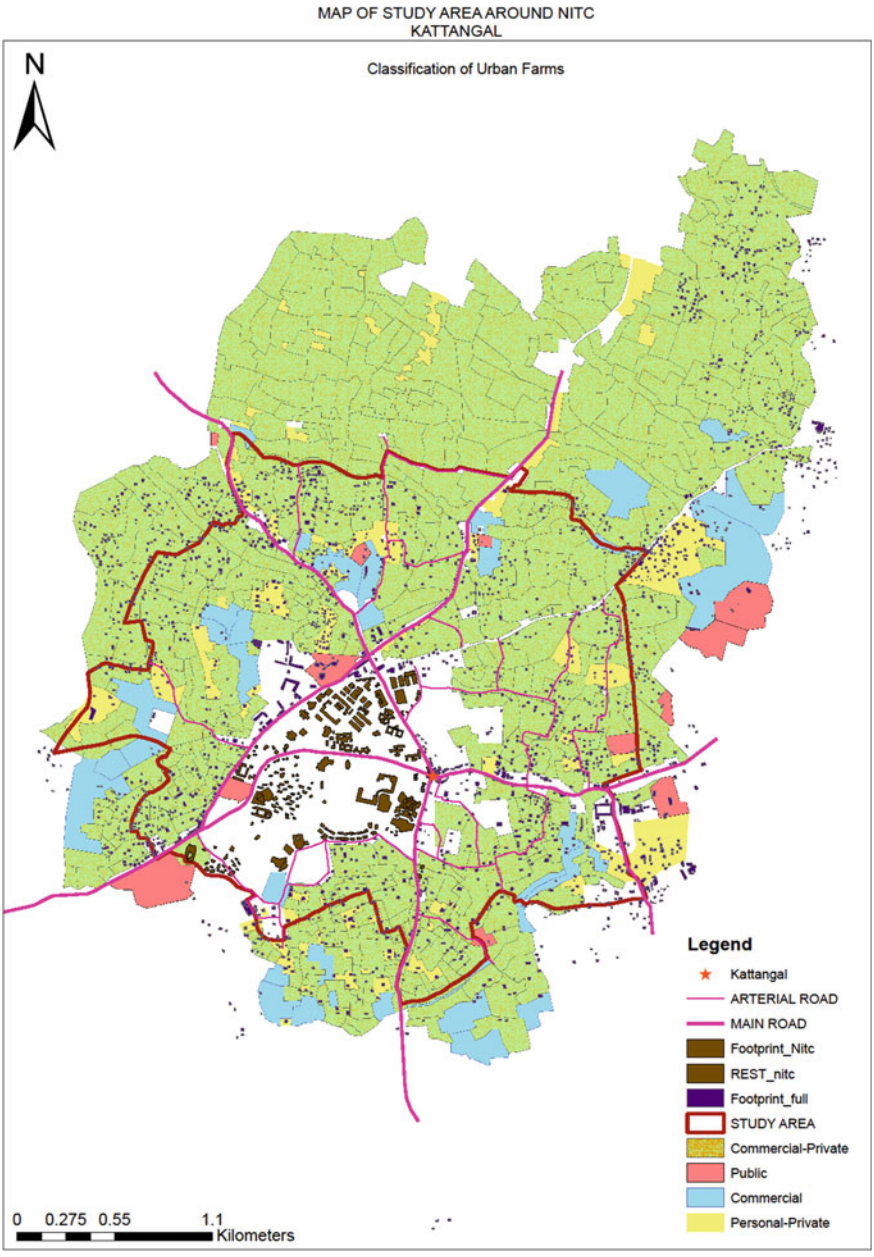


Fig. 33 Map showing classification of urban farms [1]

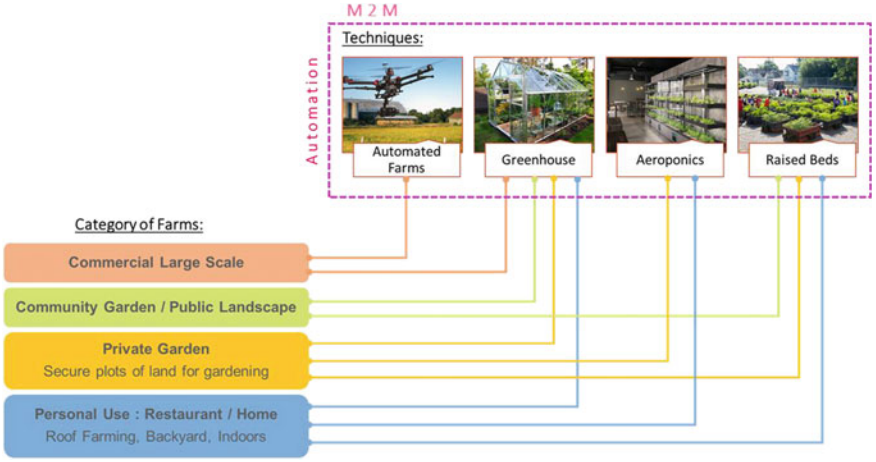


Fig. 34 M2M Techniques on Urban Farms. *Source* [1]

The Figs. 36 and 37 shows an example of how the products are distributed to the nearby vendors or markets.

Smart Farm Management—M2M Framework

Agriculture M2M is a term used to describe how vehicles, irrigation systems and weather stations are connected with each other via mobile telecommunications services and core software, allowing for analysis and for delivery of instructions [5]. This is part of the 'Internet of Things' (IoT) trend where devices can be accessed and controlled over a network (such as the Internet), allowing homeowners to manage their homes remotely. The Fig. 38 gives a representation of smart urban farms.

Future farms make use of a wide range of technologies including IoT sensors, wearables, GPS services, UAVs, robots and drones operating in the field which provide real-time data to systems helping to monitor the production line and support decisions as shown in Fig. 39.

Figure 40 illustrates the envisioned, m2m framework for smart farm management. It involves four stages:

i. **Data Input**: 'Connected things' include various farm equipment and farm sensors. These sensors and devices collect data and transmit to the cloud, where it is stored and undergoes further processing. Other ancillary data, like the weather data from the cloud, market analytics or benchmarks from institutions, are also uploaded to the cloud.
ii. **IoT Gateway**: It helps in transmitting the real-time data from the sensors and devices to the IoT platform.

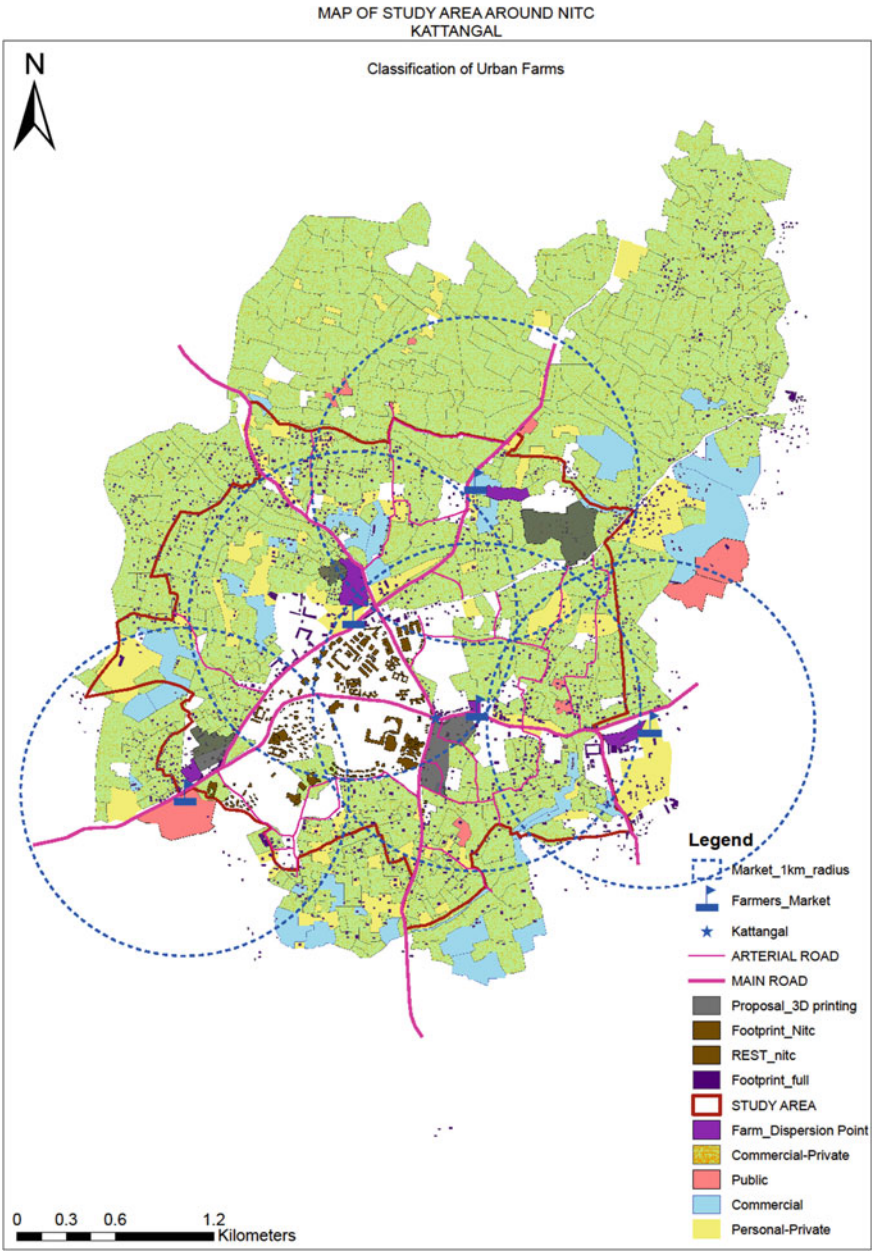


Fig. 35 Classification of urban farms [1]

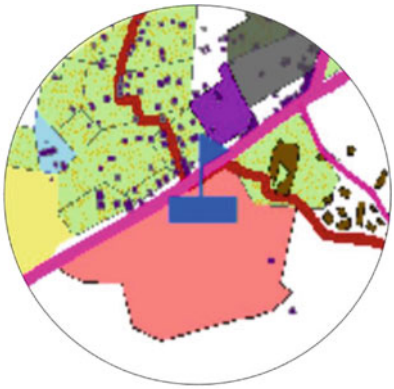


Fig. 36 An example for distribution points for farm products. (*Source* Author)

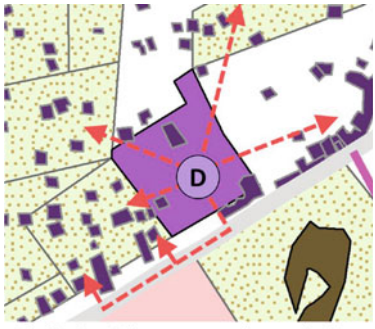


Fig. 37 Supply chain for farm products

iii. **IoT Platform**: The collected data is stored in the cloud. The stored information is integrated, managed into different datasets and layers and finally processed using various algorithms, machine learning and AI techniques.

iv. Output: The output after processing the data is integrated and deployed in the form of maps, predictive analytics and dashboards for the end-users through different interfaces. The interfaces include web portals, smartphone applications and SMS alerts. These applications even enable the end-users to remotely manage the farms from anywhere in the world.

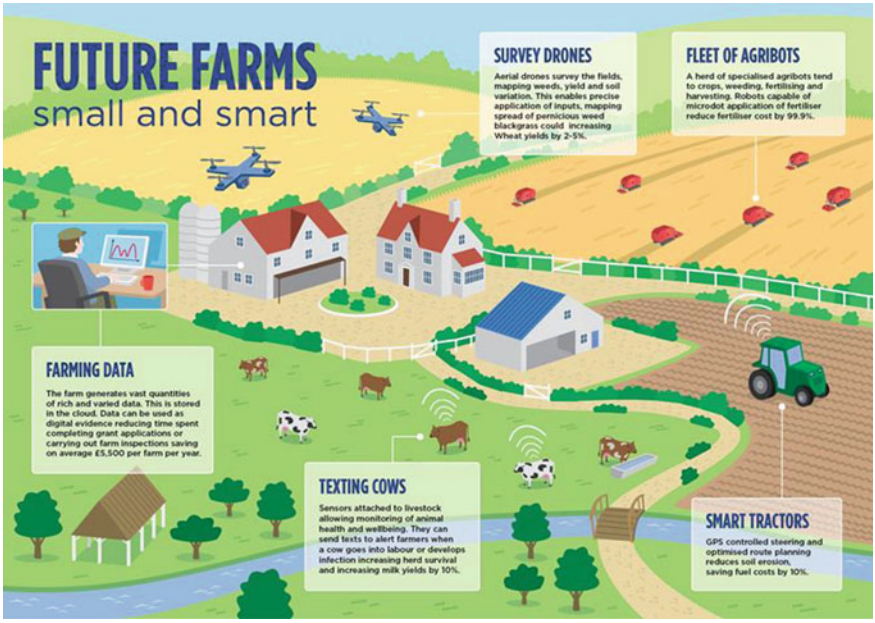


Fig. 38 A representation of smart urban farms. *Source* [6]

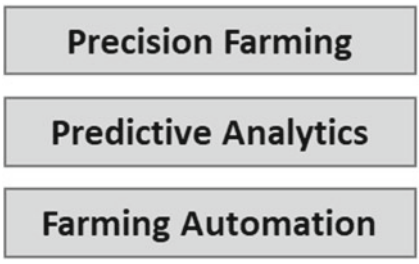


Fig. 39 M2M-enabled farm services

Smart Supply Chain—M2M framework

Proposal: Figs. 36 and 37 illustrates the proposed supply chain. The local produce can directly reach the consumers through farmers' markets, which is the shortest supply chain. It also can be supplied to online customers, businesses like restaurants, caterers or supermarkets in and around the town, which becomes part of the local extended supply chain.

M2M: Fig. 41 below illustrates the envisioned M2M framework for the smart supply chain management involving the local extended supply chain. The stages include:

i. **Farm management:** as illustrated in Fig. 40.

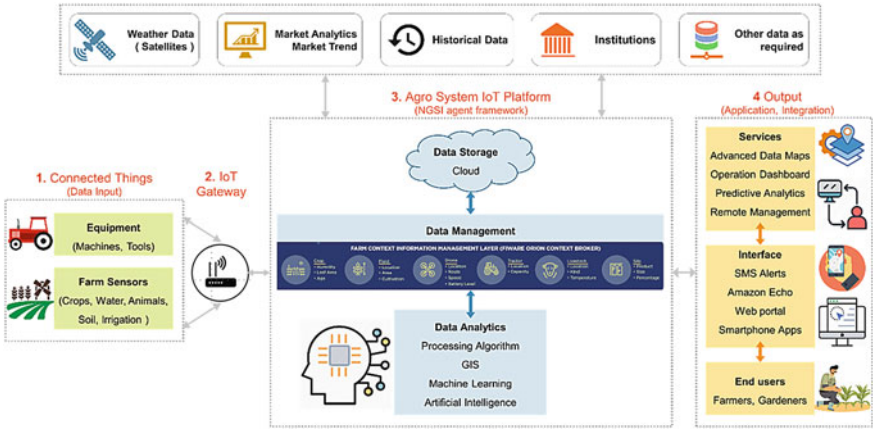


Fig. 40 Smart farm management—M2M. (*Source* author)

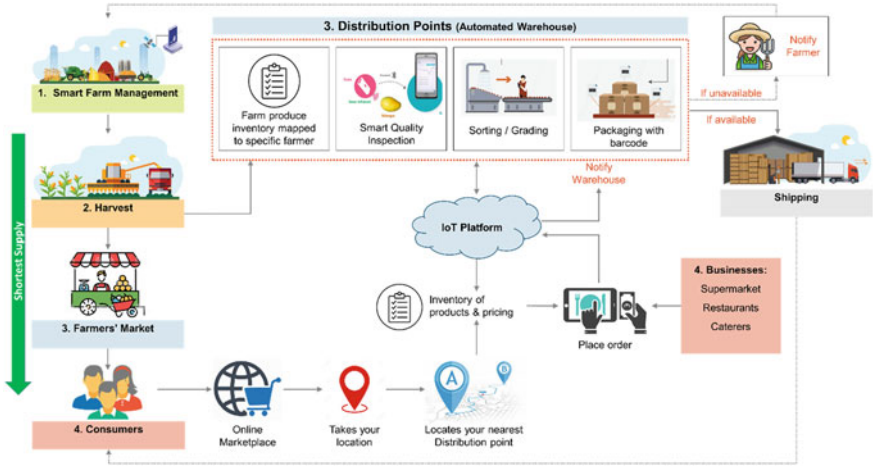


Fig. 41 Smart supply chain—M2M (*source* author)

ii. **Harvest**: which would involve harvest planning and record of cash transactions using M2M.

iii. **Distribution Points**: They are the automated warehouses where inventory mapping, quality detection, sorting and grading and packaging with barcodes take place. The packages with barcodes ready to be shipped are finally stored here. All the processes are automated to reduce human interaction and make the process efficient. The data from the mentioned stages are stored in the cloud. This helps in maintaining an inventory of products, managing customer orders and shipment.

Conclusions

Future smart cities would have IoT- and M2M technology-based working urban systems. It would use a combination of GIS (Geographic information system)-enabled city planning, data capture technologies such as sensors and CCTV cameras and hand-held devices for excellent user control. The like which are already being developed, for example, Nano Ganesh, which allows farmers to use mobile phones to remotely monitor and switch on irrigation pumps in remote locations. The app, developed by Ossian Agro Automation (Pune), works in conjunction with Tata Teleservices phones.

While the proposals in the report seem like a futuristic vision that is far removed from the current reality of Indian cities, nonetheless, it is essential to recognize that IoT and M2M technologies are central towards making incremental improvements in city management.

5.2.3 Place-Based Economic Development

Placemaking as an economic development strategy, also called place-based economic development, is the practice of using a community's public amenities to make economic progress. Using the unique features of particular places, building on existing assets to attract new investment and strengthen existing businesses.

The transformative place-making serves socio-economic development by enhancing the image of the place to pull investors and crowd thereby stimulating socio-economic improvement.

Placemaking focuses on inducing civic activities and food joints along streets, public plazas, organizing street vendors, edge permeability and access to rear site for improving land value and usability.

Co Locating Cultural and Community Activities

The Focus can be given to the improvement of parks and gardens and multipurpose community and sports centres.

Recreation Economy

It involves improving the infrastructure including resorts & homestays of global standard in scenic terrain, creation of rental grounds and turfs, and introduction of activities such as hitchhiking and mountain biking trail.

Placemaking—Placemaking of available vacant land and recreational spaces, junctions and commercial nodes as well as streets, major & minor roads should be performed. A sample proposal is given in Fig. 42. The map given in Fig. 43 demarcates the proposed recreational spaces based on analysis carried out.

Fig. 42 Existing vs Proposed nodes in Kattangal. *Source* Author

5.2.4 Smart Environment

The proposals under Smart environment includes: enabling a circular economy, provision of solid waste management and treatment incentives, establishing upcycle and recycle industries.

The Figure 44 represents the working of a circular economy.

5.2.5 Smart Mobility

The following PPP projects are proposed under smart mobility includes:

- Public Transport Sharing + Convenience Store
- Paid Smart Parking with EV Charging Stations
- PV Field
- Electric Rickshaw Sharing and App

Smart Parking

Bike Sharing System

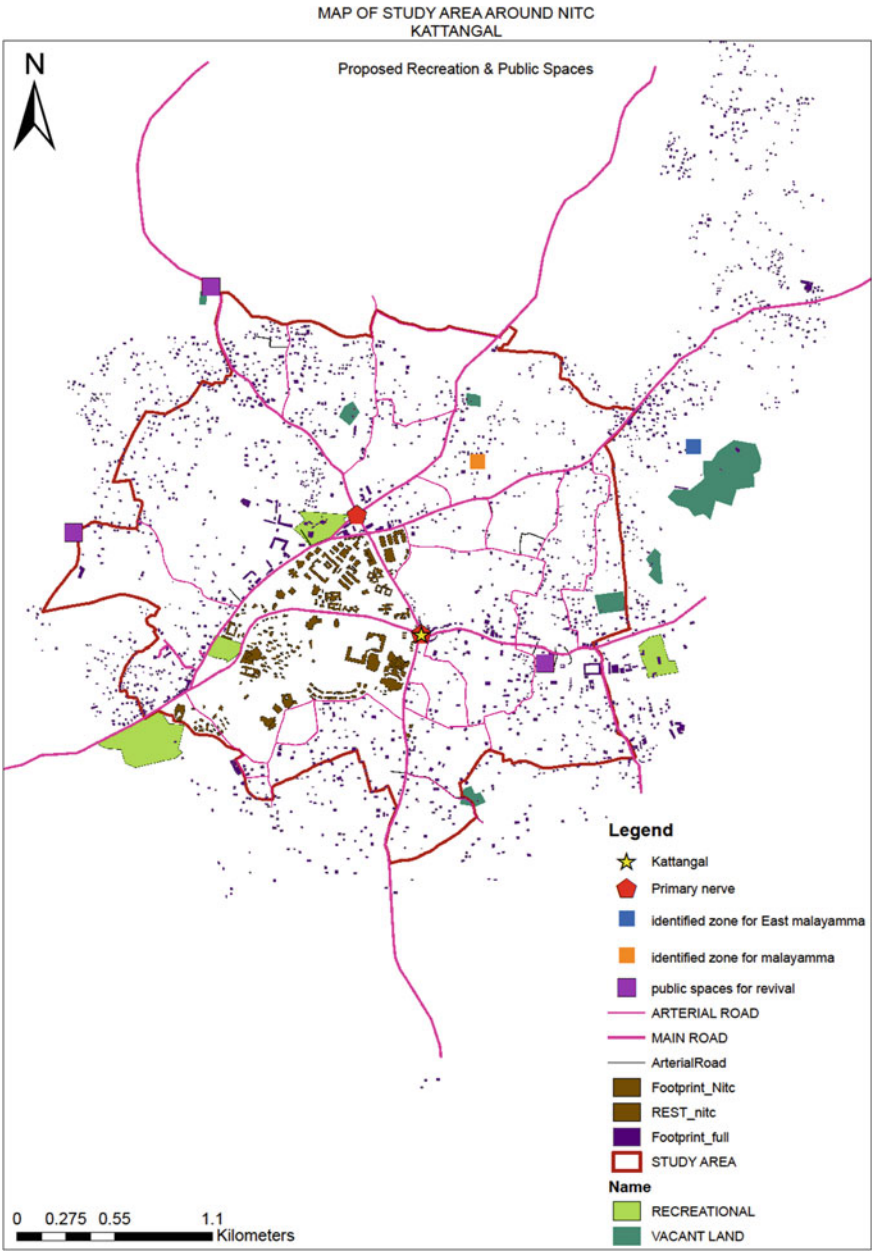


Fig. 43 Map showing proposed recreational spaces in Kattangal

Fig. 44 Circular Economy [7]

Fig. 45 Benefits of smart parking. *Source* Author

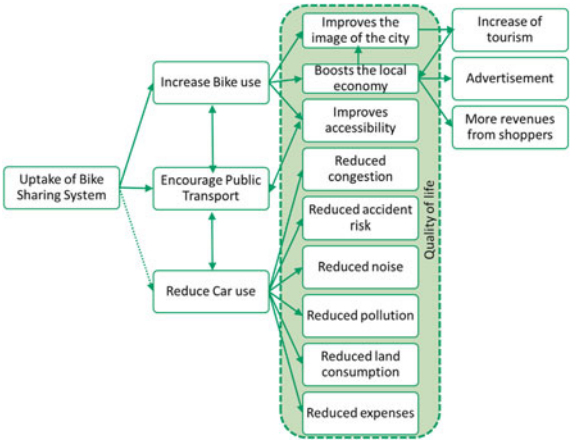
Increase in space availability

Prevent leakages in tariff collection

Reduction in car park abuse

Run by private operators as business

Fig. 46 Benefits of Bike sharing system [1]



5.2.6 Urban Enterprise Hub

Urban Enterprise hub provide facilities for global business community [8]. The major growth nerve of Kattangal SGEC is shown in the Fig. 47. The site selection for the urban enterprise hub will be carried out along the growth nerve. The main components of Urban Enterprise Hub is represented in Fig. 49.

Site Selection

A land area of 17,000 sq.m. classified as vacant land under current land use is proposed to be developed as Urban Enterprise hub, the chose site has a very close proximity to the core of Kattangal neighbourhood with the main Kattangal junction being just 1Km1 km away. The development might be composed of three blocks.

Urban Enterprise **Hub:** Urban Enterprise hub provide facilities for global business community. The main area requirements are as given in Table 11.

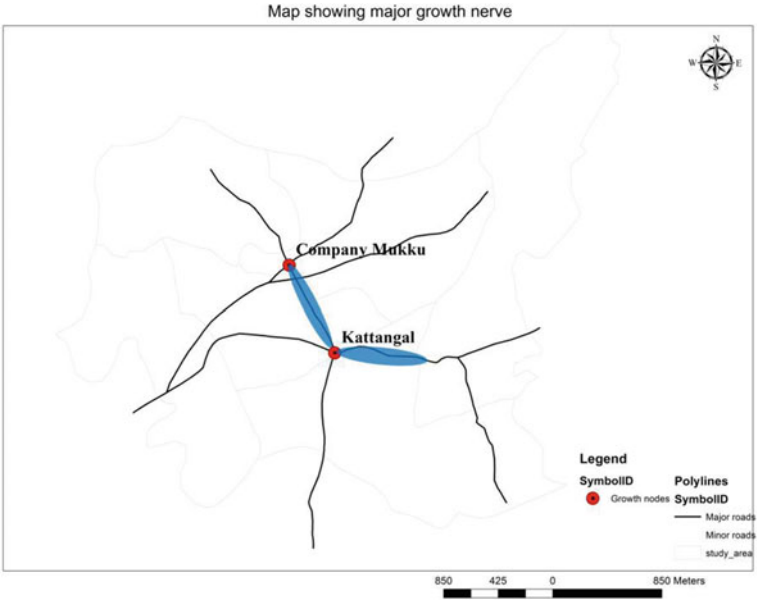


Fig. 47 Major growth nerve. *Source* Author

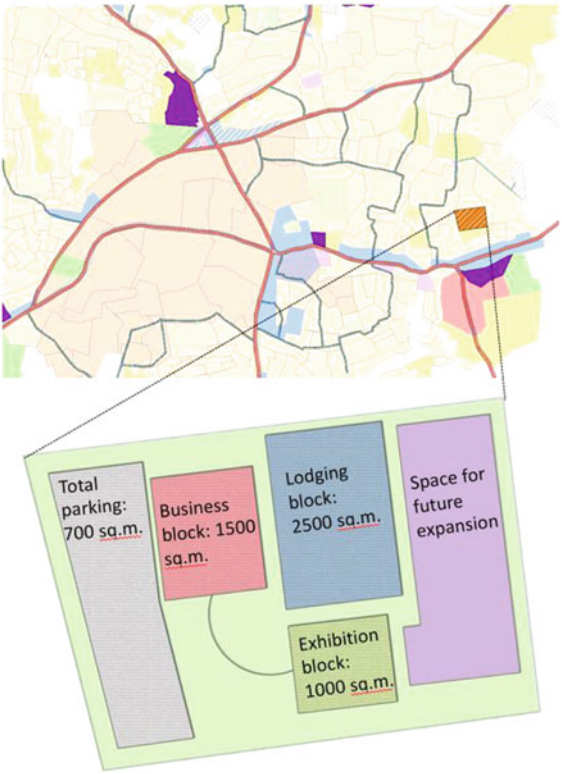


Fig. 48 Site selection for Urban Enterprise Hub. *Source* Author

Approximated area:

Business block: 1500 m^2.

Lodging block: 2500 m^2.

Exhibition block: 1000 m^2.

Total parking: 700 m^2.

5.3 Smart Living

Smart Living is a trend comprehending advancements that promote people the opportunity to benefit from new ways of living. It involves original and innovative solutions aimed at making life more efficient, more controllable, economical, productive, integrated, and sustainable [9].

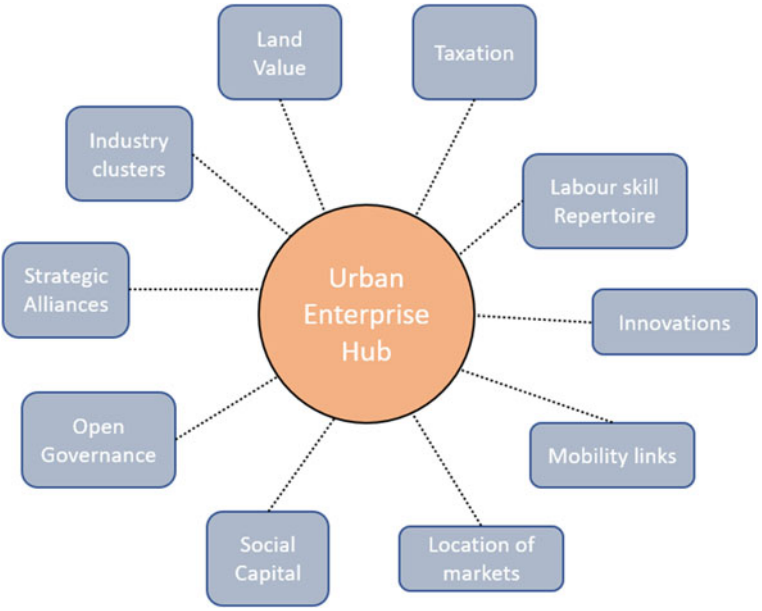


Fig. 49 Components of Urban Enterprise Hub. *Source* [8]

Table 11 Space requirements for an urban enterprise hub. *Source* Author

Infrastructure	Area (m^2)	Area%
Currency exchange hall	200	Facilities for foreign currency exchanges
International bank's transfer instalments	200	ATM's, web-transaction portals, etc.
Business Hub	800	Office space for managing the Urban Enterprise zone
Lodging facilities	2500	Stay and recreation facilities—for 50 people
Official meeting halls	250	For business meetings
Exhibition Arena	1000	Small-scale business innovation displays
Food and allied services	800	Canteen with other basic infrastructure
Booking office	30	For cab—booking and freight contacts
Parking	700	Parking for management and guests

5.3.1 Urban Open Spaces and Cultural Spaces

The age-group distribution of population of study area as depicted in Fig. 50 shows a significant population aged 50 and above. The maximum share of population is in 23-49 age group who will be soon added to above 50 age group, thus increasing the old age population. Hence it is of utmost importance to cater to their needs and design facilities considering them.

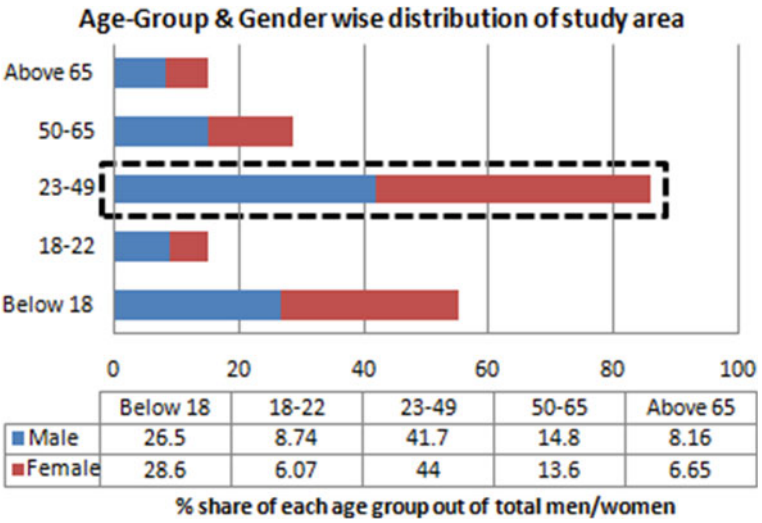


Fig. 50 Age group and gender wise distribution of population. *Source* [1]

- Based on age group distribution, there should also be some parks specially designed for old people above age 49.
- In SGEC Kattangal different types of open spaces were allocated. There was nothing to innovative using ICT/IOT.
- AI monitoring systems in various spaces for security and movement of the people around public spaces are necessary.
- The proposals are to advance the allocated space for parks, playgrounds and gardens.

The study area has five recreational spaces, four libraries and ten religious spaces. The study area has five schools and a college university. The existing and proposed parks and open spaces are shown in Figs. 51 and 52.

Since Kattangal is planned as a smart global economic community, several proposals for public spaces were identified which were seen as necessity.

Accordingly, three-order public spaces were identified for revival:

- first-order multi-purpose parks,
- second-order parks (existing open spaces),
- third-order local open spaces.

- Smart monitoring systems are proposed in the existing open spaces.
- New footpaths are required in the commercial areas.
- The proposed open spaces are located near commercial area, so they can be used as multipurpose areas as shown in Fig. 53.

Online renting, availability and location of open spaces for social or cultural programmes like marriages, gathering, etc.

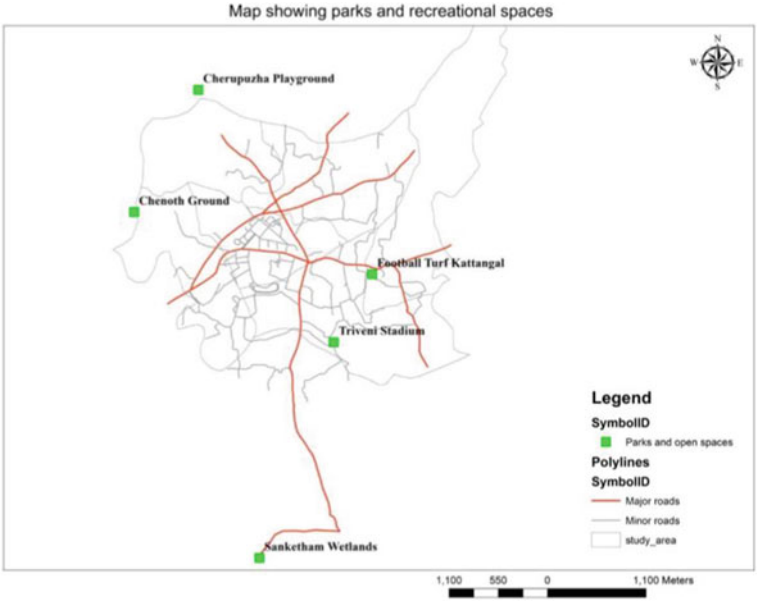


Fig. 51 Existing recreational spaces in study area [1]

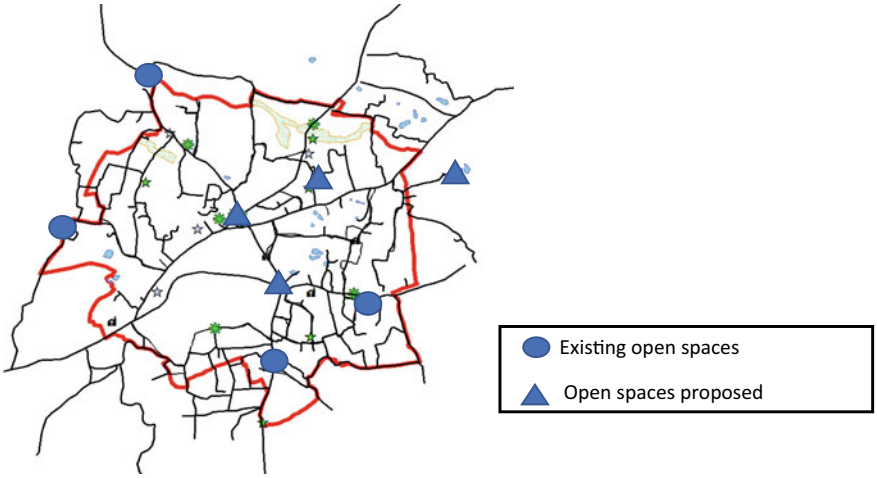


Fig. 52 Existing vs Proposed open spaces in SGEC Kattangal [1]

Additional proposals include:

- Provision of efficient lighting. Sensory lighting for different spaces.
- Digital signages for various activities.
- Green walls.

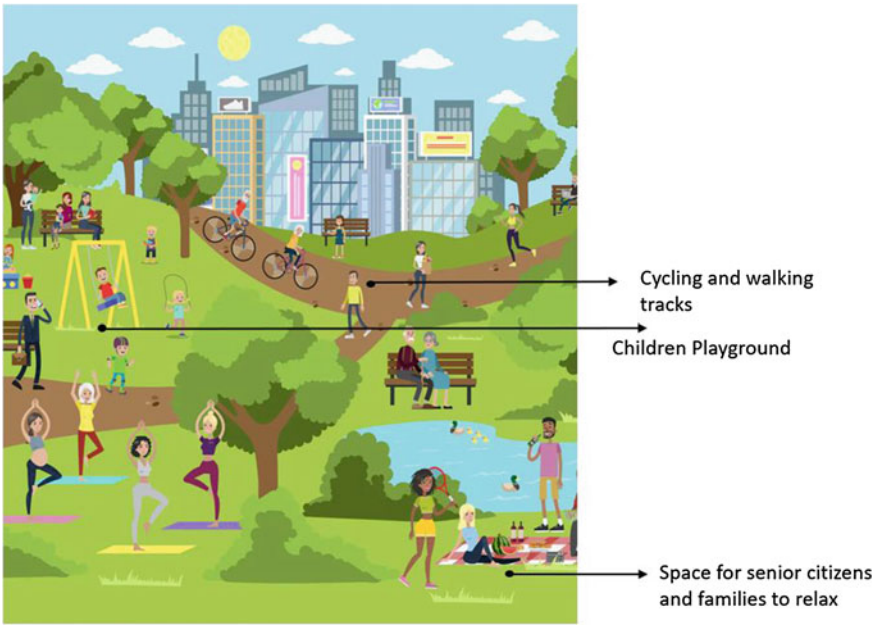


Fig. 53 Open spaces with multiple recreational values. *Source* Google

- Pervious Paving.
- Energy-generating exercise equipment.
- Monitoring green areas for quality of air, water and soil to save the cost and resources.
- Solar-powered trash compactors reduce how often trash needs to be collected.
- Solar shade structures provide protection from the sun, like traditional umbrellas and canopies, while collecting solar energy and providing services, such as cellular phone charging.

Smart benches offer visitors seating and can provide access to the Internet, track park usage and/or gather environmental data. The information can be useful to engage the community, streamline operations and monitor park use.

Restroom occupancy sensors can be helpful in parks with crowded restrooms, especially those that regularly host large events. By visually displaying which stalls are available or occupied, the sensors can increase privacy, reduce wait times and alert maintenance staff to issues that need attention.

5.3.2 Safety: Fire Services

Kattangal comes under the jurisdiction of Mukkam Fire and Rescue Department. Currently, there are no facilities for fire safety apart from a few commercial buildings

and institutes with fire safety system. The houses are sparsely placed and hence are less vulnerable to fire incidents, whereas the junction area needs proper installation of fire safety measures due to its compact nature. The Fig. 54 shows location of fire station with respect to the study area and Fig. 55 is a photo captured of Kattangal junction.

Buffer zones are demarcated to perform the analysis based on fire and safety as shown in Fig. 56.

- Fire hydrants are to be provided along the major roads at a distance of 400 ft. on the pedestrian way. These fire hydrants will work on an IoT-based system and will be connected to water lines. When the high temperature is detected in real-time DEM, the fire station will be informed and water from pipelines will enter the hydrants for the use of servicemen. The buildings near the junction area have to

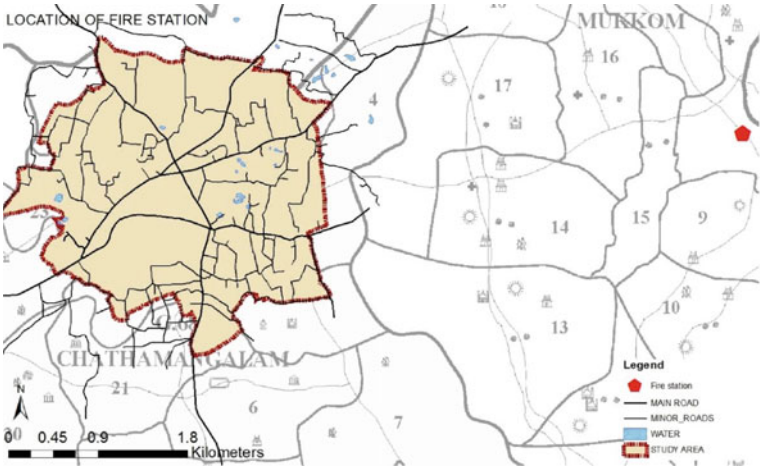


Fig. 54 Location of Fire Station. *Source* Author

Fig. 55 Photograph of Kattangal Junction. *Source* Author

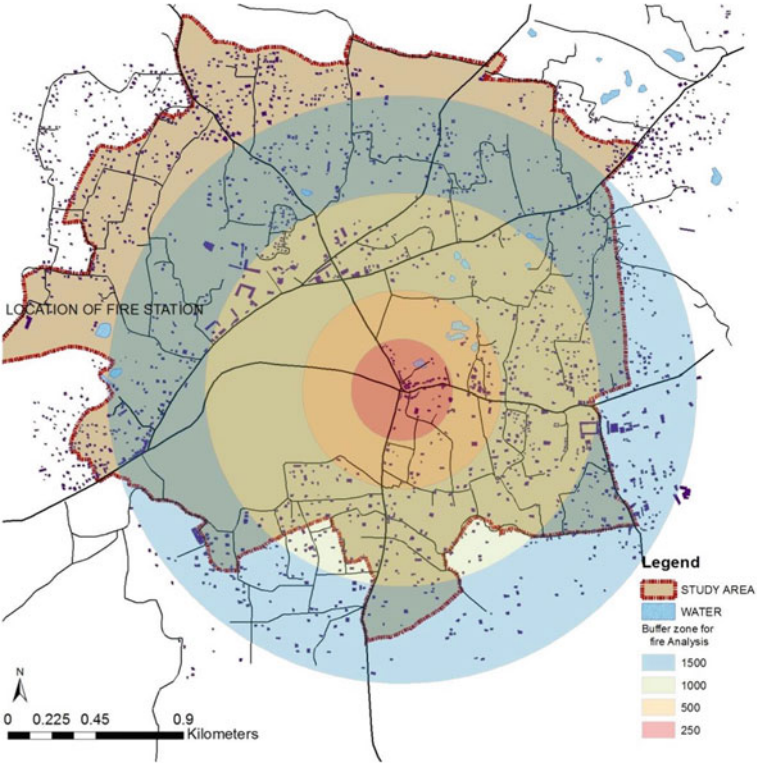


Fig. 56 Buffer Zones for fire analysis. *Source* Author

be retrofitted to accommodate fire safety measures, with proper IoT set-up to deal with fire incidents.

The Fig. 58 shows the proposed road section with fire hydrants. Apart from the main water line, the water from various water retention ponds proposed thoughout the study area can be used in case of emergency.

5.3.3 Healthy Lifestyle

The existing scenario in Kattangal proves that wet agricultural land is a visual treat to many, especially to the elderly who yearns for peaceful activity time. A 14-m-wide dedicated elderly activity space with continuous looped passage tracing the side of agricultural land, connected at both ends to main arterial roads is proposed as shown in Fig. 59. This will undoubtedly provide benefits for elderly, differently abled, farmers, vendors and also act as recreation for mentally unsound along with self-help group meetings.

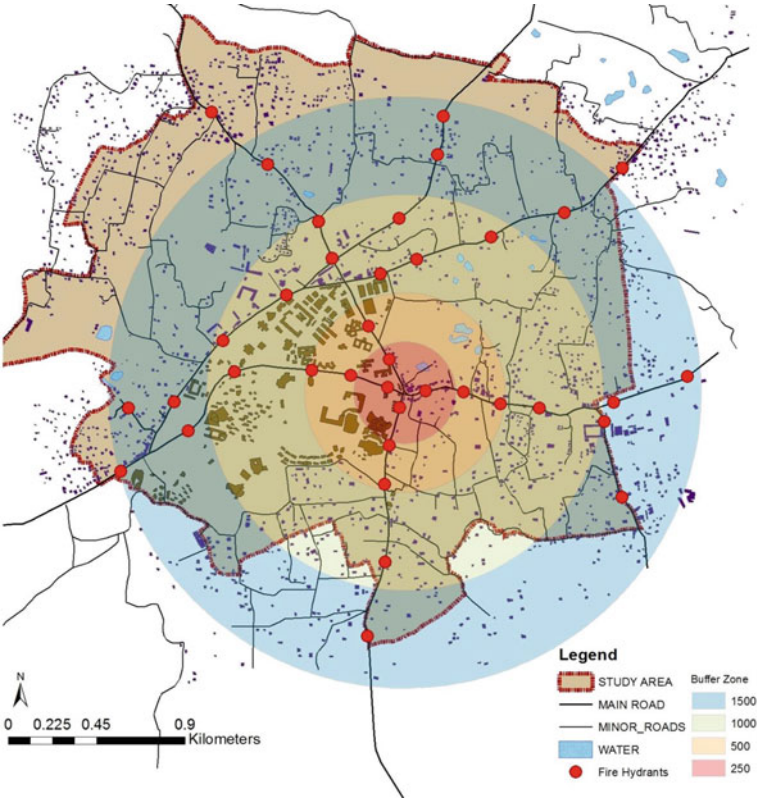


Fig. 57 Fire hydrant map for Kattangal. *Source* Author

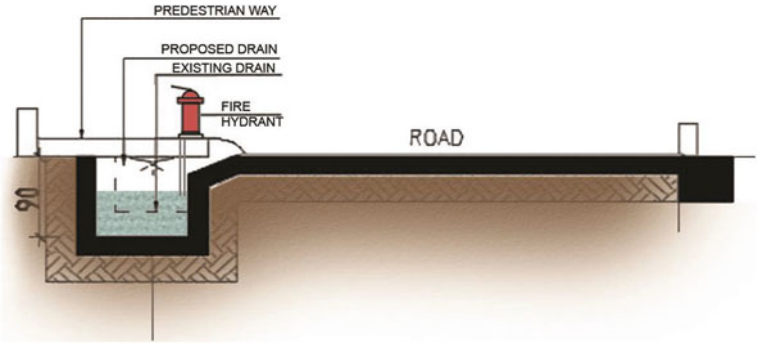


Fig. 58 Proposed Road section with fire hydrant. *Source* Author

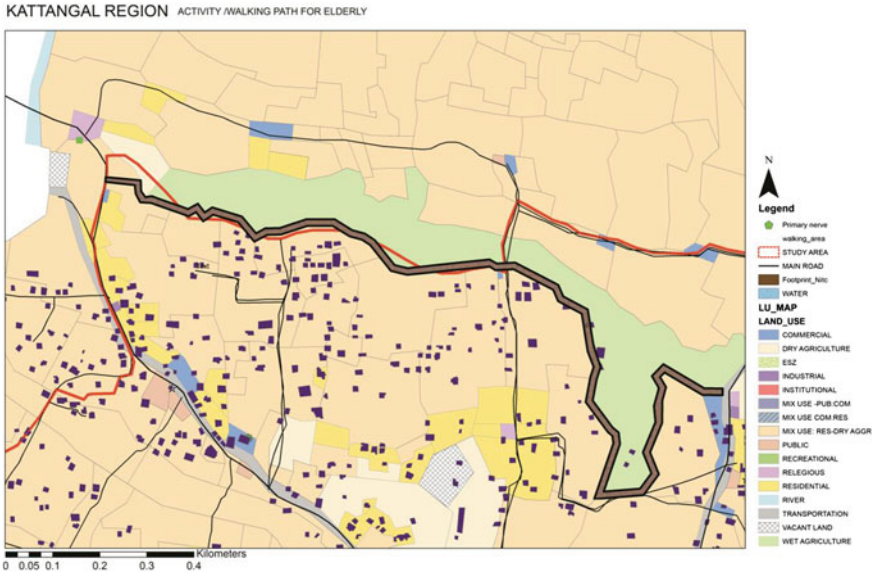


Fig. 59 Proposed walking path for elderly population in Kattangal. *Source* Author

Wet agricultural land: some of the regions that are going out of cultivation can be renewed to encourage urban farming. Direct selling of the produce can also be encouraged.

Walking path: Lifestyle diseases can be reduced by including healthy habits of brisk walking. An active public life can also help them battle health issues.

From the land use analysis, wet agricultural lands are gradually being converted to drylands and then left vacant. Creating this walkway serves two purposes of protecting the wet agricultural land as a barrier and helping the local farmers interact with the residents and global visitors.

5.3.4 Urban Poverty Alleviation

In the Chathamangalam Panchayath where the study area falls, 33% of people are Below Poverty Line which is more than the district poverty rate (27%).

Different dimensions of poverty are identified through literature studies. Proposals for required dimensions are given.

The working population is only 34% in the study area as shown in Fig. 61.

- Increasing the opportunities and developing the skills of the people in the area will decrease unemployment and thereby the poverty rate.
- Kattangal is proposed as a Smart Global Economic Community, which will provide jobs to the majority of the population living there.

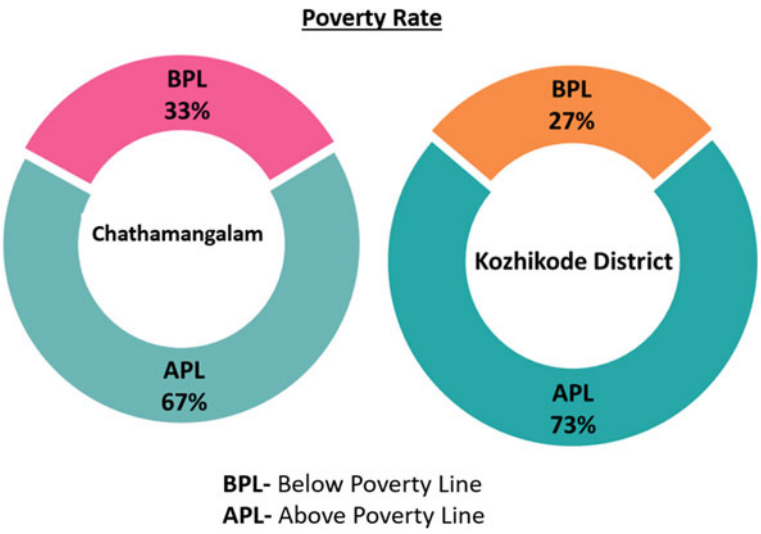


Fig. 60 Poverty rate in Chathamangalam Panchayat [10]

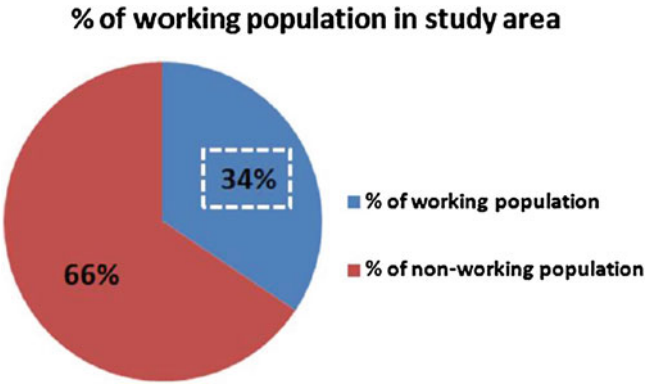


Fig. 61 Percentage share of working population in the study area [1]

- Training centres are also recommended in the Kattangal SGEC for skill development

A candidate database is proposed for Kattangal SGEC. All the candidates in the community can create a profile in this database with details of their education, experience, skills, etc.: A sample of the interface is as shown in Figs. 62 and 63.

All the employers in the SGEC can recruit required people from the community itself through this platform.

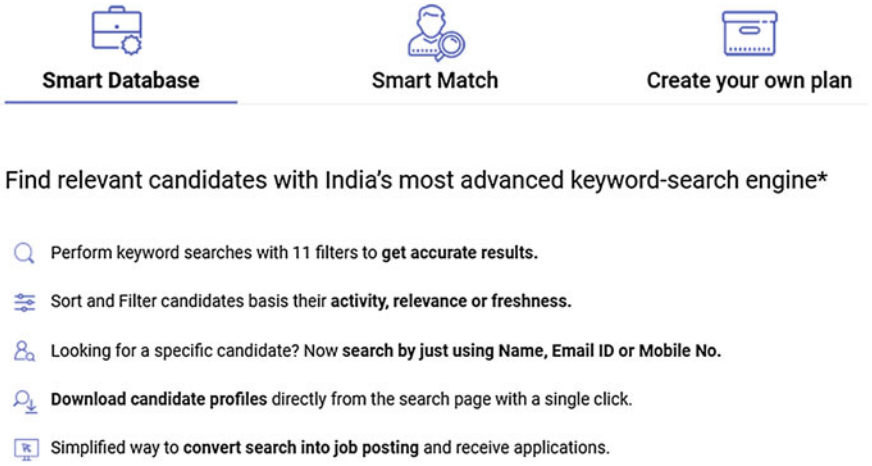


Fig. 62 A sample of the interface of candidate database proposed for employment. *Source* Author

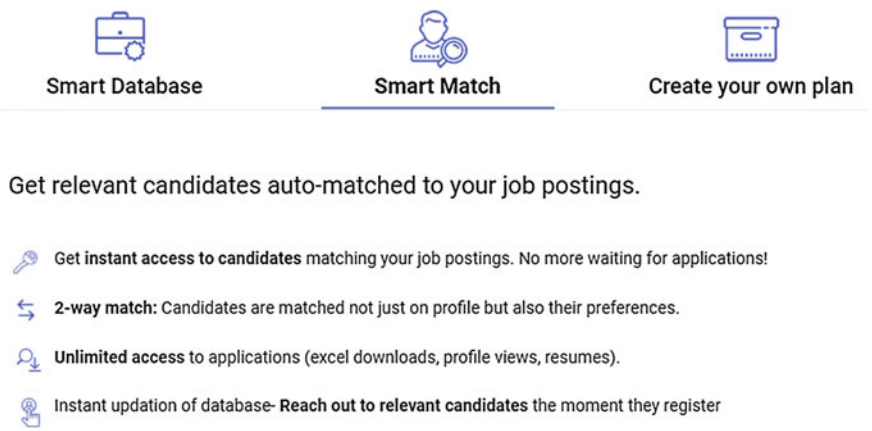


Fig. 63 A sample interface oof Smart match for recruiting employees. *Source* Author

Online training

Training centres are proposed in Kattangal for developing a smart economy. Online training for skill development can be provided. Various institutes provide online skill development programmes. These online classes can be organized in the training centre proposed in the SGEC. Some online skill development programmes are listed below:

– Free online skill development courses by the National Skill Development Corporation (NSDC).

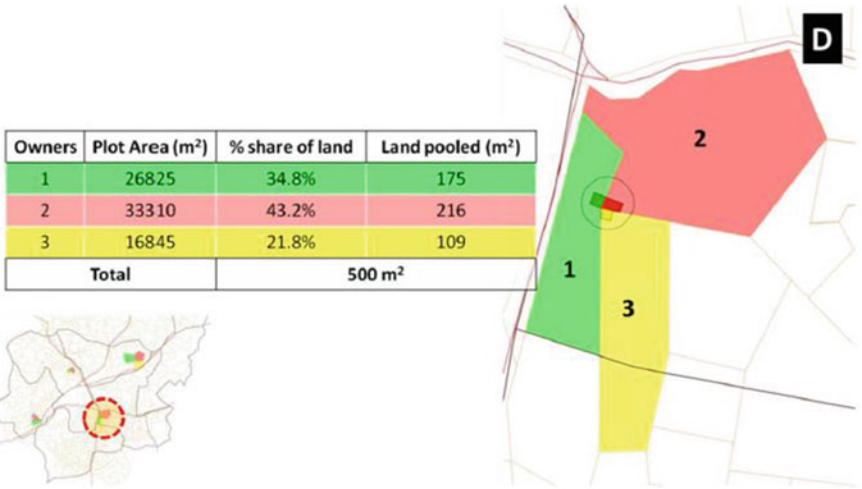


Fig. 64 Area requirement of training centres [1]

- Courses on soft skills, languages, culture, digital literacy and entrepreneurship by online platform www.indiaskillsonline.com launched by the Ministry of Skill Development and Entrepreneurship.
- Various courses by Coursera.
- Courses by E-skill India. The area requirement for training centres are as shown in Figs. 64 and 65.

Affordability of healthcare

KMCT medical college, MVR Cancer Centre, etc. are in the Kunnamangalam Grama-Panchayath. But affordability of healthcare in these institutions is a problem for poor people.

The 71st Round of the National Sample Survey Organization has found 85.9% of rural households and 82% of urban households have no access to healthcare insurance/assurance. More than 17% of Indian population spend at least 10% of household budgets on health services. Catastrophic health care-related expenditure pushes families into debt, more than 24% of households in rural India and 18% population in urban area have met their healthcare expenses through some sort of borrowing.

Community-based health insurance (CBHI)

- Community-based health insurance (CBHI) is more suited than alternate arrangements in providing health insurance to the low-income people living in developing countries.
- The universal health insurance scheme, launched recently by the Prime Minister of India, is only one of the forms that CBHI can take.

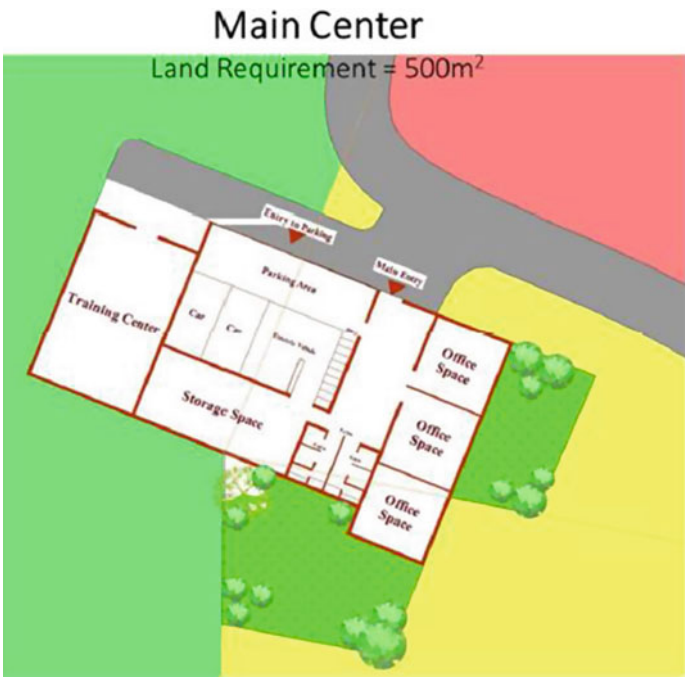


Fig. 65 Land requirement for the main centre. [1]

- The employers and employees of the SGEC together can save and pay the premium.
- Popularizing insurance among low-income people requires conveying the idea, canvassing for it, collecting premiums and verifying claims, and then reimbursing these claims.
- Monthly premium can be deducted by the employer from the salaries of the employees and the payment can be done by the employer.
- A digital platform can be used for transactions.

Organization and Participation

Sixty percent of the HH have organizational membership, out of which almost 70% are associated with Kudumbashree and 62% of HH claim to be benefitted from it in terms of social, recreational and financial benefits as shown in Figs. 66 and 67.

The government of Kerala has introduced a lot of schemes for poverty alleviation through Kudumashree, Community Development Societies (CDS), etc. Kudumbashree is also providing various employment opportunities. There is a tailoring unit functioning in Kattangal under Kudumbashree.

Smart Kudumbasree: Kudumbasree can be made smart by developing websites and apps for making the application process and distribution of loans in the poverty eradication schemes easily.

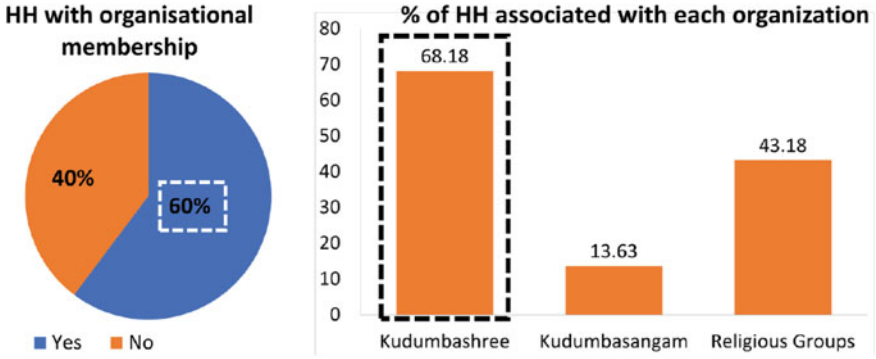
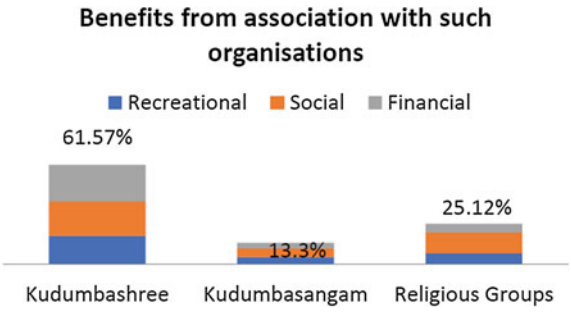


Fig. 66 Share of households associated with Kudumbashree. [1]

Fig. 67 Benefits from association with Kudumbashree. [1]



5.4 Smart Environment

The main goals of the smart environment are keeping the environment pristine by managing these environmental factors within safe limits. For this, the goals are being converted into components as shown in Fig. 68 such as:

- Smart water management,
- Smart waste management and
- Renewable energy advocation.

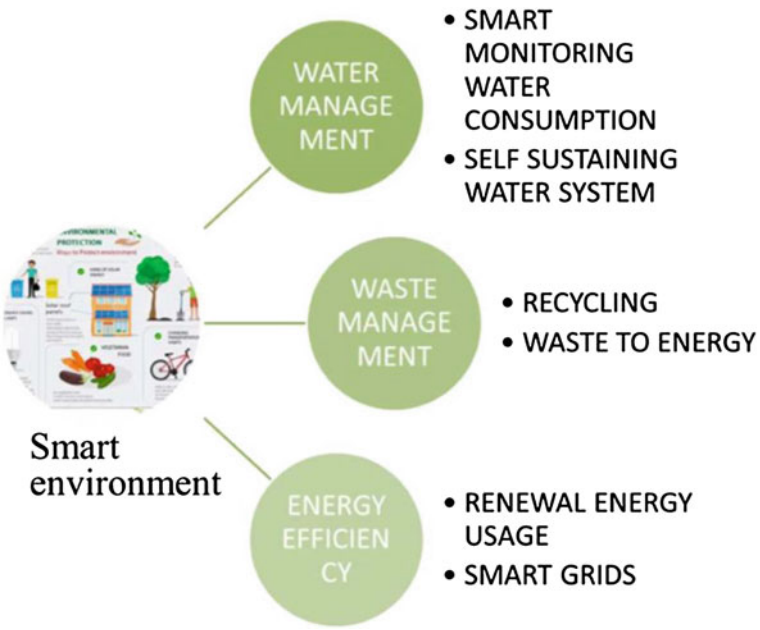


Fig. 68 Components of smart environment

Table 12 Quantities of waste generated

Organic waste (51%)	4937.3 kg/day
Inert/non-organic waste (32%)	3001.9 kg/day
Plastic waste (10%)	938.1 kg/day
Paper waste (7%)	656.7 kg/day

The main culprits of environmental degradation in Kattangal are

- Improper waste dumping.
- Draining off wastewater from the septic tank.
- Plastic waste, etc.

5.4.1 Solid Waste Management

From secondary data of a household survey conducted on sample size of 146 households, the following analysis can be made:

- Municipal Collection is done only for plastic waste, in which only 46% of the plastic waste of collected.

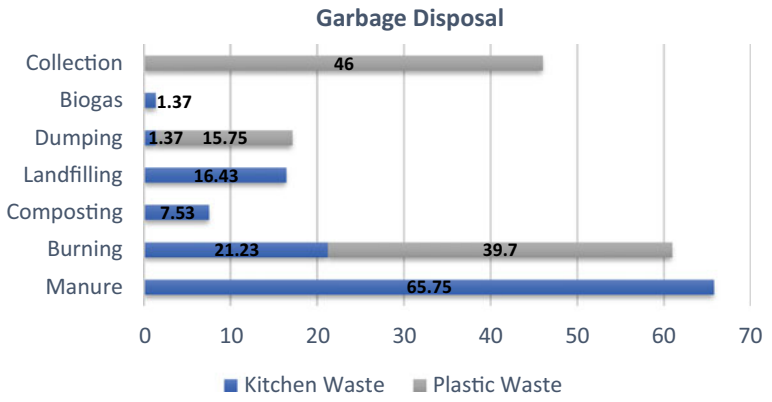


Fig. 69 Disposal methods of waste. *Source* Household survey

- Almost 70% of the households are handling organic waste at household level and utilizing it in the form of manure or biogas. The Fig. 69 shows the different disposal methods adopted in Kattangal.

  The amount of waste generated is computed as given in the Table 12:
  According to the Union Ministry of Environment, Forests and Climate Change,
  The average waste produced per capita = 450 g/person/day,
  Total waste produced = 17077 × 0.45 kg = 7,684.65 kg/day.
  According to a 2014 India Planning Commission MSW study,

  51% of MSW is organic or biodegradable,
  32% is inert or non-organic and
  17% is recyclable waste (10% plastic and 7% paper).

In order to achieve a net-zero waste, certain aspects like 100% collection of plastic waste from residential, commercial and institutional buildings, its primary-level treatment (shredding and bailing) and export it further, achieving 100% treatment of organic waste at the origin itself have to be looked at.

Time frame for a Smart Global Economic Community is 3–7 years and it should be reviewed every 3–5 years (URDPFI guideline). Considering population projection for a decade till 2031 for infrastructure proposals,

Total Estimated Population: 20846,

Total quantity of waste to be handled = 20846 × 0.45 kg = 9381 kg/Day.

The plastic waste is collected under Nirav program, where the waste collected is sent to a plant at Karnataka and local recycling is absent. The kitchen waste or bio degradable waste is used as bucket compost at household level, which serves as manure for trees.

From the primary survey, almost 70% of the HH are handing organic waste at the HH level and utilizing it in the form of manure or biogas, market and commercial organic waste is collected and treated by municipality through vermicompost pits.

There is no specified area in the study region for primary-level treatment of recyclable waste.

Plastic Waste Recycle Plant

A plastic waste recycling plant is proposed. The area calculation is as follows:

Required area for primary treatment of plastic waste:

Area required to treat 1000 kg/day = 1000 ft.^{2}

Minimum area required to treat 940 kg/day = 940 ft.^{2}.

Steps The identified site and area allocation for the plant is as shown in Fig. 70

Adequate Steps need to be taken to reduce the quantity of non-biodegradable waste. Involvement of NGOs in creating public awareness about segregation of waste, different types of non-recyclable waste and participation in decentralized solid waste management system is encouraged. Schemes to plan centralized biogas plants or compost pits at community levels and compulsory organic waste treatment plants should be planned in institutional buildings like schools and colleges are required. Improving worker strength in order to extend the service to every part of municipality and supplying more collection vehicles and extending its services to every part of municipality will improve the situation.

Implementation and Governance

The Funding of the project by the Government of India through national missions such as AMRUT, Smart Cities, etc., is a feasible option. The municipality is to employ Kudumbasree Unit to process the waste at the facility and convert the waste plastic material, brought into the facility, into shredded plastic suitable for recycling and prepare it for forwarding for further recycling. The end products of the process is employed to be sold by the municipality in the open market or P.W.D/L.S.G.D for the construction of polymerized roads based on the requirement.

Smart Waste Management method

For smart waste management, IoT/ICT-based smart waste bins will be installed at each ward level. Smart bins at houses with sensors will send messages to the municipality authorities once the bins are full. Authority will come and collect the waste, which will make a hassle-free method of waste management.

To implement this, there will be a need to create awareness among people of the community to segregate waste at home: degradable and non-biodegradable waste, conduct training workshops to teach people about how this system will work and to

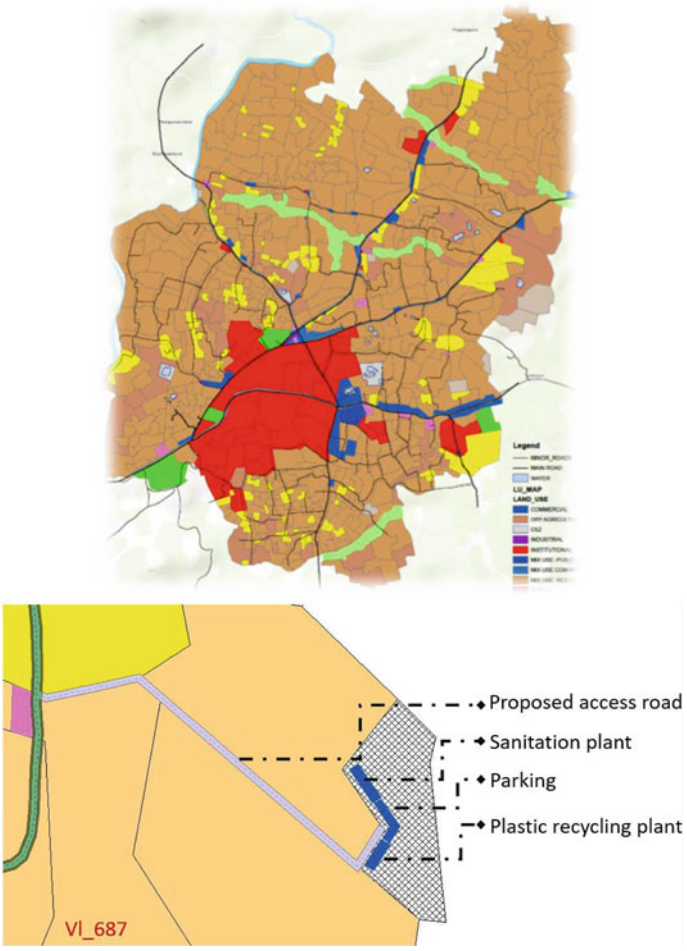


Fig. 70 Space allocation for plastic recycling plant. *Source* Author

make this system a successful one. Tools like Cloud Computing, IOT Sensors, GSM/GPRS, RFID and other Low Power Wireless Technologies to be used to manage the system efficiently. Figure 71 depicts the architecture for smart waste management.

5.4.2 Sewage Management

From the secondary data collected from household survey, the following observations are noted:

- Almost 65% of the land use is residential + dry agriculture.
- Almost complete region is having scattered housing

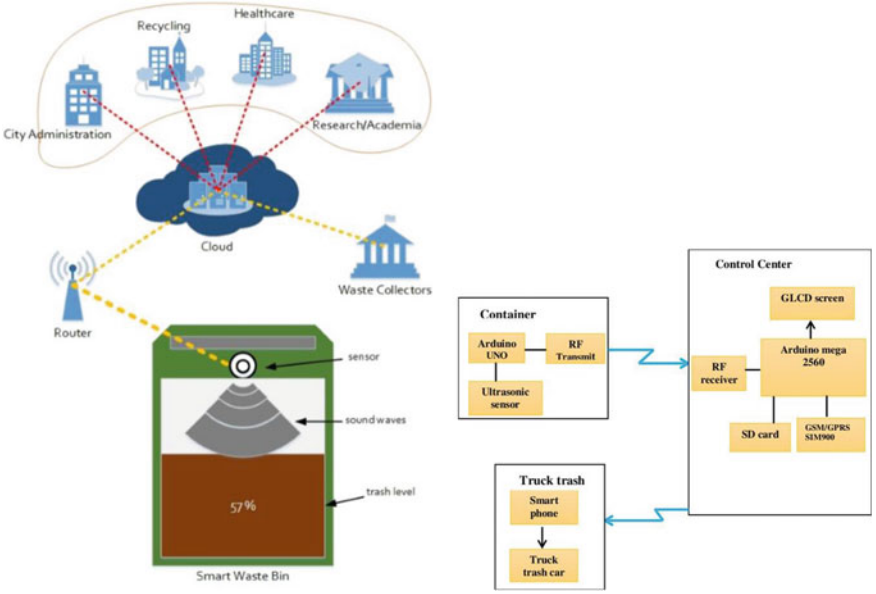


Fig. 71 Cloud based smart waste management architecture. *Source* Author

- Some of the residence don't have proper tarred road access, nor do some roads have proper drainage.
- More than 90% of the household have septic tanks and do not face flooding during rainy seasons as shown in Fig. 74.
- 55% of household faces water scarcity in summer seasons even for agricultural purposes as depicted in Fig. 72. The sources of drinking water is given in Fig. 73.
- Because of scattered housing, sewage pipeline layout will be very expensive.

Hence, normal sewage treatment plant or Dewat system is not much feasible in this zone.

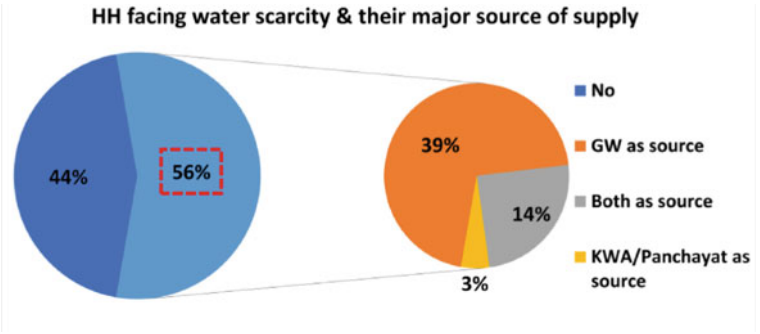


Fig. 72 Households facing water scarcity. *Source* Author

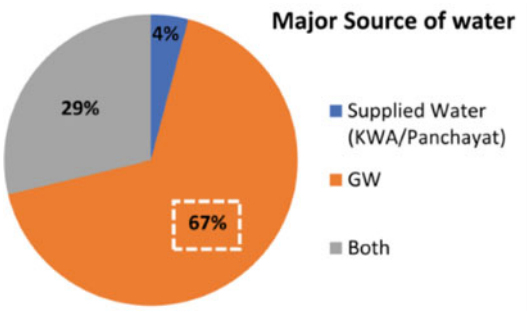


Fig. 73 Source of drinking water [1]

95% of the houses have septic tanks and 90% face no water logging or flooding issue.

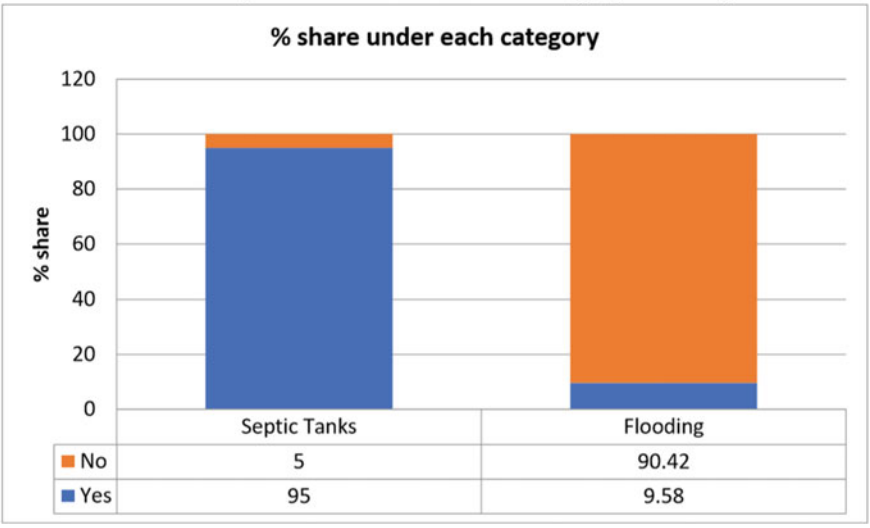


Fig. 74 Households with septic tanks and flooding issues. *Source* Author

Since 65% of the area is residential + dry agriculture, maximum households are having huge compound areas. In these types of situations, on-site disposal systems are best suited.

A decentralized wastewater treatment system is consisting of a septic tank and a trench or bed subsurface wastewater infiltration system (drain field) (See Figs. 75 and 76.

- Effluent filters through the stone and is then further treated by microbes once it reaches the soil below the gravel/stone trench.
- A drain field may be designed to offer several separate disposal areas for effluent from a single septic tank. One area may be "rested", while effluent is routed to a different area.

- The nematode community in the resting drain field continues feeding on the accumulated biofilm and fats when the anaerobic septic tank effluent is no longer available.
- Dispersion trenches shall be 1.0 m deep and 1.0 m wide.
- Each trench should not be longer than 30 m.
- A gap of at least 2 m is there in between two trenches.

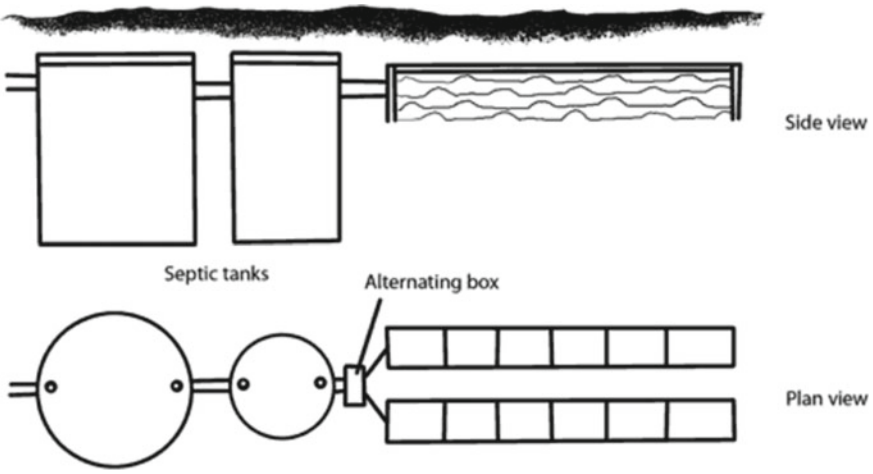


Fig. 75 Septic tank and brick leach drain. *Source* Author

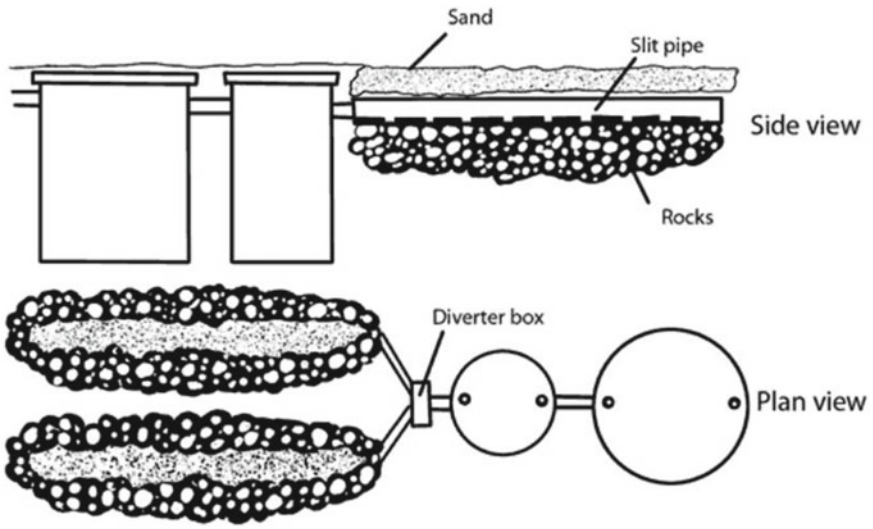


Fig. 76 Septic tank and French drain (rubble drain). *Source* Author

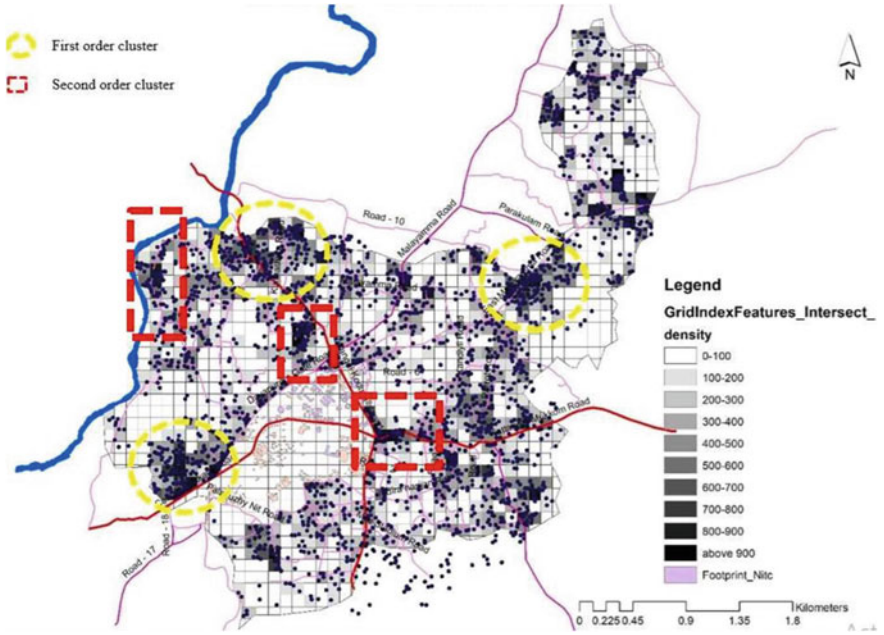


Fig. 77 Location of high density cluster housing

In the 6% of core residential areas, a cluster/community drainage field system can be adopted. The residential density is higher along the major roads and lesser in the interior lands. The Fig. 77 shows the location of high-density cluster housing.

The drainage system could be conventional (see Fig. 78) or cluster type (see Fig. 79). A Control room is required in case of community drainage field trench system to manage the flow of effluent from outlet pipe through the distribution box into the trenches. To switch the valve from one trench to other, so that One area may be "rested" while effluent is routed to a different area. Compared to a soak pit, the leach field might be somehow safer, but is considerably more sophisticated in its construction.

Smart Operation and Maintenance Methods

- A leach field will become clogged over time, although this may take 20 or more years, if a well-maintained and well-functioning primary treatment technology is in place.
- Leach fields require a large area and unsaturated soil with a good absorptive capacity to effectively dissipate the effluent and should be located 30 m away from a drinking water supply.

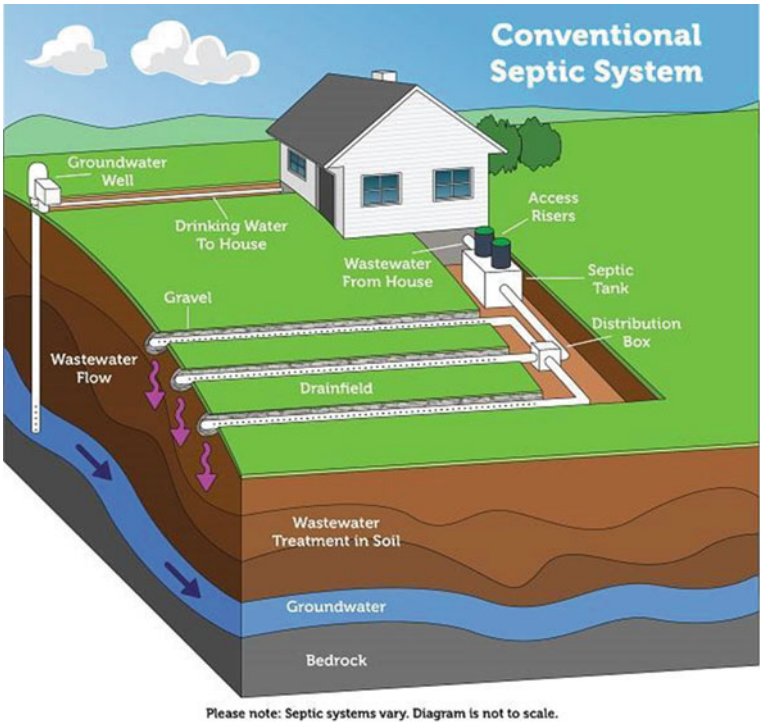


Fig. 78 Conventional septic system

- Homeowners who have a leach field must be aware of how it works and of their maintenance responsibilities. Trees and deep-rooted plants should be kept away from the leach field as they can crack and disturb the tile bed.
- Moreover this Requires expert design and construction.

With the help of smart technologies, maintenance and operational part at the user level can be made easier and more adaptable. With the help of RF communications, through remote devices and technology, we can control the valve of the distribution box in the drainage trench system and even have a record of the same data which can be utilized for maintenance purpose. Sensors can be used to check the water quality of well water or underground water source to check whether effluent is treated properly or not before mixing with groundwater and proper response can be taken on time.

Grey Water Treatment

Greywater is easily available and cheaper to treat and reuse than sewage. By treating greywater, we can reduce the sewage treatment load in large quantities. So, greywater

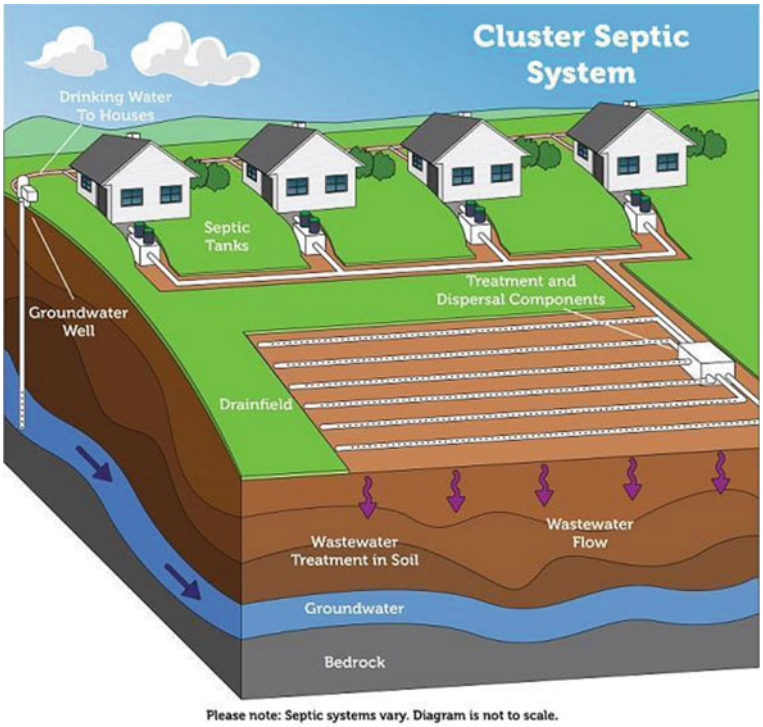


Fig. 79 Cluster septic system

should not be mixed with sewer water, and it can be used to recharge groundwater with the help of soak pits.

Soak pits are appropriate for rural and peri-urban settlements. Hence, every HH should have proper constructed soak pits to discharge greywater and treat them on site.

Policy-Level Proposals

- Policies should be made to construct three-compartment septic tanks compulsory in new constructions.
- With the help of NGOs, awareness campaigns should be conducted for the residents to make them aware of the different sewage treatment systems and what are their roles to maintain onsite effluent treatment (drainage field) systems.
- Subsidies and financial assistance should be provided to the residents to promote the construction of proper drainage field and soak pit at household and community levels.

5.4.3 Urban Agriculture and Agroforestry

Since Kattangal is a global smart economic community, the agricultural and forest-based product produced in and near Kattangal are supposed to be sold in an M2M manner. Large-scale macro-farms are replacing family-owned micro-farms. The demand for food is escalating. Agribusiness is turning to the IoT for analytics and greater production capabilities. Farmers create more efficient operations to gather information in the field, quickly synthesize data and make intelligent decisions to manage their business and reap the benefits of precision farming.

Row of smart marketing system can be implemented for Kattangal to implement as a Global Market Contributor of the agricultural product in both domestic and international markets as listed in Fig. 80.

Assessing the yield gap of existing cropped lands will indicate the possible extent of yield increase from actual values. As long as the dedicated large-scale agricultural production area of Kattangal is very limited, this yield analysis can be used to ensure maximum production by utilizing inadequate amount of land. Spreading of seeds with the help of drone technology effectively reduces the amount of wastage of seeds and make the process more precise. Use of smart mobile apps such as Crop Diagnosis mobile application that will improve pest management decisions by making crop diagnosis more accurate, selection of indicated chemical error-free and application assisted by personalized instructions. By using the application, a grower can prevent errors like cost time and money.

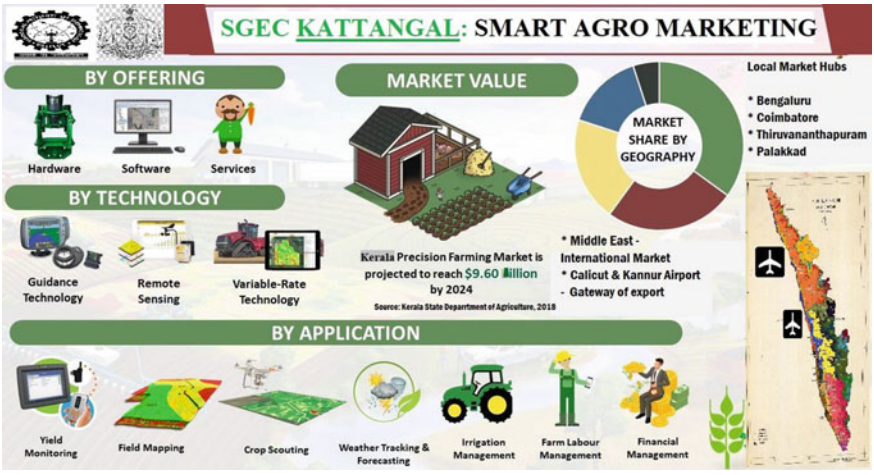


Fig. 80 Smart Agro Marketing. *Source* Author

Smart Agro-Marketing in Kattangal

Agro-marketing agencies based in larger cities like Kozhikode or Thiruvananthapuram might be tied-up with their producers directly through state-of-the-art mobile apps. Kerala Department of Agriculture, Karshika Keralam can develop such apps. This smart application-based marketing system will directly reduce the effect of commission agents and middlemen in the agro-marketing business and hence increase the profit of the producers and ensure fresh products to the consumers at a rapid pace.

5.4.4 Cattle Ponds, Prevention of Cruelty on Animals

Provision of cattle ponds tor allow cattle to drink water and bathe is being proposed. Fencing should be provided around the pond at some distance which includes green area so that they can graze and drink water within the fencing. A floating fence and rock ramps allow cattle to access the pond to drink, yet keep them from wading into the water. This prevents soil erosion, extends the life of the pond, improves water quality and enhances wildlife benefits. The Fig. 81 shows the proposed cattle pond in Kattangal SGEC.

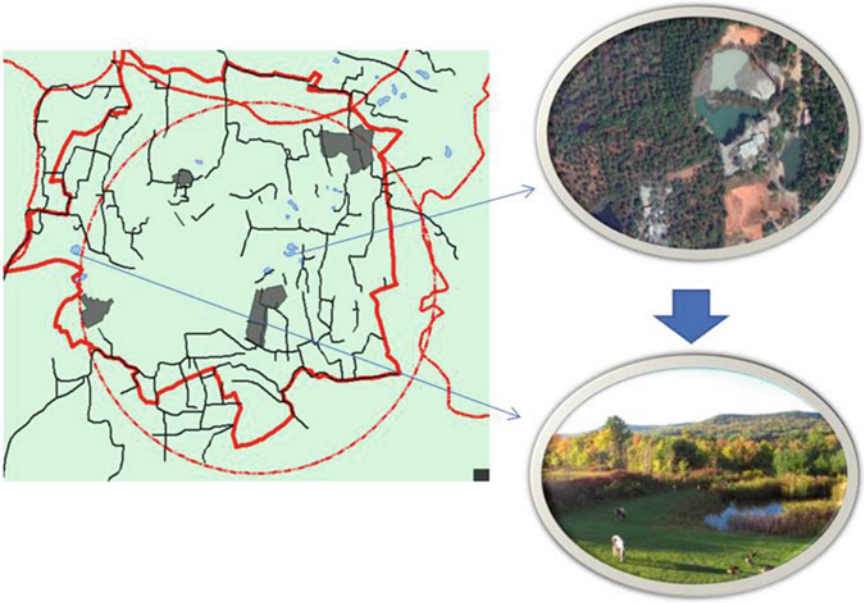


Fig. 81 Proposed cattle pond in Kattangal

5.5 *Smart Mobility*

The vision is 'To provide a safe, convenient & sustainable transportation system for Kattangal'. Intrazonal Accessibility and Interzonal Connectivity shall be strengthened. The proposals are as shown in Fig. 82. The benefits of implementing smart mobility include:

- Safety: Measures include a reduction in the overall number of accidents, and its severity, injury and fatality rates. Surrogate measures include monitoring vehicle speed or accounting the number of violations of traffic safety laws.
- Mobility: Measures include the amount of delay (in units of time) and the reduction of travel time.
- Capacity/throughput: It is measured by the maximum number of persons or vehicles that can commute per hour at a point. It will increase making optimum utilization of resources.
- Customer satisfaction: Measures related to satisfaction include time and convenience of travel through various modes, mode choices and quality of service, as well as the volume of complaints and suggestions.
- Productivity: Measures include operational efficiencies and cost savings.
- Energy and environment: Measures of effectiveness include changes in emission levels and energy consumption. Specific measures for fuel use and emission levels (kilograms or tons of pollutants for carbon monoxide (CO), oxides of nitrogen (NOx), hydrocarbons (HC) and volatile organic compounds (VOC); fuel use (liters or gallons); and fuel economy.
- Reduce delay caused by traffic and toll collection.
- Reduce crime; make travel safe, secure and convenient.

The objectives include:

- To develop low-cost energy-efficient solutions for the improvement of people.
- To develop IoT/ICT-based traffic and transportation information system for the junction community.

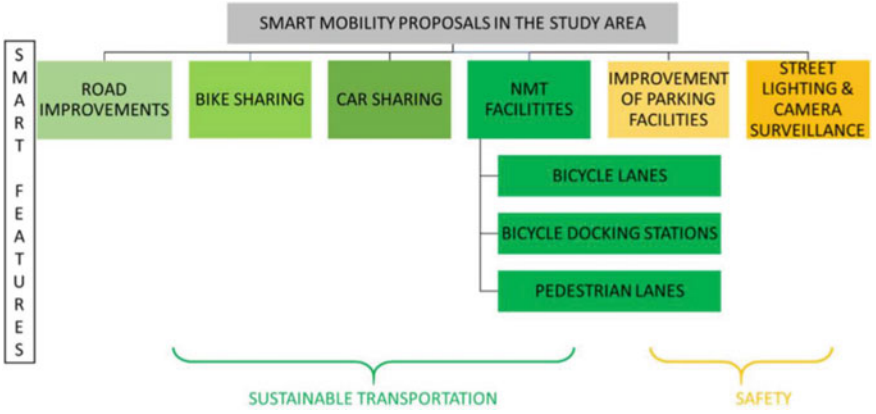


Fig. 82 Smart mobility proposals [1]

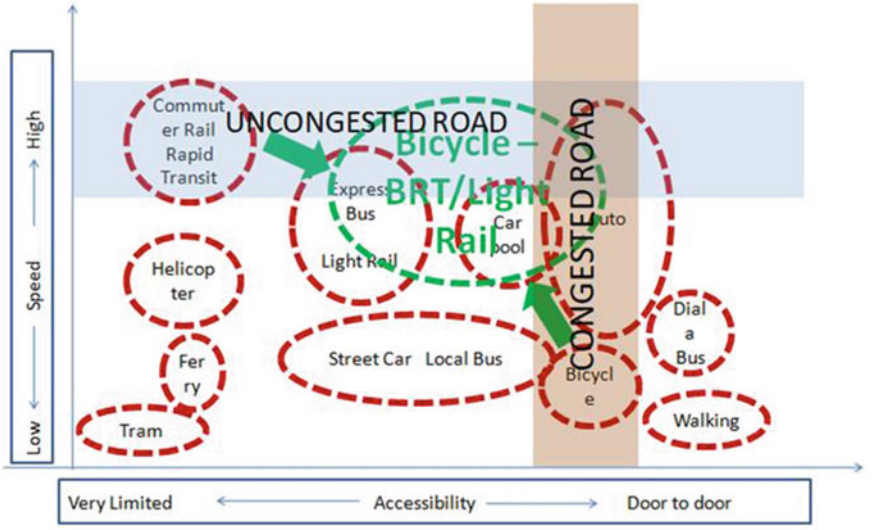


Fig. 83 Speed vs accessibility of different modes. *Source* Author

- To identify various means for pedestrianization of town and reduce the pedestrian–vehicle conflict to the extent possible.
- To increase connectivity to major nodes [1].

The above Fig. 83 plots different modes of transit in speed vs accessibility graph. Non-motorized transport is proposed for Intrazonal and Mass Rapid Transit for Interzonal transport is being proposed. The factors addressed include last-mile connectivity, seamless flow of information, low-cost, enjoyable, environment-friendly and highly efficient mode of transport.

5.5.1 Street Lights

In Kattangal, a very few roads have street lights; out of which, most of them are not in working condition. The distance between two street lights is way more than the standards, the street lights are mostly placed in the junctions rather than throughout the stretch. The standard distance between the poles should not be more than 30 m. A staggered arrangement is proposed which can increase the efficiency of lighting. Considering 12-h usage per day with 36w beta-lighting will be required per day for whole study area.

Two types of street lights are provided here:

- 12 m for bigger and wider main roads (414 no. in study area with 30 m interval).
- 6 m height street lights for smaller inner roads (1116 no. in study area with 30 m interval).

Solar panels are included for the reduction in power consumption. Surveillance camera is also fitted onto the streetlights for effective monitoring. Digital advertising boards are also placed for revenue generation. Figures 84 and 85 show the section details of street lights with 6 m and 12 m of heights, respectively. The map given below in Fig. 86 depicts the spatial allocation of street lights of both heights.

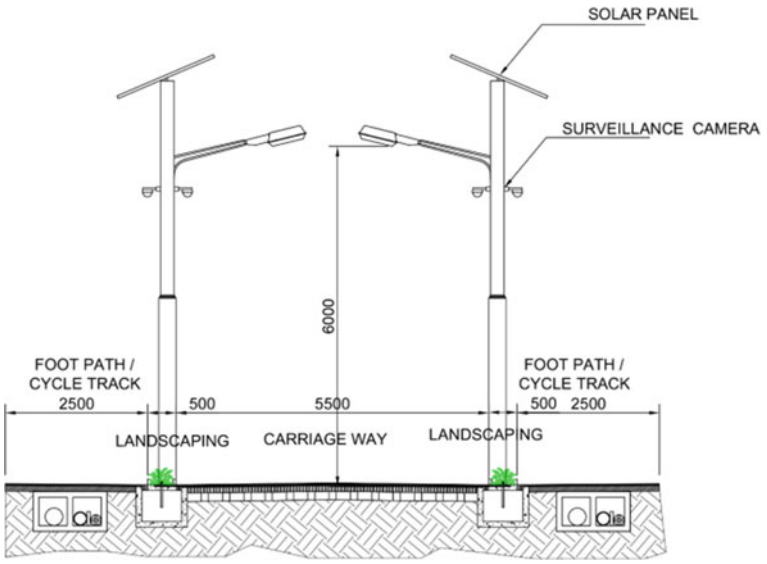


Fig. 84 6-m-high street light

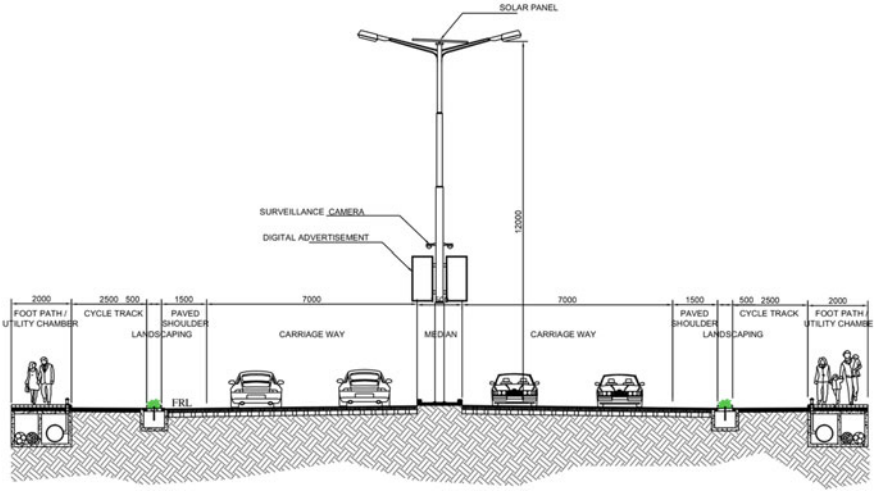


Fig. 85 12-m-high street light

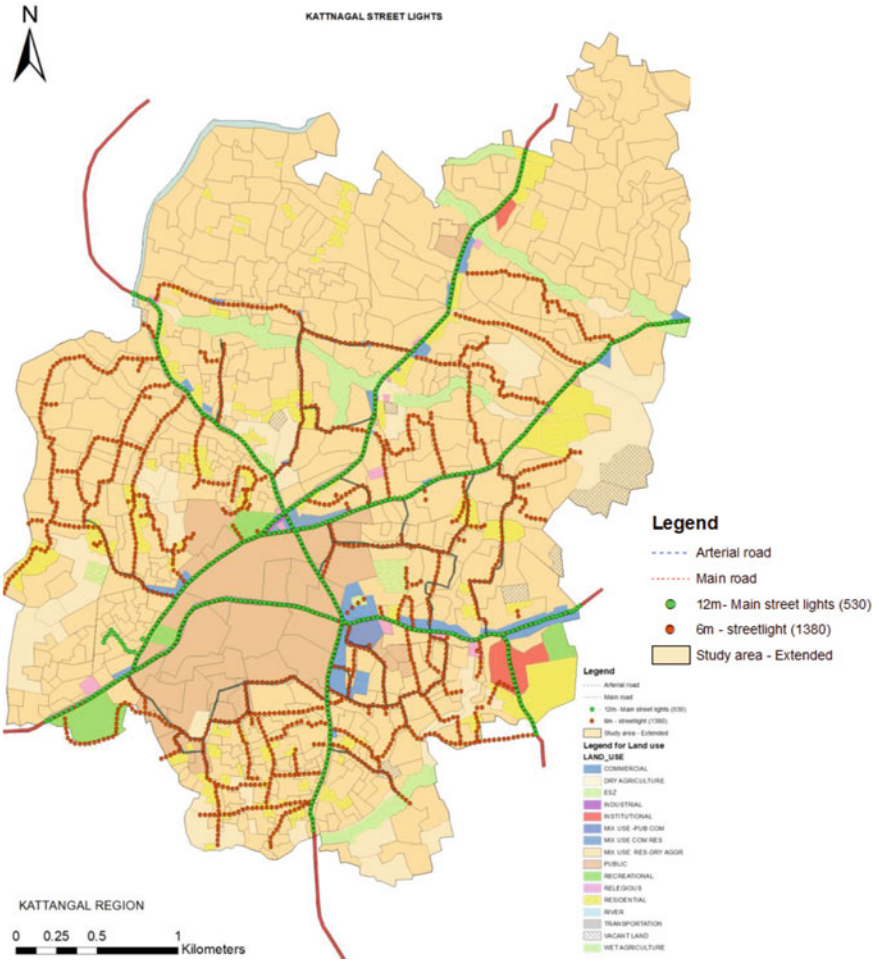


Fig. 86 Spatial allocation of 6 m and 12 m high street lights. *Source* Author

5.5.2 Bus Stops

The lack of properly facilitated bus stops is very evident in the Kattangal region and its converging roads. The heavy rainy climatic conditions of Kattangal make it more susceptible to depend upon good infrastructure.

Poor choice of its location, especially near busy junctions like Kattangal creates a lot of traffic congestion and accidents (Fig. 87).

The proposal is to relocate the bus stop and ensure adequate number of bus stops are provided. An average distance of 30–50 m is maintained from the junctions to the locations of bus stops. The following considerations are taken into account for locating bus stops:

Fig. 87 Existing location of bus stops in Kattangal. *Source* Author

- Away from sites likely to be obstructed.
- Clea visibility of driver and prospective passengers to each other.
- Close to main junctions without affecting road safety or junction operation.
- Back-to-back on opposite sides of the road.
- Close to (on the exit side of) pedestrian crossings.
- Availability of sufficient footpath width.
- Availability of space for bus shelter.

The possible locations for bus stops after careful analysis are shown in Fig. 88.

5.5.3 Kattangal Junction Design

Kattangal junction is a busy sprawling junction with a commercial activity centred around NITC Calicut student population as shown in Figs. 89 and 90. This lively junction lacks proper parking space, footpath. Continuous sprawling of vendors is also seen along the side of the road. The roads do not have enough street lights to light up during the night making it seems uninviting to walk through. The roads do not have pathways on both sides. The surrounding environments do not look maintained. There is a lot of space wasted between the roads and the commercial buildings.

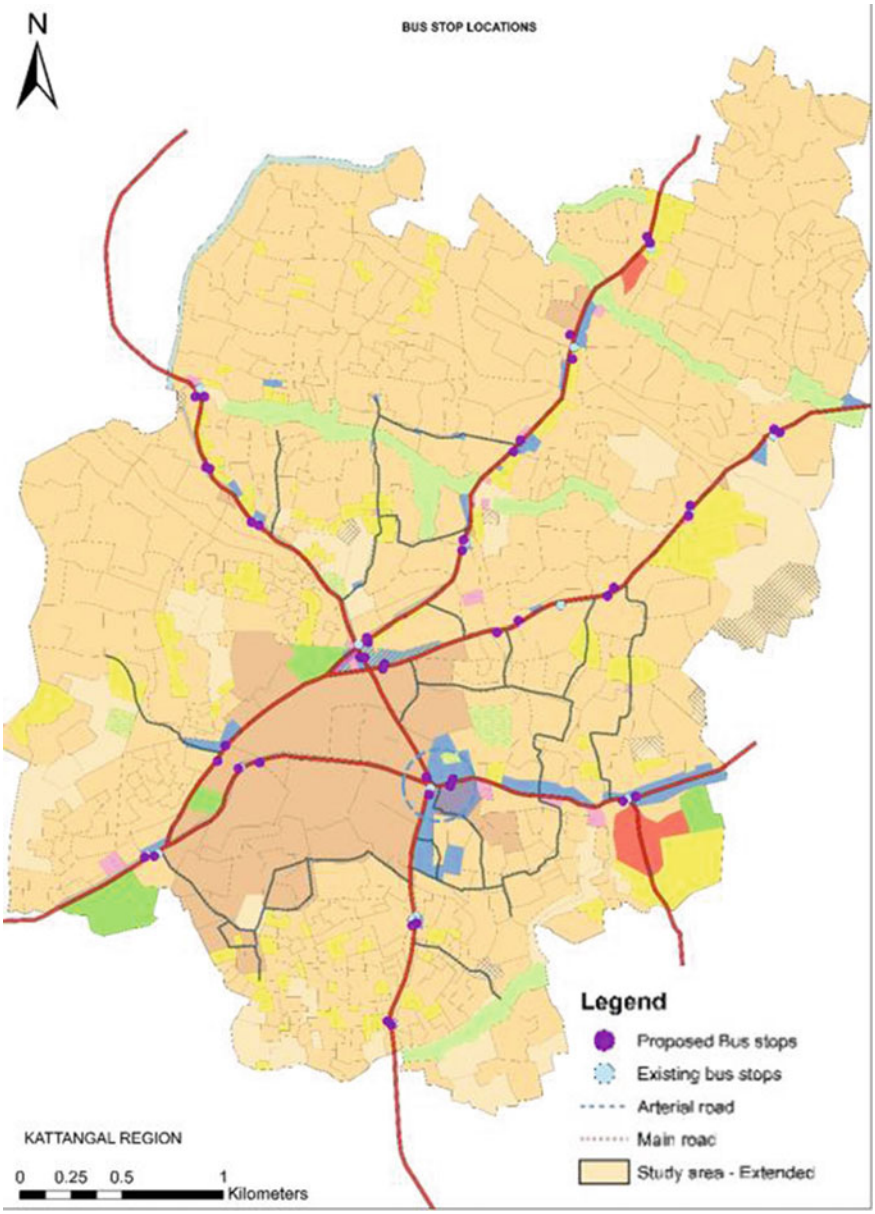


Fig. 88 Location for bus stops

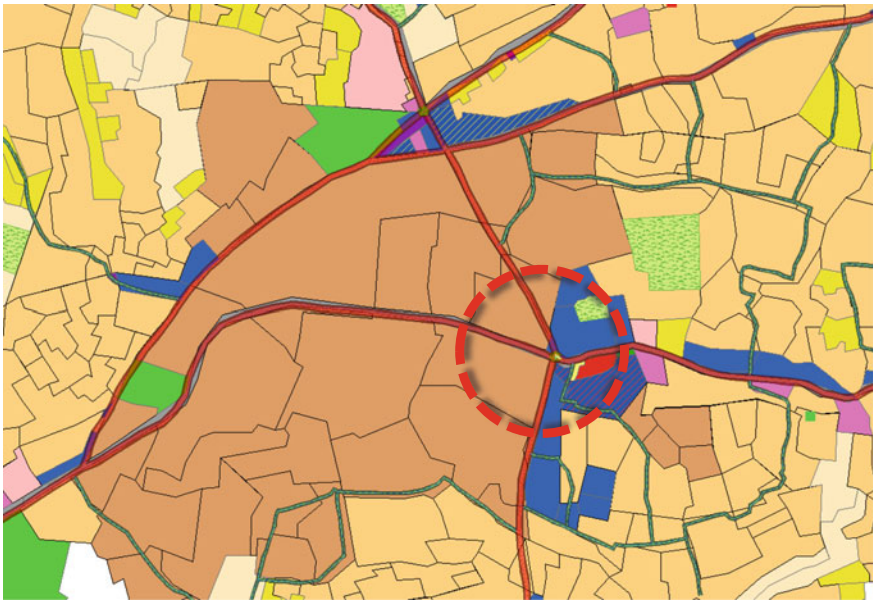


Fig. 89 Kattangal junction

Fig. 90 Existing condition of Kattangal junction and nearby surroundings. *Source* Author

A redesign of spaces was attempted for the junction. The Figs. 91, 92 and 93 shows the visualized Kattangal junction with spaces utilized to maximum making it a hub for the global economic activities envisaged.

5.6 Smart People

'Smart People' solutions enhance the creation of an accessible and inclusive environment to increment prosperity and innovation within a city or community. Participation, open-mindedness, and creativity are some aspects that are enabled by implementing intelligent solutions. Various proposals are formulated to make the residents smart, as follows.

Fig. 91 Redesign of spaces in Kattangal junction

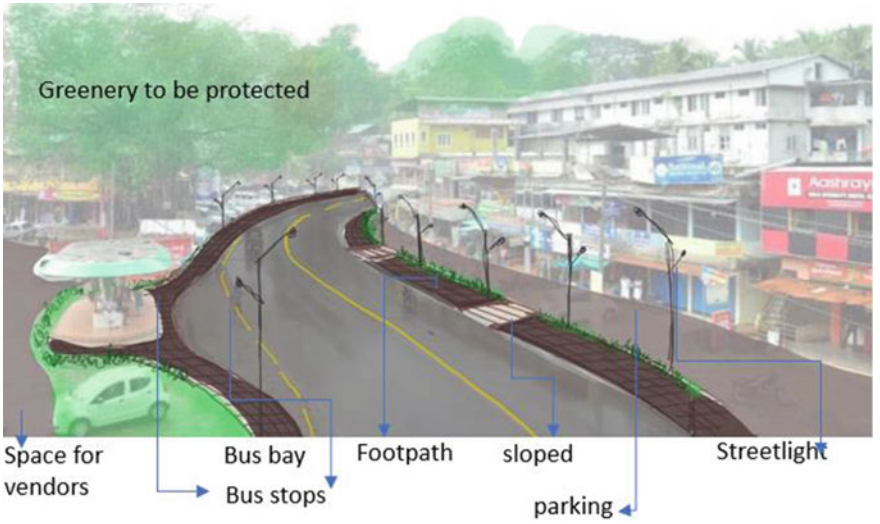


Fig. 92 Redesign of spaces in Kattangal junction

Fig. 93 A sample design

5.6.1 Slum Improvement and Upgradation—Marginal Workers

A SGEC Management Portal is proposed. The management portal, is the system to manage all the resources which are land, water, energy and environment. It has the interface to manage the workspace and storage space component of the SGEC as well. The management portal is aimed at making the people smart people. Smart governance is the key stone of a SGEC as it is making all the smart services and products accessible for the people making them smart people [1]. In the district, 79.5 of the workers are main workers and 20.5% are marginal workers (Kozhikode Census 2011), and 21% of people are marginal workers, mainly secondary and primary sector workers and some tertiary sector employees like drivers, etc. as shown in Fig. 94.

Twenty percent of working people show willingness to work alternatively which can be attributed to the fact that 21% are marginal workers. Also, 45% people are willing to switch to community-generated local employment. Figs. 3 and 17 had already discusses the statistics related to the same.

The management portal is the system to manage all the resources which are land, water, energy and environment. It has the interface to manage the workspace and storage space component of the SGEC as well. The management portal is aimed at making people smart people. Smart governance is the keystone of an SGEC as it is making all the smart services and products accessible to the people making them smart people.

Pages or groups for marginal workers including migrant workers can be created. This is an opportunity for the marginal workers to connect with other workers and can also cater to migrant workers. This should be programmed in different languages as well.

Important Statistics					
		State		District	
		Number	Percentage	Number	Percentage
Literates	Persons	28,135,824	94	2,615,443	95.08
	Males	13,704,903	96.11	1,266,939	97.42
	Females	14,430,921	92.07	1,348,504	92.99
Scheduled Castes	Persons	3,039,573	9.1	199,191	6.45
	Males	1,477,808	9.22	97,279	6.61
	Females	1,561,765	8.99	101,912	6.31
Scheduled Tribes	Persons	484,839	1.45	15,228	0.49
	Males	238,203	1.49	7,429	0.51
	Females	246,636	1.42	7,799	0.48
Workers and Non-Workers					
Total Workers (Main and Marginal)	Persons	11,619,063	34.78	948,981	30.75
	Males	8,451,569	52.73	752,333	51.15
	Females	3,167,494	18.23	196,648	12.17
(i) Main Workers	Persons	9,329,747	27.93	754,187	24.44
	Males	7,179,828	44.8	637,099	43.31
	Females	2,149,919	12.37	117,088	7.25
(ii) Marginal Workers	Persons	2,289,316	6.85	194,794	6.31
	Males	1,271,741	7.93	115,234	7.83
	Females	1,017,575	5.86	79,560	4.93
Non-Workers	Persons	21,786,998	65.22	2,137,312	69.25
	Males	7,575,843	47.27	718,609	48.85
	Females	14,211,155	81.77	1,418,703	87.83

Fig. 94 Demography of Kozhikode District. *Source* Census 2011

5.6.2 Male and Female Marginal Workers

Connecting female marginal workers with Kudumbashree for training, workspace sharing and cultural inclusion.

5.6.3 Deen Dayal Upadhyaya Grameen Kaushalya Yojana-

This central government scheme adds diversity to the incomes of rural poor families and caters to the career aspirations of rural youth

5.6.4 M-health—Asha Workers

Asha Workers can provide immediate health facilities and education to women.

5.6.5 Smart Workers App

For information, networking and support services to the marginal workers where migrant workers will also be included. This will allow the workers to feel safe where peer support is given to people who are in trouble. Information on work permits, domestic workers' rights and other employment issues should be delivered through animations that are in easy-to-understand formats. Information about health facilities can also be provided at affordable costs.

5.6.6 Padhai App/Education App

Language lessons and other tutorials to educate girls and boys who don't get a chance to go to school. This can help the families of the marginal and migrant workers.

Other proposals include recreational zones for migrant workers to celebrate their festivals and recreational activities. Cultural zones can also be added to these for the celebration of festivals and activities.

The architecture of all the three proposals are depicted in Figs. 95, 96 and 97 respectively.

5.7 Proposals for Smart Governance

Smart master planning concept integrates information and communication technology (ICT), nd various physical devices connected to the IoT network to optimize the efficiency of operations and services in the planning area and connect to citizens. ICT and IoTs allow officials to interact directly with both community and city

Fig. 95 Architecture of Smart workers app. *Source* Author

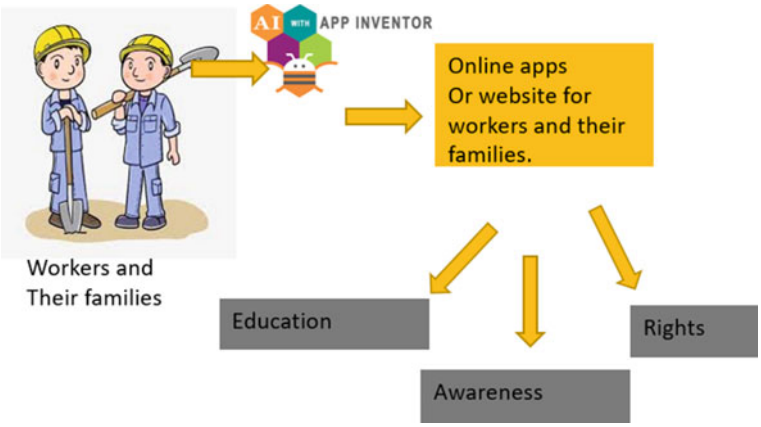


Fig. 96 Architecture of Padhai App. *Source* Author

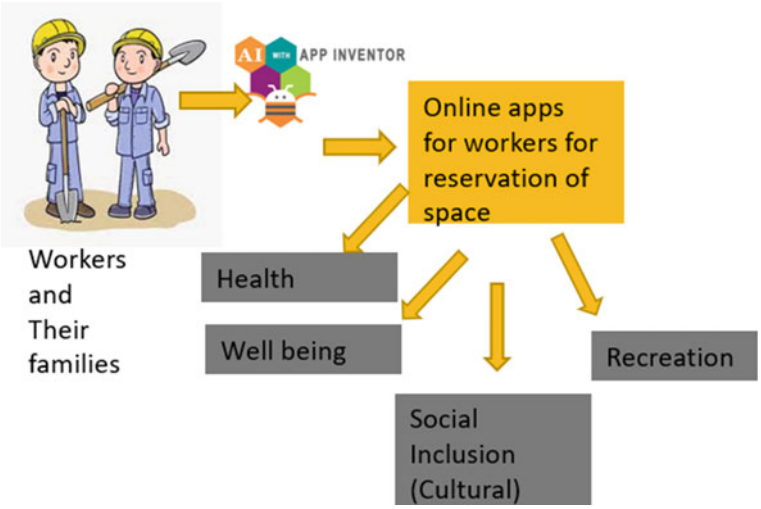


Fig. 97 Architecture for application to promote socio economic development of workers. *Source* Author

infrastructure and to monitor and help in decision-making through e-democracy and e-governance as well.

5.7.1 Regulation of Land Use and Building Construction

The land use and building constructions in any local self-government jurisdiction are majorly regulated through two tools, namely:

(1) Building permit, essentially the permission by the local body to carry out building construction activities.
(2) Occupancy certificate, the stage at which it is ensured that the constructed buildings are in accordance with the permitted drawings and specifications. A survey carried out among various beneficiaries resulted in the following inferences:

- Verification of applications for various rule compliances carried out manually by the concerned officials causes major delays in processing permit applications.
- Currently, there is no integration among different line departments issuing NOCs and the respective LSGs processing the permit applications
- The process of rule verifications needs to be simplified, streamlined and made easily accessible to the public through ICT/IoT means
- Corrections and resubmissions happening in submitted drawings are another major cause of delay in the permit process
- Clerical delays cause unnecessary hurdles in issuing building permits.
- Majority of the application for building permit fall under the category of single-family residential buildings with an area ranging 50 to 150 m^2.

So, the efficiency of regulation of land use and building constructions can be largely enhanced through the use of M2M connectivity. It is proposed to have the following stages of verifications as shown in Fig. 98.

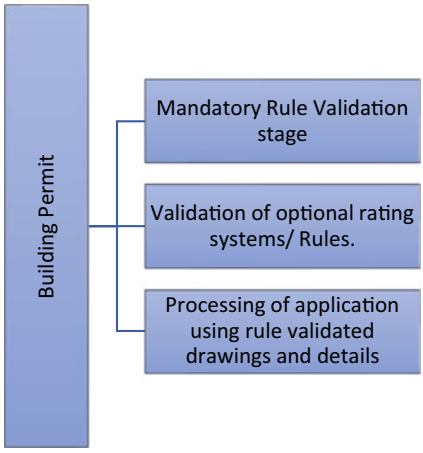


Fig. 98 M2M stages of verifications proposed for processing building permit applications. *Source* Author

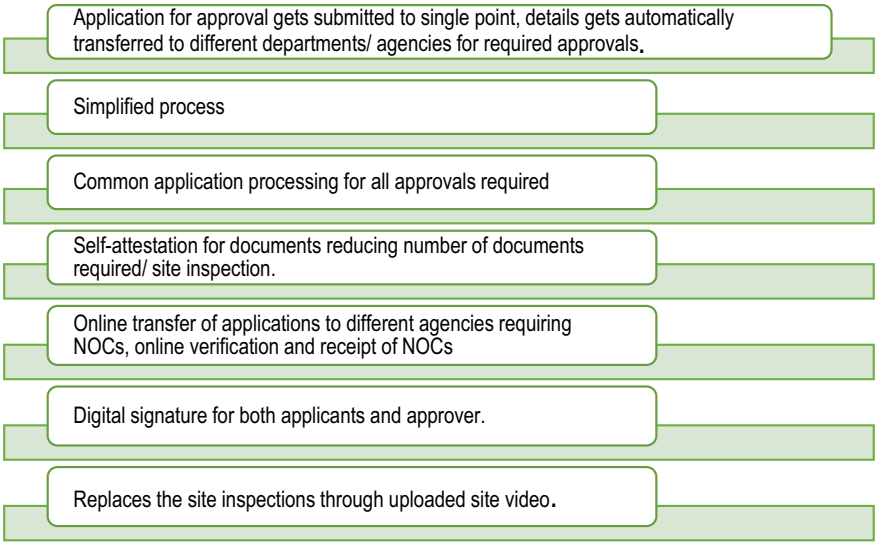


Fig. 99 Steps involved in Single-window clearance system. *Source* Author

Web-Based Processing of Building Permits and Occupancy Certificates

This involves an integrated licensing process, with a single point of application to simplify the entire licensing/permitting process in line with the requirements of the Smart Global Economic Community.

A single-window online clearance system has been proposed. The procedure involved is shown in Fig. 99.

Land uses and the construction of buildings in regions belonging to Panchayath are mainly regulated through the following rules and regulations:

- The respective development control regulations (zoning regulations) of the sanctioned master plans/detailed town planning schemes if any.
- Kerala Panchayath building rules, latest amended on 08 November 2019.
- Coastal regulation zone (CRZ) rules.
- Kerala conservation of paddy and wetland rules.
- Fire and safety requirements by the Kerala Fire and Rescue Department.
- Land use regulation requirements by defence, railways, Kerala Urban Arts Commission, State-Level Environment Impact Assessment Authority, Kerala Pollution Control Board, Airport Authority of India, Archaeological Survey of India.

Kattangal Smart Global Economic Community belongs to Chathamangalam Grama Panchayath, of Kozhikode District. There are no legally sanctioned master plans/detailed town planning schemes in the planning area. Kerala Panchayath Building Rule 2019, and fire and safety requirements by the Kerala Fire and Rescue

Department form the regulatory mechanism for the construction of buildings in Kattangal SGEC. Many areas in Kattangal SGEC fall under Kerala Conservation Paddy Land and Wetland Act of 2008. There is no area to be regulated under CRZ regulation, Defence, Railway, Kerala Urban Arts Commission, State-level Environment Impact Assessment Authority, Kerala Pollution Control Board, Airport Authority of India, Archaeological survey of India in Kattangal SGEC.

6 Smart Zonal Plan

The proposals discussed in the previous chapters will be implemented through the Smart Zonal Plan that envisages the spatial and execution details. The land use pattern and the spatial allocation of proposals are shown in Fig. 100.

6.1 Land Use Strategies

The land use pattern of the study area is derived from the location of major nodes and the road infrastructure. The residential units are distributed in a homestead pattern and the commercial areas developed around the major nodes of activity. The residential density is higher along the major roads and lesser in the interior lands. All the telecommunication lines are laid along the major roads where the power grid line is taking route through the least dense area as it is of high risk. The strategies which could be opted based on the inferences are:

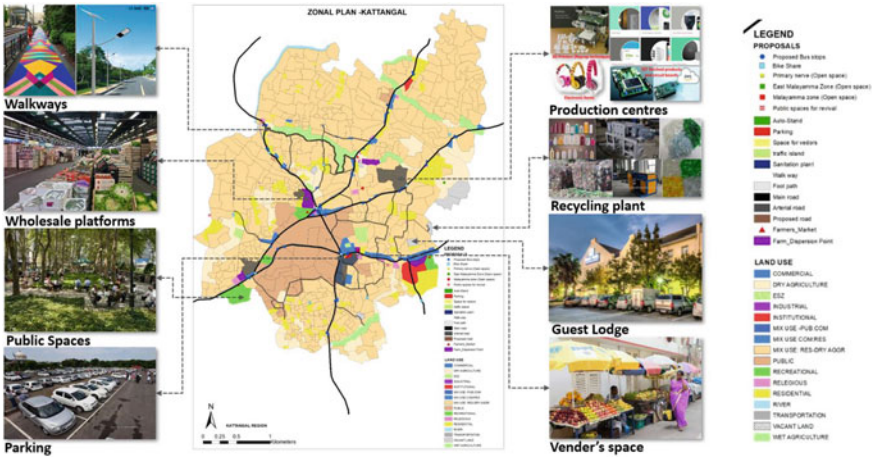


Fig. 100 Land use plan for zonal plan, SGEC Kattangal. *Source* Author

- The workspace can be provided at the locations with higher residential density since they are the most serviced areas and easy to pool the workforce.
- The remote areas or interior land can be used for power generation area with the installation of PV cell systems.
- The available vacant land can be used for incorporating recreational spaces.
- The poorly maintained agricultural land can either be used to revamp the agricultural production or to create more open spaces for public recreational activities.
- The natural slope towards the natural watersheds can be effectively used to design the water supply and sanitation network facilities.
- Since the area is covered with 4G mobile network coverage and is deployed with an optical fiber network which can be updated to 5G in future, the use of ICT devices and equipment are very much possible
- With the help of smart governance systems, it is possible to incentivize the landowners who are ready to pool their land for work pace or storage space for SGECK.

6.1.1 Social Capital Creation

Social capital refers to the institutions, relationships and norms that shape the quality and quantity of a society's social interactions. Social cohesion is critical for societies to prosper economically and for development to be sustainable. Social capital is not just the sum of the institutions which underpin a society, it is the glue that holds them together.

6.1.2 Standard of Distribution Based on Relative Value

Since land values are rarely homogeneous, the distribution based on relative value is practiced more widely in Germany. The principle of this method is to share the benefit created by the development project between the government and the landowners.

6.1.3 Web-Based E-Real Estate

A portal with all the economic status, from the percentage profit in each business to rise/fall in land value. This could function like a stock market on land and property, the registered enterprises could access the data online and make calculated investments.

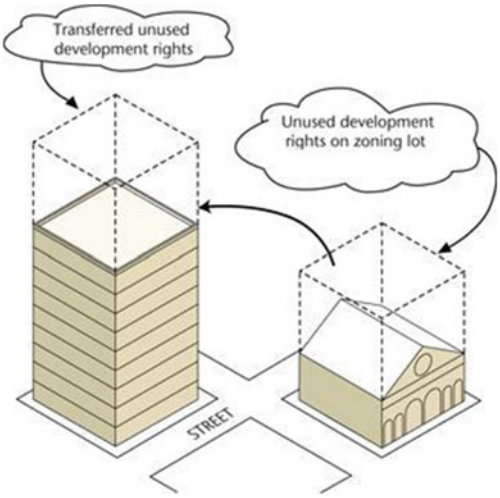


Fig. 101 Demonstration of TDR

6.2 Tools for Cashless Land Management

6.2.1 Transfer of Development Rights (TDR)

Under the TDR concept, the development potential of a plot of land partly or fully reserved for public purpose can be separated from the land itself and be made available to the owner of the land by way of TDR in the form of Floor Space Index.

Such award entitles the owner to the Development Right Certificate (DRC), which he may himself use or transfer to another person. If the FSI granted cannot be used on the land not covered by acquisition, the landowner is free to use the additional FSI on the lands located in other parts of the city. This way, the exorbitant costs of acquisition of urban land for public purposes can be met by a system of compensation in kind rather than in cash (Fig. 101).

6.2.2 Computer-Based Management

Urban land use management is a multi-component and multidisciplinary process, which requires more than a single method for reasonable results. Land management details will be available to citizen through a web portal. Each land use can be tagged with:

- Associated TP scheme.
- Transfer of development rights.
- Land acquisition details.
- Involvement procedure.
- Documents required to be uploaded.

Fig. 102 Space allocation for farm market

The visitor should be able to access the ongoing processes of e-ULM and past ones. The land values can be updated regularly by fixing a cap price by a regulating board. The plots availed with FAR increase will be visible.

The precise boundaries of the target project area are legally defined and the responsibilities for the same lie with the local governments. The draft plan of infrastructure is drawn up to calculate the estimated project budget and determine the availability of the national subsidies, land needed from landowners for public use and saleable use. The consent is solicited from the landowners. For the association-led projects, the legal requirement is 66% of landowners owning 66% of the land must sign a contract consenting to the project before it can proceed. The re-plotting design, financial plan, project implementation plan and land contribution of each landowner must be approved by the Board and 66% of landowners in association-led projects. Project completion, financial reconciliation and return of readjusted parcels to participating landowners shall be specified.

6.2.3 Farm Market

The area estimation of farm market is given in Table 13 and the spatial detailing is shown in Fig. 102.

6.2.4 Proposed Walkway

The area estimation of the proposed walkway is given in Table 14 and the spatial detailing is shown in Fig. 103.

6.2.5 Waste Treatment Plant

The area estimation of the proposed walkway is given in Table 15 and the spatial detailing is shown in Fig. 104.

Table 13 Area calculation for farm market

Proposal	Land Required (sq.m.)	Land taken from (AN Plot Number)	Original Plot Area	Revised Plot Area	Original Land use	Proposed land use	Land use change
Farm Market-1	35974.6	MX_R-DA_599	28540.8	0	Mixed – Residence & Dry Agriculture	Commercial	Yes
		MX_R-DA_596	9188.35	0	Mixed – Residence & Dry Agriculture	Commercial	Yes
		MX_R-DA_595	1726.36	0	Mixed – Residence & Dry Agriculture	Commercial	Yes
Farm Market-2	18712.6	WE_354	18712.6	0	Wet Agriculture	Commercial	Yes
Farm Market-3	10075.6	MX_R-DA_531	10075.6	0	Mixed – Residence & Dry Agriculture	Commercial	Yes
Farm Market-4	19010.4	MX_R-DA_728	16926.5	29671.85	Mixed – Residence & Dry Agriculture	Commercial	Yes
		REC_729	31687.5	0	Recreational	Commercial	Yes
Farm Market-5	4819.16	MX_R-DA_406	4819.16	0	Mixed – Residence & Dry Agriculture	Commercial	Yes

Table 14 Area calculation of proposed walkway

Proposal	Land Required (sq.m.)	Land taken from (AN Plot Number)	Original Plot Area	Revised Plot Area	Original Land use	Proposed land use	Land use change
Walkway	28959.2	MX_R-DA_16	12005.4	9991.98	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_622	12207.5	10497.7	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_20	35175.3	026913.9	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_22	19778	26913.9	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_23	38131.3	33845.39	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_24	40995.8	39978.1	Mixed – Residence & Dry Agriculture	Recreational	Yes
		C_746	350.98	205.35	Commercial	Recreational	Yes
		MX_R-DA_25	39415	34527.2	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_35	31597.4	27669.93	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_38	39219.9	38244.15	Mixed – Residence & Dry Agriculture	Recreational	Yes
		MX_R-DA_161	34436.2	28962.03	Mixed – Residence & Dry Agriculture	Recreational	Yes
		C_44	4789.63	4199.15	Mixed – Residence & Dry Agriculture	Recreational	Yes

Fig. 103 Spatial detail of proposed walkway

Table 15 Area estimation of waste treatment plant

Proposal	Land Required (sq.m.)	Land taken from (AN Plot Number)	Original Plot Area	Revised Plot Area	Original Land use	Proposed land use	Land use change
	377.12				Vacant Land	Industrial/Infrastructural	Yes
Sanitation plant		VL-687	11405.6	10391.7			
Parking	352.5				Vacant Land	Industrial/Infrastructural	Yes
Plastic recycling plant	284.24				Vacant Land	Industrial/Infrastructural	Yes

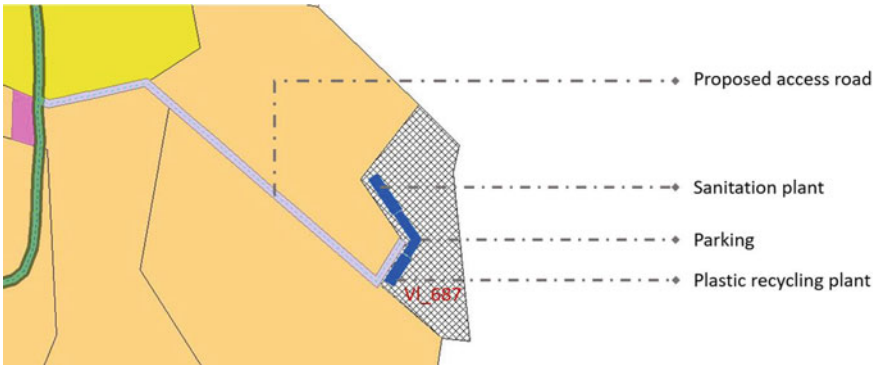


Fig. 104 Space allocation for waste treatment plant

6.2.6 Alpha-Numeric Coding

Alpha-numeric coding could be employed in spatial planning to integrate every activity in a planning process. This could provide ways to formulate instant and clear transactions in checking for approvals. The streamlining of various land use

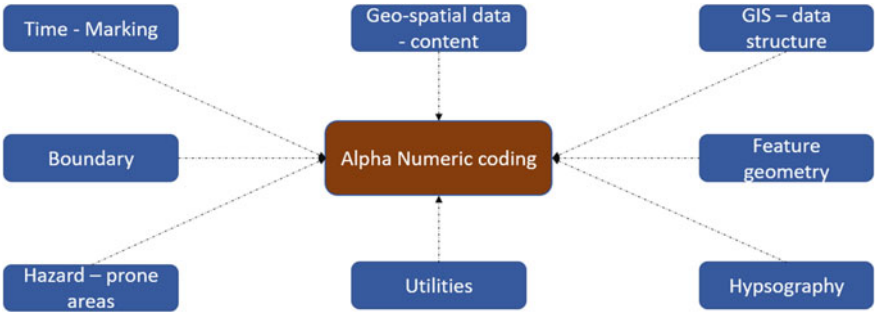


Fig. 105 Alpha-numeric codes built based on AMRUT Guidelines

classes could be done very efficiently. Interactive and easily understandable plans could be prepared. Many planning organizations throughout the world are still formulating ways and structures to induce planning operations with alpha-numeric coding (Fig. 105).

6.3 Web-Based Interactive Map for Kattangal SGEC

A web-based interactive map 'smartkattangalonline' is created using ArcGIS online platform. It includes unique alpha-numeric codes for features. An interactive legend is created using Public Information app. The shareable link is available on the upper right-hand side of the map. The map display can also be viewed as 'topography' or 'imagery with labels'. This map can be updated frequently to reflect changes. The multiple layers available are depicted in Fig. 106.

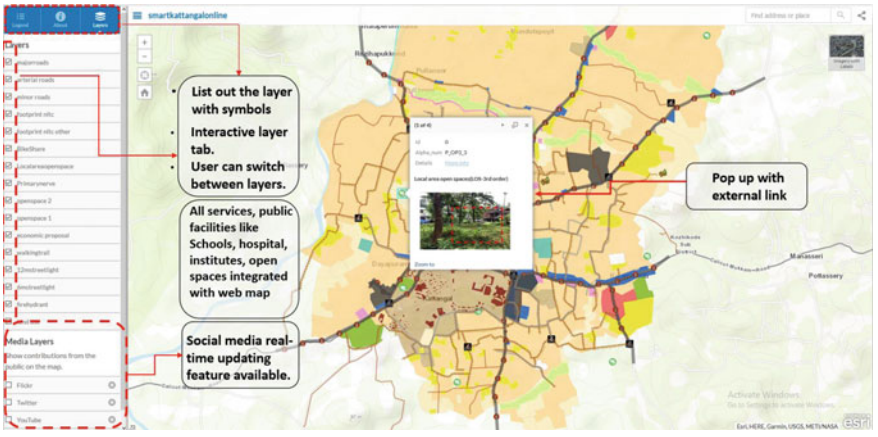


Fig. 106 User interface of smartkattangalonline

7 Conclusions

The study captures global prospects of the locally available resources and skills and implements smart planning to achieve a Smart Global Economic community. Governance is simplified through the use of web-based system and ensures smooth transactions between domestic and international regions. Transparency is ensured for all. Globally inviting facilities and dedicated facilities for enterprises are planned. The basic needs of the residents, shopkeepers and the weaker sections of the community are addressed. Public healthcare and education facilities can be accessed by all and availed from a single platform. The consideration of recreational spaces being provided for a healthy community and inducing a creative atmosphere for various entrepreneurs and artists will help them contribute to future proposals of business transactions in the global market.

The plan is formulated towards not just achieving a productive link between local markets and Global Economy but also enabling greater economic self-sufficiency in the study area. The inclusive and democratic mechanism established through various IOTs and ICTs could add greater social cohesion and collective decision-making. The emphasis is also given to economic growth through sustainable measures with schemes to move towards circular consumerism and renewable energy with frugal waste management measures. Overall, Kattangal is envisaged towards a stable and thriving local economy that influences Global Market by facilitating the local social infrastructure and enriching them with every productive return. That makes it a Smart Global Economic community.

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Conclusion

International Collaborative Research: Smart Master Planning of Cities Case studies of Digital Innovations and Conclusions

T. M. Vinod Kumar

Abstract This chapter has two parts. In the first part, objectives and the organizational details of the international collaborative research project 'Smart Master Planning' is discussed. The second part is presented in consultation with the team leaders of the city study, their general conclusions of the study Smart Master Planning.

Keywords Study · Organization of study · Results

1 Smart City Research and Smart Master Planning

The International Collaborative Research Projects on Smart Master Planning.

This book is 11th and 12th in two volumes, in a series, Professor T. M. Vinod Kumar conceived, coordinated, implemented and edited about articulating the various aspects of smart cities and roles of Smart People in Smart Cities. These two books discuss how smart people innovatively create Smart Master Planning.

The first book in this series entitled 'Geographic Information System for Smart Cities' in 2014 [1] was aimed at creating a comprehensive and spatial self-awareness of city functioning every second and every day in real time which is the foundation of Smart City. Geospatial technologies, sensors and analytics can be used to augment the awareness and use it in real time for various types of use by Smart People. How it can be used for a variety of urban issues commonly observed globally is what that book is all about.

These Smart People thereby progress towards their self-directed goals, such as they demand Smart City that connects more people for smart community action, and Smart Economic Development that change their living. They aspire to the highest level of quality of life in Smart city living which they can very well afford by expanding many folds the economic development opportunities to satisfy higher income and employment needs to sustain Smart People. No smart person in a city

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is an island or isolated elite, but they share a common destiny and common urban space, urban realm and social and physical infrastructure. The government as the regulator is required that none of the Smart People is denied of all cities provides for irrespective of their income level and social status or they are above or below the poverty level. Hierarchy of government exists in a city, but their governance needs to be for a Smart City that is fully aware of itself every second and as against Government who comes to know about the issue when a case is filed in the court which takes many decades to get a final judgement. The existing governance systems are obsolete being a product of sixteenth century or earlier designed for colonial rulers and not for smart inhabitants, built on the model of East India Company's administration in India or elsewhere which cannot be used for Smart city economic development and the smart global megacity creation and functioning. However, those who aspire to live in Smart Cities are in the twenty-first century and no more part of an exploitative empire under the iron hand of a colonial administrator. Therefore, the twenty-first-century Smart Cities require a Smart city e-governance system that was the subject matter of the second book entitled 'E-Governance for Smart Cities' [2]. This book is all about E-Governance in Smart Cities in action. It is divided into three parts, State of the Art Surveys, Domain Studies and Tools and Issue of E-Governance in Smart Cities.

The third book in this series is, 'Smart Economy in Smart Cities' [3]. This book explores possibilities for rapid change in the income level and employment opportunities of those Smart People below or above the poverty level in a Smart City, and to make the NDP growth rate to a desired higher level consistently for the next many decades. Then, the current trend of urban local economic development is required to be converted to Smart city Economic Development. A 10% NDP growth rate envisaged for the next three decades in India and many other countries can only be realized through Smart city Economic Development. The projection that Indian GDP in PPP will be the second largest in the world after China in 2050 can only be realized through smart metropolitan or megacity economy. Smart Cities and the related conceptualization boast of the Smart Economy but not much has been systematically researched or documented about it so far. This calls for a study of many cities across the world to document what constitutes a Smart Economy. There are two groups of cities being studied in this book. Some of them have been designated as Smart Cities by learned societies, but others are not but aspire to be Smart Cities. These call for different approaches to research design and studies. It was seen from case studies both these cases in different countries emphasize different approaches, establishing that there are no cookbook solutions. The cities being studied in this book are spread across several major continents and regions, including North America, Europe, Africa, the Indian subcontinent and East Asia. They are Ottawa in Canada; Stuttgart in Germany; Bologna in Italy; Dakar in Senegal; Lagos in Nigeria; Nairobi in Kenya; Cape Town in South Africa; New Delhi, Varanasi, Vijayawada and Kozhikode in India; Hong Kong in China, Cape Town, Dakar, Nairobi and Lagos in Africa.

The fourth book in this series is 'E-Democracy for Smart Cities' [4]. The world over, participatory democracy is worshipped and preached but what is practised is representative democracy at the city level and beyond. It is believed that in meta

cities, megacities and metropolitan cities, only representative democracy with elected representatives will work. However, democracy practised in small cities like Athens in Greece, and the Licchavi Republic in India in ancient times and many parts of the world documents face-to-face democracy in practice. In these cities, everyone in a city sat together and jointly decided on all aspects of the city/country during war or peacetime. Citizens not only participated in decision-making but also acted together as one government and even as an administrator for a task and as a regulator. There were no permanent administrators then. With the advent of ICTs in Smart Cities of the twenty-first century, it is possible to go back to the face-to-face democracy in meta city with 20 million-plus population, a megacity with 10 million-plus population and metropolises with one million-plus population that, by any measure, is much superior to representative democracy. We do not want middlemen the representative of the citizen to make legislations but all citizen using electronic medium demonstrates the creation of regulations based on their ability to think and act under the constitution. The fourth book is all about E-Democracy in Smart Cities in action. It is divided into three parts, State of the Art Surveys, Domain Studies and Tools and Issue of E-Democracy in Smart Cities.

The fifth book in the series is' Smart Metropolitan Regional Development: Economic and Spatial Design Strategies' [5]. Here, these cities however large these cities may be, need to be converted to smart metropolises using the specific design of economic and spatial strategies and not by purchasing smart technologies alone. The city studies for the 'Smart Metropolitan Regional Development' result in many insights into many smart spatial and economic strategies using the Internet of Things, Internet of Democracy and Internet of Governance oriented to the specific issue of a town and its potential; taking into consideration that the Smart metropolitan city is an integrated six systems in which Smart Economy is a dominant component. The smart economy can relate to Smart Mobility or Smart Environment. Based on the elaboration of the Smart metropolitan city System, if one must develop any metropolitan region, then a country- and city-specific economic and spatial design strategies for a Smart metropolitan city, must be designed based on a local ecological and cultural system of the city and not a type of universal design. Location-specific and culturally acceptable economic and spatial strategies can be locally evolved, governed, and managed. This is the only way local culture will find expression in the Smart metropolitan city using specific economic and spatial strategies by utilizing local, creative talents of smart people in many institutions in Smart Cities. Sixteen cities were studied in this project, namely, Pittsburgh in the USA, Stuttgart in Germany and Naples in Italy, Dakar in Senegal, Conakry in Guinea, Abuja in Nigeria, Johannesburg in South Africa and Nairobi in Kenya, Ahmedabad, Gandhi Nagar, Bangalore, Chandigarh, Jaipur, Kozhikode, New Delhi, Surat in India and Hong Kong and greater Pearl River Delta Region from China.

The sixth book that was published in mid-2019 by Springer-Nature is entitled 'Smart Environment for Smart Cities' [6] as a product of international collaborative research. This book is aimed at developing the Design and Protocol and Practice of Smart Environmental Resources Management for Smart Cities. Environmental Resources are common proprieties where an active role of Government and People are

required and hence its management is a joint and synchronous effort of E-Democracy, E-Governance and IoT system in a 24-h 7-day framework on any resource in any smart city.

Smart environmental resources management is a practice that uses information and communication technologies, Internet of Things, Internet of Governance (E-Governance) and Internet of People (E-Democracy) along with conventional resource management tools to realise the coordinated, effective and efficient management, development and conservation that equitably improves ecological and economic welfare without compromising the sustainability of development ecosystems and stakeholders. This book presents many cities case studies (Hong Kong in China, Ahmedabad, Gandhi Nagar, Chandigarh, Kozhikode, New Delhi, Patna, Surat, Yokohama in Japan, Nairobi in Kenya and Dubai in the UAE), that is centred on one or all environmental resource each in a city.

The Seventh and Eighth Book in two volumes published by Springer-Nature in 2020 are on smart living for smart cities [7, 8]. The first volume focus on cities case studies and the second volume on community studies and ways and means. This book, based on international collaborative research, is aimed at developing state of the art design of 'Smart Living' for metropolises, megacities and meta cities as well as a community and neighbourhood level. Smart living is one of the six components for Smart Cities: the others being smart people, smart economy, smart environment, smart mobility and Smart Governance. Smart living in any smart city can only be designed and executed by active roles of Smart People and Smart City Government and is a joint and synchronous effort of E-Democracy, E-Governance and ICT–IoT system in a 24-h 7-day framework on all activities. In addition to uses of information and communication technologies, Internet of Things, Internet of Governance (E-Governance) and Internet of People (E-Democracy) the design of smart living utilizes domain-specific tools of many aspects of living by age cohorts to realise the coordinated, effective and efficient management, development and conservation that improves ecological, social, biophysical, psychological and economic well-being equitably without compromising the sustainability of development ecosystems and stakeholders. This book presents many case studies covering many cities centred on domain-specific smart living components.

The ninth and tenth books are on Smart Global Megacities [9, 10]. The editor and coordinator of the book series T. M. Vinod Kumar and many authors who participated in the earlier eight books felt that there is a gap in knowledge about Smart global megacity. Funding for such a collaborative research project like all earlier books was another issue. Universities and research centres dominated in collaborating these smart megacity city research projects. We also found that along with universities, some not-for-profit national and international networks and institutions, city governments and regional governments in certain countries also came forward to participate in this collaborative research programme. The editor and coordinator of the project again felt that this international project shall not seek any external funding other than the internal resource mobilization from within the participating universities.

The 11th and 12th books were entitled Smart Master Planning: Innovations. This book researches the Smart Master Planning of Cities discussing innovations using

case studies. Cities are urban agglomeration the true representation of urbanised geographic space as per the census of India and UNHABITAT and not Municipal boundary, planning area or other towns' administrative boundary fixed arbitrarily. Master Planning approach differs in countries as per the governing system followed whether it is a Communist, Capitalist, Secular, Theocratic or Democratic country, besides based on, emerging urban issues and long-range vision of the city. The Constitution determines the governing system and approach to the City Master Plan by several regulatory legislation encompassing all aspects of city life. This differs from country to country and federal state to state. The constitution is a living document, an instrument that makes the government system work.

The adjective smart indicates a better and more responsive way of doing Master Planning than practised now but goes much beyond. Undoubtedly, there were several such attempts in the past in many countries and federal states to do that from time to time resulting in an ever-growing body of knowledge in planning theory and techniques. However, the concept of smart as applicable to Master Planning is a product of the twenty-first century, which is an emerging topic of great significance, largely unknown and not practised under many systems of Governance. The smart may also involve moving the legacy Master Planning that uses a system of IoTs, ICT, E-Democracy and E-Governance.

These books, based on international collaborative research, is aimed at developing state-of-the-art design for 'Smart Master Planning' for all metropolises, megacities and meta cities as well as at sub-city zonal and community and neighbourhood level. Smart Master Planning accepts that all cities are the smart city in making in a limited way as far as the six components for Smart Cities; namely, smart people, smart economy, smart environment, smart mobility and smart Governance are concerned. The smart Master Planning in any city can only be designed and executed by active roles of Smart People and Smart City Government and is a joint and synchronous effort of E-Democracy, E-Governance and ICT–IoT system in a 24-h 7-day framework on all activities. In addition to uses of Information and Communication Technologies, and Remote Sensing, the design of smart Master Planning utilizes domain-specific tools of many aspects of the city to realize the coordinated, effective and efficient planning, management, development and conservation that improves ecological, social, biophysical, psychological and economic wellbeing equitably without compromising the sustainability of development ecosystems and stakeholders. These two books will present 24 case studies covering more than 24 cities or more cities centred on domain-specific smart planning components. Some studies can be comparative. There will be 26 parts/chapters with one introduction and one conclusion and 24 studies from the study team listed below.

Fig. 1 The location map of the studies conducted in this book

2 Study City's Locations

This book presents many city case studies as shown in the map above (Fig. 1).

3 Design of the Collaborative Research Programme

Research Collaborations worked out is purely voluntary and without any financial support that binds a project together. Since collaborators are universities, Government, research institutions, professional networks and not-for-profit associations from several countries, complete independence for pursuing the research was there, free of the baggage of ideologies of granting organization. They need not accept existing smart cities policies of study cities in their research. The coordinator Editor of the project has no financial or administrative control over an institution participating in the project since he was not in receipt of any grants and did not distribute it. Typologies of the institutions involved in this international project are given in Fig. 2. All these autonomous institutions are guided by the highest standard of scholarship and timely completion of research and publication.

Fig. 2 Typologies of research institutions participating in this book

4 Research Questions on Smart City Research

The kind of collaboration in this international research project requires that all participating institutions shall formulate their research questions and research the methodology which is of use to the country or federal state where these study cities are located. Depending upon the type of city some of which are leading Smart cities, and some are not, the approaches must differ? However, the paucity of empirical evidence on the Smart city opens a new area of research: What strategy intervention brings about Smart city? This is the central focus of the book.

Do smart cities awaken social, cultural development and ecological (environmental) management through smart city development? This question lies at the heart of the proposed international collaborative research programme, and unpacking it gives us four interrelated research questions, as follows:

I. What constitutes a Smart city beyond its official definition by UNHABITAT? This will need identification of the key ingredients and their role in making Smart city and Spatial changes in cities.
II. What changes the Smart city brings to social development, cultural preservation, heritage conservation and ecological management? This calls for understanding the inter-linkages between a Smart city on one hand, with social development, cultural preservation, heritage conservation and ecological management on the other.
III. How and what processes facilitate the changes to the smart city? Do cities bring to social development, cultural preservation, heritage conservation and ecological management? These may include:

    (a) innovation–diffusion (by ICTs and other modes),
    (b) spatial planning,
    (c) sectoral planning (including economic, social development, cultural preservation and ecological management),
    (d) Heritage conservation and management plan and
    (e) institutional and governance processes, among others.

IV. How and what changes can be brought to improve the processes to achieve improved/optimal results? These changes related to the various processes as mentioned in Research Question III.
V. A deeper understanding of changes in the social, cultural and ecological system of the Smart city with the advent of the Smart City and Smart People for smart city development is the focus of study. This research programme and the institutions selected for this purpose as academic collaborators are an effort to address this research gap.

5 Scope of Research

The following outlines the areas that may be covered when researching the 'Smart city' programme. This is an indication only, and it is left to the team to decide what is appropriate.

I. A time-series study of changes in the urban parameters and identifying distinctive features of evolving to the Smart City.
II. Study of theories of the smart city interventions at the smart city level and modelling for study city.
III. The concept of accessibility in the Master Plan and its changes to the increasing use of ICT in Smart Cities for smart city development.
IV. Changing the role of the hierarchy of service areas or watersheds in a Smart city is influenced by the increasing use of ICT to make the city smart.
V. Evolving structure of megacity urban agglomeration and changes required in a Smart city when transformed.

VI. Evolving structure of cities in urban agglomeration and changes required because of the increase in the use of ICT.
VII. Change of spatial standards in a Smart metropolitan city.
VIII. Changes required in zonal policies and plans.
IX. Study of Town and Country Planning legislation and suggest changes as per the special requirement of Smart city.
X. Change of role of community-based organizations (for example, Residential Associations in India) in a Smart city with an increase in the use of ICT.
XI. Change of role of Ward Committee in a Smart city with an increase in the use of ICT.
XII. Change of role of the Municipal Council in a Smart city with an increase in the use of ICT.
XIII. Change of role of the Planning system in a Smart city with an increase in the use of ICT.

Note: The scope of research can be further elaborated by the collaborating institutions but need not be uniform for all study cities. Each department of the university participating in this research programme shall incorporate relevant Smart city Development features appropriate to the goals of each department. The coordinator of this project does not intend to dictate the direction of the research and have a diverse group of collaborating universities, and they should orient their study strictly based on the academic goals of their department.

6 Study Cities

The study city will be selected as a study area by each of the collaborating universities independently, which will be the place the 1-year and two-semester combined effort to conduct this research. Universities participating in this programme adopted different types of collaboration. Some universities used, their doctorate and postdoctorate students, while others used students at masters and first professional degree level. A postdoctoral student in the department can work on a narrow subject area in the study as individual work. While graduate and undergraduate students can work on design solutions for Smart City, Research institutions can charter their strategic areas of research.

7 Project Details

One city will be selected as a study area by each of the collaborating universities independently, which will be the place the 1-year and two-semester combined effort to conduct this research. Universities participating in this programme adopted different types of collaboration.

Table 1 Project details

Parts	Study city	State/country	Authors	Institutional affiliation
1	Introduction		T. M. Vinod Kumar	School of Planning and Architecture, Delhi
2	Hong Kong	China	Sujata Govada	Chinese University of Hong Kong
3	Stuttgart	Germany	Satyendra Singh	University of Applied Sciences, Stuttgart
4	Nairobi	Kenya	Silas Muketha, kienja Kevin, Daniel Githira, Perpetua Mutindi, Naomi Karanja, Romanus Opiyo	University of Nairobi, Tana, and Athi River Development Authority, Alliance Planners and Eco Consultants Ltd
5	Kissi Town	Kenya	Wilfried O. Omollo	Kisii University
6	Coimbatore	Tamil Nadu, India	M. Sumathy Mohan	Bharathiar University
7	Delhi	Delhi, India	Shovan Kumar Saha, Prof. P. S. N. Rao, Vinod Sakle, Rommel Mehta, Chandrani Bandopadhyay, A. K. Sen Gupta, Seva Ram	Sharda University UP, M/A ARCH PLAN Bangalore, Institute of Hygiene and Environmental Sanitation, New Delhi, Sharda University, School of Planning and Architecture, Delhi
8	Ahmedabad	Gujarat, India	R. Srinivas, Sudeep Roy, Harpal Dave	Town and Country Planning Organisation, Ministry of Housing and Urban Affairs, Government of India
9	Surat	Gujarat, India	Krupesh Chauhan	SV NIT, Surat
10	Vadodara	Gujarat, India	Bhasker Bhatt, Jyoti Gill. Pranav Bhangaokar	APIED, Vallabh-Vidyanagar, Anand, D. C. Patel School of Architecture, Vallabh Vidyanagar. (GEPRI) Gujarat Power Engineering and Research Institute, Mehsana

(continued)

The project details of the study city are given in Table 1.

Table 1 (continued)

Parts	Study city	State/country	Authors	Institutional affiliation
11	Bhuj	Gujarat, India	Mona Iyer, Gargi Mishra, Siddh Doshi	CEPT University
12	Gurgaon	Haryana, India	Prabh Bedi	Ansal University
13	Bangalore	Karnataka, India	Shovan Kumar Saha, Vidyadhar Wodeyar, A. K. Sen Gupta, Chitra Chidambaram, Dipti Parashar, Shafia Ahmad	Sharda University UP, M/A ARCH PLAN Bangalore Institute of Hygiene and Environmental Sanitation, New Delhi, Sharda University
14	Kochi	Kerala, India	Fathim Rashna Kallingal, Kenny Joy	
15	Kozhikode	Kerala, India	T. M. Vinod Kumar, Bimal, Firoz Mohammad, Praveen Sankaran, Gopakumar G.	School of Planning and Architecture, Delhi, National Institute of Technology Calicut
16	Bhopal	Madhya Pradesh, India	Amit Chatterjee, Vidhulekha Tewari	School of Planning and Architecture, Bhopal
17	Mumbai	Mharashtra, India	Paulose N. Kuriakose, Adwait Limaye	School of Planning and Architecture, Bhopal
18	Udaipur	Rajasthan, India	Rina Surana, Shovan Kumar Saha	Sharda University, Malaviya National Institute of Technology Jaipur
19	Hyderabad	Telangana, India	Paulose N. Kuriakose, Shalakha Dubey	School of Planning and Architecture, Bhopal
20	Lucknow	Uttar Pradesh, India	Swati Singh, Shovan Kr Saha	Sharda Universit
22	Kolkata	West Benga, l India	Arnab Jana	Centre for Urban Science and Engineering
23		India	Prmod Kumar	Indian Institute of Remote Sensing
24	Singapore	Singapore	Malone Lee Lai Choo	National University of Singapore
25	Dubai	UAE	Ashmita Karmarkar, U. Saheb	Informal Technology Centre, Dubai

(continued)

Table 1 (continued)

Parts	Study city	State/country	Authors	Institutional affiliation
26	Sans Diego	USA	Neha Goel Thripathi, Malti Goel	School of Planning and Architecture, New Delhi, School of Planning, Centre for Science Policy, Jawaharlal Nehru University, Delhi
27	Cincinnati	USA	Sweta Byahut, Sudeshna Ghosh, and Calvin Masilela	Auburn University, University of Pennsylvania
28	Conclusion		T. M. Vinod Kumar	School of Planning and Architecture, New Delhi

8 Way of Working the Programme

8.1 Integrating Smart City Research with Academic Programmes

This international collaborative research programme, with the participation of many countries and many study cities as tabulated above, was conducted by many diverse university departments, research institutions and others as shown in the table above.

8.2 Role of Students

This international collaborative research programme is essentially meant for students since they are the future and being part of an internal academic programme of the university. We consider they are the main actor and shall be given an important role in this programme. Perhaps many that age group will live in the Smart Cities than their older faculty. Under the direction of faculty, new concepts were introduced in the studio and empirical studies were conducted around these concepts.

8.3 Role of Faculty

The faculty is the designer of the programme within the framework of existing curricula in design studios and theory courses of each participating university.

I. The project duration is one academic year or two semesters.

II. They guide and monitor student work as usual as part of the academic programme.
III. They monitor students' input to the monthly progress report.
IV. They rewrite the output of the project for a book to be published by an international Publisher giving due credit to their work.

8.4 Co-design and Co-production of Knowledge

This international collaborative research programme is founded on the principles of co-design and co-production of knowledge. In today's interconnected world, such collaboration is physically and intellectually possible—thanks to the Internet and ICTs. The collaborative aspect of the research programme will be actualized in the form of:

I. Co-design the programme with the partner academic institutions.
II. Co-production of knowledge through an interactive process of sharing, reviewing and finalizing research findings.
III. Within each partnering institution, co-design and co-production of knowledge can be implemented through design studio/laboratory work between faculty and students.

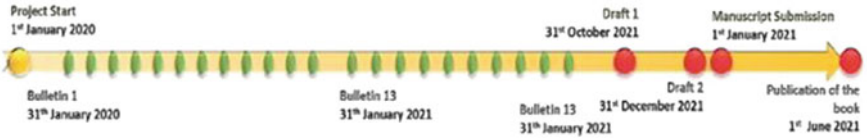
8.5 Research Output

The key output of the 'Smart city' research programme will be these books edited by the coordinator Professor T. M. Vinod Kumar, to be published by Springer-Nature, an internationally reputed publisher in 2022.

9 The Project Milestones

The project Milestones with the expected outcome is diagrammatically given below.

MILESTONES



Bulletins envisaged was not implemented.

10 Summary of Conclusions and City Case Studies

10.1 Smart Master Planning for Cities—Innovation and Case Studies

The first chapter introduces the theme of the book which researches the Smart Master Planning of Cities discussing digital and domain innovations using case studies. The adjective smart indicates a better, effective and responsive way of doing Master Planning than practised now but goes much beyond. Master Planning has two main functions regulatory and development. All existing legislation of the nation and federal state applicable to the city is used for urban regulation and integrated and comprehensive area or spatial development is called development. The smart city and smart master planning are conceived around the concept of six components systems smart people, smart mobility, smart economy, smart environment, smart government and smart living working together in an integrated manner.

Part 1 in this introduction for the theme of the book, orients smart master planning in its full meaning. **The second part** gives the most recent understanding of the scope of work of Master Planning practised in many parts of the world. **Part 3** deals with the evolution of Master Planning in India since the British colonial period. The archaeological investigation on the prehistoric cities in Harappa and Mohenjo-daro shows the urban design of cities for common people planned with a high level of spatial design, civil engineering skill and great care for the use of all showing a democratic master planning. The same is true in cities planned based on the Vedic planning period. However, we do not have abundant written pieces on the master

planning of these cities at that period and hence omitted in this chapter. In contrast, during the British Colonial period, we have considerable written pieces available, and this chapter concentrate on that. This is despite we have an inferior sample of British Master Planning in comparison with Mohenjo-daro and Harappa period and Vedic and Mughal period. The only justification to study this period is because the Master Plan being practised in several parts of India was evolved in the colonial period and continued in many states even very recently with no change despite its not so satisfying approach. **Part 4** looks at cities in the 2011 census and earlier for India, and Master Planning efforts in India. This is compared with available qualified city planners in India recommending an organisation of planning services in the private sector for its effective role. **Part 5** is a summary of a literature survey that critically look at the past Master Planning effort in all its shortcomings. I may warn here no one who wrote these papers do have a high opinion on the Master Planning effort in India. They are unanimous in not celebrating these efforts but accept that as a necessary evil in the absence of worthwhile alternatives. Can we find a legally valid alternative is the focus of this book? **The sixth part** looks at the alternative to Master Planning and discuss the architecture of Digital Master Planning. **The seventh part** discusses the implementation of digital master planning in Barcelona (Brownfield). **The eighth** part presents a new town planned and implemented as a case study of Greater Springfield's digital master plan: a New Town in Brisbane Australia (Greenfield). **The ninth part** presents an attempt at making a digital Master plan as a Case Study Dublin, Ireland Digital Master Planning (Brownfield). **Part 10** briefly presents the approaches of Master planning suggested in this book as a city case study in Kozhikode Metropolitan Area. Finally, part 10 concludes this chapter with some definitive statements.

The present-day Master planning in Kerala and many states in India is based mostly on legislation and planning techniques framed by the British colonial rulers. Since then, there has been considerable development in the knowledge base of Urban Planning which does not have a place in the current Master Planning practice. These rules are partial to themselves the colonial rulers in the sense it benefits more the East India Company and now the rich and the influential that ruled India than all Indians unlike Mohenjo-daro and were made to ease their ongoing colonial exploitation in urban areas. Our legislators in parliament and assembly had never debated and reject or partially accept with modification, all these legislations which was made for colonial rulers and not for native Indians whom they considered as slaves to be exploited like the raw material they extract for industrial use. Even the imported competitive politics in Indian democracy after the independence of India is an alien concept in India where traditionally Indian believes in peaceful consensus politics. The rationale is legislation is for all and why not make it the best pooling the intellectual resources of the opposition party. Unfortunately, there seems today some continuity with the British period than the best practices of Master Planning in prehistoric days in India. Harappa cities, Vedic period cities of Mughal period Cities which resulted in the archaeological a city for all than a present divided city giving more benefits to the colonial rulers of East India Company.

Let us look at the professional planners in India. The Minister of State for Urban Development Babul Supriyo said in a written reply in 2020 that there are about 5,000 registered urban planners or one per every 75,000-urban population in India. Though this ratio may be low compared to that of developed countries, the adequacy of urban planners needs to be seen in the context of the scale of urbanisation in India.

In summary, I enumerate the following for 2011.

1. Total Number of Cities and Towns: 7,933
2. Total Number of Master Plans: 2,738 (34%)
3. Total Number of Statutory Towns: 4,041
4. Total Number of Statutory Towns having Master Plan: 1,938 (48%)
5. Total Number of Census Towns: 3,892
6. Total Number of Census Towns having Master Plan: 800 (20%)
7. Percentage of Urban Population in Statuary Towns 85%
8. Percentage of Urban Population in Census Towns 15%.

The governing terms of reference of the 12th schedule 74th constitution amendment call for all Municipal local bodies to prepare Master Plans and Govern and in other words conduct urban regulations based on the Master Plan. The above facts show they are not doing that because of several constraints enumerated, but they cannot ignore it. Now, what can be done?

1. Planning departments whether in Municipalities or State government Departments in every state are not expanding to meet this gap in manpower for Master Planning. Do we want it to expand the Government planning department or privatise planning?
2. The Municipalities need not use Government departments to prepared Master Plans and so the case for expanding planning departments to meet this task is not tenable.
3. Although few national and international consultancies are active in India, they are not able to adequately meet the demand for planning.
4. The budget available for consultants to plan to adopt the current Institute of Town Planners Professional fee document is not provided for in many municipalities.
5. The Government planning support system such as Digitization of Maps which started in the 8th five-year plan period has not yet covered all cities with the lapse of many decades in between mainly due to less of objective achievements of a total government-run project and not involving private companies. The output came generally very late. Why not use the private agency for urban mapping as well as cadastral survey mapping.
6. While Master planning is transiting to digital planning many more disciplines like computer science for E-Governance support and urban information system, electronics engineers specialising in IoTs, Mechanical engineers for Industry 4 applications in Master Planning along with conventional collaborators like Economist, Sociologist, ecologist, law and geographers shall be part of the Planning service company.

7. State and central government finance commissions are not giving sufficient budget to local bodies to hire the best talents from within or outside India to execute their constitutional responsibilities.
8. Municipal administrations seem less autonomous even though they are constitutional bodies to be more under state government and it should change for independence in Master Planning.

The only way out is summarized below

a. Reduce the Government Planners to 10% present strength and post all of them to the state headquarters to manage the legal process of planning and prepare Urban Planning policies.
b. Research set up like Niti Aayog may be instituted at state levels to support urban and regional planning in respective states and give research-based direction which is much useful than mere administrative directions as practiced today.
c. Form at the national level, a public–private Planning Services Company like the successful model of Kochi International Airport company to perform all planning services starting with digital cadastral maps and ending up with E-Governance and all types of digital planning with the remaining 4,500 registered planners under virtual office system to give e-serving of Master Planning to all cities.
d. The equity participation for the above company is less than 49% shall be from Central and state and local self-government levels. The remaining equity shall be from private individuals or organizations including planners themselves.
e. Institute of Planners India and all planning schools shall be represented in the technical and executive board of the company.
f. The company shall not have a large brick and mortar office, but a digital virtual office shall replace them, and service can be digital and mostly online.
g. The state-level branch of the Planning Service Company shall operate in virtual offices at the state level using the network of consultants largely on a job basis scattered all over India.
h. The details of this company need to be worked out by a competent group of professionals are drawn from the Institute of Town Planners India, State and Central Government Planning Officers and leading Planning Schools in India.

Many studies [11–37] are there enumerating the shortcoming of the Master Plan and it is summarised in this section. Most of them are written based on urban planners own experience of preparing a Master Plan and watching its various process by experienced authors, but there are also academicians looking at these aspects in the references given. Sometimes the same conclusions are reached by many authors.

Therefore, I have summarised their conclusions of these papers in a summary form below without presenting statistics of opinion by authors. This will form the basis for one of two volumes for the book for Smart Master Planning focussing mainly on selected domain studies.

1. Master Plan as a guide for planned development ultimately become a sort of document which was less amenable/accommodative to the **unforeseeable changes** in the city requirements such as flood or COVID-19 pandemic.
2. **Disaster management** is not given importance in Master Planning.
3. Master planning methods adopted over the last few decades in India have not produced a satisfactory physical environment [36] and have not been **effective** in the outputs as well as outcomes [33].
4. The planning process in the past has been **unduly long** mostly five years some more than 10 years and largely confined to the detailing of land use aspects.
5. Functionally, master plans paid inadequate attention to the provision of city-specific major infrastructure like metros rails. Once it is implemented the structure of the city as envisaged in the Master Plan is no more valid.
6. Environmental conservation was neglected and there was no ecosystem planning.
7. Financing issues and commitment did not figure in Master Plan including strategies to circumvent any related issues and made Master Plan unrealistic proposals without the budgetary commitment from State and Central Government and stakeholders in private sectors [33].
8. The master planning approach did not exhibit a holistic view of urban development that integrates city economic development, social change and cultural development and did not deal with interconnecting all these aspects spatially. For example, master plans cannot be translated into socio-economic development plans creating cultural change and integrated development.
9. The physical planning exercises in Master Plan generally were restricted to core urban areas without much integration with the peripheral areas and rural hinterlands.
10. Attempts to adopt an integrated development plan approach, based on national, state and regional strategies and recognition of the spatial and functional linkages between settlements of different orders have not been made in Master Plans.
11. In the process of plan-making and plan implementation, no adequate attention to the integration of land use and transport, planning has been made. The fact that transport is a key determinant of land use and 'leads' development is sometimes ignored.
12. The shortcomings of the Master Plan approach are in the resulting design, conceptual issues and procedures that are resulting in unacceptable delays and the evil of delays are not questioned by the public.
13. The Master Plans are too static incapable of addressing emerging issues from time to time as it appears, and they take an exceptionally long time to prepare and are too infrequently updated.
14. Master Plan is subservient to vested interest and there have been case-by-case relaxations in the plan to serve vested interests.
15. Proposals/estimates have not kept pace with the unprecedented growth and future requirement of cities.

16. Master Plans are generally silent on costing and financial management for infrastructure provisioning.
17. No specific set of incentives were outlined in terms of financial assistance to implement the Master Plan.
18. Master Plan instead of becoming a tool for regulated development has become a platform for stakeholder dissent (as experienced in Master Plan of Delhi).
19. Zoning and Development Regulations are cumbersome to follow, vaguely stated to call for controversies and long court cases and result in weak enforcement.
20. Master plans rarely provide guidelines on the techniques of implementation.
21. Master plans are often based on the unrealistic appraisal of the economic potential of the planning areas and, in some cases, on the needs.
22. Master plans seldom provide detailed land use and elaborate and unambiguous land use regulation or suggests control by Community or elected representatives and NGOs, Academics and the Business community are not involved in the planning process meaningfully.
23. The Master plan details out the urbanized and urbanizing areas under its jurisdiction and suggests land use up to the neighbourhood level. This minute detail for 20 years has resulted in a lack of flexibility and has hindered individual self-expression.
24. The plan projects and 'end state' scenario for 20 years is not realistic for short- and medium-term actions.
25. The plan is mostly static and not amendable to quick mid-course corrections.
26. Inordinate delays in Master Plan preparation and approval of zonal plans and urban land management schemes and, besides, difficulty in obtaining possession of land sought to be acquired for the purpose is the main hindrances to a speedy and successful implementation of the Master Plan.
27. The efficacy of the Master Plan is adversely affected by the divergence between the presentation of urban growth envisaged 20 years ago and emerging urban growth reality.
28. The mechanism for public participation is ineffective in the process of development planning, in both its preparation and implementation. It is more top-down than a bottom-up approach.
29. Master Plan preparation is undertaken with a very weak information base especially on socio-economic parameters, housing and environment.
30. The plans prescribe impractical densities and layout high standards to improve the quality of life in a city. These are generally higher than what the city population, particularly the poor, can afford.
31. Estimates of financial outlay do not match the development works envisaged in the Master Plan. The strategies for raising resources required for plan implementations are never an integral part of the plan.
32. Urban planning in India has been overshadowed by its spatial content instead of the realization of social and economic objectives. Town planning exercises tended to concentrate on the physical order and environmental quality of the

city and were isolated from the mainstream development planning, decision-making and implementation strategies.

33. The absence of machinery for systematic and continuous collection of data on the movement of land and tenement prices undermines the implementation of the Master Plan.
34. Through a significant portion of the development is due to the initiative of the private sector, this factor is not recognized in the Plan.
35. The regulatory mechanisms in the Master Plan are to enable better management of the city but too restrictive controls are costly enough to provide incentives for breach rather than compliance.
36. The root cause of the urban maladies has been the divorcing of the plan preparation from plan implementation and Ineffective plan Monitoring.
37. An institutional and information system does not, generally, exist for plan monitoring. Since the budgetary system does not explicitly consider the requirement of plan implementation, the problem of resources is not periodically highlighted.
38. Master plans or Development plans have been taken as given from the past colonial system prevalent before the independence without enshrining the good features after independence, especially after 1991 such as the market economy. The result of this traditional planning approach in the form of master plans is turning out to be frustrating.
39. Urban planning in the past was primarily influenced by central planning principles of the post-independence until 1991 era and the characteristics of the communist planning of the now-defunct Soviet model. The idea was everything on City Planning is decided by Planning Commission for the Nation and Planning Board for State and Master Plan of the city is expected to follow that in the way it is to be implemented as suggested by this Planning bodies. Now the Planning Commission is no more, and the Planning Board have doubtful life, but no alternate approach is suggested. What was left at local self-government was arithmetic of central planning for allocation of central funds at city level by some formula which will not make comprehensive city development. This, unfortunately, do not allow local initiative and innovation by local stakeholders. The negative empowerment of bureaucracy over municipality by communist planning act as a retardation mechanism for urban development.
40. In the liberalized era and globalized world, the planning processes must serve the economic and social objectives of the global society through the creation of a growth enabling physical spaces and infrastructure in cities. This changing context itself calls for identifying alternative approaches and strengthening existing planning mechanisms and institutions at the city level.
41. There are no efforts to link the short term or investment plans with the existing Master Plan. For example, every state has an annual budget and plan but there is no connection between the annual plan and Master Plan. One of the reasons for this disjuncture between the Master Plan, investment plans and governance structure is that the first one is a very the long-term plan and the medium-term zonal plan is never given due importance and flexibility.

42. Land use designations are usually determined or justified on one of the three principles in the Master Plan: as responsive to existing conditions, to enable smooth traffic flows, or as a part of some larger conceptual plan for the city. The distribution of various land uses has been made even to reduce traffic congestion inside the old city and to reduce the number of commuting trips in the peripheral areas. The local level conceptual plan, i.e., micro-level land use planning is completely lacking in the Master Plan. The land use plan is responsive rather than act as the location of many of the land uses are determined by the existing condition or the character of the land. For example, the illegal growth of residences near the industrial area the land surrounding the industrial area has been declared for mix residential and commercial development. Likewise, the location of transportation nodes, private bus stands and the truck terminus is also compromised in the Master Plan.
43. The master plan is highly bureaucratic in its processing and design oriented as it is prepared by the planners, engineers and architects of the Town Planning Department who are very much interested in sketching out aesthetic layout plans of the city and have little concerns of differing socio-economic needs or its changing character from one part of the city to another. For instance, delimitation of planning zones seems to be arbitrarily done because the basis of delimitation is not clear and erroneous. There lies a considerable difference regarding socio-economic structure and level of development of existing land use in each zone. For example, the old city zone covers the oldest part of the city on one hand are highly dense and in contrast, the sparsely developed areas are the newly developing areas. These differ from each other in many aspects and have their own needs and problems which require different approaches and methods of planning to tackle the planning issues and strategies. The approaches and methods applied for the old city cannot apply to sparsely developed areas. Hence, putting together two heterogeneous areas to form a planning zone is erroneous as well as unscientific for urban development. The story is the same for the rest of the planning zones except the peripheral zone which is entirely rural. Therefore, the planning standards adopted cannot be uniform but change realistically from one part of the city to another.
44. A planning zone has been defined as an area where the community is self-contained in terms of employment, housing and other community facilities. This is a highly unpractical approach to land use planning in which coordinated and integrated land uses and functions of the city has been completely overlooked. Further, the urban society of a specific area cannot be made fully contained in terms of employment, schooling and healthcare facilities particularly in Indian cities.
45. The short-term measures to bring about improvement in existing conditions particularly in the old city area is ambiguously mentioned with refraining phrases of relocation, provision of community facility, conservation, reconstruction and redevelopment. Such measures need a huge amount of money and people's active participation about which the Master Plan is silent.

46. One Master Plan in India took an inordinate time of 16 years (from 1973 to 1989) in preparation and approval of the Master Plan and, in obtaining possession of land sought to be acquired for the very purpose. All these whiles, several changes, i.e. increase in population and economic activities, growth of socio-economic facilities, a boom in the service sector of the economy, a decline in manufacturing activities due to shifting and dislocation of road alignment away from the city, change inward boundary and so on occurred in the city. Consequently, the city's development has been taking place without proper implementation of the Master Plan.
47. Lack of public awareness and public participation in preparing and implementation of Master Plan has negatively influenced the realization of its objectives and goals. Hence, the Master Plan is more top-down than a bottom-up approach to planning.
48. Master Plan has been prepared for a projected population and in many cases, the projection was not correct when plans are reviewed.

The master planning approach in urban planning has received little success and so there is a case for smart master planning. Major causes and factors attributing to partial fulfilment of objectives of the master plan include excessive time consumption in plan preparation, approval, sanctioning of financial resources and acquisition of land with outmoded land acquisition legislation, lack of trained staff and other requisite planning support resources, inappropriate legislations, lack of coordination between government institutions and accountability, poor governance, widespread corruption, lack of will and responsibility and above lack of public cooperation and participation. The timely solution of the above impediments is essential for the preparation of a good plan and its successful implementation. Further, the top-down approach of master planning must be reverting to a bottom-up approach ensuring active public participation in planning and decision-making processes. Here, the role of government institutions should be as a facilitator in urban development. The partial success of the master plan indicates that it needs much more positive and concerted efforts for full implementation rather than questioning the relevance of this approach as some academicians do. Further, short- or medium-term action plans must be formulated attuned to the long-term master plan for the avoidance of failure and increasing its effectiveness. As far as Master Plan is concerned, it has been implemented with partial or minimal success. It is because a few proposals lacking in ground realities and coherence. It also indicates lacunas in plan preparation processes and administrative hindrances in the implementation of the plan. These shortcomings need to be eliminated through concerted efforts to avoid failure of the master plan in future.

The outcome of the Master Planning during the colonial period as well as the post-independence period has been largely disappointing. There is nothing to showcase to the world about its achievement. We are unable to find through Master Planning how cities are made into engines of economic development and for rapid social and cultural changes. Instead, what we see there is the ugly hydra of bureaucracy that makes citizens and entrepreneurs immobilized depleting their all initiatives. Bureaucracy is there in its full force as discussed during the plan-making and its implementation

is mostly self-serving but not for the citizen or city. Cities cannot function without urban regulations and Master Plan act as the legal instrument for urban regulation and therefore you cannot remove Master Planning however imperfect it may be, but bureaucracy can be minimized and partially eliminated which saves money to Government in terms of their salary and upkeep if the citizen can own Master planning and do self-regulation using science and technology using a bottom-up process.

This book explores the capabilities of Smart Master Planning as against legacy Master Planning of cities practised. Master Planning of cities exists because cities under change need uninterrupted and ongoing integrated area development and urban regulation that benefits and protects the rights of all citizens under the constitution. Despite many shortcomings of Master Planning as discussed in this chapter, and which made some big-ticket national urban development projects replacing it with other short-lived plans with different names by the Union Government still exists in India and all countries being revised once every 20 years as per the constitution since no alternative has emerged to replace it. The 100 Smart City Programme and Jawaharlal Nehru Urban Renewal Mission (JNNURM) of India were two big-ticket National projects involving a larger amount of public investment ever received by Indian cities so far were not using Master Plan and detailed town planning schemes for its implementation for integrated area development but is based on some other non-statutory limited time and limited scope plans which by design is short lived and intend to die soon after the project is over with no continuity for integrated development of cities. The 100 Smart city project is strictly not even using local self-government institutional mechanism under the constitution but a special purpose vehicle to implement, unlike JNNURM. Despite all these circumstances, local self-governments continue to prepare and execute Master Plans as their constitutional responsibility despite some plan holiday years. One intends of this book is to evolve and not replace Master Planning of cities with Smart Master Planning which can broadly be classified as digital master Planning or based on innovations in some domains of Master Planning practices as alternatives keeping the intent of intention of the Constitution of India respected and implemented. This book searches for an effective strengthening of Master Planning mentioned in the 74th the constitutional amendment of India which we call Smart Master Planning. This can be digital or with domain-specific changes in master planning. This chapter assesses quantitatively the candidate cities for Master Planning in India based on the census 2011 and compares them with registered professional urban planners to plan it. Then discuss how the supply of candidates' master Planning cities and demand for planners can be balanced in India. This chapter explores the first scope and the approach of past colonial legacy in Master Planning followed by a critique by many scholars and practising planners. This will be the basis of domain-specific master planning innovations. The Digital Master Plan which is emerging in a limited manner is then studied from practices of certain countries as an alternative for legacy master planning first with its architecture, followed by three international case studies Barcelona in Spain, Greater Spring fields in Brisbane Australia and Dublin in Ireland. Finally, it is followed by an introduction to the case study chapter by the author and his study team in one of two volumes entitled Smart Master Planning: domain innovation and digital innovation.

10.2 Application of Artificial Neural Network in Master Planning for Cities—A Case of Simulating the Land Use and Land Cover Changes in Bhopal

The cities are evolving faster than ever due to the fifth industrial revolution. Several urban schemes were launched after 2014 further catalysed this process in India. The rapid development thus requires that the urban administrators and planners speed up their planning processes.

The technology itself provides us with the solutions as well. Machine Learning (ML) can help solve several urban issues, one of which is predicting and studying the urban growth pattern. Cities are complex systems and delegating scientific and mathematical parts of the planning process to computers, while working on the art of governance and management will indeed ensure better efficiency in development.

A case study was done in Bhopal, Madhya Pradesh, to understand the applicability of ML in urban planning by simulating urban growth with the help of an Artificial Neural Network (ANN), an ML algorithm. The results showed that ANN is exceptionally accurate in urban growth modelling and can be actively used in preparing master plans of the cities. Moreover, urban schemes like the Smart City Mission can easily integrate several ML tools. While the Government of India is already investing in the development of Artificial Intelligence and Blockchain technologies, tools like ANN provide us with excellent opportunities to develop the current Urban Planning techniques.

10.3 Smart Master Plan and 3D GIS Planning Support System—A Case of Chennai City, Tamil Nadu, India

Urban planners are beginning to think three-dimensionally to address the ever-growing urban problems, particularly in dealing with the built environment, as 3D modelling tools and approaches become more popular. The possibility and need for incorporating 3D GIS as a planning support system for Smart Master Plan are discussed in this chapter. This study's interactive, dynamic, information-rich 3D model demonstrates a novel technique for disseminating urban planning data for the benefit of both urban planners and the public. Planners can use this 3D information-rich model to get up-to-date information on city development for better analysis, planning, and decision-making. Sharing 3D information-rich models in the public realm improves transparency in planning processes. One of the most significant benefits of having a 3D city model is the capacity to quantify the activities that occur in a specific location, not only in two dimensions but also in three dimensions. Planners can use volumetric data to quantify and assess activities in terms of volume against infrastructure services available.

This study also demonstrates the usage of 3D models to compare envisioned growth plans to present development trends. When there is an increase in built-environment intensity without a simultaneous enhancement of existing infrastructure services, certain zones within the study area critically overshoot the network's designed carrying capacity. The methodological framework created in this study demonstrates how 3D models can be used as a smart master plan tool in everyday urban planning operations. The main critical planning factors (physical infrastructure) that can be obtained using 3D city models have also been discussed in this study. Apart from zoning restrictions, all physical and social infrastructure elements must be analysed holistically for informed planning and decision-making. 3D volumetric analysis is one such technology that can integrate all these parameters into daily urban planning operations, allowing for improved analysis, planning, and decision-making. Furthermore, 3D volumetric assessments that are within the designed carrying capacity of the entire in situ infrastructure can be used to determine the study area's appropriate development intensity.

The process of 3D modelling and analysis is time-consuming. Integrating 3D models into urban planning processes necessitates substantial study into a variety of topics, including modelling approach simplification, data integration and enhanced and simplified analytical techniques, among others. Furthermore, the 3D volumetric analysis used in this study is based on static 3D models created with Arc Scene. The dynamic nature of the urban planning process necessitates dynamic 3D volumetric analyses. More study into 3D dynamic volumetric measurements is needed. Every city has its plan-making process and integrating 3D models and 3D volumetric evaluation methodologies must be done by industry standards. From data collection strategies to analysis and presentation, more study on customization in the integration of 3D models is required.

The research presented in the chapter has helped to broaden the applications of 3D city models in urban planning towards a smart master plan approach. Although 3D city models provide enhanced analytical capabilities, incorporating them into everyday planning processes requires additional research in terms of superior analytical capabilities and flexibility. There is also a strong need for the development of 3D tools that are simple to use and freely available, and that integrate spatial and non-spatial data more thoroughly. Urban planners will be able to plan more efficiently by incorporating 3D volumetric analyses into existing urban-related planning processes.

10.4 Spatial Planning of Mukkam Smart Economic Community

Mukkam a small municipality found at the outskirts of Kozhikode (Calicut City) and bordering the Kozhikode District of Kerala state, India, is taken as a case study for this book chapter. The significance of this small area is its strong agricultural trade-related backup together with potentials for development. After analysing the

existing situation analysis of the area, a SWOT Analysis was undertaken for the potentials and prospects of the study area. So, the city problems and prospects were found. The commercial area Character of the city is studied via a reconnaissance Survey. The results reveal that the area requires decongestion, and activities need to be organized spatially. The user experience can be enriched through placemaking and pedestrianization of some zones. The vacant properties should be made economically practical and be used in a way to increase the intensity of the area. Such a development would increase the intensity of the area, which can have grown socio-economic benefits.

It is expected that a smart master planning process addressing all the six components of the 'SMART' development can help in better development of the city. So, spatial planning and analysis was undertaken about the previously mentioned six components, namely

- Smart Economy
- Smart Living
- Smart Environment
- Smart Mobility
- Smart People
- Smart Governance.

This concept plan for smart planning and the development of Mukkam is envisaged for improving the city against the conventional planning approach.

Smart economy: development of the Commercial Hub, Urban Farms/local foodshed using modern technologies, Agri-based and Ayurveda products, Rental economy—short-term renting of commercial spaces—stores, storage spaces, homes, knowledge-based economy Ayurveda and healthcare sector-based proposals were envisaged.

Smart living: Activity Zone for improving the social life of the region, specialist areas for vendors, cultural spaces for religious congregation and activities, open spaces and health facilities, recreational facilities and smart parks, riverfront development, neighbourhood parks and public spaces, Football turfs, Sports centre, cultural and community centres, etc., were proposed. Further, safe living with protection from fire, etc., is also proposed.

Smart Environment: Smart waste management, Sanitation and sewage, Smart water supply network, drainage system and utilities, riverfront improvement, urban agroforestry, etc., was proposed to be planned. The water conservation infrastructure shared water trade, the solid waste collection, treatment and recycling business, etc., is envisaged to improve the spatial structure of the city.

Smart Mobility: For the development of the city, the following smart proposals were envisaged namely, the widening of roads, proposal for a new bus stand, bus stops and parking areas, proposals for cycle stands and urban utilities, etc., were proposed. Proposals include bicycle sharing, paid parking, EV charging stations, PV field and transport sharing.

Smart people: Mental Health Improvement, Urban Poverty Alleviation, Proposals for the improvement of the migrant workers, etc., were envisaged.

Smart Governance: The essentiality of Building Permits as a smart system against the conventional process of building permit and occupancy certificate; a web-based application process flow for building permits, etc., are proposed for the city. Governance Kiosks, switching to digital and automation, single window system, simple and efficient processing and management, etc., are expected to improve the governance system of the city.

The chapter concludes with the strategies and proposals for Land Management Tools including participatory management, Interactive GIS Map Zonal Plan for Smart Economic Community, etc.

10.5 Spatial Planning of Kattangal Smart Global Economic Community

The master plan of a city serves as a blueprint for the development of a city for about 20 years. In most places, a Master Plan is a legal document, which is to be followed. Legal backing is required as it is essential to ensure a coordinated development for the benefit of all the citizens. The master plan preparation needs a large volume of data about all aspects of urban life. Often the gathering such a huge volume of data for the master plan preparation itself takes years. Analysis and mandatory verification processes demanded by the legal framework are also time-consuming. In the age of smart cities and ICT, the master planning process must take advantage of them.

This chapter looks at the traditional master planning process and finds opportunities to automate the processes as much as possible. Kattangal is a small town in Kerala, which developed in the middle of rural settlement along with the development of the National Institute of Technology Calicut at its centre and taking energy from the rural–urban continuum of Kerala. The presence of a technological university and the high level of digital literacy of its population gives its intellectual capital, which is the most essential potential needed to be a smart global economic community. A master plan was proposed to develop the area into a Smart Global Economic community. This chapter attempts to relook the masterplan process to utilise the ICT framework to automate the master planning process and to make it dynamic.

To elevate the community to a global economic community, the strategy adopted is to make the workforce more dynamic capitalizing on their high technical and digital literacy levels. This involves continuously training the workforce to the skills in demand in the global economy. This level of continuous learning demands an investment of significant time of an individual. This is made possible by freeing up the time one must spend on repetitive and chores that does not require active attention with the help of Machine to Machine (M2M) communication and IoT. The duties of local self-governments identified by the constitution of India were examined to look for possibilities to streamline and automate them for the benefit of the public. Identified interventions are regrouped under the six elements of the smart city.

Goals are proposed for each of the six elements and their corresponding interventions are grouped under M2M, IoT and spatial interventions. The demand for various activities is assessed through a system of semi-automated stakeholder surveys and usage statistics. Usage statistics collected through IoT systems are logged continuously and can reveal a lot of insights when analysed with various socio-economic parameters. Planning interventions are formulated with the help of human planners who benefits from the insights gained through automation. Smart interventions are proposed for Urban Land Management (ULM) and zonal plan preparation. A web-based implementation of zonal codes and development approval system ensures the compliance to masterplan and zonal plan nearly automatically.

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