Chapter 15
Green Buildings: Building a Greener City, a Greener Future—An Indian Perspective

Kriti Kanaujia

Abstract Green building as a concept has become popular in recent years due to concerns of un-sustainability and climate change. It is premised on being energy and resource efficient from its inception to manifestation; in order to minimize environmental and energy consumption costs. Although, the concept may seem new, but the practice has been done since centuries in India in the form of white roofs of Jaisalmer to rain water harvesting methods of baolis (step-wells), hauz (water reservoir) and tals (lakes) in numerous old forts and palaces of India. Even in contemporary India, many sustainable techniques are being promoted by the Government of India in synchronization with State governments. Green buildings are the need of the hour because they will help reduce our ecological footprint by adapting to the existing climate and helping us to mitigate the effects of climate change to a considerable level. Green buildings are the building blocks of Smart Cities.

Keywords Green building · Old practices · New energy efficient techniques · Sustainability · Urban areas · Smart cities

15.1 A Need to Rethink Our Urbanization

It has been many centuries since Urbanization appeared and influenced the human lives. It has evolved through many stages and continues to evolve to keep in sync with the changing necessities of time and people. In the recent decades of urban history, a need for change in the approach to urban and its dynamics has been felt severely. It is in this light that a debate between development and regeneration emerged on the urban scene. While urban development acts as a mediator and facilitator for transformation, urban regeneration on the other hand, acts as a catalyst extending the process of transformation and as a means of sustaining urban development. An area may develop to be urban but it cannot continue to sustain itself beyond a point of time

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without regeneration. This has been exemplified by western experiences especially that of London, post-reunified Berlin, Boston, Pittsburg, Scotland and many other European cities (Mitrojorgji 2003). Urban regeneration means differently to different people and contexts.

Broadly, urban regeneration is an attempt, a vision and a practice aimed towards achieving all encompassing, resilient as well as sustainable solutions towards myriad urban or urban related challenges while simultaneously providing improvements in physical, socio-economic and environmental conditions of a specific area that has been subjected to change(s). Regeneration encompasses these four aspects in entirety namely; community, infrastructure, employment, health, literacy and so on. Each aspect interacts with other aspects in an interrelated and complex manner along with their in/direct impact(s) on other aspects (Carrion and Hanley 2007). Therefore, it can be said that regeneration is not an individual oriented approach; rather is an all-encompassing perspective that is premised upon sustainable development. Urban regeneration is; therefore aimed at self-sustaining planned and regulated urban development (Kanaujia 2016).

Urban development of the world at present is extremely rapid and unsustainable with haphazard growth; especially in the developing world. Most of the West European countries and USA are highly urbanized due to industrialization and modernization. Urban regeneration has been accompanying urban development in the West; with major emphasis after the World War II period. It was only after many decades of urbanization experience as well as billions of dollars invested in urban development which led to the realization of the importance of urban image, quality of life and urban environment as necessary stimulants for economic development of cities (Lawless 2010). It was in this context that urban regeneration was adopted as an instrument of revival and rejuvenation of urban development in depopulating and degrading urban centres; with the aim of self sustaining development from that point forth. Urban Regeneration and not Redevelopment was adopted because the cities required more than spatial re-configuration and renovation (Brodies 2009). The cities were subjected to regeneration in order to revive economy, culture and a sense of community among its inhabitants. Unlike urban development, urban regeneration has the versatility to mould itself in order to meet the challenges of the time in a specific area aimed at specific section of society (Carrion and Hanley 2007). Urban regeneration is not a "one size fit all" approach, it needs to be modified and appropriated according to the needs of the area and its people in question (Brodies 2009). Urban regeneration as a concept works better and in synchronisation with the concept of Green Buildings since both are premised upon self-sustainability.

With recent drastic and changed weather phenomenon being witnessed; we need to relook at our current practices and norms and especially in urban areas because the world is rapidly progressing towards urbanization and urban population growth (refer to Fig. 15.1). Even though the urban population growth rate would register a declining trend in upcoming decades, it is important to note that the World urban population would continue to rise in absolute numbers implying that even a declining growth would imply huge population increments.

Fig. 15.1 Trend of Urban Population Growth (in percentage) from 2015 to 2030. *Data source* Urban Population Growth: 2015–2030 (World Health Organization 2014)

At present, 54% of the world's population resides in urban areas and it has been estimated that it will increase to 66% by the year 2050 (UN DESA 2014). It is in synchronisation with the estimates made in the year 2007 and 2014 (refer to Fig. 15.2) for the urban population growth by UN. There is an upward trend in urban population numbers across major regions of the world. Although the increment seems to be slowing, yet in absolute numbers the population added is large and will put immense burden on existing resources giving rise to mega cities (refer to Figs. 15.3 and 15.4) with multi-million urban populations. These cities would be characterised by high density, massive built-up area, unplanned growth and resource scarcity if actions and relevant measures are not taken up immediately. In this light, we need to question ourselves as to what kind of cities do we really want to live in or what kind of cities we ought to live in.

Many cities are already facing the problems of over-urbanization along with severe environmental impacts like water-logging during monsoons and Urban Heat Island effect. In this context, we really need to question the very notion of what we understood as Urban or as a City, should we really continue to conceive, plan and implement cities the way they are being planned and implemented or is it really the need of the

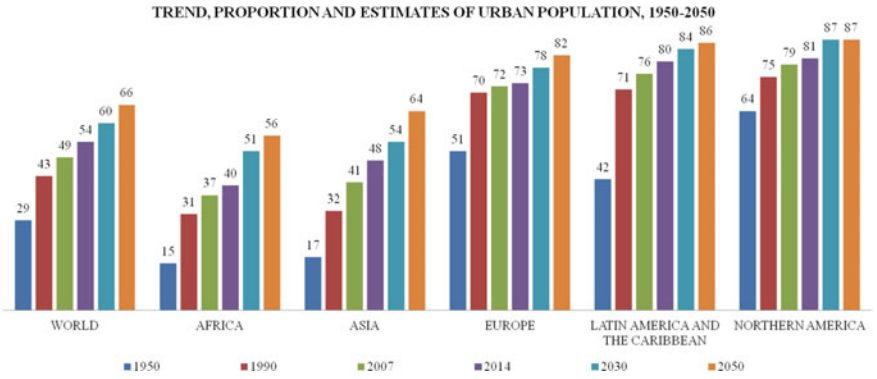

Fig. 15.2 Trend, Proportion and Estimate of Urban population growth (in percentage) from 1950 to 2050*. *Data source* World Urbanization Prospects: The 2005 Revision (UN DESA 2006), World Population Data Sheet (Haub 2007) and World Urbanization Prospects: The 2014 Revision (Highlights) (UN DESA 2014)
*[The data excludes Oceania's proportion of urban population (71, 71 and 74 for 1990, 2014 and 2050 respectively)]

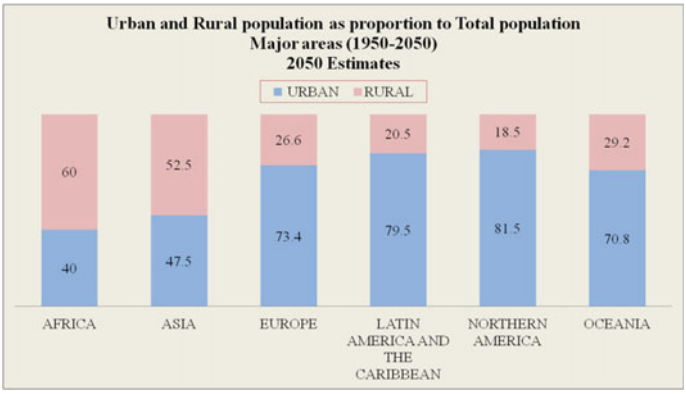

Fig. 15.3 Distribution of World Population according to Urban and Rural in Major regions. *Data source* World Urbanization Prospects: The 2014 Revision (Highlights) (UN DESA 2014)

hour to re-conceptualize and re-visualize the planning and implementation notions of and for a city.

It is in this context that, a need arises for sustainable urbanisms and urbanization which is centred upon living life in greener, smarter, sustainable, energy and resource-efficient ways. Green buildings or building in greener ways is a stepping stone towards the realization of Smart Cities' initiative and a relationship which needs to be pursued more rigorously. But the concept and usage of green buildings is a not a new phenomenon or idea, it has been a practice and an ideology that has been in existence since several decades and centuries premised on ingeniously living in-synchronization with the local geography.

15.2 Traditional Green Buildings: Living Smart in the Past

Human civilizations understood and learnt to live in synchronization with their natural surroundings by adapting themselves, their habitations and being ecological and resource efficient. This may be exemplified by traditional Ogimachi houses of Japan (wooden structures) which are built from the locally available resources and extremely adept at its environmental and seismic surroundings, or by the white facades of the numerous houses in Santorini, Greece or the locally suited stone tiled roofs of Apulia in Southern Italy. Perhaps the best examples of green buildings can be gathered in places like Ghana, Africa where the houses are designed to withstand extreme high day time temperatures and scarcity of building resources or the thatched or grass laden roofs of Portugal, Iceland and Norway respectively exemplifying being one with the nature, living in nature with nature. Perhaps it is important to point out one of the most famous examples of green buildings; Igloos. The Igloos are traditional houses in the northern frigid zone of our world, wherein the houses are

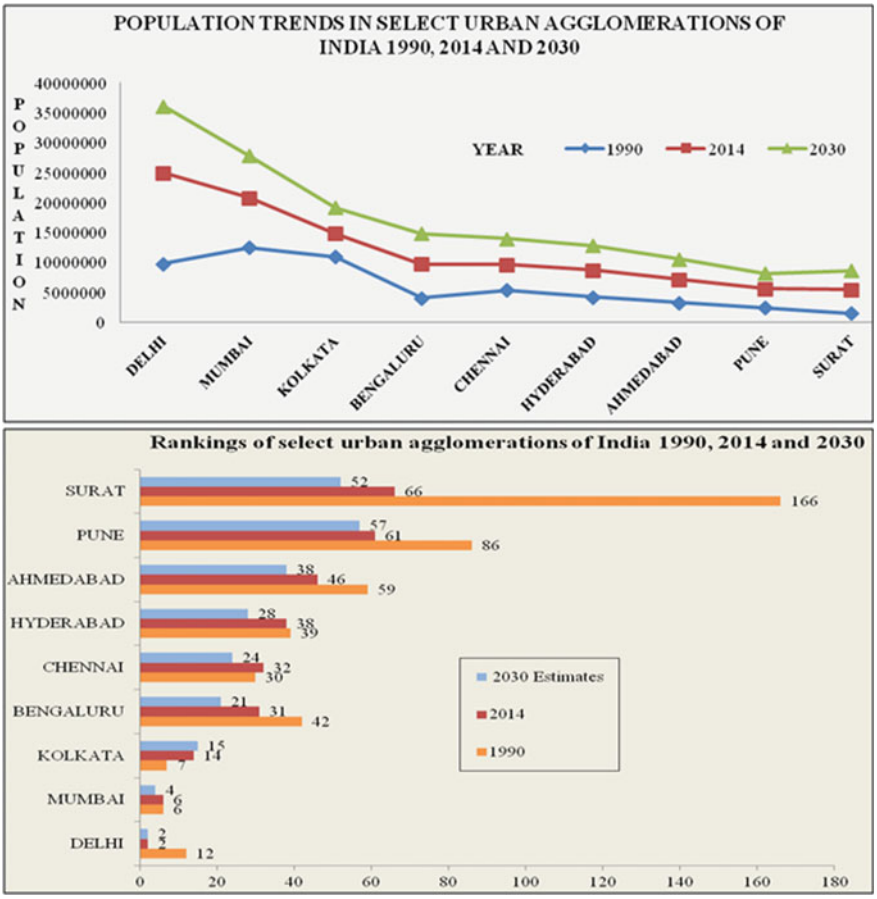

Fig. 15.4 Population Trends and Ranking of select Indian urban agglomerations with more than 5 million inhabitants as of 1 July 2014, for the years 1990, 2014 and 2030. *Data source* World Urbanization Prospects: The 2014 Revision (UN DESA 2014)

made by carving out bricks of ice. These houses are exceptionally environmentally sustainable since they cause no damage to their surroundings and are premised upon reuse–recycle.

Indians like their counterparts elsewhere; were aware of and makers of green buildings even in historical times. Traditional homes were built in accordance to the spatial and cosmological (the four cardinal directions, Vastu Shastra) location, local climatic regime, available building materials and the idea of utilising nature at its maximum.

Traditionally, Indian houses were made of baked roof tiles (red in colour) and clay for construction of walls which proved to be energy efficient as they were able to maintain cool ambience during summers and warmth during winters. Even till today, many of the traditional rural houses utilize this age old technique to maintain

temperatures naturally and with locally available construction materials like clay, wood, jute ropes and so on. The traditional layout or architecture of the houses was also constructed to be in synchronisation with the geographical location. Hence, the buildings in hot and drier regions were characterised by corridors which naturally directed the wind to cool while in wet regions, architecture was built in a way to naturally use light and breeze. The presence of central courtyard in many traditional houses was premised upon the natural use of light, ventilation, cooling of the inner chambers and so on.

Many forts and palaces of India are built on the green building concept. A key element was always the presence of a water harvesting method within the confines of the building in order to be self sufficient and to ensure the smooth working of such large structures. They also acted as cooling fountains and an element of aesthetic pleasure as in case of Char Bagh style of Mughals' garden construction or Fatehpur Sikri or the various baolis and hauz that mark the cultural and environmental history of India.

Another aspect that predominates in green buildings of times gone by is the use of intricately designed Jaalis (decorated and carved windows of stone) on a massive scale in hot and drier regions of India to help in natural ventilation, acting as a mediator to cool the darker recesses of the buildings. A prime example is Hawa Mahal located in Jaipur city in the Indian state of Rajasthan which is predominated by these intricate jaalis to allow for natural ventilation and several other forts and palaces of North-West India.

The knowledge of green building was not confined only to the Royals but seeped deeply into the perception of the commoners as well and this can be exemplified by the use of white limestone or chuna for painting the roofs of houses in Jaisalmer (refer to Fig. 15.5). This is a necessity as well because Jaisalmer is located in the arid zone with very high temperatures and in order to maintain habitable temperatures, the

Fig. 15.5 Comparison of rooftops of Delhi and Jaisalmer respectively. *Data source* Author's illustration, compiled from Google Earth Imagery; Image ©2018 DigitalGlobe

Fig. 15.6 Baolis in Purana Qila and Humayun's Tomb Complex, respectively, New Delhi. *Data source* Author's illustration

roofs are white-washed to reflect and not absorb insolation. This practice is followed till today.

Delhi being a city located in the sub-tropics, experiences harsh summers with water scarcity. In order to sustain life in such a scenario, several rulers of Delhi and its various cities constructed and maintained; Smart and green structures to harvest water and provide a perennial source of water supply all year round for the needs of the Empire and its several citizens. These traditional water harvesters vary from tanks/kunds/hauz, baolis/step wells (refer to Fig. 15.6) or huge wells/kuan (like former Dhaula Kuan). These structures were self sustaining, and resource efficient in their complete building cycle. Few of the surviving and recorded traditional water harvesters of Delhi are listed in this section (refer to Figs. 15.7 and 15.8) wherein the status 'Exists' indicates that those structures could still be brought into water harvesting uses with few repairs.

On a national level in India, traditionally and even in contemporary times, different types of water harvesting and harnessing practices and systems are still used in accordance with the local environmental and anthropogenic conditions and cultures. The names vary according to the local dialects while the structures vary according to locally available materials and micro/regional geography.

Dams, tanks, wells, artificial lakes and ponds, reservoirs, systems and practices of irrigation, rain/water harvesting measures are few examples. Dams are stereotypically considered to be symbols of modern technology and progress but the idea and the practice is not so modern. In different parts of India, these were and till today being used to harness or conserve the precious resource of water. They are referred by many names across India such as Bhanadaras (check dams/diversion weirs) in Maharashtra,

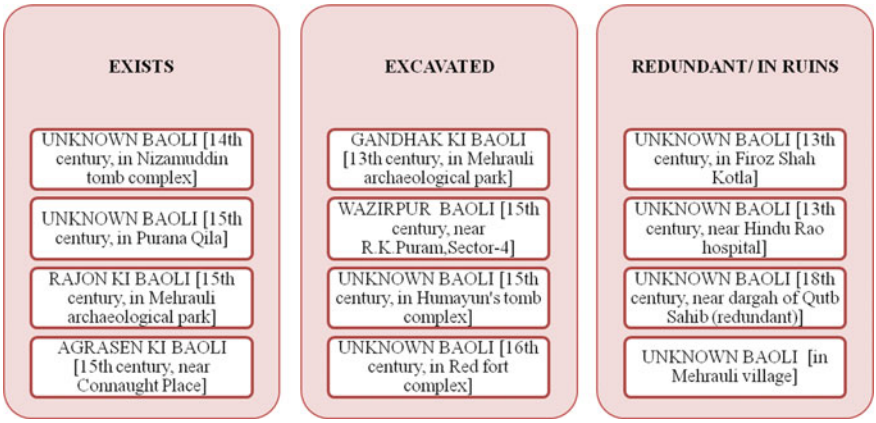

Fig. 15.7 Traditional green structures and smart water providers in Delhi: Step wells or Baolis. *Data source* Delhi: A thousand years of building (Peck 2009)

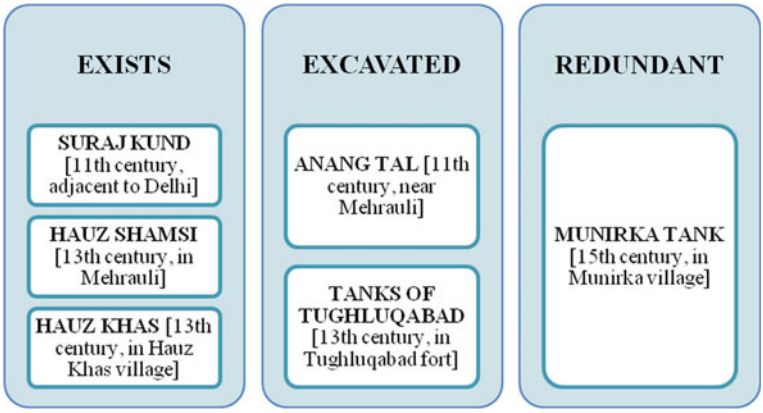

Fig. 15.8 Traditional green structures and smart water providers in Delhi: Tanks. *Data source* Delhi: A thousand years of building (Peck 2009)

Johad (small mud check dams) in Alwar district, Rajasthan, Naada/Bandha (stone check dam) in Mewar region of Thar Desert (Padigala 2017), Katas/Mundas/Bandhas (strong earthen embankment) in Odisha and Madhya Pradesh and Korambus/Chira (temporary dam) in Kasaragod and Thrissur district, Kerala.

Among other types of natural and artificial reservoirs are lakes which are referred as Sagar/Samand (bigger lakes), Talab/Bandhis (medium sized lakes/reservoirs), Talai (reservoir area of less than five bighas) and Pokhariyan (ponds) in Bundelkhand (natural) region and Udaipur (artificial), Rajasthan, Nadis (village ponds) in Jodhpur, Rajasthan and Dongs (ponds) in Assam. Tanks are far more prominent in South India due to topography of the region but are also found in north-western India as well.

They are named as Chandela (small sized tanks), Bundela (larger than Chandela tank), Tobas (natural ground depression) and Tankas (small home tank) in several areas, Rapat (percolation tank) in Rajasthan and Cheruvu (runoff storage reservoirs) in Chitoor and Cuddapah districts, Andhra Pradesh. In other parts of India, they are referred by several names such as Jhalaras in Rajasthan and Gujarat, Kohli in Bhandara, Maharashtra, Kere in Central Karnataka Plateau, Eri in Tamil Nadu and Ooranis in South Travancore, Tamil Nadu to name a few.

Wells are one of the most abundantly marked artificial reservoirs of water in Indian maps and especially in rural or village maps. Many a times, they have played significance in maintaining socio-cultural relations and power-politics in the village space. Their names and roles are signifier of their importance in community life. They may be referred as Baoris/Bers (community wells) in Rajasthan, Saza Kuva (open well with multiple owners) in Aravalli hills in Mewar, eastern Rajasthan, Virdas (shallow dug wells) in Great Rann of Kutch, Gujarat (Padigala 2017) and Vav/Vavdi/Baoli/Bavdi (stepwells) in Gujarat (refer to Fig. 15.9) and Rajasthan. It is also in the villages that agriculture and specifically traditional agricultural practices are utilised for crop production. Irrigation plays a major role in agricultural productivity especially in a sub-tropical monsoon dependent nation. Several types of irrigation practices are employed in India in different parts of the country; in-synchronization with the local geography and suitable conditions. These practices may be referred to as Bamboo drip irrigation (Bamboo pipes for irrigation) in Khasi and Jaintia hills of Meghalaya, Cheo-oziihi (channel irrigation) in Nagaland, Pat (irrigation system) in Jhabua district, Madhya Pradesh, Dungs/Jampois (small irrigation channels) in Jalpaiguri district, West Bengal and Apatani (wet rice cum fish farming system) in Arunachal Pradesh to name a few.

Fig. 15.9 Traditional Green building: Bavdi in Baroda, Gujarat. *Data source* Author's illustration

In several other parts of India, the abundance of water is utilised efficiently for times of scarcity. Several kinds of rain water and surface water harvesting systems are used to conserve, utilize and store abundant water availability rather than allowing it to be just run-off. Amongst the myriad rain water harvesting practices in India; Jackwells in Great Nicobar Island, Andaman and Nicobar Islands, Khatri in Hamirpur, Kangra and Mandi districts, Himachal Pradesh, Kuis/Beris in western Rajasthan, Kunds/Kundis in Thar desert, Rajasthan and partially in Gujarat and Zabo/Ruza (impounding rainwater run-off system) in Nagaland are some significant few to mention. Ahar Pynes in south Bihar is a unique practice of harvesting flood waters while Kuhls in Jammu and Kul in Spiti valley, Himachal Pradesh are a practice revolving around the utilization of surface channels as well as Naula (surface water harvesting) in Uttaranchal. Khadin/Dhora is a surface run-off harvesting system found in Jaisalmer, western Rajasthan while Surangam/Thurangam/Thorapu/Mala is unique tunnel water harvesting system found in Kasaragod district of Kerala. Other names of water harvesting systems in different parts of India are Paar in western Rajasthan, Phad in Dhule and Nashik districts, Maharashtra and Zings in Ladakh to name a few.

It is in the light of this rich heritage of green buildings, that the relationship between green buildings and smart cities need to be rigorously pursued for attaining smarter cities with smarter solutions for maximum sustainable efficiency.

15.3 Green Buildings and Smart Cities: A Relationship to be Pursued

To understand Green buildings better, one can peruse this definition for a general understanding behind their conception. Green Building is:

Any built structure that is designed to judiciously and efficiently utilize its key components namely site, energy, water and materials (but not limited to) in an environment-friendly and sustainable manner along with the practical implementation of reuse and recycle ideology for improving quality of human life and environment. They are mediation between the best of both worlds that is; they are highly energy and water efficient as well as sustainable and economic in the longer duration.

Green Buildings are an integral part of a sustainable way of life especially necessitated in urban areas which are at present characterised by innumerable problems of over population, pollution, unplanned; haphazard, chaotic and congested urban spaces and energy scarcity with increasing economic and environmental costs over time. With so many problems and challenges, Green buildings provide an energy efficient, healthier and environmentally sustainable way of life. Green buildings are also paving way towards a greener, sustainable future by exhibiting resilience towards climate change, giving time for adjustments and for finding newer alternatives to adapt to climate change economically, socially, ecologically and even psychologically. Recently, in the Indian context, Green buildings and their key characteristics have found prominent place in the Smart City initiative.

To define a Smart City is difficult because it is not a "one size fit all approach", just like urban regeneration and green buildings. Hence in order to understand or explain the concept of smart city, there is no universally accepted definition for it; since it would imply different perceptions and understandings to different people, for instance in this case; it implies green buildings as an integral part of or a building block of a smart city.

The conceptualisation of a Smart City as stated in the Mission document released by the Ministry of Urban Development (MoUD), India in June, 2015, therefore defines it as a perceptual, spatio-temporal and resource-based approach. This implies that the concept itself would differ spatially in context of developmental levels, intention to change and reform and dependent upon the resource availability and aspirations of urban dwellers in a specific space and time. Even then, few parameters are required to act as guiding forces in this Mission which have been outlined as the list of essential urban infrastructures namely; the availability of sufficient as well as continuous: water and electricity supply, sanitation and solid waste management services, accessibility, affordable housing with special emphasis upon the urban poor, well networked information and communication technologies, effective governance along with citizen participation, safety and security of citizens, effective health and education system as well as environmental sustainability (MoUD 2015).

An urban area is typically premised upon inclusive and widespread development which can be broadly categorized into myriad physical, socio-economic and institutional infrastructure. It may be long or short term depending upon the needs and challenges of the situation, area and people. Smart cities are premised upon or imagined as the spaces providing a suitable quality of life to its inhabitants through comprehensive development and availability of essential infrastructure while simultaneously assuring hygienic, ambient and sustainable environment through Smart solutions' application. The comprehensive development through the addition of essential layers would progress towards incremental smartness. Towards the intention of smart city through green building, the strategies of retrofitting in and of existing buildings along with implementation of green building and energy efficiency codes would be implemented in Greenfield developments.

Green buildings are the need of the hour primarily because they are efficient in energy and water savings and provide a better alternative to harmful and wasteful utilization of resources especially in urban areas. Green buildings also fulfil the targets or goals set by the Urban Sustainable Development Goals and Smart Cities initiative. Even at the environmental level, Green buildings are a strong necessity given the present environmental scenario and the amount of non-renewable energy being consumed wastefully.

Green buildings like regeneration are not a "one size fit all" approach rather they are micro-based solutions that are better adept at tackling problems and resource scarcity at hand and appropriate to local conditions. It is high time that we relook at our present spate of urbanization and implement greener options to make our cities more sustainable and adept at tackling climatic changes along with bearing more resilience to urbanization related issues. Green buildings are an answer to many problems simultaneously and effectively and are also regenerative in the sense that

they are based upon self-sustainability implying that much can be achieved in a positive sense if buildings are adopted, constructed or modified to be green. But all this can only be achieved or implemented if the people at their individual level become aware of the problems at present and the need for such measures to sustain a greener future and our future generations.

15.4 Green Buildings: Paving Way for a Better, Greener Future

In September, 2013, the campaign for Urban Sustainable Development Goal (USDG) was launched by Sustainable Development Solutions Network with the support of UN Habitat and many other organisations and agencies for Sustainable Cities and Regions (UNSDSN 2013). It is within the spirit and context of USDGs that the Green buildings are placed as an intention; to be pursued in solving and mitigating urban and urbanization challenges. Even in India, with Prime Minister Narendra Modi's vision of 100 Smart cities (India Today 2014), again due importance is premised upon the need for Green Buildings.

The concept of Green Buildings is somewhat rooted in the self-sustainability aspect of regeneration. To many, the concept of Green Building may appear to be new or modern or innovative but the fact is that the concept is as age old as human habitation. The practice to stay in synchronisation with our environment and seasons has been practiced since times gone by and to an extent are practised till today as part of rural traditions and techniques.

The concept of Green Buildings is premised upon Recycle and Reuse, Energy efficiency and Water management as key concepts from plan to implementation stage. Green buildings (refer to Fig. 15.10) are thought green, built green and use green to sustain and efficiently work. Even if they are not initially built green, simple measures and modifications can ensure greener use of the buildings. A green building must be in synchronisation with its environment and specifically with its local climatic regime because if this is not the case, then the added temperature controlling mechanisms will render the building non-green and unsustainable as it would consume energy to regulate an adequate temperature regime within the confines of the building. In such a scenario, the important role is played by the design of the building and the construction material.

At present in urban areas, the green building mechanisms employed range from using solar water heaters, solar panels for energy generation and solar cookers for cooking, rainwater harvesting systems for groundwater recharge, storage tanks, wastewater recycling system to minimize water loss and increasing efficient use, using motion sensors to switch off/on lights and air-conditioning, energy efficient appliances, CFLs or compact fluorescent light bulbs, using bio-degradable waste

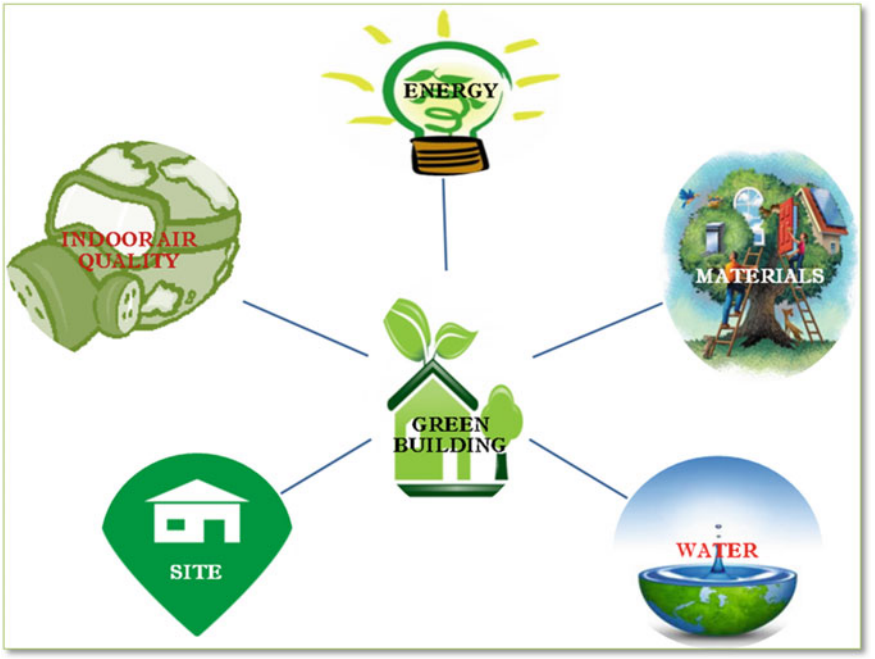

Fig. 15.10 Basis of Green building efficiency. *Data source* Based on LEED- India approach (2001)

from kitchen as compost manure for house garden and so on. Even the use of building material is also scrutinised to be in synchronisation with the local climate implying that glass is more appropriate for use in colder climates because it creates a greenhouse effect keeping the inside of the house/building warmer than the outside whereas wood, mud and lighter wall colours must be used in hot climates to keep the buildings/houses cooler without much dependence on artificial sources of ventilation and temperature control mechanisms. Green buildings are premised upon efficiency of water and energy saving and utilization which is extremely required in the present scenario.

15.5 Greening Smart Cities: Present Practices and Policies

Any green building in contemporary times resonates with Smart Technology. Smart technology helps in resource and energy conservation, efficiency and judicious utilization over time. To exemplify, Taipei 101, located in Taiwan can be observed as an energy efficient, smart-green building. Taipei 101 is the world's tallest green building standing at a height of 508 m above ground with smart technology (solutions provided by Siemens in 2008) such as motion sensors that detect and allow other technologies to function only in the presence of inhabitants, along with automatic ventilation

control for air conditioning, improved insulation for heating and lighting controls utilizing natural light. It is (Leadership in Energy and Environmental Design) LEED-Platinum rated building. Further, Siemens has provided smart technology solutions to Crystal, London, UK in 2012; under its Sustainable Cities initiative. The Crystal is an all electric building that utilizes solar power and ground source heat pumps to fulfil its own energy requirements. It is an 'Outstanding' certified building by (Building Research Establishment Environmental Assessment Methodology) BREEAM (a Green building rating agency, similar to GRIHA, LEED and BEE). Apart from these two, a sustainable and green city is being constructed in Abu Dhabi, UAE referred to as Masdar—City of Tomorrow. The city is proposed to use Green building concepts and solar energy to fulfil its necessities to live in an environmentally sustainable and smart way.

In India, few preliminary steps have been taken towards green and smart buildings and one of the prominent examples at present is the Cochin International Airport in Kerala, India. Very recently, the Cochin airport achieved Power Neutrality, the first of its kind; at this scale in India. The airport at present is running upon the energy derived from the solar panels and works on principle of energy sharing. When they have excess energy, they supply to the grid, when they do not have adequate quantity, then they borrow from the grid, making them energy-neutral. They have emerged as a light house to guide others in adopting such cleaner, greener and smarter technological practices.

At present, India has a total of 752 certified green buildings, which are fully functional and operational (The Economic Times 2018) while their number is still increasing. To refer a building as a Green building in India, it is necessitated to apply for one of the following rating systems. The **GRIHA** or Green Rating for Integrated Habitat Assessment is an Indian rating system which has been jointly developed by TERI (The Energy and Resources Institute) and the Ministry of New and Renewable Energy, Government of India (www.glassisgreen.com, accessed 2018). It is an evaluation process comprising of three tiers. GRIHA rating system comprises of 34 criteria classified in four sections and includes such criteria as site selection and site planning, conservation and efficient utilization of resources, building operation and maintenance and innovation (www.grihaindia.org, accessed 2018). Prime examples of GRIHA buildings are Commonwealth Games Village, New Delhi, Fortis Hospital, New Delhi, CESE (Centre for Environmental Sciences and Engineering) Building, IIT Kanpur, Suzlon One Earth, Pune to name a few (www.greencleanguide.com, accessed 2018).

Another important rating system is the **IGBC** or Indian Green Building Council; which has licensed the LEED Green Building Standard from the USGBC or the U.S. Green Building Council. The Leadership in Energy and Environmental Design (LEED) is the rating system developed by U.S. Green Building Council (USGBC) for certifying Green Buildings. LEED is a framework for assessing building performance against set criteria and standard points of references. The benchmarks for the LEED Green Building Rating System were developed in year 2000 and are currently available for new and existing constructions (www.greencleanguide.com, accessed 2018).

LEED-INDIA approach for Green Buildings Confederation of Indian Industry (CII) formed the Indian Green Building Council (IGBC) in year 2001 (Madhumathi and Sundarraja 2014). IGBC facilitates Indian green structures to become green buildings. At present, nine Green Building rating systems are available under IGBC such as; LEED India 2011 for New Construction, LEED India 2011 for Core and Shell, LEED 2009 (V3) for Homes, LEED 2009 (V3) for Neighbourhood Development, LEED 2009 (V3) for Commercial Interiors to name a few (www.usgbc.org, accessed 2018).

Yet another green building rating system in India is the **BEE** or Bureau of Energy Efficiency. BEE rating is measured as a range of stars from one to five with more stars implying better energy efficiency. It also developed Energy Performance Index (EPI) specifically for rating air conditioned and non-air conditioned office buildings wherein one unit is measured as Kilo watt hours per square meter per year. The Reserve Bank of India's buildings in Delhi and Bhubaneshwar, the CII Sohrabji Godrej Green Business Centre are few examples that have received five star ratings from BEE (www.greencleanguide.com, accessed 2018).

At present, there is no nationwide initiative for building green buildings but the scenario is slowly changing in their favour. Around the year 2000, for instance in Haryana and Delhi, there was a rule for installing rain water harvesting systems on roofs of individual houses in order to get house completion certificates. At present, there are serious dialogues on benefits to be given to the owners of green buildings for reducing their carbon footprint. These green buildings may use solar water heaters and panels to fulfil their energy needs and use water harvesting and wastewater management systems to fulfil their water needs and so on. In several states across India, the need and importance of green buildings are being recognised and initiatives taken accordingly as in the case of Tamil Nadu; wherein the State government has targeted the rural poor to provide solar power run green houses while allocating Rs. 1,080 Crore for construction of 60,000 green houses (The Hindu 2011).

The Kerala State Housing Board initiated the work on sixty eco-friendly apartments (as limited scale commercial venture) located in Kochi and Thiruvananthapuram under the GRIHA system. This intention is further pursued under the Saphalyam Housing Scheme for the financially weak in the districts of Kottayam, Kollam, Idukki, Kozhikode, Malappuram, Palakkad and Thrissur. Several plans are also underway to implement GRIHA while constructing the new government residential flats as well as for rehabilitating slum dwellers in a green building way (The Hindu Business Line 2012). Furthermore, there are comprehensive plans by several states namely; Haryana, Rajasthan, Uttar Pradesh, West Bengal in north, Gujrat and Maharashtra is west, Odisha in east and Andhra Pradesh, Karnataka and Tamil Nadu in south along with the union territory of Delhi; to implement the Energy Conservation Building Code (ECBC) for all new commercial constructions (Institute of Building Efficiency 2012).

Recently in Green building context, the Delhi Development Authority or DDA has formally stated a need and initiation for talks of a policy concerning promotion of green buildings (The Economic Times 2014). Even at a personal level, people, communities and organizations are adopting for living and building green as in the

case of Govardhan Eco Village in Thane, Maharashtra. This is a community which has built buildings with compressed stabilized Earth blocks, Rammed Earth Technique, Cob Houses (Adobe Bricks) with traditional thatched roofs. These buildings have received a five-star rating from GRIHA to be certified as Green buildings (www.teriin.org, accessed 2015). Another example is of Green One in Chittaranjan Park, New Delhi which became the first individual home to register for a green building rating from TERI in June 2011. This ultimately led to the initiation of the pilot project for Small Versatile Affordable Green Rating for Integrated Habitat Assessment or SVAGRIHA, TERI's adaptation of the GRIHA system for small homes. In January 2014, Green One became the first individual home in India to get a green rating, earning a five-star SVAGRIHA rating from TERI (www.teriin.org, accessed 2015). Along with this, the newly built TERI gram/village located on Gurgaon-Faridabad road is also rated as a green building.

In Delhi, institutions such as Centre for Science and Environment (Tughluqabad), Indian Spinal Injury Centre (Vasant Kunj) and Rashtrapati Bhawan (New Delhi), residential colonies namely Nizamuddin East and Defence Colonies (New Delhi) are prime examples of Rain water harvesting systems and thereby transformation (refer to Fig. 15.11) leading towards green buildings, green communities, green neighbourhoods (Singh 2015) and green city.

Further, the notion of green buildings is surpassing myriad activities, practices and processes; geared towards environmental and urban sustainability. Increasingly, industries are also being encouraged and mandated to go green, to exemplify; the recent instructions of the National Green Tribunal, 2015 (Times of India 2015) which state that all Textile Industries must fulfil Zero litre Discharge mandate wherein the concerned units are required to install Effluent Treatment Plants in conjunction with Reverse Osmosis plant to recycle and reuse waste/discharge water and minimise dependence upon fresh withdrawal of water for their processes. Essentially this system can be termed as individual wastewater treatment plants, a bold smart solution.

Green buildings are inclusive of myriad building and functional types and it is when all of them go green, become green and stay green, can we say that we can progress towards a future revolving around a smart city.

15.6 Building Greener Smart Cities

With the Smart Cities' initiative, the time has come to build and modify the buildings we live, work and access as Green for resource and environmental efficiency, embed smart solutions and technologies for efficient utilisations for an integrated system of smart-green buildings and neighbourhood. They also provide us with ways to mitigate climate change; for instance through the implementation of Green roofs (Castleton et al. 2010) which can have solar panels for power generation, rain water harvesting systems (Mentens et al. 2006), plant/grass cover for natural cooling or a roof top agricultural farm (Oberndorfer et al. 2007) and so on which may provide us

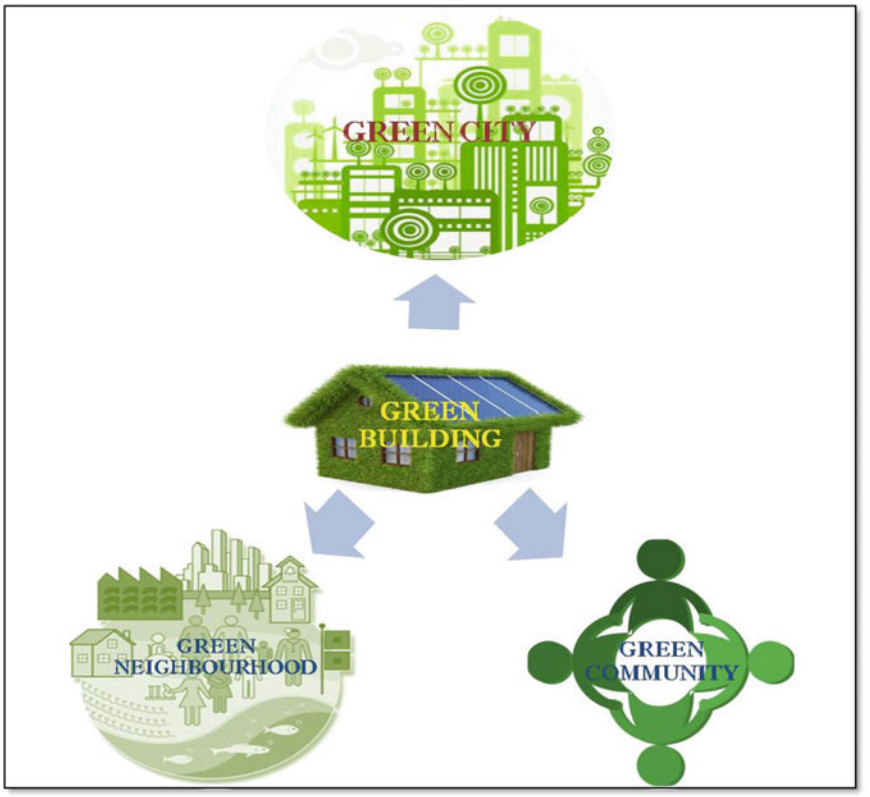

Fig. 15.11 The cyclic nature of building green: A step towards Smart City. *Data source* Author's illustration

with several opportunities and efficiencies. Some studies also indicate towards their positive role in tackling air pollution and climate change.

It is a fact and an initial desistance that building green buildings is slightly expensive than conventional buildings but this is true only in a very short run. In the longer run, green buildings have proven to be far more cost-effective than their conventional counter parts. Green buildings are a profitable venture in social, ecological and economic contexts and hence must be vigorously pursued. Green buildings have been built since time immemorial but in contemporary times riddled with several urban issues; they are needed with utmost urgency to sustain urban and urban ways of life but in an environment-friendly manner. Green buildings are a way to increase resilience towards climate change and to tap environmental degradation.

Green buildings have been made an integral part of Urban Sustainable Development Goals and Smart Cities' initiative because of their multiple uses and efficiencies in tackling so many challenges simultaneously along with providing an opportunity to

live healthy, sustainably and pollution free lifestyle. Smart Cities are premised upon Green buildings without which the smartness can never be achieved completely.

References

Brodies LLP (2009) Urban regeneration–the great debate. Scotland. http://www.brodies.com. Accessed 28 Dec 2012

Carrion MF, Hanley LM (eds) (2007) Urban Regeneration and revitalization in the Americas: towards a stable state. Comparative Urban Project, Woodrow Wilson International Center for Scholars. https://www.wilsoncenter.org/sites/default/files/CUSP_Q.pdf. Accessed 20 Feb 2015

Castleton HF, Stovin V, Beck SBM et al (2010) Green roofs: building energy savings and the potential for retrofit. Elsevier Energy Build 42:1582–1591

Green Clean Guide (2012) Green buildings. http://greencleanguide.com/three-primary-rating-systems-for-green-buildings-in-india/. Accessed 22 Aug 2012

Green Rating for Integrated Habitat Assessment. http://www.grihaindia.org. Accessed 3 Jul 2018

Haub C (2007) World population data sheet. Population Reference Bureau, Washington, DC. http://www.prb.org/pdf07/07wpds_eng.pdf. Accessed 20 Feb 2015

India ranks third among top 10 countries for LEED green buildings. The Economic Times, 23 Jan 2018. https://economictimes.indiatimes.com/news/economy/indicators/india-ranks-third-among-top-10-countries-for-leed-green-buildings/articleshow/62619975.cms. Accessed 3 July 2018

India Today (2014) 5 key elements of PM Narendra Modi's 100 smart cities, New Delhi. http://indiatoday.intoday.in/story/pmnarendramodi100smartcitieskeyelements/1/382021.html. Accessed 15 Aug 2015

Institute of Building Efficiency (2012) Building efficiency: a key to fixing India's energy crisis. http://www.institutebe.com/energy-policy/Fixing-India%E2%80%99s-Energy-Crisis.aspx. Accessed 13 Apr 2016

Kanaujia K (2016) Urban regeneration: mediating geo-anthropogenic environment- a case study of urban villages of Delhi. In: VAV Raman (ed) Geoanthropogenic environment: an appraisal, A. K. Publications, New Delhi, pp 149–164

Lawless P (2010) Urban regeneration: is there a future? People, Place and Policy Online (4/1):24–28. http://extra.shu.ac.uk/ppp-online/issue_1_260410/documents/urban_regeneration_future.pdf. Accessed 22 Feb 2013

LEED in India. https://www.usgbc.org/help-topic/leed-in-india. Accessed 3 Jul 2018

Madhumathi A, Sundarraja MC (2014) Buildings in hot humid climatic regions using phase change materials as thermal mass in building envelope. Energy Environ 25(8):1405–1422

Mentens J, Raes D, Hermy M (2006) Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? Elsevier Landsc Urban Plan 77:217–226

Ministry of Urban Development (MoUD), Government of India (2015) Smart city: mission statement & guidelines. http://smartcities.gov.in/upload/uploadfiles/files/SmartCityGuidelines(1).pdf. Accessed 15 Aug 2015

Mitrojorgji L (2003) Urban regeneration in Berlin, Germany: new approaches at the neighbourhood level. Concentration paper, Department of Urban and Regional Planning, University of Illinois, Urbana-Champaign. https://www.ideals.illinois.edu/handle/2142/68736. Accessed 20 Feb 2015

Oberndorfer E, Lundholm J, Bass B et al (2007) Green roofs as urban ecosystems: ecological structures, functions and services. BioScience 57(10). http://www.bioscience.org. Accessed 15 Aug 2015

Padigala BS (2017) Traditional water management system for climate change adaptation in mountain ecosystems in reconsidering the impact of climate change on global water supply, use, and management. IGI Global

Peck L (2009) Delhi: a thousand years of building. INTACH Roli Guide, New Delhi
RB Singh's tweet (9.41 AM on 12 Sept 2015) stating a strong relationship between Green buildings and Green neighbourhoods
The Economic Times (2014) Delhi development authority to have incentive policy for green buildings soon. http://articles.economictimes.indiatimes.com/2014-10-30/news/55595601_1_green-buildings-delhi-development-authority-delhi-govt. Accessed 3 Mar 2015
The Energy and Resources Institute, TERI. http://www.teriin.org/. Accessed 15 Aug 2015
The Hindu (Madurai, India) (2011) Construction of solar-powered green houses for the poor to begin soon. http://www.thehindu.com/todays-paper/construction-of-solarpowered-green-houses-for-the-poor-to-begin-soon/article2625763.ece. Accessed 15 Mar 2015
The Hindu Business Line (2012) Kerala begins work on green buildings. http://www.thehindubusinessline.com/portfolio/kerala-begins-work-on-green-buildings/article3562966.ece. Accessed 13 Apr 2016
Times of India (2015) Green tribunal cracks whip on industries along Ganga. http://timesofindia.indiatimes.com/city/lucknow/Green-tribunal-cracks-whip-on-industries-along-Ganga/articleshow/46527347.cms. Accessed 15 Mar 2015
UN DESA. World urbanization prospects 2014. http://www.un.org/en/development/desa/news/population/world-urbanization-prospects-2014.html. Accessed 15 Aug 2015
United Nations (2006) World urbanization prospects: the 2005 revision. United Nations, New York.http://www.un.org/esa/population/publications/WUP2005/2005WUPHighlights_Final_Report.pdf. Accessed 20 Feb 2015
United Nations, Department of Economic and Social Affairs, Population Division (2014) World urbanization prospects: the 2014 revision, highlights (ST/ESA/SER.A/352). http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf. Accessed 20 Mar 2016
United Nations, Department of Economic and Social Affairs, Population Division (2015) World urbanization prospects: the 2014 revision (ST/ESA/SER.A/366). http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Report.pdf. Accessed 20 Mar 2016
UNSDSN, Why the world needs an urban sustainable development goal (2013). http://unsdsn.org/resources/publications/why-the-world-needs-an-urban-sustainable-development-goal/. Accessed 15 Aug 2015
WHO, Urban population growth. http://www.who.int/gho/urban_health/situation_trends/urban_population_growth_text/en. Accessed 15 Aug 2015
WWW.GLASSISGREEN.COM. https://www.glassisgreen.com/knowledge-centre/glass-green-ratings/. Accessed 6 Aug 2018