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Fumihiko Seta
Joy Sen
Arindam Biswas
Ajay Khare *Editors*

From Poverty, Inequality to Smart City

Proceedings of the National Conference on Sustainable Built Environment 2015

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Preface

Indian urbanization is a complex puzzle which is extremely difficult to comprehend. Yet, as academicians, it is our responsibility to study, comprehend, analyse, assimilate, and express on salient happenings in our urban systems. The expressions aim at the larger sections of the society to disseminate technical evaluation in a comprehensible note. This edition focuses on awaking the society on the contextual reality of urban India and also enabling policymakers with the situational understanding of Indian cities. It may provide the necessary tools and techniques to tackle the extreme situation of Indian cities. Some of the strategies are listed in the articles published in this book. The strategies are carefully crafted with profound thoughts behind each of it. Each author has demonstrated great skills and aptitude and recorded their observation with matured academic responsibility. This book covers two basic issues pertaining to India but with greater global implications. While half of the global population lives in cities, almost 900 million urban population lives in slums or slum-like situations. The situation is more difficult for developing countries like India. Unreleased data from socio-economic census in 2015 reveals that almost 35 % of urban India lives below poverty line. It is much higher than the government's data of 26.4 %. In many publications and survey, the figure varies between 30 to 50 %. Census itself reveals that 65 million population lives in slums. There is a considerable amount of challenge lies ahead to developing Indian cities. Population starving in poverty plays a significant role for functioning urban India. Non-availability of those activities seriously jeopardise effective functioning of any Indian cities, particularly the bigger cities. Unequal distribution of asset and financial capability resulted in denial of basic minimum services for a human being in these huge urban populations. In contrast, the cities also consist of sizable number of people who has the ability and knowledge to use resources, and create opportunities and augment innovation for rapid growth of city and region. In a resource crunch society, the dilemma for policymakers is to choose between these two extreme priorities.

At this moment, Indian cities are implementing strategies both for expanding minimal infrastructure and augmenting innovation in cities. These issues have been raised in several platforms but are forgotten in the aftermath. But we were deter-

mined to follow up the deliberations of the august gathering for Sustainable Built Environment 2015 conference at the sprawling campus of IIT Roorkee during April 10–12, 2015. The aim was to garner more meaningful contribution towards the society and the very people living in there. This book presents argument from contrasting quarters, which deliberates context from fulfilling basic amenities to innovative ideas for creative and smart cities. Authors in each part have presented their arguments through innovative work and working methodology. We hope that the ethos of this publication and every word printed in this book will further captivate the society to enhance knowledge to comprehend Indian urbanism. This book discusses on our understanding poverty and inequality and comprehend India's journey towards smarter cities. It is also the responsibility of the editorial team to critically endure every word and see that all the efforts by the contributors become audible to the greater society. The purpose for this approach is to make it more holistic rather focusing on only one dimension of cities. We have piece together all the evidences from empirical study to theoretical argumentation and encourage critical views from the contributors. Therefore, it's not only records the theoretical connotations but also showcases careful critique. This book covers two major issues which have profound impact on development of our society, community, neighbourhood, cities and regions. These issues are interrelated and have broader implications both regionally and nationally. But somehow it is also connected in the very root of built environment which starts from an individual family, their shelter and networking with space and society. The book received overwhelming response from the contributors across the country. And, finally, all their ideas, thoughts and contributions have been combined in two volumes.

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Kharagpur, West Bengal, India — Joy Sen
Roorkee, Uttarakhand, India — Arindam Biswas
Bhopal, Madhya Pradesh, India — Ajay Khare

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We have sincerely tried to contact and acknowledge copyright owners. The authors and publisher would be extremely pleased about any errors or omissions brought to their attention. We will make all the necessary corrections and include them in a later edition.

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Part I
Poverty, Inequality and Urban Infrastructure

Chapter 1
Municipal Solid Waste Management: A Paradigm to Smart Cities

Anita Singh Batar and Tarush Chandra

Abstract The smart city concept refers to a new paradigm for urban planning and management. Based on advance use of technology, it aims at accomplishing better cities. These cities are more likely to have an integrated viewpoint which includes social, economic, and environmental aspects. Managing solid waste is among the important challenges in urban areas throughout the world. In developing countries like India where a rapid increase in population has been observed in past decades, solid waste management has become a critical issue. Of the different smart service delivery areas, solid waste management is also one of the key service areas for making a city smart. Like many fast-growing metropolitan cities in India, Jaipur is a metropolitan city having quite an inefficient, outdated, and unscientific system for handling of municipal solid waste. The lack of organized system of door-to-door collection, inefficient transportation, unscientific and uncontrolled open dumping of waste, etc. needs to be improved. This paper attempts to assess the existing status of municipal solid waste management in Jaipur City by identifying the related issues. The study concludes with select proposals to use identified best practices in planning for municipal solid waste management toward making a city smart.

Keywords Municipal solid waste management • Smart city • Jaipur

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1.1 Introduction

Smartness in a city means different things to different people. It could be smart design, smart utilities, smart housing, smart mobility, smart technology, etc. Institutional infrastructure (including governance), physical infrastructure, social infrastructure, and economic infrastructure constitute the four pillars of a city. A broad classification of each of these may be understood as follows. Institutional infrastructure refers to the activities related to governance, planning, and management of a city. Economic infrastructure includes skill development centers, industrial parks, export processing zones, trade centers, service centers, financial centers, etc. Social infrastructure relates to the components which work toward development of human and social capital. These include education, healthcare, entertainment, etc. Physical infrastructure refers to cost-efficient and intelligent stock such as urban mobility, housing, energy system, water supply, sewerage and drainage, sanitation facilities, solid waste management, etc. (http://indiansmartcities.in/) (Fig. 1.1).

1.2 Definition

Municipal solid waste mainly includes wastes generated in commercial and residential areas within municipal or notified areas. Mostly, this excludes industrial hazardous wastes but often includes treated biomedical wastes (http://www.moef.nic.in).

Solid waste management is defined as the application of techniques to ensure an orderly execution of the various functions of collection, transport, processing, treatment, and disposal of solid waste (Zia and Devadas 2007).

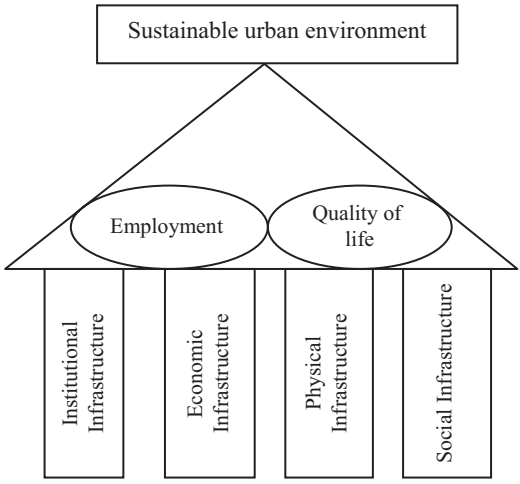

Fig. 1.1 Pillars of a smart city (Source: http://indiansmartcities.in)

1.3 Urbanization and Municipal Solid Waste

India is the second largest country in the world with a population of 1.21 billion, which is 18 % of the world's human population. Three hundred seventy-seven million, i.e., 31.2 % of the total population lives in towns. The proportion of population living in urban areas has increased from 17.35 % in 1951 to 31.2 % in 2011 (Census, 2011), and it is projected that 50 % of India's population will live in cities in the next 10 years (Vij 2012) (Fig. 1.2).

Indian cities add 0.2–0.6 kg of solid waste per capita per day. The rate of annual increase in waste generated per capita is 1.3 %, and the yearly rate of growth of urban population in India is 3.35 % (Census of India, 2011). So the increase in solid waste generated annually in urban area is greater than 5 %. According to 3i network report (2006), waste generated by Indian cities is 0.115 million ton/day or 45 million ton/annum, and The Energy Resource Institute estimates that waste generation will exceed 260 million tons per year by the year 2047, which is more than five times the present level (Asnani 2006).

According to the Central Pollution Control Board report, there is no comprehensive short- and long-term plan with municipal authorities to handle MSW in accordance with the MSW Rules 2000. Majority of the municipal authorities do not have preparedness to set up waste processing and disposal facilities. So there is a need of efficient and smart solid waste management system in order to make a city smart and habitable (Status report on Solid Waste Management).

1.4 Management of Municipal Solid Waste

Management of municipal solid waste (MSW) involves various stages starting from primary collection, secondary collection, transportation, processing, and disposal in the last stage. A detailed flow chart of the various stages involved in the phenomenon of municipal solid waste management is shown in Fig. 1.3.

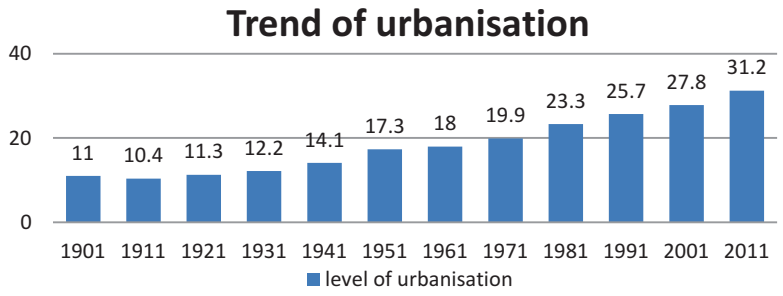

Fig. 1.2 Illustrating the trend of urbanization over the last decades (Source: Census of India, 2011)

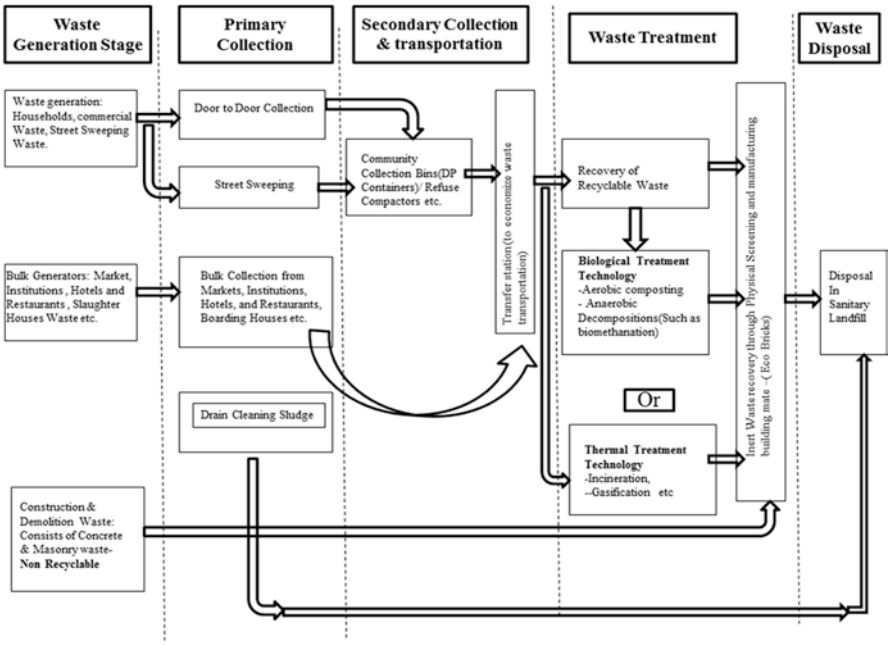

Fig. 1.3 Illustrating the typical flow diagram of various stages involved in municipal solid waste management (Source: CPHEEO Manual on MSW, 2014)

The quantity and composition of municipal solid waste are the result of a global marketplace for the production, packaging, and consumption of products and services. The waste stream is significantly influenced by products manufactured from all over the world. The World Bank estimates that worldwide municipal solid waste generation was 1.3 billion metric tons in 2012. This is projected to increase to 2.2 billion metric tons per year by 2025. Most of this increase will come in rapidly growing cities in developing countries where there is inadequate infrastructure to handle it. In many parts of the world, citizens do not receive the basic services to assure that solid wastes are managed in a way that provides for protection of public health and the environment (Skinner 2015).

According to the International Solid Waste Association, in many developing countries, less than 50 % of the waste is collected on a regular or frequent basis, and disposal sites are no more than open uncontrolled dumps. As a result, wastes accumulate along roadways and in water bodies and are the source of public health problems and the spread of disease.

In terms of opportunity, solid waste management holds the potential to become a major participant in international climate agenda. This can also create access to financial resources to assist in development of functional waste management infrastructure in developing countries.

Waste offers a significant source of renewable energy. Waste-to-energy, landfill gas recovery and utilization, and use of anaerobic digester biogas can play important roles in reducing fossil fuel consumption and greenhouse gas emissions. Waste

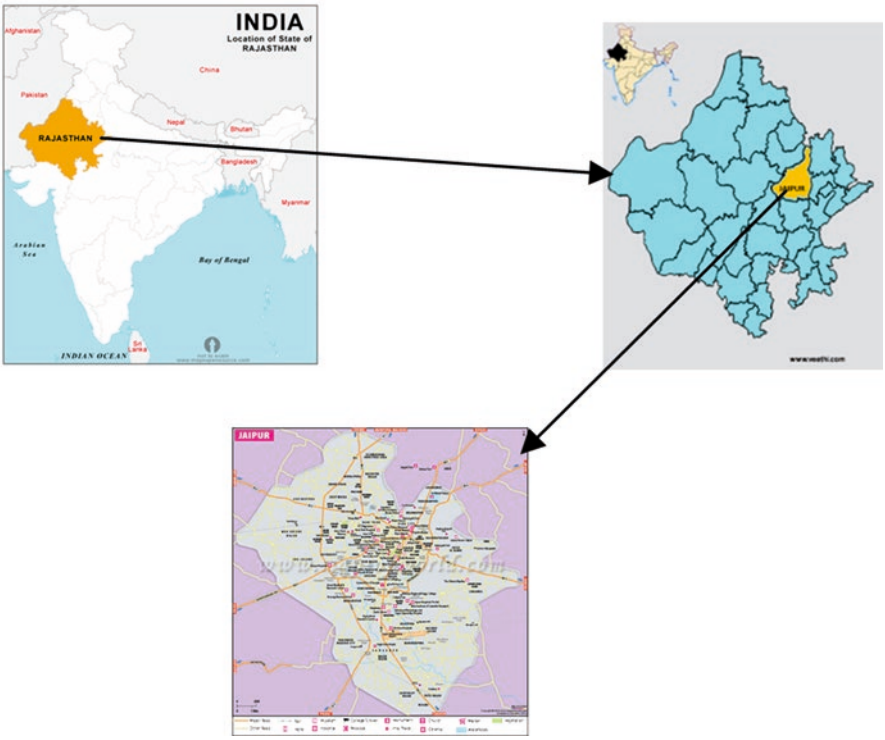

Fig. 1.4 Location of study area, Jaipur (Source: http://www.mapsofindia.com/map/rajasthan/)

prevention, recycling, and composting can also significantly reduce GHG emissions. Waste policies and regulations can be strong national drivers of change. This has been clearly demonstrated in the US. The 2014 Environment Protection Agency's GHG Emissions Inventory reported that the emissions from waste operations decreased by 30 % from 1990 to 2012. This was due to the increased recycling of organic wastes (paper, paperboard, food waste, and yard trimmings) and a significant increase in the amount of landfill gas collected, recovered, and used as a renewable fuel. This is a remarkable success story that shows how waste reduction and resource recovery can play a major role in reducing GHG emissions from solid waste management activities (Skinner 2015).

1.5 Introduction of Study Area

Jaipur is the capital and the largest city of the Indian state of Rajasthan. It is located in the eastern part of Rajasthan. It is flanked the Aravalli Range on its north and east direction. The climate of Jaipur is semiarid. The mean maximum temperature is 31°C, and the mean minimum is 18.5°C. Average annual rainfall is 66.8 cm (Fig. 1.4).

Table 1.1 Illustrating the decadal growth of population in Jaipur City

Year	1951	1961	1971	1981	1991	2001	2011
Population (in millions)	0.3	0.41	0.64	1.02	1.52	2.32	3.07

Source: Census of India, Govt. of India

1.5.1 Jaipur and Its Population Growth

The city has been experiencing a high growth rate of population. Table 1.1 shows that in the post-independence period, the population of Jaipur has increased by more than ten times.

1.6 Existing Status of Municipal Solid Waste Management in Jaipur City

Jaipur Municipal Corporation (JMC) is responsible for solid waste management in Jaipur. The solid waste generated in 2001–2002 was estimated to be 1040 metric tons per day (MTD) by JMC. For the same period, Rajasthan Urban Infrastructure Development Project (RUIDP) estimated it to be 1239 MTD. However, according to the Central Pollution Control Board estimates published 2004–2005, the amount of waste generated was 904 MTD, which instead of being numerically higher is much less than the estimates given by JMC and RUIDP for earlier years. This represents a clear inconsistency in recording data of amount of waste generated. This may be so as there was no scientific practice of handling the solid waste and is largely the same at present as well. A large proportion of waste collected from garbage bins and open waste depots is still carried in trucks, tractors, compactors, and dumpers. The whole quantity of waste collected is taken to landfill sites where open dumping of waste without any processing or treatment is done. This is among the most unscientific and conventional practices of handling solid waste and have a wide range of adverse effects on environment and public health.

According to JMC, around 1200–1300 MTD solid waste is collected every day. This is almost 85 % of the waste generated each day. Therefore the estimated quantity of waste generated in the entire city is around 1500–1600 TPD. While the estimated quantity of waste generated in 2001 was around 1040 MTD, 80 % of it was being transported each day as per JMC. This comprised of fresh as well as backlog of old waste. Table 1.2 also shows the present efficiency in collection and transportation of municipal solid waste in each of the zones with respect to their population and estimated amount of waste generated.

In Jaipur, we can see that the total municipal solid waste generated has increased by 41 % (2001–2014), and the yearly rate of increase in amount of total waste generated is 3.15 %.

Table 1.2 Illustrating the zone wise waste generation, 2014

Sl. No	Zone	Zone wise population	Waste generated (MTD)	Waste collected daily (MTD)
1	Hawa Mahal East zone	357,710	182	170
2	Vidhyadhar Nagar zone	728,309	371	240
3	Civil Lines zone	535,568	273	230
4	Mansarovar zone	365,543	186	120
5	Sanganer zone	424,564	217	140
6	Moti Dungri zone	291,251	149	130
7	Hawa Mahal West zone	177,918	91	80
8	Amer zone	165,300	84	70
Total		3,046,163	1554	1180

Source: Jaipur Municipal Corporation
**MTD* metric ton per day

Table 1.3 Comparison of population and amount of waste generated

Population		Amount of waste generated	
Year 2001	Year 2014	Year 2001	Year 2014
2,289,072	3,046,163	1040 MTD	1500–1600 MTD

Source: Jaipur Municipal Corporation

From Table 1.3, it can be seen that the population of the city has increased by 33 % (2001–2014), while the total municipal solid waste generated has increased by 41 %, which indicates faster rate of municipal waste generation (Fig. 1.5).

At present, per capita waste generation rate is 0.44 kg/c/d (Tables 1.4 and 1.5).

1.6.1 Waste Segregation

Waste segregation is one of the major steps in the municipal solid waste management, but there is no procedure of waste segregation that takes place at the source of generation in the whole city. It results in difficulties in separation of the waste at later (Fig. 1.6).

1.6.2 Waste Storage and Collection

The facility of storage of municipal solid waste is lacking in most of the places in the city. Waste collection in the city is being done by different methods. The citizens throw out the waste in the garbage bins. These garbage bins provided by the

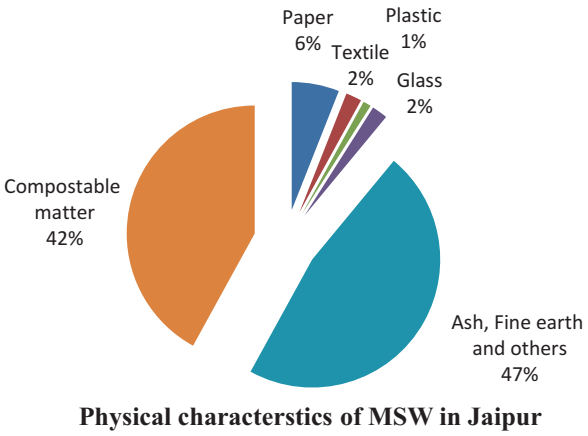

Fig. 1.5 Physical characteristics of waste in Jaipur (Source: Central Pollution Control Board Report, 2000)

Table 1.4 Waste generation rate (kg/c/day)

Sl. No.	Year	Waste generation rate (kg/c/d)	Source
1	2001	0.48	JMC
2	2004–2005	0.39	CPCB
3	2014	0.44	JMC

*kg/c/d.- Kilogram per capita per day

Table 1.5 Physical characteristics of MSW in Jaipur (% by weight)

Paper	Textile	Plastic	Glass	Ash, fine earth, and others	Compostable matter
6.00 %	2.00 %	1.00 %	2.00 %	47.00 %	42.00 %

Source: Central Pollution Control Board Report, 2000

Fig. 1.6 Waste segregated by ragpickers (Source: Primary Survey, 2014)

municipal corporation have no segregation facility and are common for biodegradable and nonbiodegradable waste. Primary collection of waste is being done by sweeping of roads and drains by sweepers (Figs. 1.7 and 1.8).

Fig. 1.7 Waste being collected by sweeper in wheelbarrow and dumped at open waste depots (Source: Primary Survey, 2014)

Fig. 1.8 Communal bin of capacity 1.1 cum and 7 cum (Source: Primary Survey, 2014)

Fig. 1.9 Stray animals creating nuisance (Source: Primary Survey, 2014)

The door-to-door waste collection system does not involve segregation of biodegradable from the nonbiodegradable. Waste is collected and stored in containers or left at the roadside for JMC workers to collect and transport it from there. This creates a lot of nuisance with stray animals spreading the waste. Waste management is absent in slum and *kacchi basti* areas where waste is dumped into *nallahs* (drainage) (Fig. 1.9).

This problem is mainly occurring in the old city, where there is no single collection bin has been placed. The sweeper generally cleans the street and makes a heap instead of dumping the collected waste in the garbage bin. (Fig. 1.10).

Fig. 1.10 Plastic waste littered on road in walled city (Source: Primary Survey, 2014)

Table 1.6 Municipal Zones and Ward Number (2015)

Sl. No.	JMC zones	Ward number
1	Hawa Mahal East zone	63,66,67,78,69,70,71,72,73,85,86
2	Vidhyadhar Nagar zone	1,2,3,4,5,6,7,8,9,10,11,12,13,14,23,24,25,79,80,81,82
3	Civil Lines zone	15,16,17,18,19,20,21,22,26,27,28,30,56,57,58,76
4	Mansarovar zone	29,31,32,33,34,40,41,42,43,44,55
5	Sanganer zone	35,36,37,38,39,45,46,47,48,49,50,52
6	Moti Dungri zone	51,53,54,59,60,61,62,64,65
7	Hawa Mahal West zone	74,75,77,78,83,84
8	Amer zone	87,88,89,90,91

Source: Jaipur Municipal Corporation

The whole area under Jaipur Municipal Corporation is divided in eight zones which includes 91 wards. Zone wise ward list is shown in following table (Table 1.6).

There are 1462 containers placed by the Jaipur Municipal Corporation; out of which, 898 containers are of 1.1 cum capacity, 357 containers are of 3 cum capacity, and 80 containers are of 7 cum capacity.

According to the Jaipur Municipal Corporation, there are almost 3500 waste collection depots; out of which, only 1462 are containerized; the remaining are open depots. *Sixty-one wards are non-containerized* and having only open waste storage depots.

The communal bins have been placed only in five zones out of total eight zones. The totally neglected zones include Hawa Mahal East zone, Hawa Mahal West zone, and Amer zone. The entire walled city comes under the Hawa Mahal zone. In these zones, no garbage container is placed, and waste is dumped into open collection depots. The city is unable to provide waste collection services to all parts of the city. Overcrowded low income is the most neglected.

1.6.3 Waste Transportation

After the collection of the waste, it is transported to disposal sites by transporting vehicles. Trucks and tractors are generally used for transportation. These vehicles are open and usually remain uncovered which results spilling of waste over roads

Fig. 1.11 A compactor collecting MSW (Source: Primary Survey, 2014)

Fig. 1.12 Tractor carrying waste from the old city (Source: Primary Survey, 2014)

and creates nuisance. JMC has 164 vehicles for the transportation of the municipal solid waste from the storage bins to the disposal sites.

Dumper placer and refuse compactors are also used for transportation. There are basically two types of dumper placer; one can carry a single container of 7 cum carrying capacity, while another one can carry two containers of capacity 2.5 cum each. Compactor is also an important vehicle which has hydraulic lift arrangement for automatic lifting of waste, generally collects the waste from collection bins of 1.1 cum capacity. It has capacity of 14 cum and can carry waste up to 9 tons. The waste transported from small vehicles is first of all collected at the transfer stations and then after loaded into large vehicles for final disposal. At present, three transfer stations are operating in Lal Dungri, Parasram Circle, Vidhyadhar Nagar, and Manasarovar (Figs. 1.11 and 1.12).

1.6.4 Disposal of Waste

The Jaipur City has a total of 530.65 acres area for waste disposal sites (CPCB). There are three main sites for waste disposal, which are located at Mathura Das Pura, Sewapura, and Langadiyawas areas. The total areas of the sites are 108.7,

Fig. 1.13 Location of landfill sites (Source: Google maps)

123.5, and 298 acres. (The area has been given in *bighas*, and in Rajasthan, one *bigha* is equal to 2500 square meter, so the area was 176, 200 and 483 *bighas*, respectively). All the waste generated in the city is being deposited at these three disposal sites.

Open dumping of waste is in practice at all the three sites. No scientific method of waste disposal is adopted. At Sewapura landfill site, one composting plant of 250 MTD capacity is established, and one MSW processing plant (RDF plant) has been established at village Langariyawas site, by M/s Grasim Industries Ltd. to process municipal solid waste received from Jaipur Municipal Corporation, which is designed to handle about 400–500 TPD of MSW and generation of 130–140 TPD refuse-derived fuel (RDF) (Fig. 1.13).

During processing of MSWM, first of all, the waste is categorized into different categories, according to their densities. Waste having high calorific value is more suitable. The waste having high calorific value (plastics and polythenes) is converted into RDF, which can be used as a substitute of coal in kilns in cement factories. The RDF produced at Jaipur RDF plant located at Langariyawas landfill site is transported to cement factories in Rajasthan and Madhya Pradesh where it is used as a fuel in substitute the coal (Fig. 1.14).

Total waste transported to the landfill site is ranging from 1300 to 1400 MT per day.

So here we can conclude from the existing scenario of Jaipur City that the current practices of handling municipal solid waste are old and unscientific. Methods of disposal of waste are also degrading the environment.

By comparing existing status with the national service level benchmarks, we can see that there is a huge gap between the service level benchmarks and the current status. Here, a detail of existing status with comparison of national level service benchmarks has been discussed (Table 1.7).

Fig. 1.14 Open dump site at Mathura Das Pura and Sewapura (Source: Primary Survey, 2014)

Table 1.7 Service Level Benchmark indicating the status of solid waste management in Jaipur City

Sl No	Indicator	Performance measure	National benchmark	Status (2010–2011)	Inferences
1	Household level coverage	Total number of households and establishments with daily doorstep collection/total number of households and establishments in the service area	100 %	7.3 %	JMC has not provided DTD facility in most parts of the city
2	Efficiency of collection of MSW	Total quantum of waste that is collected by the ULB or authorized service providers/total waste that is generated and which needs to be collected	100 %	83.3 %	Low efficiency of vehicles or machinery used for collection
3	Extent of segregation	Quantum of waste that is segregated/total quantum of waste that is collected by the ULB or authorized service providers	100 %	0.0 %	Lack of awareness among the residents of regarding storage of garbage at household level and DTD collection
					No separate container for collection
4	Extent of MSW recovered	Amount of waste that is processed or recycled/total quantum of waste that is collected by the ULB or authorized service providers	80 %	6.3 %	Processing or treatment plants have lower capacity than amount of waste generated
5	Extent of scientific disposal	Total waste disposed in "compliant" landfills every month/total waste disposed in all landfills every month	100 %	0.0 %	No scientific landfill site is available

(continued)

Table 1.7 (continued)

Sl No	Indicator	Performance measure	National benchmark	Status (2010–2011)	Inferences
6	Cost recovery	Total annual operating revenues/total annual operating expenses	100 %	0 %	Lack of door-to-door collection
					Poor marketing of processed material
7	Efficiency in collection charges	Current revenues collected in the given year/total operating revenues billed during the given year	90 %	0.0 %	User charges are not mandate

Source: Government of India, "Service Levels in Urban Water and Sanitation Sector" Ministry of Urban Development, 2012

1.7 Results and Findings of the Major Problems Related to MSWM

From the above discussions, following issues have been found:

1. Absence of segregation at the source.
2. Limited door-to-door collection provided through PPP.
3. Inconsistency in record-keeping and data management.
4. Shortage of community garbage bins.
5. Open bins for community garbage.
6. Open transportation vehicles
7. Long routes and high fuel costs resulting in high transportation expenses.
8. Lack of community participation.
9. Service level benchmark not as per national standard.
10. Unscientific disposal practices in open landfills.

1.8 Discussions

1. *Separate community bins for biodegradable and nonbiodegradable wastes:*
   Should mandate separate community bins for biodegradable and nonbiodegradable wastes. These bins should be
   - Fully covered and leakage free, so that any kind of bacterial infection can be prevented.
   - Must be in at least three colors, with biodegradable, nonbiodegradable, and recyclable waste.
   - Must be placed at walking distance, most preferably within the 100 m, so that every person can reach easily to the bins.

2. *Promote door-to-door collection system with source segregation*: Door-to-door collection system should be promoted with the facility of segregating waste at the point of generation. For this awareness among the residents about the importance of source segregation should be improved through a proper information educational campaign to sensitize the people about waste management.
    - Separate collection of biodegradable, nonbiodegradable, and inert waste at household level.
    - Collection of biodegradable waste at no cost.
    - Earn profit by composting at ward level using neighborhood parks or vacant land.
    - Collection of recyclables on a weekly basis.
3. *Proper data record*: Proper data of amount of waste generated and collected should be maintained for the establishment of suitable treatment system according to the quantity and composition of the data.
4. *Abolition of open storage*: By adopting door-to-door collection and replacing the open storage community bins, the open storage can be eliminated.
5. *Use of covered vehicles during transportation*: During transportation of waste from collection point to landfill sites, the vehicle used should be covered to avoid spill of waste on road.
6. *Decentralized treatment system at ward level*: To avoid high transportation and collection cost, the waste treatment plant should be kept decentralized. By adopting decentralized treatment system, we can curtail the transportation cost. It involves public participation. Informal sector can also be regularized in segregation and recycling of the waste at ward level. The model has been tried successfully in few cities like Chennai.
7. *Natural gas-powered vehicles*: To reduce the carbon emission and adverse effect on environment, natural gas-powered vehicles should be used for collection and transportation.
8. *Improvement of final waste disposal*: Final waste disposed in open landfills can be harmful for the environment due to pollution caused by open waste dumping. The waste left after the treatment, which is of no further use, should be disposed in proper designed sanitary landfills.

1.9 Conclusions

With rapid urbanization and increasing per capita waste generation rate, the municipal solid waste has become a very important service to be taken care of for a smart and livable city. With increasing level of environmental pollution and greenhouse gases, municipal solid waste also holds opportunity for a major resource of renewable energy in international climate agenda.

Managing municipal solid waste is under the purview of urban local bodies. Public apathy and low social status assigned to SWM activity by local bodies are a

great hurdle in solving this problem. During the last decades, the population of Jaipur City is growing at a faster rate, and the amount of municipal solid waste generated is also increasing significantly. Also as per the future estimations, the amount of municipal solid waste generated is supposed to be increased at a very faster rate.

The existing status of waste clearly speaks about the poor environmental health of the city. The existing SWM system in the city is totally inefficient. The lack of storage and collection bins, poor transportation, and unscientific disposal methods illustrates the present scenario of the municipal solid waste management system of the city. There is, therefore, an urgent need to improvise the situation to stop further decay and deterioration of the city. The aforesaid policies, if implemented, have the potential to bring an improvement in the SWM system in the city, which shall lead to healthier life in the city.

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Chapter 2
Urban Poverty: Trends, Assessment, and Inclusive Planning as a Solution

Mayank Mausom and Ankita Choudhary

Abstract Poverty in India has been a historic problem, its people being suppressed by rulers and foreign occupants for centuries, depriving them of basic rights. Poverty in India escalated and reached its peak in 1920s. Though, it has in the past remained majorly a rural problem, the trend seems to be shifting now due to migration of people into the urban areas. In the face of the fact of its emergent stature as an economy powerhouse in the world, and even almost seven decades after independence and sensitive self-governance, India has a whopping 65,494,604 of its people living in substandard conditions in slums (notified, recognized as well as identified slums) in its urban areas. This shows a decadal growth rate of 25.1 % from 2001 (Census of India 2011).

Poverty is generally understood in terms of deprivations – human, material, education, dignity, and basic rights, etc., as well as exclusions – political and social. Our country equates poverty to material deprivation and defines it in terms of level of incomes and consumptions – calorific intake. As per McKinsey report 2010, 75 % of urban population in India belongs to the bottom income segment and earns less than an average of Rs. 80, which implies that 254 million out of 341 million urban population fall in this category.

The paper looks into the causes of urban poverty and this colossal socioeconomic divide between the poorest and the rich. This paper also investigates into the various dimensions and characteristic of urban poverty like socioeconomic, demographical, and spatial aspects. The paper concludes by advocating pro-poor inclusive planning as a solution to this disparity and pitches for provision of basic physical and social infrastructures for the urban poor.

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Keywords Poverty • Deprivation • Inclusive planning • Urban poor • Slums • Basic infrastructure • Migration

2.1 Introduction

Urban poverty is usually defined as an absolute standard established on a least amount of income required to sustain a healthy and minimally comfortable life.

- "Poverty as lack of access to power"
- "Poverty as systemic right of suffrage"
- "Poverty as deficit and as lack of material resources"
- "Poverty as lack of knowledge"

The United Nations now defines poverty as follows: "Fundamentally, poverty is a denial of choices and opportunities, a violation of human dignity. It means lack of basic capacity to participate effectively in society. It means not having enough to feed and clothe a family, not having a school or clinic to go to, not having the land on which to grow one's food or a job to earn one's living, not having access to credit. It means insecurity, powerlessness and exclusion of individuals, households and communities. It means susceptibility to violence, and it often implies living in marginal or fragile environments, without access to clean water or sanitation."

2.2 Global Poverty Trends

The last decade has witnessed a rapid phasal reduction in poverty across the globe – developing nations in particular. Recent estimates show that there has been poverty alleviation of an astounding 500 million people from below the poverty line (the World Bank poverty limit of 1.25$/day), owing to the rapid economic growth in the developing nations between 2005 and 2010. From 2005 to 2010, the nations, classified as low income, have reduced by 40 % in number – from 66 to 40, and the number of nations classified as middle income has increased to over 100.

The following graph combination (Fig. 2.1) shows the transition in the state of poverty in the 20 major developing countries over the last decade. The four dimensions along which they have been compared are the number of poverty-stricken people which is represented by the relative radii of the circles, degree of fragility, per capita income of the people, and time. These nations together account for over 90 % of the total poor in the world and hence, more or less, regulate the state of the global poverty.

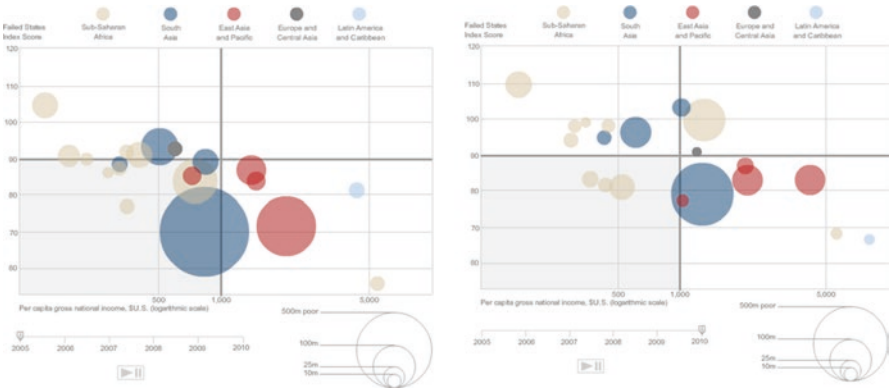


Fig. 2.1 Global poverty trends – situation in 2005 vs. situation in 2010

2.3 Indian Trend

The poverty demographics vary with the context of the urban and rural. As estimated, in 2011–2012, 26 % of all rural people are below the poverty line, and almost 14 % of all urban population is below the poverty line. Overall, 22 % of all the population of India is poor.

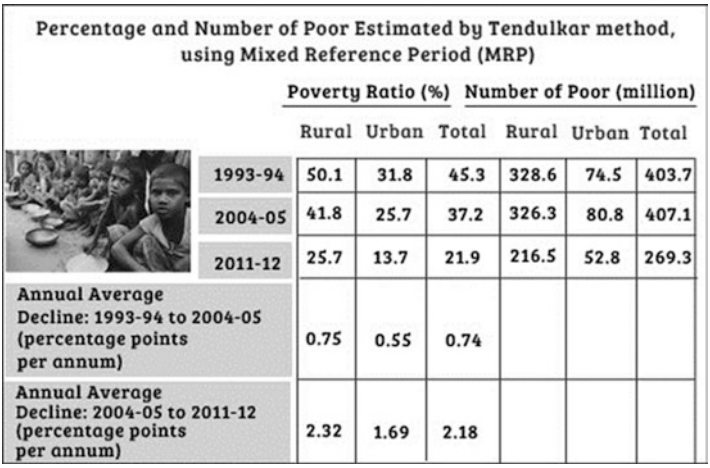
In contrast, in 2004–2005, the percentages were 42 for rural and 26 for urban areas. The overall percentage of population deemed poor in 2004–2005 was almost 37. Further down in history, in 1993–1994, it was worse – just over 50 % in rural and almost 30 % in urban settlements. Overall, it was just over 45 % for the whole country.

As evident from the adjoining table (Fig. 2.2), there has been a reduction in the number of people below the poverty line. As compared to over 407 million in the year 2004–2005, the number of people below the poverty line got reduced to around 270 million by 2011–2012 that means over 137 million people were lifted over the poverty line in a span of just 7 years. In this same period, the rate of decline of poverty was 2.18 which was more than thrice of that in the period from 1993–1994 to 2004–2005, 0.74.[1]

This might appear to be heartwarming statistics but is far from the truth; the benchmark set for BPL is too low and caters to the least possible needs for minimalist survival. The actual number of urban poor is much greater than what the statistics show.

Compared to other countries like China, the poverty reduction rate is much slower in India, as shown in Fig. 2.4 below. If the World Bank's $2 benchmark be taken, then India will have over half of the world's poverty-stricken population (refer Fig. 2.3) which amounts to almost 870 million people or over 75 % of the

[1] "Inclusive Urban Planning Empowering Poor Through Urban Poverty Reduction Strategies" by B.C.Dutta.



Percentage and Number of Poor Estimated by Tendulkar method, using Mixed Reference Period (MRP)

	Poverty Ratio (%)			Number of Poor (million)		
	Rural	Urban	Total	Rural	Urban	Total
1993-94	50.1	31.8	45.3	328.6	74.5	403.7
2004-05	41.8	25.7	37.2	326.3	80.8	407.1
2011-12	25.7	13.7	21.9	216.5	52.8	269.3
Annual Average Decline: 1993-94 to 2004-05 (percentage points per annum)	0.75	0.55	0.74			
Annual Average Decline: 2004-05 to 2011-12 (percentage points per annum)	2.32	1.69	2.18			

Fig. 2.2 The misleading statistic, Indian poverty trends

People Living on Less than $2 per day (PPP) in Selected Large Developing Countries

Country	*% of Population Living on $2 per day or less (PPP)(2005)*	*Population (2009)*	*Poverty Headcount Approximation (unadjusted for income / pop. growth 2005-10)*
Bangladesh	81%	162,220,762	131,934,146
Brazil	18%	193,733,795	35,530,778
China	36%	1,331,460,000	483,003,716
Egypt	18%	82,999,393	15,321,688
India	76%	1,155,347,678	873,425,905
Indonesia	54%	229,964,723	123,643,352
Pakistan	60%	169,708,303	102,351,077
Total		*3,325,434,654*	*1,765,240,662*

Global Sherpa 2011; Source: World Bank

Fig. 2.3 India's share of poor in the developing world

total population of the country.[2] India is still a home to one-third of the poorest people in world (Figs. 2.4 and 2.5) which demand more intensive research and analysis in this field.

[2] World Bank (2011).

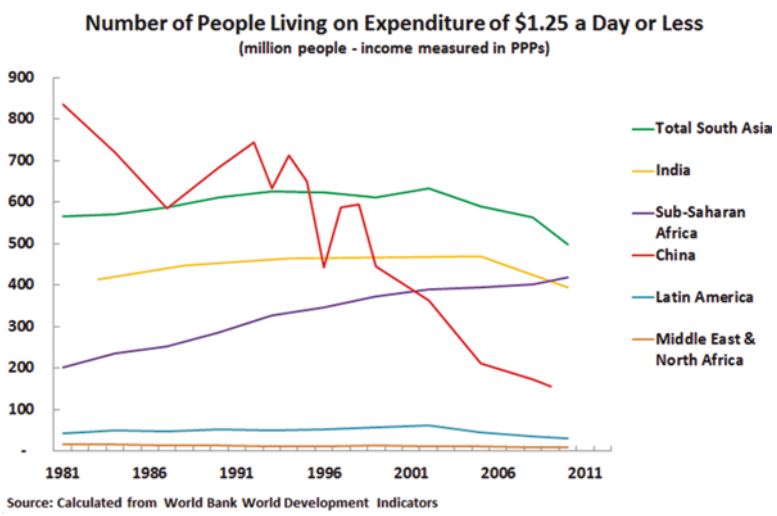


Fig. 2.4 India lags behind China and South Asia in poverty reduction

Fig. 2.5 The bitter truth of the great urban rich-poor divide (Source – Wealth-X and UBS), India is home to one-third of the poorest population of the world

2.4 Causes of Urban Poverty

The core causes of urban poverty are mostly rooted with the migration of already poverty-stricken people from the rural areas in hope of getting rid of the same poverty. Urban areas offer more opportunities to grow from time immemorial – initially as trading centers for rural produces and then as manufacturing centers for post-industrialization.

The lack of facilities and opportunities in the villages has resulted in mass unemployment in rural areas. This has in turn caused migration of the masses to the cities in search of employment and opportunities of better life and education and thus the resultant shift of rural problems into the cities.

The following can be summarized as the major causes of urban poverty:

- Migration of poverty-stricken people from rural areas.
- Insecurity, partial employment, and underemployment.
- The absence of social and health security schemes to majority population especially those who belong to the informal sectors.
- Majority of migrants work in the informal sector at very little wage.
- Exploitation of the rural migrant because of the lack of wage regulation in the unorganized work sector.

There is no sense in pushing forth the economic recovery in terms of purely GDPs without pushing for the increase in the employment, and unfortunately, that seems to be the current trend.

2.5 Characteristics of Urban Poor

The scenario is pretty complex with the total poor population of India almost equal to the population of Europe. The characteristics of the urban poor which have to be kept in mind while planning are mentioned herewith (Fig. 2.6):

- *Economic activity* – Majority of the urban poor being daily wage workers, working in unorganized sector, informal sector, or small time enterprise with unemployment, underemployment, and disguised employment being common.
- *The temporal nature of urban poverty* – Poverty is a dynamic condition; people may move in and out of it, for example, due to major macroeconomic shocks.
- *Diverse nature of urban poor* – The urban poor encompass dissimilar individuals with diverse requirements and types of vulnerability. These are due to factors such as gender, accessibility, education, disability, ethnic or racial background, as well as household structure.
- *Physical or social infrastructure* – Poor access to these basic infrastructures like sanitation, water supply, and sewerage. Education and healthcare are luxuries.
- *Environmental* – Urban poor generally live in environmentally degraded conditions, unhygienic and insanitary, and have to suffer.

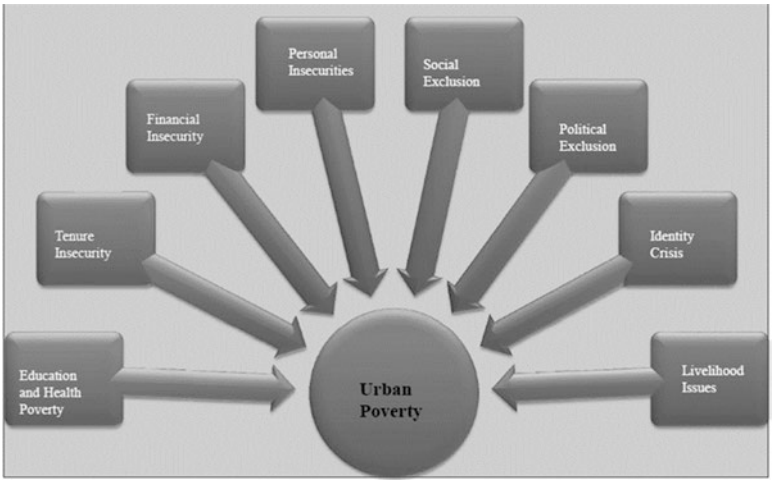


Fig. 2.6 Urban poverty – characteristics and issues (Source – TerraUrban)

- *Dependence on money* – Unlike their rural counterparts, urban poor have to buy even their food.

2.6 Programs and Schemes for Urban Poverty Alleviation

There are many ongoing and many iconic programs run in the past by various governments to empower the urban poor and alleviate them. Some of the major schemes and programs are mentioned herewith:

For housing:

- Jawaharlal Nehru National Urban Renewal Mission: Basic Services to The Urban Poor (BSUP) and Integrated Housing & Slum Development Programme (IHSDP)
- Follow-up on the National Urban Housing and Habitat Policy (NUHHP)
- Interest Subsidy Scheme of Housing for the Urban Poor (ISHUP)
- Rajiv Awas Yojana (RAY)

For better livelihood:

- Swarna Jayanti Shahari Rozgar Yojana (SJSRY)
- Prime Minister's 15 Point Programme for the Welfare of Minorities, 2006
- National Policy on Urban Street Vendors (2009) and Model Street Vendors (Protection of Livelihood and Regulation of Street Vending) Bill, 2009
- Twenty Point Programme – 2006
- Integrated Low Cost Sanitation (ILCS) Scheme

These arrangements have done their bit and helped in a colossal number of poor families attain the minimum standard of living, though their success is marred by the low permeability and large populace they are catering to.

2.7 Strategies for Urban Poverty Reduction

The current scenario of the urban poverty is far from satisfactory due to inequitable and insufficient opportunities of livelihood for the people below the poverty line in the urban areas. The efforts from the government are not sufficient to attain equitable growth for all. The cities in India themselves lack the most basic of the infrastructures, and migration only makes it worse. The cities and its urban planners generally focus more on master plans ignoring the large section of the urban poor in the process and thus depriving them from the fruits of the developments:

- Rural poverty needs to be mitigated to control urban poverty. They are interlinked and interdependent.
- Inflow and immigration to urban areas has to be controlled by providing better living conditions in rural setups and providing opportunities.
- Education system demands revamping – it has to be job oriented – in rural as well as urban areas by focusing more on skills and vocational training.
- Promoting small-scale industries and cottage industries in rural areas.
- Productive and affordable education for all so that even the poorest have access.
- Industries should be discouraged within the city to prevent labor immigration.
- Focus should be on increasing the buying capacity of poor families. This can be done by enabling them to earn more or by subsidizing products of necessities.

2.8 Inclusive Planning

Inclusive planning is a planning done while considering even the poorest of the poor as an important component; thus, the thrust of such a planning focuses on the upliftment of the downtrodden. A major focus of inclusive planning is to create employment opportunities and reduce poverty. Rapid urbanization in Indian cities has led to urban crisis which results in a lack of adequate infrastructure and a sharp social division. The small and medium towns as well as cities of India are facing incredible pressures in terms of population influx and economic developments which are leading to adverse primary and secondary impacts on the status of environment and health of the people, as well as on the unbiased distribution of resources and development funds and schemes. Here, urban planning becomes an essential component to provide a spatial dimension to the other developments – social and economic. The intent of the urban planning is to make the socioeconomic developments more equitable, contextual, localized, and most importantly – pro-poor.

Main emerging issues for poor people are mainly related to inadequate and unhealthy infrastructure, job opportunities, lack of essential physical and social infrastructure, and lack of credit and finance. So inclusive planning is the tool that helps in overcoming all these issues. It helps in reducing poverty through providing livelihood opportunities as in eleventh development plan rapid growth in economy at employment generation sector is supported by livelihood programs to reduce poverty. The Government of India does have a document that focuses on inclusive planning, "the State of Urban Poor Report 2013," and covers a whole lot of areas related to inclusive planning – regulatory, institutional, as well as legislative frameworks. It broadly implies the inclusive development to be "access for all for jobs, shelter, services, and infrastructure."

The conventional methods of planning are not adequate enough to cope up with the ever-growing requirements and aspirations of the citizens and the awareness of a better standard of living. Additionally, the municipal bodies and development authorities, in an attempt to catch up with the demand of providing basic infrastructures, often resolve to stopgap planning measures and initiatives which end up controverting the very principles of sustainable development. Broader components of urban planning such as all-inclusive, pro-poor planning with a systematic approach are seldom considered. Moreover, more specific areas of planning such as heritage conservation or environmental preservation are not even considered; currently, they are out of the radar of most municipal bodies. For the purpose of governing and planning, urban areas are subdivided into various wards, which are then governed by their own administrative bodies, so as to encourage and promote public participation and self-governance. These governing bodies occasionally do try to bring in urbanists, experts, and professionals to resolve the development and infrastructure-related issues; the voices of those present often include only middle class, because of their majoritarian nature, instead of the collective interests of an economically diverse city or of only the powerful upper class of the city. What is needed, albeit, is a combined and interdisciplinary effort to solve these rather multifaceted urban concerns, but it must embrace the voice and concerns of the lowest-income populace – the urban poor.

2.9 Conclusion

Urban poverty has continued to persist despite several schemes and efforts because of the lax implementations of the same. These interventions either end up excluding the poor from participation itself or aren't designed well enough. They are neither reproducible nor scalable and thus remain constricted within constraints; additionally, there are no feedback mechanisms to ensure timely interventions and changes. If a plan is made for the poor and the poor himself is not a stakeholder, then the chances of the plan to succeed diminish significantly. There has to be an equitable distribution of basic services such that there are no disparities in the hierarchical growth of various economic strata. Solar, biofuel, gobar gas, and other

nonconventional and renewable energy sources need to be harnessed wherever feasible, and India, being a tropical resource rich country, offers a lot of such opportunities. Complete coverage of all habitations through electricity connections has to be ensured as it has assumed a basic role in all growths.

Basic services and amenities should be equitably provided to small and medium towns and large cities as well as villages specially opportunities of employment and education. This would lead to lesser migration of people into cities and would go a long way in decongesting the larger cities. It is an acknowledged fact that rural poor live with some dignity, not in the undignified, treacherous state of their urban counterparts. Long-term planning and provisions should be made to prevent the rural poor from becoming urban poor by providing opportunities of improvement of the living standards in the village itself.

Constitutional amendments – the 73rd and 74th amendments – advocating decentralization, which was very novel, have been supported up by definite transfer of powers and accountabilities as well as their usage by the local bodies such as municipalities and gram panchayats. There has been gross misallocation of the amenities wherein the targeted population has missed out on much of the subsidies planned for them. Much of the endowed amenities have been utilized by the high- and middle-income populations; the requirement of restructuring of disbursements of these programs and schemes is much needed, immediately. This will ensure that all government subsidies and schemes are made unequivocal through stringent stipulations, targeting only the vulnerable segments of the populace. Implementation at the ground level holds the key to success. Apart from these, slum rehabilitation and improvement are also required to be carried out urgently. As the slums are generally small, slum communities can be organized, and self-help principle can be applied for the upliftment of their living standards. Taking care of the slums would be very critical because slums house an overwhelming majority of the urban poor.

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Chapter 3
Influence of Changing Real Estate Scenarios on Affordable Housing in India

Ratna Ghosh and Sanket Subhash Mane

Abstract It has been observed that the supply of housing and their associated prices have been a consequence of the existing scenario of real estate markets. In fact, housing and real estate are two interdependent sectors. The growth in one sector impacts the other. However, in the mutual profit-making process, the affordability component is often neglected. It is of relevance to note that in the post-economic meltdown in 2008–2009, the focus of the real estate developers has shifted to increasing affordability in the housing sector. With the launching of the "Housing for All by 2022" campaign, many private developers have launched many projects across Indian cities, primarily focusing on the affordability segment.

The main objective of the paper is to identify and analyze the various factors responsible for the shift in the market thrust to affordable housing in the recent years. It presents the driving and limiting forces which influence the interest of the developers in mass-scale housing supply. It can be concluded from this study that the element of affordability in housing has only recently acquired attention of the real estate developers due to shifting market scenarios and currently, it forms one of the leading areas of investment due to its tremendous business potential, now and in foreseeable future.

Keywords Real estate • Developers • Economic crisis • Housing • Affordability • Driving forces • Challenges

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	Income Level	Size of Dwelling Unit	Affordability
EWS	<INR 1.5 Lakhs per annum	Upto 300 sq ft	**EMI to monthly income:** 30% to 40% **House price to annual income ratio:** Less than 5:1 (Task Force headed by Deepak Parekh)
LIG	INR 1.5 – 3 Lakhs per annum	300 – 600 sq ft	
MIG	INR 3- 10 Lakhs per annum	600 – 1,200 sq ft	

Fig. 3.1 Definition of affordable housing – KPMG

3.1 Introduction

The involvement of private players in the housing sector is one of the major breakthroughs in a rapidly growing economy like India. Traditionally, housing was controlled by the housing boards and development authorities. In 2007–2009, the tremors of the global liquidity crisis affected the Indian market significantly, leaving the developers with land parcels acquired at peak prices with stress in their balance sheets.[1] The developers facing funding shortage and fleeing foreign investors tried to entice buyers by price cuts and incentives but to no avail. At this time, they identified the widespread housing demand of the Low Income Groups (LIGs) and Middle Income Groups (MIGs), to meet their business needs. Their keenness was welcomed by the aspiring masses waiting for the cost cut, willing to invest in a house of their own. Therefore, the concept of affordable housing emerged, targeting the majority of the population.

The RICS[2] report states that "affordable housing is provided to those whose needs are not met by the open market." The term "affordable" has been given different meanings by various published reports (refer to Figs. 3.1, 3.2, and 3.3). As an understanding, it is a relative concept that can have several implications as per context. Although there are some criteria specified in the Task Force Report[3] and CREDAI[4] report pertaining to parameters of size, income, and affordability, nonetheless the RICS definition – "adequate shelter with tenure security" – has a greater relevance in the Indian context.

[1] The property prices in major Indian cities like Delhi, Mumbai, Bangalore, and Chennai began to slide in 2008 and by 2009 had dropped by as much as 30 %.

[2] Royal Institution of Chartered Surveyors – world's leading professional body for qualification and standards in land, property, and construction.

[3] Task Force for Promoting Affordable Housing, MoHUPA, headed by Deepak Parekh, 2012.

[4] Confederation of Real Estate Developers' Association of India.

Fig. 3.2 Definition of affordable housing – MoHUPA (2008)

	Size	Cost	EMI or Rent
EWS	300 - 600 sq ft carpet area	not exceeding four times the household gross annual income	not exceeding 30% of gross monthly income of buyer
MIG	not exceeding 1,200 sq ft carpet area	not exceeding five times the household gross annual income	not exceeding 40% of gross monthly income of buyer

	Size	EMI or Rent
EWS	• minimum of 300 sq ft super built-up area • minimum of 269 sq ft (25 sq m) carpet area	not exceeding 30–40% of gross monthly income of buyer
LIG	• minimum of 500 sq ft super built-up area • maximum of 517 sq ft (48 sqm) carpet area	
MIG	• 600–1,200 sq ft super built-up area • maximum of 861 sq ft (80 sqm) carpet area	

Fig. 3.3 Definition of affordable housing – MoHUPA (2011) (Source: Guidelines for Affordable Housing in Partnership (Amended), MoHUPA 2011)

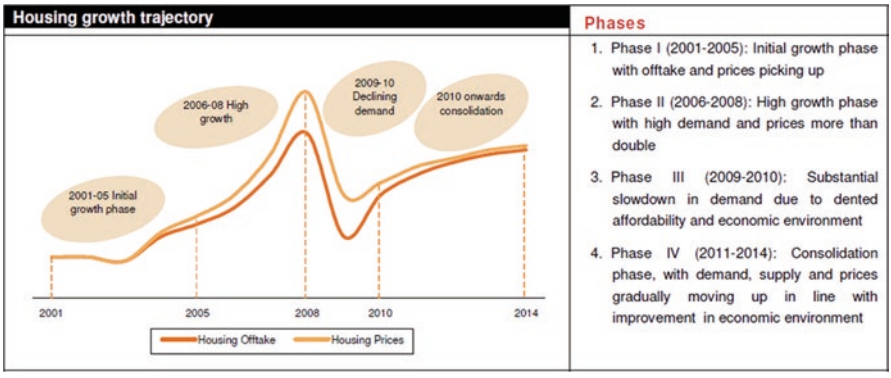

Fig. 3.4 Phases of housing growth in India (Source: CRISIL (Credit Rating Information Services of India Ltd – a global analytical company providing ratings, research, risk, and policy advisory services) Research)

3.2 Phases of Residential Real Estate

Broadly, the residential real estate industry can be divided into four growth phases as illustrated in Fig. 3.4.

It is observed that there is a steep variation in the growth curve around the years of economic slowdown, showing its significant bearing on the market. The changing behavior of housing market is also attributed to the shifting funding patterns during this time period, illustrated in Fig. 3.5. Hence, considering the time of crisis as the

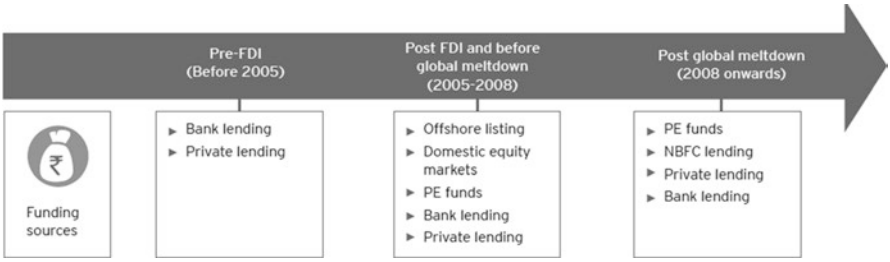

Fig. 3.5 Primary sources of real estate financing (Source: EY (Ernst & Young Global Limited) Research)

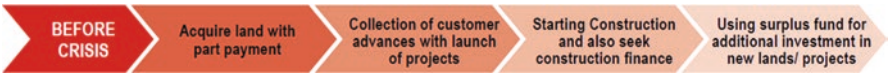

Fig. 3.6 Investment methodology prior to the liquidity crisis (Source: JLL (Jones Lang LaSalle Incorporated – Professional services and investment management company specializing in real estate) Research & REIS)

yardstick, the various scenarios of the real estate and corresponding implications on the housing sector are analyzed here.

3.2.1 Scenario A: Before Crisis

The methodology shown above (Fig. 3.6) meant and required regularity in cash flows to fund a chain of projects. The same was made possible by the FDIs that were a resultant of the liberalization of the Indian economy in 1991 and subsequent encouraging reforms by the government to streamline the processes in 1997 and 2006. However, as illustrated in Figs. 3.7 and 3.8, the FDI inflows in real estate started only after 2005 and continued to grow until 2009 crisis.

The percentage of inflows in the housing sector increased from 0.42 % in 2005–2006 to 33.39 % in 2009–2010, which is approximately 80 times. With such an upsurge, the focus of development was directed toward mega-scale projects such as development of townships, infrastructures, and services. The Indian real estate sector had transformed itself into a profit-making speculative business having low accountability. Amidst this, the most important stakeholder, the average Indian, was neglected.

Fig. 3.7 FDI inflow trends in India (Source: UN Conference on Trade and Development)

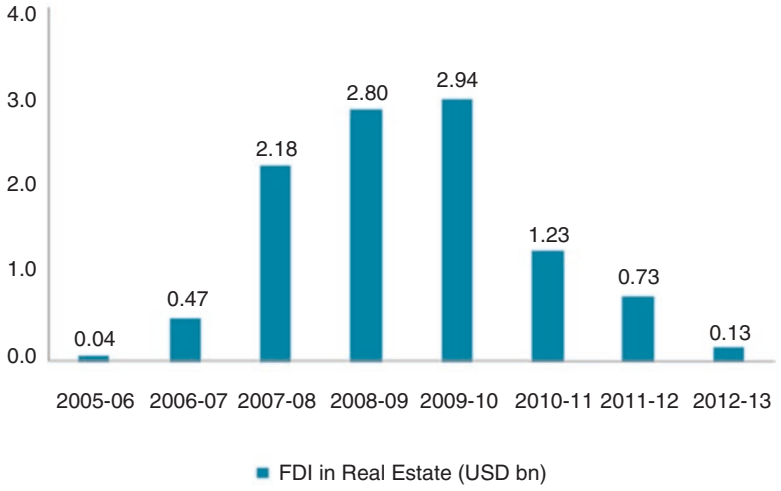

Fig. 3.8 FDI inflow trends in real estate (Source: FDI Statistics, DIPP)

3.2.2 Scenario B: During Crisis

The weakness of the model was highlighted in the wake of the economic slowdown and the subsequent muted demand for real estate. As a result of the retraction of finances, the construction activities suffered, projects were postponed, and the developers had to resort to deep discounts and other incentives. The phenomenon is illustrated in Fig. 3.9.

Fig. 3.9 Investment methodology during the liquidity crisis (Source: JLL Research & REIS)

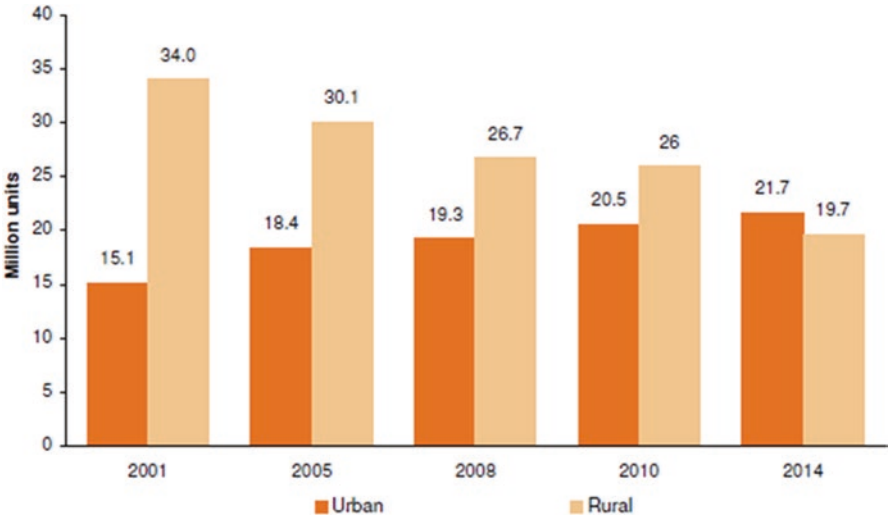

Fig. 3.10 Housing shortage in India (Source: CRISIL Research)

By now, the country had already reached to a point where it was facing a housing shortage of over 24.7 million[5] in urban areas with 99 % in the EWS and LIG categories. Ironically, the deficit was more pronounced in the urban areas rather than rural areas. This fact is represented by Figs. 3.10 and 3.11.

The greater demand-supply gap in the housing for lower-income groups presented a solution to the developers due to their mass appeal and lower development costs. This leads to creation of a new market segment of affordable housing, which would be robust and free from the volatile macroeconomic environment. The model strategically fit in the Indian context, whereby the demand was compelling and more profound in the Tier 1 cities, thereby promising potential gains to the investors.

[5] Standing Committee Report on Urban Housing, 2007–2008, MoHUPA.

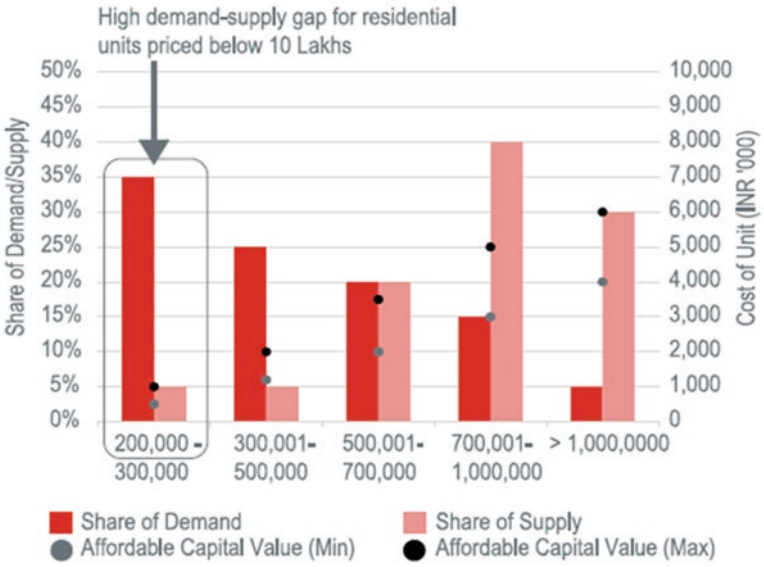

Fig. 3.11 Housing demand-supply gap across various income groups (Source: JLL Analysis)

Fig. 3.12 Investment methodology after the liquidity crisis (Source: JLL Research & REIS)

3.2.3 Scenario C: After Crisis (Present and Future)

The post-crisis situation saw mounting demands for housing as global economy improved, bringing back financial confidence to home buyers along with low interest rates. End users, who had put their purchasing plans on hold due to fall in affordability levels and job-related uncertainties, started booking houses (CRISIL 2010). The investment methodology, represented by Fig. 3.12, focused on building of more housing that is affordable to the common masses comprised of LIG and MIG sections.

3.2.3.1 Growth in Market Size and Potentials

The potential of affordable market size in urban India was forecasted to grow about 1.5 times from 2010 to 2030,[6] maximum in the Tier 1 and Tier 4 cities housing the urban poor. This was supported by favorable market dynamics (refer to Fig. 3.13),

[6] India Urbanization Affordable Housing Model, McKinsey Global Institute Analysis.

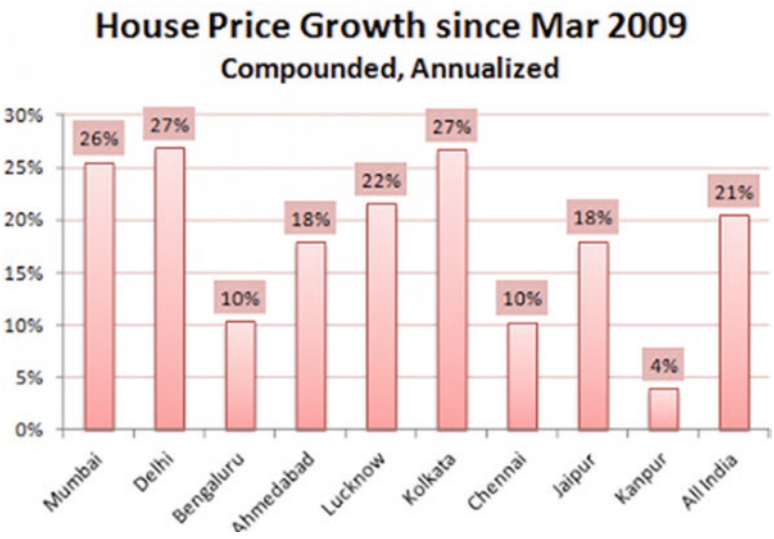

Fig. 3.13 House price growth (Source: globaleconomicanalysis.com)

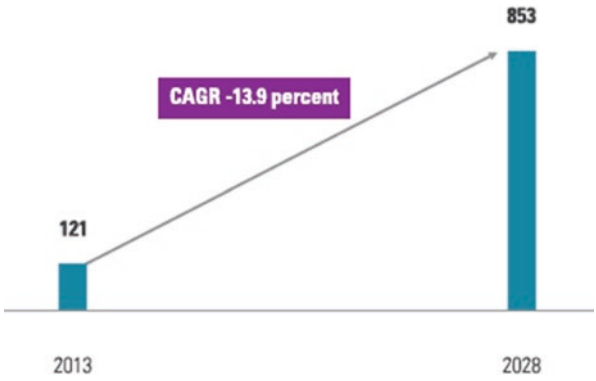

Fig. 3.14 Estimated growth in CAGR (compound annual growth rate) of real estate sector (Source: CREDAI 2013, KPMG Analysis, World Bank Analysis)

with an environment full of opportunities to bridge the widening demand-supply gap.

Despite of declining FDI inflow in the real estate sector after 2010, there has been a sustainable growth in the demand, which can be attributed to rapid growth in the economic activities translating into more people with higher disposable incomes, increasing demands of the rising middle class, and the emergence of rental housing in urban areas as a result of migration.

In the future, the real estate sector is expected to jump almost seven times from 2013 to 2028, as estimated by CREDAI (refer to Fig. 3.14). Its share in the national GDP is estimated to increase from 6.3 % in 2013 to 13 % by 2028. The cumulative effects of all these factors make the affordable housing market more attractive to investors.

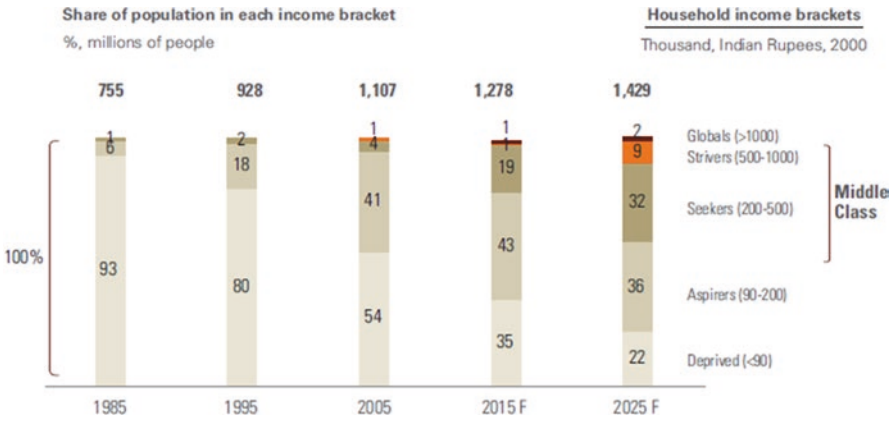

Fig. 3.15 Indian income class and population dynamics (Source: The 'Bird of Gold': The Rise of Indian Consumer Market, 2007)

3.3 Driving and Limiting Factors

That affordable housing is a promising and profitable area for investment at present and at future is established through the changing population dynamics which shows a rising lower- and middle-income class (refer to Fig. 3.15). Nevertheless, considering business prospects, it presents its own set of opportunities and challenges to the potential investors. So far, most of the affordable housing need has been met directly and largely through public delivery system. However, the contribution of private sector in the same has been increasing post-economic meltdown as discussed in the earlier sections (refer to Fig. 3.16).The demand drivers favoring the growth of private "affordable" housing market can be seen in the light of the following factors:

- Continuous growth in population
- Migration toward urban areas
- Ample job opportunities in service sectors
- Growing income levels
- Rise in nuclear families
- Easy availability of finance
- Demand and supply side incentives launched by the government
- Relaxations of market regulations on FDI
- Launching of AHP[7] Scheme promoting public–private partnership (PPP) model
- Institutional approach to buy and to rent

At the same time, the supply of prerequisites may pose constraints for private delivery of affordable housing as discussed in the following statements:

[7] Affordable Housing in Partnership, 2013, MoHUPA.

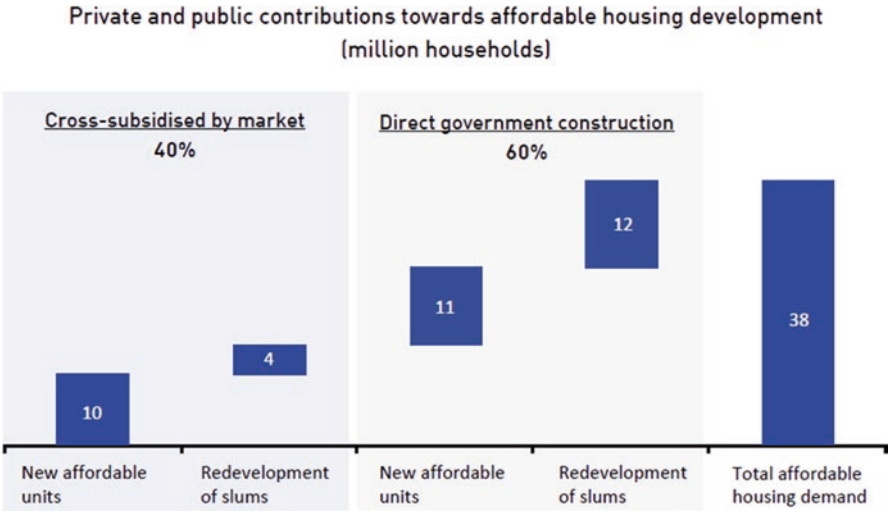

Fig. 3.16 Private and public contributions to the affordable housing development (Source: India Urbanization Affordable Housing Model, McKinsey Global Institute Analysis)

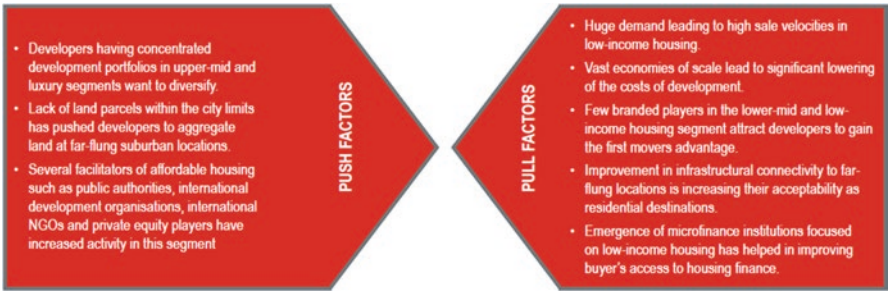

Fig. 3.17 Push and pull factors for entry of private players in affordable housing (Source: JLL Research)

- Limited availability of land in urban areas.
- Rising threshold costs of construction.
- Financial and regulatory constraints in securing housing finance to the LIG and EWS categories.
- Excessive development control on land parcels creating artificial shortage.
- Land titling issues and lack of information.
- Lengthy approval and land-use conversion process.
- The lack of clarity in building bye laws and guidelines and continuation of archaic laws.
- The importance of rental housing for low-income migrant workers is ignored.

- Time factor not taken into consideration when fixing the selling price of the unit (refer to Fig. 3.17).

3.4 Conclusions

A recent UNCTAD[8] survey projected India as the second most important destination for investments (after China), especially due to the underlying demand for housing, expected to grow further in the future. This paper intends to highlight the relationship that the housing market has had with the real estate industry in the past and is assumed to have in the foreseeable times. At present, the housing sector alone contributes 5–6 % to the country's gross domestic product (GDP). It can be analyzed from this that the recession – driven transformation of the developers' approach toward housing supply – has indeed proven to be a blessing in disguise for the Indian middle and lower middle class by addressing the market gaps to a certain degree. Provided that this situation is allowed to continue and supported by the government, this may provide an answer to the numerous housing-related woes of the not-so-affluent people of the country.

The Indian public sector till date remains unequipped with appropriate technical expertise and financial status to be able to meet the rising requirements. This calls for inclusion of the private players in the housing market as major financers and service providers. With the evolution and adoption of the PPP model in implementation of the housing policies, the public sector has established a win–win strategy by assuming the role of a facilitator rather than a provider.

In the interest of both the public and private sector bodies, thrust is given toward the growth of the real estate industry, indirectly boosting the housing sector. Using this partnership, innovative business models are developed to translate "affordable housing" from a "need-based" to "profit-based" sector, while fulfilling the market demands satisfactorily. With immense opportunities and a favorable environment, it will be interesting to know how the existing affordable housing scenario would respond to the unpredictable variations in the sensitive real estate industry in the future.

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[8] United Nations Conference for Trade and Development.

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Chapter 4
Market Situation of Unauthorized Colonies in East Delhi: A Case Study of Guru Ram Dass Nagar

Rohit Kumar

Abstract Development of unauthorized colonies is emerging as a big issue in many large cities. In Delhi it caters to nearly 18 % of its population and acts as a major source of housing. Guru Ram Dass Nagar in East Delhi is one of the oldest unauthorized colonies in Delhi. Being unauthorized and due to many other factors, the residents are unable to avail loans from financial institutions which lead to the growth of builder floors in which a developer collaborates with the property owner to redevelop the property. These activities magnify the existing problems like the high population density and the load on the existing infrastructure. The East Delhi zone is also highly vulnerable to natural hazards. This paper explores the functioning of the real estate market of unauthorized colonies in East Delhi and looks at the impacts and influences it has on them. The study highlights the uniqueness of the market and how it contributes to the already deteriorating situation of the colonies which is an issue to be resolved rather than a problem to be solved.

Keywords Agreement • Builder floor • Colonies • Congestion • Tenure

4.1 Introduction

More than half the population of Delhi lives in slum designated areas, resettlement colonies, unauthorized and recently authorized colonies, etc. About 18 % of Delhi's population was living in unauthorized colonies[1] (UCs) by 2011. Notably, the estimated annual population growth rate in UCs (3.1 %) was more than the total urban

[1] The Government of National Capital Territory of Delhi defines "unauthorized colony" as a colony/development comprising of contiguous area, where no permission of concerned agency has been obtained for approval of layout plan and/or building plan (NCTD, 2011). In essence, it means illegal land subdivision. GNCTD classified unauthorized colonies into unauthorized colonies (fresh ones), unauthorized colonies that came up outside of existing urban villages as extensions

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population growth rate (2.45 %) in Delhi during the last decade. (Lemanski and Rewal 2012).

The UCs have been mostly developed in agricultural land in peripheral areas of Delhi primarily because there was a huge demand for affordable housing which Delhi Development Authority was unable to satisfy. These landowners subdivided the land without any approval from the authorities and sold the plots (Bertaud 2014). These new owners built houses of one or two stories, and some even built shops on the ground floor depending upon the road width. However, over time peripheral Delhi became an integral part of Delhi, and land price has exponentially increased due to better accessibility (GNCTD 2011). Such increase in land price leads to increase in housing price in UCs which ultimately led to overutilization. After 50 years, these buildings have started deteriorating. Now, builders approach the owner and offer to redevelop the building in exchange for floors. As per primary survey, 58 plots out of 468 in Guru Ram Dass Nagar have been redeveloped, about 12.4 % of the total, since it started in the early 2000s.

The research began from an innocuous article on a national daily which stated the lack of facilities provided in these colonies even after the Government declared them to be regularized. This declaration simply led to the three- or fourfold increase in the property prices without any physical difference. This indicated a thriving property market in such areas which existed before the Government acknowledged it (Puri 2005). This led to a postgraduation-level thesis. The information regarding property market was obtained through the help of the local property dealers. Primary survey of the Resident Welfare Association and the local residents was necessary to obtain a true picture of the physical conditions available and to get the consumer perspective.

4.2 Guru Ram Dass Nagar

Guru Ram Dass Nagar was established in the 1960s, sometime after the commencement of new bridge on the river Yamuna near the Income Tax Office by colonizers like Bhagat Ram who bought land, subdivided them, and sold them. It is located in Ward No. 222, in Laxmi Nagar in Zone E-12. It is 8 km away from New Delhi Railway Station. Guru Ram Dass Nagar was regularized in 1977 as part of the regularization of 27 unauthorized colonies of Laxmi Nagar complex.

Figure 4.1 highlights the proximity of the colony to the city center (Connaught Place or CP), which is about 10 km. Such a distance is considered small for a city like New Delhi. The colony details have been elaborated in Table 4.1.

(148 in number), extension to already regularized unauthorized colonies (567), and affluent unauthorized colonies (5) such as *Sainik* farm, *Atmaram* dairy (in RK Puram), etc.

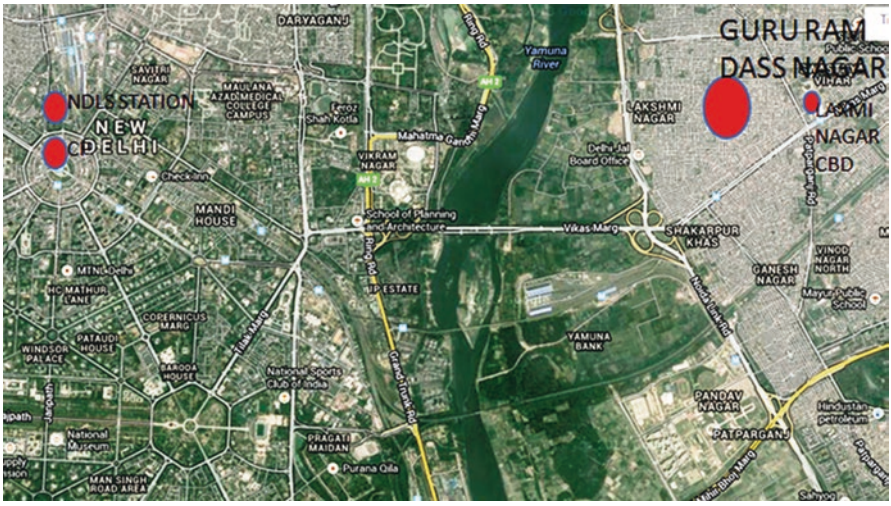


Fig. 4.1 Satellite imagery showing the study area with respect to center of Delhi

4.2.1 Facts About the Study Area

Table 4.1 About the study area

Area	5.2 ha
Population	6300
Population density	1211 persons per hectare (MPD (Master Plan of Delhi) 2021 limits it to 900 persons per hectare for group housing)
Gross residential density	269 DU (dwelling unit)/ha (MPD 2021 limits it to 200 DU/ha for group housing)
Total plots	468
Total DUs	1400
Nearest metro station	1 km (NirmanVihar station)
Major road	Vikas Marg (arterial road, 1 km away)
Mixed-use development	21 % of plots (grocery, stationery and hardware stores, property dealers)
Total plots redeveloped	58 plots out of 468 (12.4 %)

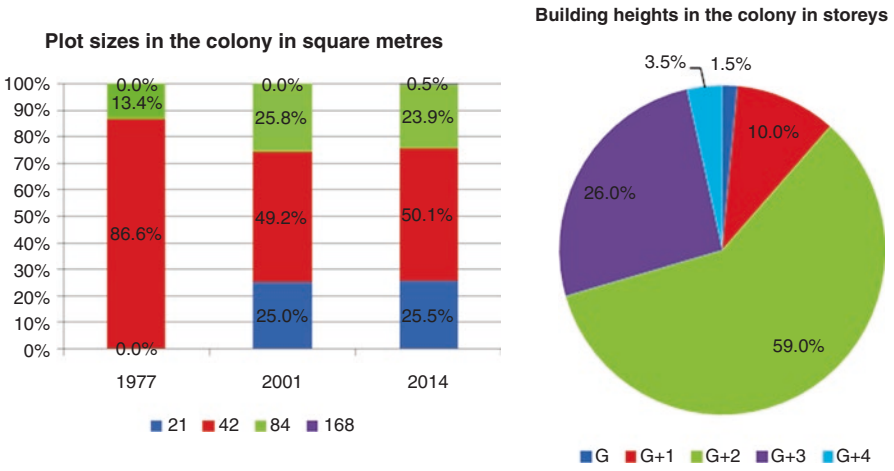
4.2.2 Existing Layout of the Study Area

As apparent in Fig. 4.5, the colony has a gridiron pattern which was designed by colonizers. The approved regularization plan shows all plots as residential with some commercial, but in reality it is mixed development. Majority (84 %) of the roads are less than 6 m wide. Those which are 6 m or more suffer encroachments from building materials, parking, and hawkers. It is a norm for bathroom and toilet

Figs. 4.2, 4.3, and 4.4 Photographs showing the newly built builder floors in the colony

Fig. 4.5 Existing layout of Guru Ram Dass Nagar

having common shaft for ventilation. Figures 4.2, 4.3, and 4.4 are photographs of newly built builder floors (Fig. 4.5).



Figs. 4.6 and 4.7 Bar graph showing the increasing subdivision of plot sizes in the study area and pie chart showing the consolidation of the colony through the building heights (88.5 % are at least three stories in height)

4.2.3 Plot Sizes and Building Heights

From Fig. 4.6, we can see that plot sizes as low as 21 square meters existed in the colony in 1977, though it was not indicated in the 1977 regularization plan. Affordability is the primary reason for the preference for smaller plot sizes. This is evident in the increase in the share of 42 square meter plot size from 49.2 % in 2001 to 50.1 % in 2014 (bar graph in Fig. 4.6). This also indicates further subdivision of the plots in the area. The pie chart in Fig. 4.7 shows the building heights in the study area which emphasizes the levels of consolidation that has taken place and the demand for such housing. About 30 % of the buildings are at least four stories in height which are almost at the limits imposed by the regulations in Delhi.

4.2.4 Street Section: Then and Now

The two sections in Fig. 4.8 show the colony when it was newly established and the present situation on the left and right, respectively. In the 1960s, when the buildings were not more than two stories high, a road width of 4 m was sufficient. But now 57 % of the residents own cars leading to parking problems. These areas remain shaded most of the day inhibiting sunlight.

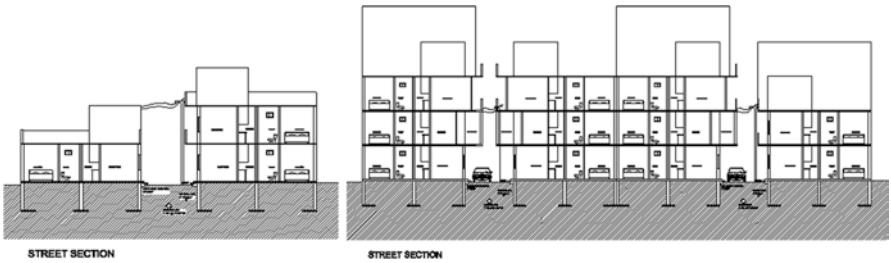


Fig. 4.8 Street cross section of the study area in 1965 and 2014, respectively

Figs. 4.9, 4.10, and 4.11 Photographs showing the road width (2–3 m) in the study area

4.2.5 Violation of Norms

Like a typical unauthorized colony of Delhi, it is characterized[2] by plot sizes as low as 21 square meters (which leads to violation of byelaws like building projections of 3′ to 5′ (Fig. 4.9) intruding upon streets to maximize floor space), lack of building setbacks, and streets as low as 1.5 m wide (Table 4.2). Commercialization on wide roads (9 m and above, vehicle parking (Figs . 4.10 and 4.11) creating obstructions), row housing of heights up to stilt plus four stories, deficiency in physical infrastructure such as sewerage and drainage problems, and so on are a common sight. Redevelopment by builders is leading to further densification and overcrowding.

[2] The constructions even in the regularized colonies are mainly unsanctioned and unauthorized. In some cases, the builder applies for plan approval but that is based on the original regularization plan. Stilt + 4-story buildings are constructed without considering if the width of the roads or the infrastructure can handle the additional population. There has been no monitoring to these colonies since regularization to find the increase in population, density, and extent of subdivision and if the existing infrastructure could handle it. Builder floor gives an option for redevelopment where finance is not available (primary survey by the author).

Table 4.2 Extent of violations of norms in the study area

Aspect	MPD-2021 norms	Existing	Remarks
Plot size	Minimum of 32 square meters	Plot size as low as 21 square meters exists here (0.8 %)	Continuous subdivision took place
Ground coverage	90 % for plot size up to 100 square meters and 75 % for sizes 100 square meters to 250 square meters	93 % of plots have no setbacks	50.1 % of plots are only 42 square meters
FAR (Floor Area Ratio)	350 % for size up to 100 square meters	140 plots (30 % have height of four stories (FAR 400%)	Consolidation has taken place
	300 % for sizes up to 250 square meters		

4.3 Real Estate Scenario in the Colony

Unauthorized colonies exist as a result of public demand (Wise 1990). It is the demand for small and affordable plots which the Delhi Development Authority as the sole provider of housing in Delhi was unable to satisfy. In the Master Plan of Delhi 1962, the minimum permissible plot size was 168 square meters. Such a size was considered luxurious even then, and people were ready to buy an affordable plot as small as 42 square meters even if it was illegal. When Guru Ram Dass Nagar was created (during the 1960s), plots were sold at the rate of two rupees to five rupees per square feet, affordable rates for land in such close proximity to the city center. But such colonies were created without the approval of the competent authority, and their existence is in violation of the land use stated in the Master Plan of Delhi (Lemanski and Rewal 2012).

This has put a question mark on their legitimacy, and this led to the lack of recognition by the authority as a residential area which deprived them of basic infrastructure by the authorities (Fig. 4.13). This was not a problem in the beginning as water was obtained from ground, sewage was taken care of by septic tanks, and electricity was not a problem because the private companies who supply electricity in Delhi do not work in conjunction with the Delhi Development Authority (DDA) or the Municipal Corporation of Delhi (MCD), so they are unconcerned of the unauthorized tag. Problems came up with the increasing population imposing load on the existing infrastructure. There is also a political angle involved as such colonies are considered to be vote banks in which the politicians promise regularization to inhabitants during election campaigns. The recent such notification of regularization of about 1639 colonies took place in 2013 which was delayed to the year 2015 due to elections.

Figs. 4.12 and 4.13 (On the *left*) A builder floor under construction and (on the *right*) social infrastructure in study area

4.3.1 Finance Availability in the Colony

Due to their status as unauthorized and due to factors like lack of clarity of tenure, violations of regulations, etc., financial institutions do not provide finance for construction activities in unauthorized colonies. Even though the study area was regularized in 1977, financial institutions still hesitate to provide loans against the property. Neither owners nor builders can avail finance from financial institutions. Builders in the colony, who undertake all construction activities, do not support finance-based transactions to potential owners, and all transactions take place by cash payment within 90 days, as this requires submission of various documents like land deed, proof of income, and so on. Builders depend upon informal sources for finance where interest rates are as high as 18–24 %. Due to this, the construction activities taking place is of a very specific nature, primarily builder floors.

4.3.2 Builder Floors

During the establishment of the colony, the original buyers who bought plots constructed one- or two-story dwellings on them. After about 50 years, when the dwellings started deteriorating, many of the residents were unable to redevelop their houses due to the lack of finance availability. With time there was a revision of the existing building regulations permitting more built-up area on the same plot. Similarly, the housing needs of a landowner may increase with time (Turner 1976, 1988). At this point, a builder would approach the landowner and offer to construct builder floors. Builder floors (Figs. 4.2, 4.3, and 4.4, 4.12 and 4.13) are low-rise buildings which usually have car parking on the ground floor (stilt floor) and four residential floors above (height under 15 m). In the builder floors, only a single dwelling unit is provided per floor which implies that a single family has the entire floor to itself providing greater privacy. Through redevelopment, an owner obtains

multiple new dwelling units from the existing dilapidated unit without having to pay for it, and this is referred to as a collaboration deal as discussed below. Allowing the construction of builder floor would lead the sharing of land among the existing and the new house owners. Such a situation would mean that the landowner becomes a joint owner of the plot and this is primarily because of financial reasons. In the majority of the cases, the landowners lack the sufficient capital required to repair or replace the dilapidating house which is why they let builders redevelop their property.

4.3.3 Collaboration Deal and Sale Prices

The redevelopment of existing units takes place through a system called collaboration deal, and a builder prefers to go for such an arrangement instead of buying land and developing it. If the investor buys land, he would hold on to it to appreciate in value rather than develop it as the former is more remunerative. As per this system, the builder constructs a four- or five-story building in which each floor has one dwelling unit. In exchange, the builder obtains either one floor or may avail two floors by paying a certain amount to the owner as remuneration for the land as shown in Table 4.3. Profit is more for units having more floor area (84 square meters and 168 square meters), but smaller ones (42 square meters) have more demand.

The increase in construction costs in larger plots in Table 4.3 is due to the increase in specifications for larger-sized plots. Prices for ground floor and first floor are similar but decrease in second and third floor. An 84 square meter unit having a rate of Rs. 8500 in ground and first floor decreases to 8000 by third floor. From the above table, let us take the example of the second case. In a plot of size 84 square meters, the total cost (including construction and other incidental expenses) is about Rs. 60 lakhs. The sale price of one unit is about Rs. 80 lakhs. Thus, a developer can easily make a profit of Rs. 20 lakhs from the sale of only one unit.

Table 4.3 Construction costs and the sale prices in the deal

Plot size	Construction cost	Amount paid by builder to owner for availing two floors	Sale price of the built unit
42 square meters	Rs. 1000/sq. ft (g+4) 25 lakhs in total	Rs. 25 lakhs	Rs. 8000–9000/sq. ft. Rs. 35 lakhs–40 lakhs/DU
84 square meters	Rs. 1300/sq. ft (stilt+4 floors) Rs. 60 lakhs	Rs. 50 lakhs	Rs. 8400–9000/sq. ft. Rs. 75 lakhs–80 lakhs/DU
168 square meters	Rs. 1800/sq. ft (stilt+4 floors) 1.25 crore	Rs. 1 crore	Rs. 8500–9500/sq. ft Rs. 1.5 crore–1.7 crore/DU

Table 4.4 Rental values of residential units in the study area

Rental values of unit as per plot size	Rent
42 square meters	Rs. 5000–10,000/month
84 square meters	Rs. 12,000–20,000/month
168 square meters	Rs. 25,000–30,000/month

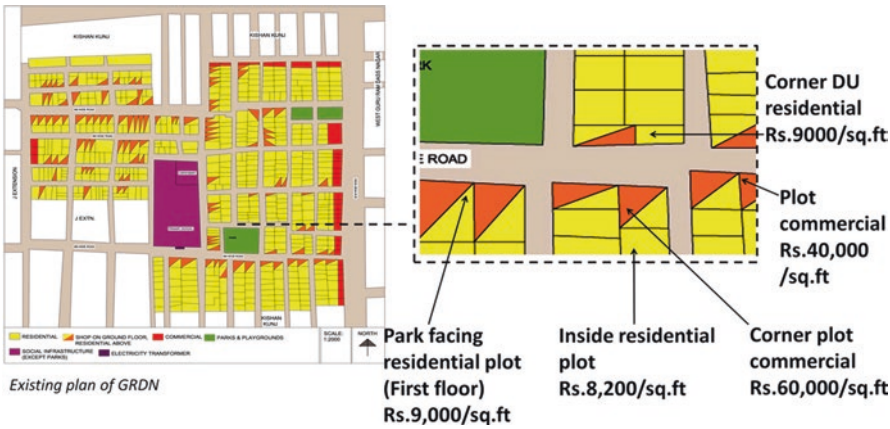


Fig. 4.14 Property prices as per location

4.3.4 Rental Values

The rental values of residential units in the colony have been tabulated in Table 4.4. The variation in rents shown in Fig. 4.14 is due to factors like location (corner plot having two sides open versus an inside plot) and height (ground and first floor command more rent than higher floors). A shop of size $7' \times 10'$ or $7' \times 12'$ rents at Rs. 7000 to 13,000 per month depending upon the location. Property prices of land having shopping frontage start at Rs. 35,000 per square feet.

4.3.5 Security Deposit System

Other than buying or renting property, a person can avail the security deposit system where a tenant deposits a certain sum with the builder and lives rent-free for a given period of time. At the end of the duration, he gets back his principal. For a house area of 168 square meters, he would deposit Rs. 20 lakhs at the builder, and the advantages have been outlined in Table 4.5.

Table 4.5 Advantages to the tenant and the builder in case of security deposit system

Tenant	Builder
Even if the tenant cannot afford to buy such a house, this system will give him access to it	This system acts as a source of interest-free capital for the builder
Rent of a 168 square meters house is about Rs. 25,000 to Rs. 30,000 per month making the interest rate about 15 % for a sum of 20 lakhs	The builder does not have to pay for maintenance such as electricity, water bill, etc. which is borne by tenant

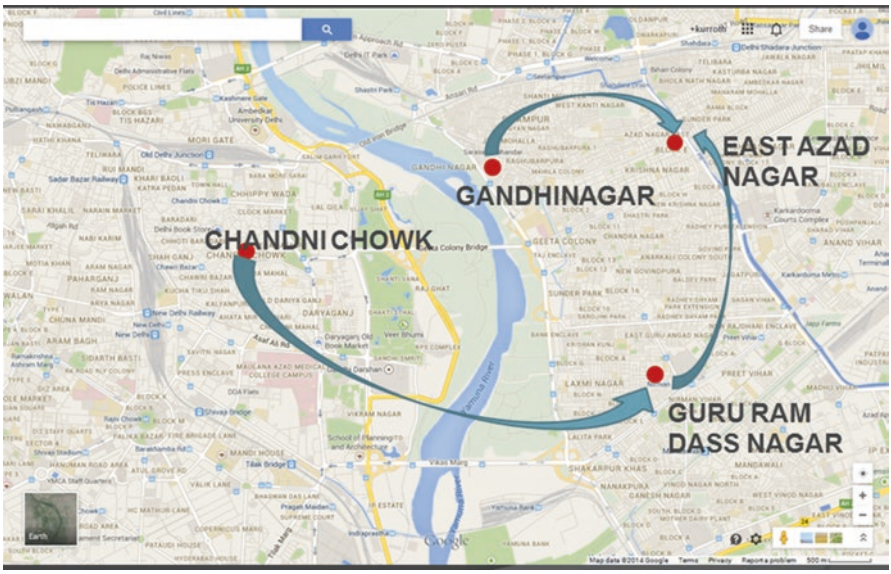


Fig. 4.15 Migration of residents to old and new unauthorized colonies in Delhi

4.3.6 New Owners in Unauthorized Colonies

Considering the problems in the study area, such as the lack of tenure clarity even after regularization, congestion, and poor infrastructure, a very select class of demography is willing to shift or acquire property in unauthorized colonies. About 65 % of the population in Guru Ram Dass Nagar has lived for 15 years or more as owners. A person who has lived in planned areas of Delhi like DDA housing, apartments, etc. will never prefer to live in an unauthorized colonies. Usually, the new owners are families from more congested areas of Delhi like Chandni Chowk, tenants of older unauthorized colonies, and previous owners of unauthorized colonies who have sold their property at higher rates due to increasing commercialization with time. For example, a present house owner in East Azad Nagar was previously residing in Gandhi Nagar as simplified in Fig. 4.15.

4.4 Conclusion

The present-day scenario of Guru Ram Dass Nagar, be it physical or real estate, was explored mainly through primary surveys, support of its Resident Welfare Association, and local property dealers and visual analysis of the colony. The colony is one of the oldest unauthorized colonies of Delhi, and the activities taking place here are similar to development taking place in other such colonies in Delhi. Due to reasons such as affordable prices of plots, flexibility in plot sizes, lack of bureaucratic hurdles for approvals, political patronage, etc., unauthorized colonies have attracted buyers. The purpose of this paper was to study the intricacy of a housing system which is common throughout India and is dependent on the forces of the market and the demands of the public.

The colony was established some time in the 1960s, and it was regularized, that is, recognized as a mainstream residential area by the authorities, in 1977. Even then the situation has continued to deteriorate. This is due to increase in population with time and subdivision of existing plots by the successive generations. The present population and dwelling unit density have already exceeded the Master Plan of Delhi 2021 group housing norms even when there is only plotted development in the area indicating congestion (observed dwelling unit density of 269 dwelling units per hectare as against the Master Plan limit of 200 dwelling units per hectare). Twenty-one percent of the plots are mixed-use development, in which there are shops on the ground floor and residences on the upper floor. Eighty-four percent of roads in the study area are less than 6 m wide; the recommended width of carriageway and areas where road width is more than 6 m suffer from commercialization leading to parking of vehicles and encroachment by hawkers. There has been an increase in the number of plot size of 42 square meters from 49.2 % in 1977 to 50.1 % in 2014 because smaller plot sizes are more affordable and hence in more demand. But this leads to further increase in population, thereby increasing the load on existing infrastructure and increasing congestion. Parking of vehicles on roads reduces the effective road width in the colony which was designed without considering vehicles, leading to parking problems. All this has been possible through violation of the norms indicated on the Master Plan, which is covered up by bribing the officials during construction such as 93 % of the plots have no setbacks though the Master Plan has stipulated that ground coverage of plot size of 84 square meters should not exceed 90 %.

At present, the majority (70 %) of the houses in the study area are at least 50 years old. Like any material object, these units have started deteriorating and require an overhaul. At this moment, a builder would approach a plot owner and offer him to construct builder floors which comprises building of four or five stories (less than 15 m in height) having one dwelling unit on each floor. The owner obtains two or three floors, and the rest is obtained by the builder who sells them to recover his expenditure, and this arrangement is called a collaboration deal. Through this a builder is able to make a profit, and the owner is able to obtain houses with more floor area on the same plot without having to spend a penny. At present, 12.4 % of

the plots have been redeveloped. Due to its unauthorized tag and lack of clarity in the title deed, the residents of the colony are unable to avail loans from financial institutions to repair or redevelop their property in which case builder floor is the only option left to them. Such information was obtained through primary surveys of residents and from questioning of the local property dealers.

On the face of it, such arrangements lead to further congestion, increase in population density, and increasing load on the infrastructure and that has been observed here. But builder floors provide an opportunity for redevelopment for a colony whose residents cannot avail finance facilities to upgrade their properties, an advantage restricted to a very limited section of plot owners. For those lacking capital, the system of security deposit is making housing accessible to a larger section. These unique aspects of security deposit system make it one of a kind among real estate in the world. Hence, the need of the hour is proper regulation of development activities in such colonies.

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Part II
Smart City and Sustainable Urbanisation

Chapter 5
Smart Concepts for Integrated Rurban Development of Historical Towns in India: Case of Panipat, Haryana

Vijay Kumar and Shailja Sikarwar

Abstract Rurban, i.e. rural–urban, communities are strong webs having the mega-cities, metro cities, towns of various levels and the most important basic settlement units – the villages – as its nodes. These nodes have a strong interdependence and interlinking amongst themselves, so a comprehensive, integrated and regional approach is required to make these nodes smarter by the use of information and communication technology (ICT) in planning, implementation of development proposals, enforcement of laws and monitoring. Thus smart communities with smart villages and cities are envisaged to have smart infrastructure, energy and governance with rich and diversified economy including innovative ideas like corporate villages, rural tourism, etc. creating a better climate for investment and sustainable environment for a healthy and quality life for present and future generations.

Keywords Urban development • Smart communities • Computational technology • Smart infrastructure • Rural agrotourism

5.1 Introduction

By 2050, the cities will be housing about two-thirds of the world's population; similar is the situation in India, where due to exorbitant migration from villages, the cities are struggling hard with huge challenges regarding health, sanitation, basic amenities, livelihood and environmental sustainability. India is presently facing a rapid urbanization phenomenon; the prime reason being the lack of livelihood in the villages, extremely weak physical and community infrastructure in the villages and issues of sanitation, education and medical facilities. In 1901 only 11.4 % of the country's population resided in urban areas, but as per the latest census of 2011, about 30 % of the population lives in urban areas. As per the UN Global Population

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report of 2007, it is estimated that more than 40 % of India's population by 2030 will be residing in cities where there is a mild improvement resulting in overcrowding, slum-like situations and multiple issues of infrastructure, traffic, sanitation, etc. The probable way out to ease the situation is to reverse the migration trends from villages and promote a rationalised and regional approach to the settlement planning, growth and development. The villages should be made self-sustaining in terms of employment, infrastructure and other issues of environmental quality to achieve a life similar to the urban areas. This paper focuses to explore the possibilities of integrated urban–rural development of Panipat City and the villages within its control area boundary.

5.2 Rurban Development

Rurban development refers to the comprehensive and simultaneous sustainable growth of rural and urban areas. This concept promotes a rationalised regional development approach. Along with the development of efficient and smart cities and to maintain them for years, it is necessary that these urban centres are supported by efficient and smart villages so that the exorbitant, uncontrolled migration can be curbed, and the cities and villages both grow and develop simultaneously complementing each other on all issues related to economy, social justice, environment and organizational set-up.

5.3 Smart Cities

The 'smart city' approach is a revolutionary initiative that aims to improve the quality of life of urban citizens.

The Government of India has planned to develop 100 smart cities across the country to improve the country's urban landscape and the life quality of ordinary citizens. Smart cities as envisaged by experts shall have a smart and efficient Governance; the use of smarter energy by promoting renewable energy sources and developing and promoting smart and intelligent green buildings; and efficient transportation and mobility systems. Smart cities are expected to have an improved shape of physical and social infrastructure network by the use of smart electronic–digital technology. Promoting e-education, telehealth and electronic citizen portals is culminating into healthy, well-aware and happy citizens.

These cities shall use smarter technologies in planning, implementing and monitoring. Smart cities shall be planned using computing technologies for the development of rational land-use models, envisaging town shapes through 3D modelling

and supporting the decision-making process and community-based internet geographic information system (GIS) model and future-making assessment approach (FMA) for e-planning of various services for the town and for its community development. In a smart city, there is an effective use of information and communication technology, electronic–digital technology and computational smart technology in its operation, maintenance and governance for work, life quality, recreation, education, health facilities and effective management of waste. This technology actually provides for optimum utilization of resources. The smart city responds faster to the citizens' requirements, desires, global challenges and climatic requirements for sustainable development and other issues like unemployment, economic improvement, rationalizing and restructuring, socio-economic problems, communication and social well-being.

E-planning and smart technologies, i.e. the use of IT-based systems like GIS, database management system (DBMS), planning support system (PSS) and radio frequency identification (RFID), are some smart technologies which can be efficiently used in small Indian cities.

5.4 Smart Villages

As per Mahatma Gandhi, 'India resides in its villages'. According to the last census of 2011, about 70 % of the country's population resides in about six lakhs rural settlements or villages. This year on the eve of Independence Day, Prime Minister Narender Modi launched a new programme called 'Sansad Adarsh Gram Yojana', and made each parliamentarian responsible to develop at least one village as a model and transform it into a smart village by 2019. A village can be termed as an 'Adarsh' or a 'model village' when it has all the basic amenities, i.e. good connectivity to the urban centres and nearby villages, good interior pathways/roads, availability of water through an organised water supply systems, proper storm-water drains, provision of street lights and basic electricity for the residential/abadi area of villages and sufficient power for irrigation. Besides these, a financial mechanism to provide loans to the village population; cooperative societies to provide seeds, manure, fertilizer and insecticides/pesticides to improve agricultural produce; adequate facilities for basic education and medical services; and also an efficient basic unit of village governance of the Panchayat which can connect the village with the state and national administrative framework are the basic requirements of an Adarsh village.

Besides making Adarsh villages, there is a significant necessity for smart villages parallel to new upcoming cities in the country. This paper focuses on initiatives proposed to improve villages, especially the model villages into smart villages. The smart villages, besides having basic amenities of an Adarsh village, should be highly efficient and equipped with modern and technologically advanced rural eco-

nomic governance mechanism and with smart rural population providing a life quality of good standard with quality living and prosperity in rural areas and even more satisfying and healthy than their counterpart in urban areas.

A smart village should have priority on efficient physical and community infrastructure; it should function on multiple energy source model with lesser dependency on state-run electric grid by the extensive use of renewable energy for domestic use, street lighting and use in small-scale industrial functions and also for the irrigation. The village should not only depend on the basic agriculture for livelihood; rural economy should be diversified by promoting small-scale household, agriculture-based and ancillary industries complementing the requirement of nearby urban areas. There should be an extensive use of communication tools including the internet to communicate with government offices, industries, consumers and urban population to provide services and earn revenue while residing in the village. The waste management especially the domestic waste, animal excreta and other agricultural waste is highly suitable for the production of bioenergy fuel, and these can be effectively used to develop high-quality manure, which is demanded not only in villages but in cities too. The development of cooperatives and community dairy parallel to 'Amul' is highly appropriate in this region. The ICT-based digital land records, digital database of the manpower and skills available in villages, facilities of ICT-based computational communication with the government agencies, funding agencies and agricultural research institutes, telemedicine approach for health care and the database of every villager will be useful in providing appropriate employment and benefits of government schemes and timely payment of old-age pension with a minimum possibility of corruption. E-governance and e-Choupal are some institutions found very successful. A smart village should function as a corporate to provide services to nearby areas which is only possible by the extensive use of ICT-based communication systems to explain, advertise, inform about their natural, home-made products, provide timely delivery at doorsteps in urban areas whenever required and earn nice revenue. With the development of multi-cropping system with strong and regular guidance of experts through ICT mode, new innovative produces in agriculture like arboriculture, horticulture, new commercial crops, etc. can be explored by efficiently communicating with experts and institutions of research in these areas.

ICT can play an important role in education and in providing medical services in smart villages especially for adult and children education These facilities will make the rural population smarter. Recreation through ICT, internet can be very useful in making smart cities a popular concept. Digital database of all development schemes, funds spent, details of specification in works, accountability, etc. ICT will restrain the fund leakages and ensure appropriate utilization of funds available so that smart villages shall have a provision of e-governance services, a rural help line, digitally functional & micro-financing mechanism.

The concept of smart villages should be to reverse migration trends, to sustain the existing population and also to attract people back into the villages, especially

from mega- and metro cities, which are presently facing the urban sprawl of high magnitude. Making villages smarter means making India smart by integrating 70 % of the population into smart revolution.

The rationalised systematic development of the villages with the extensive use of ICT will be helpful in attaining the ambitious national programmes such as the National Optical Fibre Network (NOFN) and Fibre to the Panchayat (FTTP) in villages.

The programmes like Smart Rural Aggregation Platform (SRAP) are very helpful in making the villages smarter by developing agriculture advisory institutions and extending services to meet as per the requirement to enhance income, wages and self-employment.

5.5 Smart Communities

Urban–rural communities like other ecological living communities include megacities, metro cities and towns of various levels, i.e. class I, II, III and IV towns, coexisting in a region along with the most important settlement units – the villages which are the basic modules and units of settlements. There is a strong interdependence and interlinking between the various components and units of urban–rural communities. An efficiently planned and smartly developed mega- or metro city cannot sustain its efficiency for a longer span until and unless the lower cadre cities and especially the villages of its region are not efficient. The only solution is the comprehensive development of cities of different levels and interconnected/integrated rural settlements, i.e. villages, to envisage the real development.

The urban–rural community having a strong interconnected web of smart cities and smart villages is termed as smart community, and this is generally termed as a smart rurban development, a phenomenon of integrated smart rural and urban development.

5.6 Role of Seventy-Third and Seventy-Fourth Indian Constitutional Amendment Act 1992 for the Development of Smart Communities

The Constitutional 73rd and 74th Amendment Act 1992 envisaged for urban–rural communities a strong horizontal linkage and strong Panchayati Raj institutions. It provides an instrument for Panchayat at village level, municipality at intermediate level and district planning committee at district level (as per Clause-1 of Article 243ZD). This district planning committee is responsible for the fine integration between villages and the connected smaller cities on resource allocation, physical

infrastructure, social infrastructure, spatial development, commercial and service relationship as well other aspects of urban and rural development. The development plan formulated by Panchayats and municipalities are to be integrated by the DPC. This concept of coordinated and integrated planning and simultaneous implementation of development in villages and nearby cities is supplemented and strengthened with strong communication using ICT and computational technology to ascertain faster, honest and transparent governance with a strong public participation through dedicated citizen portals, which form the basis for smart communities.

5.7 Concept of Merging and Diminishing Rural and Urban Boundaries

Every urban and rural activity requires an organizational set-up with villages and cities acting as nodes to accomplish its function primarily on the economic/commercial exchange of services and goods, marketing of products and generation of employment. A strong and stable ecosystem of villages and cities is required for a better investment climate and developing growth strategy. Urban and rural planning and development is primarily a function of the regional planning (with mutual–complementary and reciprocal relationship). There has to be an integrative and comprehensive planning approach in the areas of agriculture, industry and services on all the basic aspects may it be economical,social,organizational and environmental in order to achieve a regional, sectoral and national goal, for example, the product of agriculture is the raw material and basis for a large number of industries to provide employment in both rural and urban areas simultaneously. There has to be a hierarchy of settlements interlinked and closely knit arrangement of small villages with a service/model village in a cluster complementing a service and market town which are further interlinked to larger cities, metro and megacities. This linkage weakens the geographical boundaries of these settlement nodes – villages and towns – of different scales finally culminating into a comprehensive development approach complementing each other and using technologically strong instruments like ICT which have further brought together these nodes contributing to smart and integrated communities, diminishing the geographical lines. It can further be improved by innovative technology by organizing audio–visual interface of rural and urban population for their mutual benefit and growth.

5.8 Case Study Town: Panipat, Haryana

5.8.1 Panipat

Panipat City is the main urban centre of Panipat District which is located on the central eastern zone of the State of Haryana between 29°23′N 76°58′E and 29.39°N 76.97°E at the height of 219 m from the mean sea level (refer to Fig. 5.1). This city

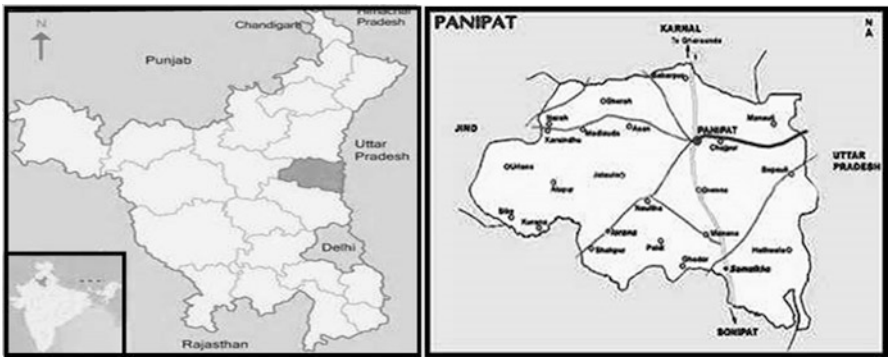

Fig. 5.1 District of Panipat, State of Haryana, India

is on Sher Shah Suri Marg of the National Highway-1. Yamuna River flows about 18 km towards the east of the city. Panipat District has two subdivisions, Samalkha and Panipat, and three tehsils, Panipat, Samalkha and Israna. Panipat is known for handloom industries. There is a thermal power station and NFL (National Fertiliser Limited) in Panipat. Panipat is also known for traditional weavers' products; the handloom industry of this city is famous all over the world, and the major products are carpet, blanket and bed sheets. It is known as the City of Weavers.

5.8.2 Geographical

The City of Panipat is primarily a part of Indo–Gangetic Plain located on Yamuna Subbasin of the Ganges basin. The topography of this town and the surrounding areas are almost flat slightly sloping in the northwestern and southeastern direction; it has a good network of canals originating from Western Yamuna Canal. The city is geographically bounded by Karnal, Sonipat and Jind, as well as the district of Shamli in the State of Uttar Pradesh.

5.8.3 Climate

Panipat has rainfalls' about 70 % of which is mainly in the monsoon season from July to September; the remaining rainfall is received from December to February. The annual average rainfall as per the meteorological department is 610 mm. The temperature of the city varies from about 6°C in January to 45°C in summers during May/June. Dust storm occurs from the month of April to June. It is dense fog in the month of January and December.

5.8.4 Population

As per the census in 2011, the population of Panipat District is 1,202,811 with a population density of 949 persons per square kilometer. The population growth rate in the last decade, i.e. from 2001 to 2011, is about 24.33 %. The sex ratio in the district is 861 females for every 1000 males, and the literacy rate of the population is about 77.5 %.

5.8.5 Economics

Panipat is an important commercial and industrial centre of the State of Haryana. The industries, trade and commercial sectors provide employment to about 40 % of the total workforce, with 4 % of the total workforce still engaged in the primary sector. Panipat has the largest centre of shoddy yarn. Blankets which are prepared using handloom and power loom are given to soldiers.

5.8.6 Historical Importance of Panipat

Panipat is a very famous ancient and historical town of the State of Haryana. Its historic name is Panduprastha and is one of the five cities founded by Pandavas during the Mahabharata period.

Three battles were fought in the area near this city. The First Battle of Panipat was fought on 21 April 1526 between Ibrahim Lodhi, sultan of Delhi, and the Timurid warlord Zaheeruddin Babur.

The Second Battle of Panipat was fought on 5 November 1556 between the forces of Akbar and Samrat Hem Chandra Vikramaditya, a king of North India, who belonged to Rewari in Haryana and had captured the large states of Agra and Delhi defeating Akbar's forces. The Third Battle of Panipat was fought in 1761 between the Afghan invader Ahmad Shah Abdali and the Marathas under Sadashivrao Bhau Peshwa of Pune. Ahmad Shah won but with a very heavy casualty rate on both sides happened. It resulted in the worst defeat of Marathas in their history. The war led to a power vacuum which later led to the British conquest of India.

The specific site of the battle itself is disputed by historians, but most consider it to have occurred somewhere near the modern-day Kala Amb and Sanauli Road. Some historical remains of Panipat are Kabuli Bagh Masjid (Fig. 5.2), Salar Gunj Gate (Fig. 5.3) and the Tomb of Bu Ali-Shah Kalandar (Fig. 5.4).

Fig. 5.2 Kabuli Bagh Masjid

Fig. 5.3 Salar Gunj Gate

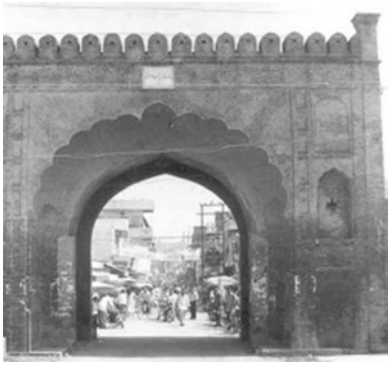

Fig. 5.4 Tomb of Bu Ali-Shah Kalandar

5.9 Smart Concepts for Urban and Rural Development in Panipat

The scope of the study in this paper has been limited to the City of Panipat and the villages within the Controlled Area Boundary (CAB) as per the Development Plan Panipat 2021 (Fig. 5.5).

5.9.1 Smart Concepts to Improve Physical Infrastructure: Urban and Rural Panipat: Following are few Smart technologies to manage infrastructure issues

5.9.2 Smart Concepts to Improve Sewerage and Drainage Systems

5.9.2.1 Existing Status

Panipat (Urban) The entire drainage of the city is presently through a drain of 4–6 m wide – known as Panipat Drain (Gandha Nalla) – flowing across the town from northwest to southeast. Rainfall in the town is erratic, and the water flow is limited only to wastewater received from residential and industrial areas. Since there is no proper sewerage system in the old part of town, domestic wastewater is disposed into open drains, which is finally discharge into the Panipat Drain. Presently about 50 % of the area has a drainage system.

Panipat (Rural) Villages located in the CAB Panipat have water reservoirs, but they are regularly been encroached or are being levelled to allot residential plots or in other use. Storm water and other wastewater generally drained to these water

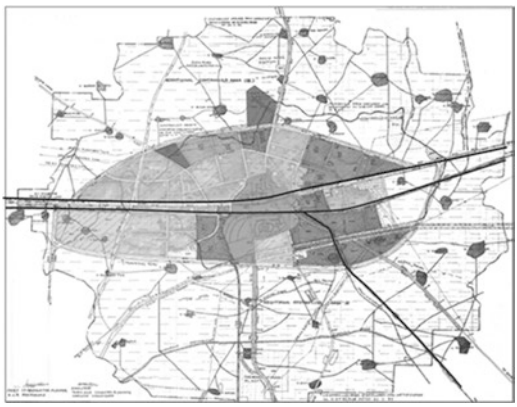

Fig. 5.5 Development Plan 2021: Panipat

features. There is no sewerage system. In rural areas, the human excreta waste is disposed through septic tanks, or people go in open grounds/fields which are extremely unhygienic.

Strategy
In Panipat urban areas, the existing drains are insufficient in Panipat, and there is a need for immediate repair work and construction of new ones especially in the areas where new colonies are in the process of regularisation. For improving the planning, designing, executing the construction of drains and managing better storm-water drainage systems, it is required to regularly monitor the characteristic and velocity of liquid waste using smart technologies. ICT has great potential in monitoring of storm-water logging, rainwater harvesting, water recycling, storage of water, etc. Phasing of works should be done, and the new industrial areas and residential areas can be taken up first to initiate electronically monitored drainage system and sewerage system.

In rural areas of Panipat, the water features need to be conserved, revived and digitally recorded after proper verification from village revenue records and require to be maintained. Drains in the villages are available but covers about 40–70 % area so there is a need to upgrade, but it can be done by a self-help concept involving the local population and through schemes like MNREGA (Mahatma Gandhi National Rural Employment Gurrantee Act). The village water features need to be electronically monitored.

There is serious requirement for community latrines with proper septic tanks and soak pits which can be developed using local population, non-governmental organizations (NGOs) and government schemes like MNREGA with government assistance/public–private partnership (PPP) model.

5.9.3 Smart Concepts to Improve Water Supply Systems

5.9.3.1 Existing Status

Panipat (Urban) Groundwater is the main source of water supply for Panipat. The depth of groundwater table ranges from 20 to 40 m, and the general flow of groundwater is towards southwest direction. The groundwater resources in Panipat are overexploited and also polluted in some areas. Deeper groundwater is by and large safe (Source: Ground Water Information Booklet, Panipat District Haryana, Central Ground Water Board, 2007).

Panipat (Rural) In rural areas about 60 % villages have a 6water supply system, but due to nonavailability of electricity, problems of maintenance and unavailability of overhead tanks, the efficiency of systems is not satisfactory. Besides this there are government- and privately owned submersible pumps, but these are again insufficient and not rationally located to serve the entire population.

Strategy For improving and managing better water supply services in Urban Panipat, especially for newer areas, electronic sensors on water supply lines can be

useful to regularly monitor the quality of supply. Monitoring of water aquifer level and quality of groundwater is a must to record the rate of depletion of the water table. A study of geological characteristics of Panipat region is required to record water reservoirs and should be regularly monitored/updated by digital sensing technology. Computational digital sensors can regularly monitor the quality, quantity and water wastage in water distribution and water leakage through smart water-metering system, smart water quality-sensing devices and smart water tariff structure, based on the concept of the more water requirement, the more costly it will be. Smart water treatment systems using electronic mechanization systems and the use of electronically controlled and managed reverse osmosis water purification system are some useful technologies to improve the water supply system in Urban Panipat, and some of these technologies can be used in rural areas also. In rural areas, the installation of more government-owned hand pumps which are not dependant on electricity will be an effective and sustainable solution.

5.9.4 Smart Concepts to Improve Solid Waste System

5.9.4.1 Existing Status

Panipat (Urban) For solid waste management, the total area of 22.5 Sq Km under the Municipal Corporation Panipat is divided into 31 zones; the road length is 270 km with 268 waste collection points. The waste generation is 358 gm per day, and the total waste generation in the city per day is about 124.5 t. Land-use wise waste component: residential (31 %), commercial (38 %), hotels (5 %), institutions (.5 %), markets (16 %), construction (8 %), gardens (3 %) and others (5 %). The waste is biodegradable (56 %), recyclable (28 %), inert and other wastes (16 %). The door-to-door collection is for about 10,000 households out of 51,000, i.e. 20 %. The collection is managed by Excellent Novel and Radical (EXNORA), an NGO which has engaged 80 sanitary workers working under a sanitary inspector headed by a chief sanitary inspector. EXNORA organizes street sweeping, drain desilting and waste transporting from collection to disposal points. The expenditure is about Rs. 349 per ton and @634 m per sweeper.

Disposal of solid waste is near Nimbri Village on Sunauli Road. Five acres of land is used which have now increased to 9 acres, but in an extremely unhealthy way.

Panipat (Rural) In rural areas there is no organized system for solid waste disposal, but the wastes, primarily the domestic, animal excreta and agricultural waste, are only used as manure in agricultural fields or dumped in outer areas of village Abadi, that too, in nonscientific manner. Presently the waste, though it has potential, does not provide significant benefits in rural areas.

Strategy
In Panipat urban area, for improving and managing better, an integrated solid waste processing and disposal systems have to be developed. Besides developing the systems to cover the entire city, ICT can play an important role with the installation of air pressure-based suction-ducting system for a mechanized door-to-door collection especially in newly planned and developed industrial and residential areas monitored by electronic system. ICT has great potential for monitoring the quality and quantity of solid waste, transportation system and disposal sites–geographical, geological and environmental implications of disposal. The waste of Panipat is 56 % degradable and 28 % recyclable and can be used to generate manure by vermicomposting and for reuses after recycling specially the glass, plastic, etc. Waste can also produce energy. The private participation shall be effective using waste for the aforesaid purpose. The integrated system approach of eliminate-reduce-reuse-recycle concept should be the policy. For the transportation of waste, pneumatic waste collection, underground ducting and gravity chutes can be adopted in a phase-wise manner. Recycled plastic can be effectively used as Polli bricks for the construction of flexible pavements. Excise duty reduction on recycled items will prove to be a strong incentive.

In Panipat rural areas through Panchayats or NGOs, there is a requirement of sensitising the population regarding the importance of proper waste management. Rural waste in this region has high (about 60–70 %) biodegradable component having the potential to be used as bioenergy fuel, high-quality manure, etc., and the agricultural waste, like rice husk, is again very useful for building construction and interior materials. Waste can generate a good revenue for Panipat villages, but needs for constitution of an agency on PPP model to explore this potential.

5.9.5 Smart Concepts to Improve Electricity Network

5.9.5.1 Existing Status

Panipat (Urban) Panipat electricity system is managed by the Uttar Haryana Bijli Vitran Nigam (UHBVN). The electrical network of Panipat is maintained by twenty-two 33 kV substations of 11.6 MVA capacity with 400-km electric line running across the district boundary. The electricity supply in the city is highly erratic with an average supply in midsummers generally for about 12–17 h and about 20 h in average during winters with very frequent incidences of grid failure and failure of local lines, transformers and substations especially in city commercial areas (Fig. 5.6).

Panipat (Rural) The electricity supply in rural areas is again not in good shape with an average supply in midsummers generally for about 7–10 h and about 12 h in average during winters with very frequent incidences of grid failure and failure of local lines, transformers and substations like urban areas.

Fig. 5.6 Commercial areas of Panipat: facing acute scarcity of electricity infrastructure

Strategy

It is evident that the total dependency of electricity supply on state-run grid managed by UHBVN is not workable. So the only probable solution is exploring the possibilities of the use of renewable energy especially the solar energy and conversion of waste into energy in urban and rural areas in a phase-wise manner. In rural and urban areas, the use of solar street light should be extensively used. Small-scale community solar panels for 20–100 houses can be installed for domestic use. Similarly solar light will be effective for domestic use in Abadi village areas. Bioenergy from biogas plants has to be explored. So by the use of smart energy and smart metering, rural and urban electricity can be made smarter.

5.9.6 Smart Concepts to Improve Traffic and Transportation Infrastructure

5.9.6.1 Existing Status

Panipat has a linear kind of development; it houses a large number of industries and important commercial and institutional premises located along the central spine posing numerous traffic and transportation problems – primarily the problem of mixing fast-, medium- and slow-moving traffic moving on the same spine (refer Fig. 5.7), weak mass transportation system, thick commercial development on circulation spines, temporary encroachments and weak traffic and transportation management system. A similar situation is also observed on other state highways like Panipat–Ganaur Road, Panipat–Jind Road and Panipat–Shamli Road. The secondary- and tertiary-level roads also have weak road infrastructure, and the presence of vendors, hawkers, rehris, kiosks, advertisement panels, hoardings and shops extending into the road width are some serious issues. Besides these, weak road geometry, faulty junctions and the absence of road graphics are some issues of concern.

Fig. 5.7 Mixed traffic on NH-1 in Panipat

In rural areas primarily, there are two types of roads: first, metallic ones connecting villages to nearby urban centres and villages and second, internal roads mostly having interlocking pavers. Most of the villages have about 60–80 % of village area that is catered by pavers, but by drain logging, animal washing and similar other practices and extremely weak maintenance on roads in outer as well as in internal areas, the surfacing layer gets spoiled very soon.

Strategy

The traffic and transportation problems of the city can be addressed by the following important measures:

- Integrating the land-use and the transport planning
- Giving a high level of priority to public transport and specially to the para-transit modes
- Segregating the movement of commercial freight traffic from passenger traffic
- Inclusion of local bus transport system
- Improving pedestrian facilities
- Increasing the capacity of road network
- Widening
- Better traffic management
- Junction geometry improvement
- GIS
- General Packet Radio Service (GPRS) computational data mapping tools that display traffic and suggest alternate travel routes
- Better connectivity to Delhi Metro
- Regional multimodal direct connectivity between Panipat, Delhi, Gurgaon and Noida
- Improvement of road geometry
- Parking management
- Better signalisation system
- Better auto rickshaw and cycle rickshaw regulations

The development of flyovers has been successful in improving traffic problems of the city (Fig. 5.8).

Fig. 5.8 Panipat flyover: segregation of regional and local traffic

The following are some important technologies which can be used to improve the traffic and transportation network in Panipat:

- Electronic vehicle tracking/digital identification systems
- E-tracking of dynamic congestion-charging programmes
- Public address
- Video communication solutions
- Electronic enabled–integrated transportation management systems
- Global positioning system (GPS)
- Radio frequency identification (RFID) and other sensor technologies
- Availability of broadband, wireless and intelligent infrastructures
- Collaboration technologies in the creation of innovative work environments related to traffic and transportation
- Bus location and information subsystem (BLIS)

Regarding the roads in rural areas, there is a requirement of sensitisation amongst villagers to maintain their roads and develop a feeling of ownership regarding the roads and pathways. Regular maintenance including restraining of activities like animal washing should be done by self-help mode and by self-checking mode. Panchayat institutions should play an important role. The roads connecting the villages to Panipat should be regularly widened to develop better transportation between rural/urban centres for better transportation of goods and public services.

Hence there is a requirement for integrated and comprehensive strategies for Panipat rurban development in infrastructure, industrial and commercial development and heritage conservation and for composite development of the city and villages of Panipat (Fig. 5.9).

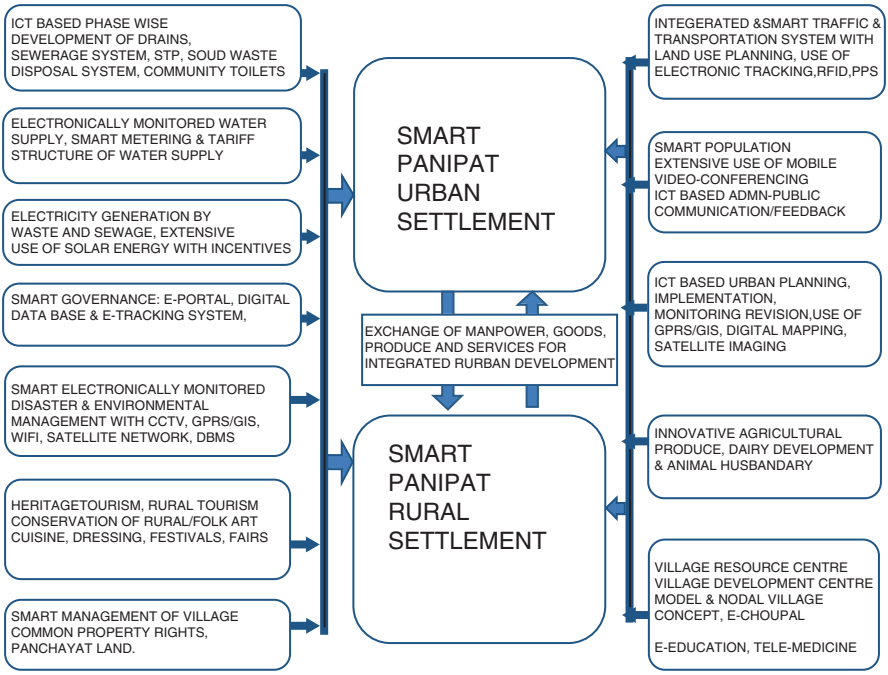

Fig. 5.9 Strategies for integrated and comprehensive Panipat rurban development (author's perspective) (the concept is evolved by author)

5.9.7 Smart Concepts to Improve Industrial Growth

5.9.7.1 Existing Status

Panipat is famous for its industrial growth and establishments. Presently there is a total of about 5500 industrial units with about 40 registered medium and large units, and registered units in the district are 4068. The workers employed in small-scale industries are about 1.00 lakhs, whereas in large industries, about 15,000 persons are employed.

The main exportable products are the handloom items like bed covers, rugs, towels, flooring and furnishing fabrics, cotton durries, etc. The growth in export is increasing by 10–15 % per year.

Presently there are about 400 units which are functioning as ancillary units of large- and medium-scale industries with future potential for industrial growth in Panipat.

Industrial activity of Panipat is scattered at various locations of the town. Some of the planned areas are developed by HSIIDC on the southeastern side of the city in planned sectors. Besides this industrial activity is also in the interior areas of city. The industrial sectors do have a good infrastructure in terms of road, drainage, sewerage and electricity network. These areas are well connected with the transport network.

Strategy Panipat has an immense potential for further industrial growth in both manufacturing especially in textile manufacturing and bathroom fitting items and service industries like textile design The city's industrial environment can be improved by shifting industries from the interior areas of the city to outside the city by using smart technologies in maintaining physical infrastructure of the industrial area–ICT-based digital monitoring of water supply, drainage and sewerage systems, geographical and environmental digital mapping, etc. The extensive use of electronic communication for commercialization, sale of products, procurement of raw material and transportation is required.

5.9.8 Innovative and Smart Strategies Are Required to Integrate Rural Areas and Urban Centres for Smart Industrial and Commercial Development in Panipat

- The City of Panipat is surrounded by about 50 villages and are strategically located around the city, which can be very finely interlinked (Fig. 5.10) with large-, medium- and even small-scale industries located in the city. The reasons for suitability of rural centres for industrial development in Panipat are:
- Large-, medium- and even small-scale industries in Panipat City require a large number of ancillary units for support, whereas land in the city is costly.

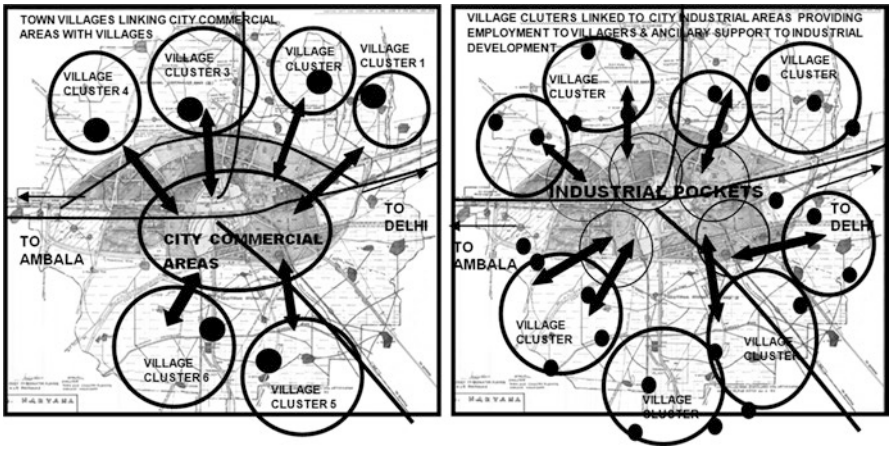

Fig. 5.10 Panipat Development Plan 2021: the village clusters (in *circles*) and the nodal villages (with village development centres) extending the city commercial areas to villages and clusters providing ancillary support to Panipat industrial areas (the concept is evolved by the author)

- Availability of abundant land with levelled topography for developing small ancillary industrial units.
- The educated/technically skilled and even well-qualified manpower is available in the rural areas of Panipat.
- There are immense potentials to develop skill-developing centres.
- These villages are efficiently connected to the city with proper road network which can further be improved and developed as per the requirement.
- Electrical power is already available which can be supplemented by solar power and bioenergy plants to generate more power for small-scale industrial growth.
- Villages are already connected with ICT, mobile towers, telephone exchanges and internet facility that are already available for fast communication.
- For the further growth, the challenges are transporting raw materials, testing facilities, developing brand identity, developing better industrial–institutional linkage, developing low-cost packaging costing, exerting effort to develop export marketing and making a market-friendly approach.

5.9.9 Use of Smart Concepts for Governance

5.9.9.1 Existing Status

Panipat (Urban) The governance in urban area of Panipat is managed by different state government offices/departments headed by the deputy commissioner. 3The major function is performed manually from the district headquarter – related to police, fire, electricity, public health, transport, food and supply, city maintenance and municipal corporation's functions regarding sanitation, street lighting, issue of NOCs, permissions, licenses and taxation departments. All communications and complaints are managed and processed manually with extremely slow and weak mechanism of transparency.

Panipat (Rural) The governance in the rural area of Panipat is managed by the village Panchayat, village secretary, patwari and different state government offices/departments headed by the deputy commissioner entrusted with different development works in villages. All revenue records, land records, cooperative functions, different government schemes like MNREGA, old pesion schemes, funding systems, loans and food and supply shops function manually with an element of unexplained confidentiality with lesser transparency and accountability.

Strategy ICT can play an important role in urban and rural governance. All functions of government/departments should be performed through dedicated district e-portals.

The movement of each file should be maintained, with digital tracking system. All communications, issue of permissions, NOCs, sanctioning of development proposals, land records, revenue, taxation-related works, public development works monitoring and management of physical and community infrastructure should be

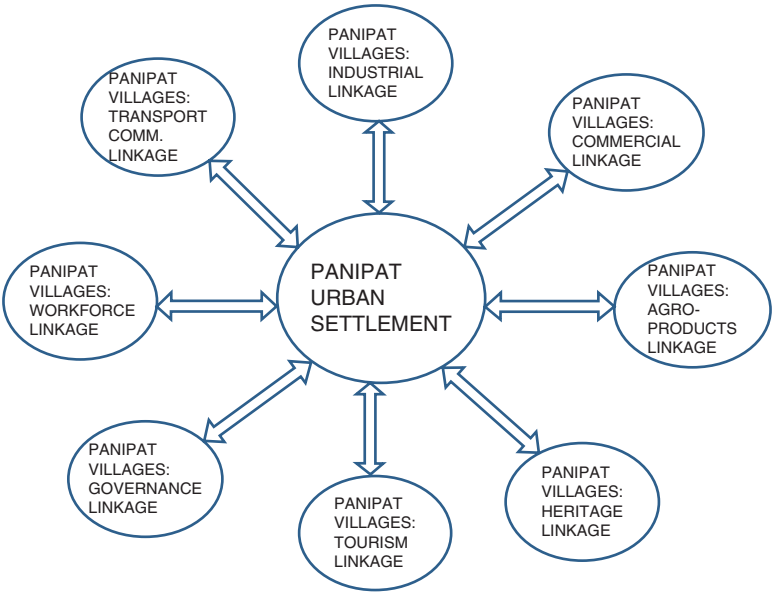

Fig. 5.11 Strong linkage and merging boundaries of urban and rural Panipat: an integrated approach to Panipat rurban development (the concept is evolved by author)

done through dedicated server lines (open to public) to maintain a high speed of functioning approach and with complete transparency. Other issues of governance include e-education, telehealth, electronic citizen portals, etc. All parts of Panipat City and even villages are well connected with telephone, mobile network and internet facilities, so the base framework to implement this technology is already available. Only the initiative is required; the entire function can be performed through computational technology in a phase-wise manner within the next five years. Thus it can be effective in diminishing the urban and rural boundaries (Fig. 5.11).

5.9.10 The Use of Smart Concepts for Disaster and Environmental Management to Make Panipat a Safe City

5.9.10.1 Existing Status

Panipat (Urban) The Disasters identified for 8Urban Panipat are chemical and industrial disasters (NFL Panipat explosions), urban fires, earthquakes, road/rail accidents (223 fatal accidents in 2011), bomb explosions (like Samjhauta Express blast), epidemics, food poisoning, festival disasters, building collapse, flood, extreme drainage, waterlogging, heat wave and cold wave, etc. Presently there is no local authority to manage the disasters. Being an industrial city, heavy traffic on

central spine is present; air pollution is high; aquifers are very low and depleting at extremely high rate; and the city is devoid of trees, vegetation, birds, etc.

Panipat (Rural) Disasters identified for Rural Panipat are village fires, earthquakes, biological disasters, epidemics, pest attacks, cattle epidemics, fire incidents, food poisoning, flood, extreme drainage, waterlogging, heat wave and cold wave, etc. Villages also do not have any established mechanism to face these kind of disasters. Water contamination in aquifer is observed in villages because of nearby industries; soil contamination is common; and soil fertility is going down by the extreme use of insecticide/pesticide and unscientific way of cropping.

Strategy The use of electronic technology is highly beneficial to handle natural disasters, environmental problems and crime. Electronic monitoring sensors to check environmental parameters, waste from industries, fire incidents and pollution of air specially on 500 m in both sides of Central Panipat spine are some mandatory equipments to be installed on priority. The use of CCTV with the control in the Central Police Control Room directs mobile connectivity with police system, GPRS-/GIS-enabled patrol vehicles and digital data. Based on the crime, the strict monitoring of vehicles in the city by computational systems and GPRS surveillance systems can be very useful. Being in the Earthquake Zone IV, this city is prone to earthquakes, and these also can be better managed by the use of smart technologies by getting regular information from seismic department, sensing and informing people about emergencies. Disaster management can be drastically improved by the use of computational systems and Wi-Fi (wireless) connectivity using satellite networks. The use of information security management and RFID technology in Panipat especially for para-transit transport modes, taxies, autos, etc. can be very useful in curbing crime on roads. Computational technology is highly effective in sensing any chemical disaster, ICT-based traffic control management and monitoring water and air quality. Climatic/weather forecasts can be useful in making correct predictions and protect people in villages and Urban Panipat to make Panipat rurban community smart.

So for smart rurban development, ICT can play an extensive role; the villages can be improved into model (Adarsh) villages by developing smart infrastructure, and by further use of ICT, they can be made into smart villages simultaneously, complementing smart cities (refer Fig. 5.12).

5.9.11 Smart Concepts to Improve Tourism in Panipat

5.9.11.1 Existing Status

Panipat (Urban) There are a number of tourist attractions in Panipat. The prominent places of tourist attraction are the historical structures of Dargah of Muslim saint Abu Ali Kalandhar, the battle grounds of the three battles which happened near this place and the Kabuli Bagh Mosque, an ancient building structure built by

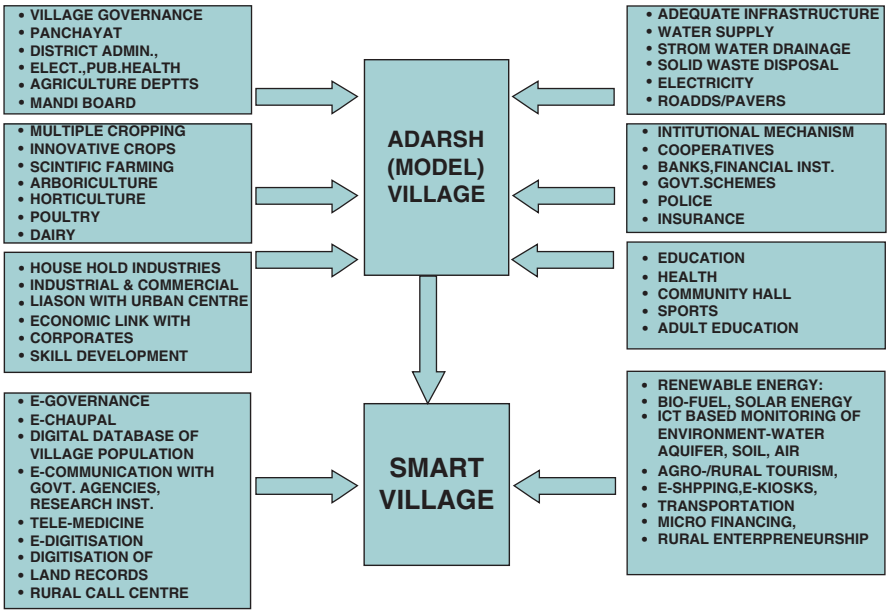

Fig. 5.12 Process of upgradation of Adarsh (model) villages into smart villages by the use of ICT and smart technologies (the concept is evolved by author)

the Emperor Babar. The grave of Ibrahim Lodi is also a point of tourist attraction. Panipat Museum is famous for local contemporary art and craft. Devi Temple of Panipat is also worth visiting. One old gate named as Salargarh Gate is also a famous historical monument. Presently there is no proper mechanism, planning and strategy to improve and explore tourism potential in Panipat.

Panipat (Rural) Villages in Haryana have a strong heritage in terms of old houses, havelies, structures of temples and mosques. Besides these are folk arts like Sanghi, traditional art of Rangoli, wall art, folk dresses, village festivals, fairs, etc. These activities and heritage are worth conserving for cultural reason; also these do have tourism potential which is lying unexplored in Panipat villages (Fig. 5.13).

Strategy

- *Panipat Heritage and Tourism Development Board*: The constitution of Heritage Tourism Development Board in the city having experts from engineering, historians, architects, planners, landscape experts, conservation architects, IT experts, etc. should be undertaken at the earliest (Fig. 5.14).
- *Panipat Heritage Walk*: A comprehensive Tourist Heritage Walk-movement pattern can be developed covering all the important monuments, building remains and precincts of historical importance in Panipat covering *Salarpur Gate*, *Devi Mandir*, *Ibrahim Lodhi's Tomb and Bu-Ali-Shah Kalandar Dragah and Kabuli Bagh Masjid* (Fig. 5.13).

Fig. 5.13 Panipat heritage corridor route

Fig. 5.14 District headquarter: Panipat

- *Development of Tourism and Physical Infrastructure*: Tourist routes should have battery-operated mobile cabins for tourists; these routes need to be improved in terms of road quality, solid waste, drainage, sewerage and the electrical infrastructure and other issues of tourism at priority.
- *Digital Engineering Database of Monuments*: The historical monuments need to be conserved with digital engineering database of all the important monuments need to be developed.
- *Development of Rural Tourism*: There are good number of villages located near the national highway, and these villages can be developed as tourist attraction by developing walks and improving security arrangements and good physical infrastructure and movement pattern inside the villages to visit the villages in their original form. Activities with facilities to provide natural home-made cuisines, eateries, folk dances, dresses, traditional lifestyle, fairs and festivals can be points of attraction in these villages. Attracting tourists will infuse revenue and income to village population and corporatisation of village generating good economy.
- *Panipat Agrotourism*: Tourists visiting villages can enjoy and purchase agro products at the source in their natural habitat and original form and in quality.

5.9.12 Conclusion

Smart communities with integrated and closely knit smart cities and smart villages (Fig. 5.9) are probably the solution to the gigantic problem of migration of rural population and the rapid urbanization in the country. Smart cities shall have e-planning and smart technologies, viz. IT-based systems like GIS, database management system (DBMS), planning support system (PPS), radio frequency identification (RFID), electronic monitoring of environmental parameters, e-database, e-plans, satellite imaging system and real-time information operated by digital technologies to operate urban services and governance.

E-communication between public, policymakers/government agencies and administrators, using technologies like 3D modelling support decision-making process and community-based internet GIS model, and future-making assessment approach (FMA) have been found very effective in planning and operating smart cities and villages.

ICT-based smart communities will promote sustainable development and finally transform existing villages and towns into smart, intelligent and energy-efficient villages and towns. The smart villages besides having the strong basic community and physical infrastructure, healthy financial mechanism, scientific and productive farming with multiple cropping and innovative agro-based activities, poultry, dairy, etc. shall also act as an ancillary industrial zone for the nearby urban industrial and commercial zones. These villages can be connected to the state administration by e-Choupals and can act as a corporate with business-related to local agro-product supply, dairy, agrotourism, rural tourism, skilled/semi-skilled manpower, nature-therapy centres, etc.

In order to promote the use of ICT to develop smart cities and smart villages, it is important that necessary modifications are made in state rural and urban planning and development Acts to technically and legally accept the records and development process monitored through electronic network, viz. digital land records; communication done through ICT modes, database, e-plans, satellite images and real-time information collected by digital technologies; ICT-based planning and designing approach and monitoring through computational technologies.

Further the administrators, planners, engineers and officials of executing and governing agencies working in the cities and villages can be trained to use these technologies.

Proper budgetary provisions and proper financial modelling at the time of inception of urban and rural development projects, preparation of detailed master plans, city development plan and rural developmental programmes with the extensive use of ICT are also necessary to shape this dream into reality. Proactive governance, digital data management, video conferencing, e-accountability and e-transparency have to be made the regular feature of administrative framework to achieve desired results.

Usage of these technologies can make a dramatic impact on rural and urban centres by increasing the per capita income, export figures, level of infrastructure and finally the overall quality of life.

Reference

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Chapter 6
Analysis of Major Parameters of Smart Cities and Their Suitability in Indian Context

Riyan Habeeb

Abstract The intent of the paper is to analyse major factors that influence the making of a smart city. In today's global networking scenario where everything is technology driven, the importance of information and communication technology (ICT) cannot be undermined. They offer swift and real-time information and are easily accessible. However, can the cities be labelled as smart just by improvising ICTs or there might be other parameters involved in making a city truly smart? The paper henceforth explores such possibilities of making a city smart by taking case studies of known cities/neighbourhoods who have optimised these standards for success. People's participation in using these technologies and the user experience is one of the important consideration so that they are ready to experience a livable smart and organised city. Smart governance, smart planning, smart economy, smart mobility, smart environment and smart living are also the main highlights of the paper on which the case studies are based to analyse smart cities and provide important basis to emphasise if the proposed 100 smart cites in India can really rise up to the level of smart city parameters and tell a success story.

Is it only the ICTs that are responsible for making a city smart or a holistic approach is required?
Are we smart enough to embrace a smart city?

Keywords Smart cities • ICTs • India • Smart governance • Smart mobility • Smart practices

6.1 Introduction

There are many definitions available for a smart city; the term smart city is still a fuzzy concept. These definitions arise from various points of views from different sectors' hierarchy, such that some definitions can be:

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- Smart Cities Council: 'A smart city is one that has digital technology embedded across all city functions' (http://smartcitiescouncil.com/).
- IEEE Smart Cities: 'A smart city brings together technology, government and society to enable the following characteristics: smart cities, a smart economy, smart mobility, a smart environment, smart people, smart living, smart governance' (http://smartcities.ieee.org/about.html).
- Business Dictionary: 'A developed urban area that creates sustainable economic development and high quality of life by excelling in multiple key areas; economy, mobility, environment, people, living, and government. Excelling in these key areas can be done so through strong human capital, social capital, and/or ICT infrastructure' (http://www.businessdictionary.com/definition/smart-city.html).
- Caragliu and Nijkamp: 'A city can be defined as 'smart' when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement' (Caragliu 2009).
- Giffinger et al.: 'Regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of citizens in the governance of cities' (Giffinger et al. 2007).

In ideal terms a working definition may be that a 'smart city' is an urban region that is highly advanced in provisions of overall infrastructure, sustainable real estate, communications and market viability. It is a city where information technology is the principal infrastructure and the basis for providing essential services to residents (CREDAI Conclave 2014).

In a smart city, economic development and activity are sustainable and rationally incremental by virtue of being based on success-oriented market drivers such as supply and demand (CREDAI Conclave 2014).

Thus some of the basic parameters that can be evolved as per given agenda are from Frost and Sullivan: 'We identified eight key aspects that define a Smart City: smart governance, smart energy, smart building, smart mobility, smart infrastructure, smart technology, smart healthcare and smart citizen' (Sullivan 2014).

These terms can be briefly explained as:

Smart governance – mean IT-enabled administration and governance; the use of integrated technology platforms that are easily accessible across various devices is certainly key to providing access, transparency, speed, participation and redressal in public services.

Smart energy – focus on alternate sources of energy, smart energy management and billing practices, improvement in energy production and distribution efficiency and the use of energy-saving technologies.

Smart mobility – improved coordination in public transportation, reduced traffic congestion through intelligent traffic management system and real-time monitoring of traffic jams through GPRS and satellite technology.

Smart building – through modern building management systems, the use of energy-saving appliances and led lights, adoption of modern water-saving techniques like low-flush toilets, recycling and proper utilisation of grey water, etc.

Smart infrastructure – the adoption of modern and fast construction practices like precast; usage of AAC blocks, hollow concrete blocks or fly ash bricks instead of traditional clay bricks; and modern facade systems using smart glass, BIPV and smart manholes.

Smart technology – like monitoring of leakages in water distribution system of the city through SCADA, high-speed public transportation, etc.

Smart citizen – educated and progressive citizens, with active participation in decision-making and implementation strategies in the city

6.2 Indian Context and Smart Cities

The paper analyses only suitability of some of the important aspects such as smart governance, smart transport and smart citizen and underlying smart practices which can contribute evenly in Indian context. How is the applicability of these indicators suitable for Indian context, where it is merged by high level of illiteracy, lethargic approach towards e-governance and indifferent attitude towards maintenance of infrastructure?

In this scenario it is better to evaluate the exact assessment of people preparedness for successful implementation of smart city concepts.

6.3 Smart Governance or e-Governance

The emergence of information and communication technology (ICT) has provided means for faster and better communication, retrieval of data and utilisation of information to its users. e-Governance is basically the application of ICT to provide government services to the citizens through Internet. However, a better or smart governance does not necessarily mean large dependence upon ICTs; instead smart governance pushes for more integrated planning and research application of governing principles such as understanding the context of the city it is suppose to familiarise with, as different cities posses unique issues to be faced depending upon historical, geographical or cultural features (Second Administrative Reforms Commission 2008).

While the international and domestic giants of the information technology (IT) have promoted and advocated the smart city definition as to only mean IT-enabled administration and governance, It needs to be acknowledged that such a restrictive definition is underrated; although enabling ICT is an important trait, other aspects of smarter ways for governance and management cannot be ignored. The following tables show online website status of respective municipalities of 100 proposed cities.

As evident from Tables 6.1 and 6.2, it can be assessed that more emphasis is needed on current state of web services first before additional ICTs can be employed

Table 6.1 Status of cities with most number of online services available

City	Website present (Y/N)	Grievance complaints/ enquiries	Online payment of taxes	Online services (birth/death/ marriage certificates)	Published budget	Published tender documents	Press releases/ notification	Recruitments/ vacancies	Building permission
Mumbai, Maharashtra	Y	Y	Y	Y	Y	Y	Y	Y	Y
Nagpur, Maharashtra	Y	Y	Y	Y	Y	Y	Y	Y	N
Ahmedabad, Gujarat	Y	Y	Y	Y	Y	Y	Y	Y	N
Surat, Gujarat	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bhopal, Madhya Pradesh	Y	Y	Y	Y	Y	Y	Y	Y	N
Indore, Madhya Pradesh	Y	Y	Y	Y	Y	Y	Y	Y	Y
Chennai, Tamil Nadu	Y	Y	Y	Y	Y	Y	Y	Y	Y
Coimbatore, Tamil Nadu	Y	Y	Y	Y	Y	Y	Y	N	Y
Madurai, Tamil Nadu	Y	Y	Y	Y	Y	Y	Y	Y	N

Bangalore, Karnataka	Y	Y	Y	Y	Y	Y	Y	Y	Y
Thrissur. Kerala	Y	Y	Y	Y	Y	Y	Y	Y	Y
Hyderabad, Telangana	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bikaner, Rajasthan	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kota, Rajasthan	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ludhiana, Punjab	Y	Y	Y	Y	Y	Y	Y	N	Y
Ambala, Haryana	Y	Y	Y	Y	Y	Y	Y	Y	Y
Bhubaneswar, Odisha	Y	Y	N	Y	Y	Y	Y	N	N
Gangtok, Sikkim	Y	Y	Y	Y	Y	Y	Y	Y	Y

Source: Author, based on Census of India, 2011 data

Table 6.2 Status of cities with least number of online services available

City	Website present (Y/N)	Grievance complaints/ enquiries	Online payment of taxes	Online services (birth/death/ marriage certificates)	Published budget	Published tender documents	Press releases/ notification	Recruitments/ vacancies	Building permission
Haldia, West Bengal	N	N	N	N	N	N	N	N	N
Bhavnagar, Gujarat	Y	Y	N	N	N	N	N	N	N
Gandhi Nagar. Gujarat	N	N	N	N	N	N	N	N	N
Burhanpur, Madhya Pradesh	N	N	N	N	N	N	N	N	N
Pattadakal, Karnataka	N	N	N	N		N	N	N	N
Thiruvallur, Kerala	N	N	N	N	N	N	N	N	N
Nalgonda, Telangana	Y	N	N	N	N	N	N	N	N
Bharatpur, Rajasthan	N	N	N	N	N	N	N	N	N
Gaya, Bihar (some data are linked with other department website)	N	N	N	N	N	N	N	N	N
Tinsukia, Assam	N	N	N	N	N	N	N	N	N
Udalguri, Assam	N	N	N	N	N	N	N	N	N
Tangla, Assam	N	N	N	N	N	N	N	N	N
Pelling, Sikkim	N	N	N	N	N	N	N	N	N

Source: Author, based on Census of India, 2011 data

to make use of better services. And other challenges for e-governance which got highlighted while surfing these websites are:

Different languages: the diversity of people in the context of language is a huge challenge for implementing e-governance projects as e-governance applications are written in English language.

Low literacy: literacy level of India is very low which is a huge obstacle in the implementation of e-governance projects. Illiterate people are not able to access the e-governance applications; hence the projects do not get much success.

User-friendly websites: users of e-governance applications are often non-expert users who may not be able to use the applications in a right manner. Such users need guidance to find the right way to perform their transactions.

Economic poverty: economic poverty is closely related to the limited information technology resources. People who are living below poverty line cannot afford a computer and Internet connection for themselves to take the benefits of the e-government and other online services.

6.4 Smart Mobility

'Smartness' in this aspect ensures efficient traffic control, minimising road accidents by traffic monitoring, usage of electric vehicles and hybrid vehicles to reduce pollution, promoting mass travel solutions like electric buses and high-speed metro rails with regenerative braking.

An important aspect is to reduce dependency on private vehicles to ensure less congestion and air pollution; hitherto the task is to provide better public transport which is efficient and connectivity. Curitiba which stands out in the development and implementation of bus rapid transport system (BRT) is marked by a grave failure of its counterpart in New Delhi BRT corridor. Whereas in Curitiba buses are classified into typology (even nowadays): direct, fast and few stops (slow buses that reach the far neighbourhoods), while in case of Delhi BRT, the authorities first proposed the corridor in the wrong place of plush South Delhi area with no communication with any other mode of transport such as metro; the already highly congested area with expensive and big cars was reduced to half by the provision of a corridor which stood alone in the humdrum of chaos. In this aspect it is clear to note that before carbon copying any smart feature from any other city, conscious and contextual approach to the city is necessary to prevent such historical failures.

6.5 Smart Citizen and Smart Practices

One of the basic and requisite principles for successful implementation of smart cities concept is people and their participation. A smart citizen must belong to a well-aware and sufficient literate population which could embrace the use of smart technologies and ICTs. Out of the proposed 100 smart cities, Tables 6.3 and 6.4 show the status of literacy rate as per census of India, 2011.

From the above tables, it can be inferred that application of technologies may not be received by all the cities in the same way as the cities with high-literacy rate compared to cities with low-literacy rate.

In this regard, the case of smart practices becomes much stronger; some of the best practices which are less dependent on ICTs are very evidently foreseen, again,

Table 6.3 Proposed smart cities with highest literacy rate

City	Literacy (%)
Kochi, Kerala	97.49
Thrissur, Kerala	97.24
Kottayam, Kerala	97.21
Ernakulam, Kerala	95.89
Shimla, Himachal Pradesh	94.67
Thiruvananthapuram, Kerala	93.72
Gandhinagar, Gujarat	93.70
Bhubaneshwar, Odisha	93.15
Nagpur, Maharashtra	93.13
Vadodara, Gujarat	92.37
Kollam, Kerala	92.1

Source: author, based on Census of India, 2011 data

Table 6.4 Proposed smart cities with lowest literacy rate

City	Literacy (%)
Tangla, Assam	55.55
Goalpara, Assam	63.37
Udalguri, Assam	65.41
Mahakuta (Bagalkot), Karnataka	68.82
Tinsukia, Assam	69.66
Bhiwandi, Maharashtra	70.17
Chandel, Manipur	71.11
Bihar Sharif, Bihar	74.8
Bishnupur, Manipur	75.85
Pelling, Sikkim	77.39
Yuksom, Sikkim	77.74

in the case of Curitiba, where it is not surprising to see common people picking up rubbish from the streets and taking it to a '*Lixo* point,' a waste collection centre. In exchange for the collected garbage, they are provided with fruits, vegetables, bus fares or theatre tickets. This innovative social experiment is successful mostly with elderly citizens or young boys from the *favela*, the poorest neighbourhood. The fruit and vegetables they get in exchange for collecting rubbish are purchased from the local farmers by the municipality.

These simple yet effective practices thus call for active public participation without any discrimination from literate state of people. Similarly such tokens or subsidies need to be provided to families which generate lesser amount of waste.

6.6 Analysis

At present a proposal for 100 smart cities remains a tentative figure, without any substantial vision and specific objectives. In the budget speech, only officially identified cities are along the Amritsar-Kolkata Industrial Master Plan, which covers seven states. Although they weren't named in the budget, seven cities have also been named along the Delhi-Mumbai Industrial Corridor, some of which would overlap with the Amritsar-Kolkata plan (Reuters).

Officially, the budget only pointed out three cities in the Chennai-Bangalore Industrial Corridor: Ponneri in Tamil Nadu, Krishnapatnam in Andhra Pradesh and Tumkur in Karnataka (Reuters).

Thus, model growth needs to be adopted by first setting examples by taking few cities and then implementing on contextual basis and concrete measures rather than generalised implementation over large number of cities.

6.7 Conclusion

Achieving the goal of developing 100 smart cities in India will require a lot more than the right technologies or ICTs, especially when the Indian cities lack basic governance and physical as well as social infrastructure. It would require a drive to change the fervour of the people, inviting them to participate, decide and dedicate their time and effort in establishing a more apt smart city. This would include their decision-making in the policies at local level by organising public meetings and announcements before the actualisation of any project, a bottom-up approach.

Relying heavily on ICTs to make city smart will only lead to further burden on economy and deter the potential self-reliability of Indian Cities which at present is still debt ridden. Smarter principles of planning need to be trodden for effective smart planning, replacing conspicuous approach with a conscious and resilient one, thus having a plan for economic growth and financial independency both for the people and the urban local bodies is essential.

Henceforth, a more detailed strategic framework needs to be adapted for the city based on its geography and economic potential, with people's participation at very initial level assessing their needs and aspirations before the cities are thronged with ICTs in the name of smart development.

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Chapter 7
Redefining and Exploring the Smart City Concept in Indian Perspective: Case Study of Varanasi

Sunny Bansal, Vidhu Pandey, and Joy Sen

Abstract Urbanisation as a phenomenon has existed since long. By 2050 almost 70 % of world's population will live in cities, hence a demand for more efficient urban systems. With many trends coming up on the urbanisation front, from 'liveable cities' to 'inclusive urban growth', the latest concern is of 'smart cities'. As an umbrella concept, smart cities have three subparts: human intelligence, collective intelligence and artificial intelligence (ICT), of which the latter is taking up the major limelight. While assessing India's urban conditions, it can be gauged out that there are various prerequisites before embedding ICT into the system. This paper attempts to redefine the smart city concept in Indian perspective reviewed through the lens of human + collective intelligence. Varanasi which has been proposed as one of the smart cities to be developed would be taken as a case study.

Varanasi, being synonymous to living continuity of traditions and deep culture, possesses a legacy of institutions for learning and innovation. However, rapid and haphazard urbanisation has disturbed the delicate balance between the city's various facets thereby making it a living laboratory for carrying out the 'smart' urban experiments. The paper takes up a holistic approach for evolving the smart city criteria and intends to define it on the basis of prioritisation models. The approach used in this paper for the purpose of analytics is 'interpretive structural modelling (ISM)'.

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7.1 Introduction

India has been home to one of the ancient civilisations in the world. Cities have taken birth, evolved and flourished on this land. It has accepted, amalgamated and assimilated various cultures and traditions into it which has kept explorers, merchants and people in general attracted to this ancient country.

Throughout this century the cities have been conceived by sociologists, planners and engineers as 'a bazaar, a seat of political chaos, an infernal machine, a circuit, and more hopefully, as a community, the human creation par excellence' (Newman 1999). By 2050 almost 70 % of the world's population will live in cities, hence a demand for more efficient urban systems. India being one of the major stakeholders, as is predicted by 2050 (International Business Times 2013) that India will become the most populous country swapping its position with China, needs to get in tune with latest tools and techniques which would serve to counter the negative effect of urbanisation and growing population and thus, preventing the ultimate collapse of our cities.

There have been many models to counter this plaguing phenomenon of urbanisation and channelise it into a more inclusive growth mode. This has included terms like liveable cities, zero-carbon cities, eco cities, green cities and smart cities. Smart cities being the latest on the scene offer a threefold application areas which need to be explored holistically. They are human (individual), collective (group/community/institution) and artificial intelligence (ICT).

The paper tries to explore 'why' and 'how' community participation and communication are necessary for smart community planning which in turn is important to achieve a holistic smart city for fast-developing countries like India. Varanasi has been taken as the case study for the application of the model.

7.2 Smart City Concept

The idea of smart cities has taken the twenty-first century by an enormous amount of enthusiasm exhibited in equal measures by both the developing and the fast-developing nations. Smart city concept is relatively new and highly context dependent (country, government, natural resources, IT knowledge and capacities) (Weisi and Ping 2014) which has in turn generated its diverse concepts. Some of the concepts have been taken under review (Table 7.1).

7.2.1 *Review of Definitions*

Table 7.1 Definition for smart cities

Definitions	Inferences
'A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens' (Giffinger et al. 2007)	Holistic approach
	Aware citizens
	Human intelligence centric
'The use of Smart Computing technologies to make the critical infrastructure components and services of a city-which include city administration, education, healthcare, public safety, real estate, transportation, and utilities- more intelligent, interconnected, and efficient' (Washburn et al. 2010)	Emphasis on smart computing technologies
'It is the implementation and deployment of information and communication technology infrastructures to support social and urban growth through improving the economy, citizens' involvement and governmental efficiency' (Hollands 2008)	Emphasis on ICT

7.2.2 *Umbrella Concept for Smart Cities*

Smart city as an umbrella concept has three broad dimensions to it: human intelligence, collective intelligence and information communication technology (ICT) (Taewoo and Theresa 2011). In ideal situation, all the three components have equal participation for the configuration of smart cities. This has been further modified into five principal axes (B. Mattoni et al. 2015), and the area of concern for this paper is 'smart community and communication' (Fig. 7.1).

7.3 Need for Smart Community Planning in Indian Perspective

India is an ancient land, and when talking about ancient lands, it is observed that the rate of acceptance of culture and rate of acceptance of technological advances vary. Seldom these places adapt easily to changing environments and accept the technological efficiencies, which might be due to various reasons including scarcity of resources, reluctance to adapt to a changing environment on the community's part, etc., among various others.

India being a developing nation has still not yet implemented the nuances of a planned and sustainable living in its developing scenario. Hence it is the need of the hour to define a proper framework of workable strategy which can be evolved and applied in the smart city revolution of India.

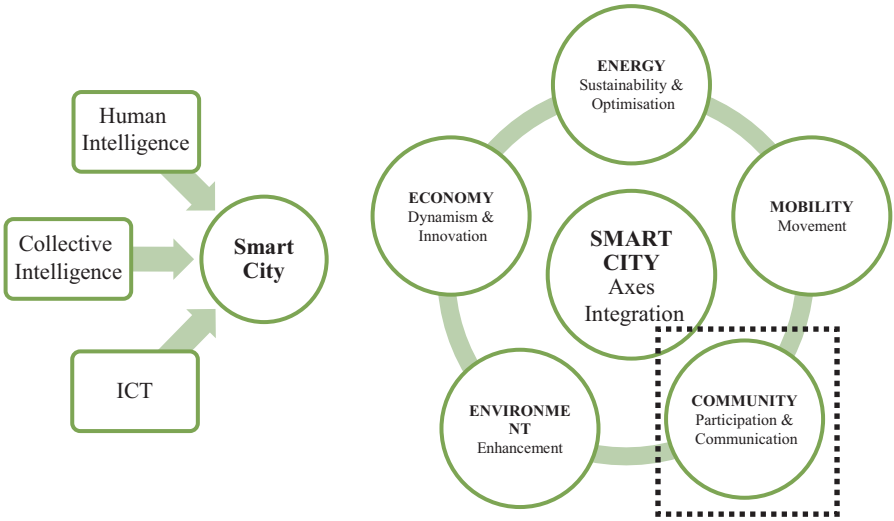

Fig. 7.1 Major components of smart city and its five axes

7.4 Challenges Faced by Cities Attempting to Become 'Smart'

A city behaves like an organism governed by various permutation and combination of services, and it is difficult to have an ideal situation (Newman 1999). The microscopic part of the modern city is people, and people themselves are open complex giant system (Cosgrave and Tryfonas 2012). The city puts so many people together, with energy, information, capital, labour, various economic, scientific knowledge and life infrastructure as the regional economy, politics, culture, education and science and technology information centre (Weisi and Ping 2014).

Sociopolitical elements cumulated along with lack of awareness among citizens have misinformed the direction of smart city revolution. The emphasis has solely been shifted on the 'ICT portion', whereas the other two criteria are getting neglected. Thus the major challenge faced by cities all over the world in general and India specifically is to steer it back towards its 'human component' or the 'human + collective intelligence' or 'smart community planning'. Here, smart community planning can be identified as planning for the betterment of communities in the long run. It will include assessing the current scenarios/conditions of the community (of a particular place/region) and then formulating planning frameworks integrated with smart solutions accordingly. This will also mean taking the people centric approach in the foreground, so that they not only remain on the receiving end of policy frameworks but can also act as catalysts of transformation.

7.5 Configuration of Traditional Heritage City Under 'Smart' Framework: Case of Varanasi

Mark Twain puts it himself: 'Benares is older than history, older than tradition, older even than legend and looks twice as old as all of them put together'. Varanasi is one of the oldest continuously living cities in the world whose fabric is woven across the web of interconnecting lanes, serving myriad services and in its ghats, along which thrives trade, commerce and lives.

Varanasi is already a creative city, that is, which inspires a sharing of culture and knowledge (Rios 2008). It has been a hub of artists, performers and craftsmen since long. The spiritual scene of the city renders it with a unique temple economy which in turn has led to evolution of various allied activities and services sprouting alongside 'ghats'. It could be said that in Varanasi, there exists an organic smartness with a potential to be structuralised. Moreover, the existing symbiotic relationship of base population and floating population due to its spiritual tourism makes this city more apt as a case study to examine the idea of smart urban experiment from the perspective of smart community planning.

7.6 Selection of Parameters for Smart Cities

To establish the groundwork for smart community planning, it involved the identification of requisite parameters. This has been done through literature studies, with major ones including 'smart communities project by Caltrans', a study by Mattoni, B.; Gugliermetti, F.; and Bisegna, F., 2015, among others. The parameters have been identified under two heads. Table 7.2 contains the smart community parameters for a generic smart city, while in Table 7.3, certain parameters specific (in italics) to Varanasi, like spiritual tourism economy, creative economic systems, etc., have been added because smart city concept can be more elaborately illustrated only when it is region specific.

7.6.1 Parameters of Varanasi

- *Symbiotic relationship between base population and floating population*: the city of Varanasi is characterised by its unique spiritual tourism phenomenon which makes it susceptible to increased load on its infrastructure due to floating population. This floating population can also be regarded as a source for revenue generation in terms of tourism. Since the study assesses the case for its smart potential with respect to community planning, hence it is required to examine the symbiotic relationship of floating population with base population.

Table 7.2 Parameters for generic city

S. No.	Parameter
I.	**Live**
1.	Interaction among the community members
2.	Personal autonomy and privacy
3.	Affinity and accessibility to information and communication
4.	Equal acknowledgement and services to all the members
II.	**Work**
5.	Job creation and entrepreneurship
6.	Inter-organisational networking
7.	Regional economy, community capital and self-help local organisations
8.	Local business participation in national or global markets
III.	**Learn**
9.	Public accessibility to technology and telecommunications for educational purposes
10.	Computer literacy and its usage
11.	Involvement of youth in community service
12.	Skill development
IV.	**Play**
13.	Usage of ICT by youth and sports organisations
14.	Community events organisation
15.	Online entertainment and web pages
V.	**Govern**
16.	Civic participation and participatory development
17.	Contact between citizen-government and intra-government communication
VI.	**Travel**
18.	Efficient traffic flow
19.	Use of alternative modes of transport

Table 7.3 Parameters for Varanasi

S. No.	Parameter
I.	**Live**
1.	Interaction among the community members
2.	Personal autonomy and privacy
3.	Affinity and accessibility to information and communication
4.	Equal acknowledgement and services to all the members
5.	*Symbiotic relationship between base population and floating population*
II.	**Work**
6.	Job creation and entrepreneurship
7.	Inter-organisational networking
8.	Regional economy, community capital and self-help local organisations
9.	Local business participation in national or global markets

(continued)

Table 7.3 (continued)

S. No.	Parameter
10.	*Spiritual tourism economy*
11.	*Creative economic systems*
12.	*Land river interface-based economy*
III.	**Learn**
13.	Public accessibility to technology and telecommunication for educational purposes
14.	Computer literacy and its usage
15.	Involvement of youth in community service
16.	Skill development
17.	*Performing arts development*
18.	*Spiritual knowledge dissemination and augmentation*
IV.	**Play**
19.	Usage of ICT by youth and sports organisations
20.	Community events organisation
21.	Online entertainment and web pages
V.	**Govern**
22.	Civic participation and participatory development
23.	Contact between citizen-government and intra-government communication
24.	*Special concern for preserving the organic character*
VI.	**Travel**
25.	Efficient traffic flow
26.	Use of alternative modes of transport
27.	*Competent water-based transportation*

- *Spiritual tourism economy*: as aforementioned, it is one of the unique features of Varanasi which needs to be examined for assessing its smart city potential.
- *Land river interface-based economy*: Varanasi offers a unique interface of river and land which augments its position as a city system. The ghats along the Ganges offer interesting economic vistas (allied industries to religious activities, cultural and creative industry) which will form an essential component in its smart city transformation.
- *Performing arts development*: this component will augment the economic and cultural quotient of the smart city transformation.
- *Spiritual knowledge dissemination and augmentation*: more emphasis should be laid in the organisation of spiritual language dissemination as it forms a unique feature of Varanasi.
- *Special concern for preserving the organic character*: Varanasi is a web of inter-connectedness and organic smartness. This character needs to be preserved while transposing it in smart city phenomenon.

- *Competent water-based transportation*: this particular sector of the city tends to be the untapped potential. It needs to be examined and utilised to its full potential for achieving smartness in the city.

7.7 Analysis: ISM

Interpretive structural modelling (ISM), a computer-assisted interactive learning process, is used to build a hierarchy for a set of elements connected by a contextual relationship. The technique has been used to configure the relationship (caters to) between the identified parameters for smart community planning. Through this technique this paper attempts to prioritise the elements and convert ambiguous mental model into a defined structural model (Sushil 2012; Zygiaris 2013).

Figure 7.2 shows the scanning method applied to obtain the reachability matrix. The process starts with the selection of an appropriate parameter as a pivotal element such that all other parameters can be uniformly distributed among the four sets: drop set (parameters which 'caters to' pivotal element), feedback set (parameters having a two-way relationship with pivotal element), non-feedback set (pivotal element 'caters to' these parameters) and vacancy set (parameters having no contextual relationship with pivotal element). The method is iterative, and after a few iterations, 'regional economy, community capital and self-help local organisations' were selected as pivotal element, and then other parameters were put into the most suitable set. Then, the reachability matrix was developed.

In the reachability matrix (Fig. 7.3), the column and row heads are the parameters identified and labelled with their serial numbers. The matrix is filled with 0s (no relationship) and 1s (relationship). In the relationship 'A caters to B', row heads are

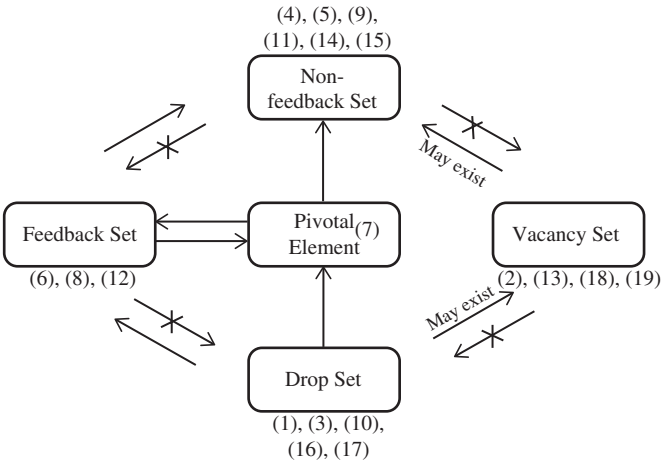

Fig. 7.2 Scanning method to develop reachability matrix (ISM) – generic

Reachability Matrix																				Reachability Set	Antecedent Set	Intersection Set	Level
	4	5	9	11	14	15	6	8	12	7	2	13	18	19	1	3	10	16	17				
4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4,5,6,8,12,7,1,3,10,16,17	4	1
5	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5,9,15	5,9,6,8,12,7,1,3,10,16,17	5,9	3
9	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5,9,11,15	5,9,11,6,8,12,7,2,13,1,3,10,16,17	5,9,11	3
11	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	9,11,14,15	9,11,14,6,8,12,7,13,1,3,10,16,17	9,11,14	3
14	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,14	11,14,15,6,8,12,7,13,1,3,10,16,17	11,14	1
15	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	14,15	5,9,11,15,6,8,12,7,2,13,1,3,10,16,17	15	2
6	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	4,5,9,11,14,15,6,8,12,7	6,8,12,7,1,3,10,16,17	6,8,12,7	4
8	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	4,5,9,11,14,15,6,8,12,7	6,8,12,7,1,3,10,16,17	6,8,12,7	4
12	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	4,5,9,11,14,15,6,8,12,7	6,8,12,7,1,3,10,16,17	6,8,12,7	4
7	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	4,5,9,11,14,15,6,8,12,7	6,8,12,7,1,3,10,16,17	6,8,12,7	4
2	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	9,15,2,13	2,10	2	5
13	0	0	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	9,11,14,15,13	2,13,2,10	13	4
18	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	18	18,19,1,3,16,17	18	1
19	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	18,19	19,1,3,10,16,17	19	2
1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	0	1	0	4,5,9,11,14,15,6,8,12,7,18,19,1,3,16	1,3,10,16	1,3,16	5
3	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	4,5,9,11,14,15,6,8,12,7,13,18,19,1,3,16,17	1,3,10,16	1,3,16	6
10	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	4,5,9,11,14,15,6,8,12,7,2,13,19,1,3,10,16,17	10,16,17	10,16,17	6
16	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	4,5,9,11,14,15,6,8,12,7,13,18,19,1,3,16,17	1,3,10,16,17	1,3,10,16,17	5
17	1	1	1	1	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	4,5,9,11,14,15,6,8,12,7,18,19,10,16,17	3,10,16,17	10,16,17	5

Fig. 7.3 Reachability matrix and level assignment (ISM) – generic

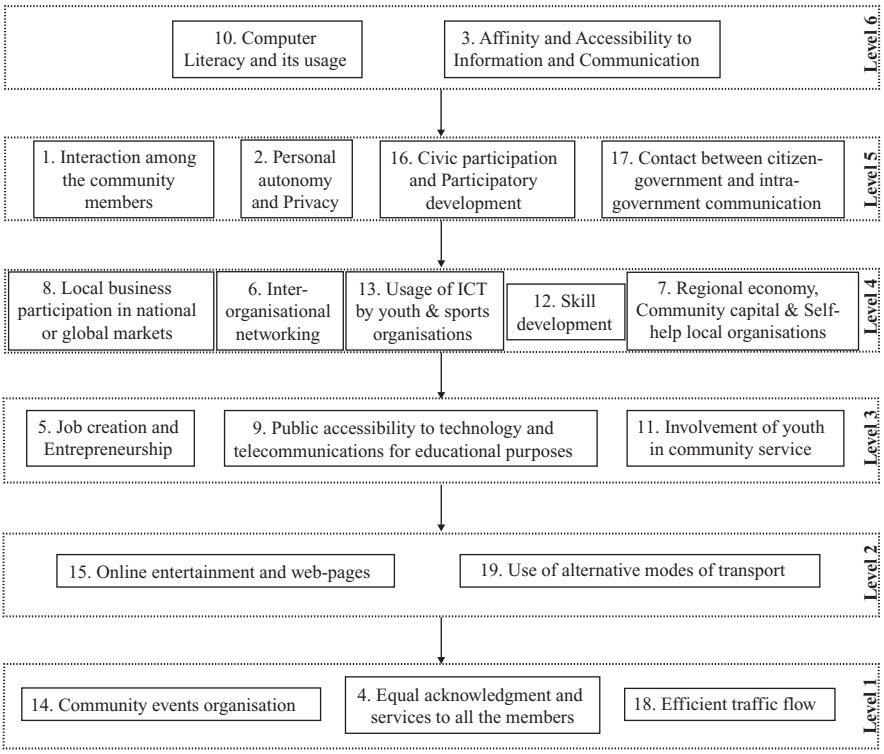

Fig. 7.4 Hierarchy model for smart community – generic

taken as A and column heads as B. Parts of the matrix are filled using transitivity and reflexivity concept. For instance, all elements in feedback loops will always lead to the elements of non-feedback loop, hence all 1s.

After assigning 0s and 1s, reachability set (elements reachable from A, 1s in row) and antecedent set (elements antecedent from A, 1s in column) are tabulated. Intersection set is further charted as intersection between both the aforementioned sets (Fig. 7.3). The parameter(s) with same elements in reachability and intersection set is assigned as Level 1. Then these elements are struck off from all the sets, and again using the same technique, the next level is assigned. The process continues until each parameter is assigned with a level. For generic parameters, six levels are obtained by applying ISM where Level 1 is the final level (Fig. 7.4).

7.8 Result: Hierarchy Model for Smart Community, Varanasi

The analysis of parameters (both generic and specific) resulted in the evolution of hierarchy models. These will help in prioritisation for initial point of action and resource allocation. The hierarchical model generated for the city of Varanasi

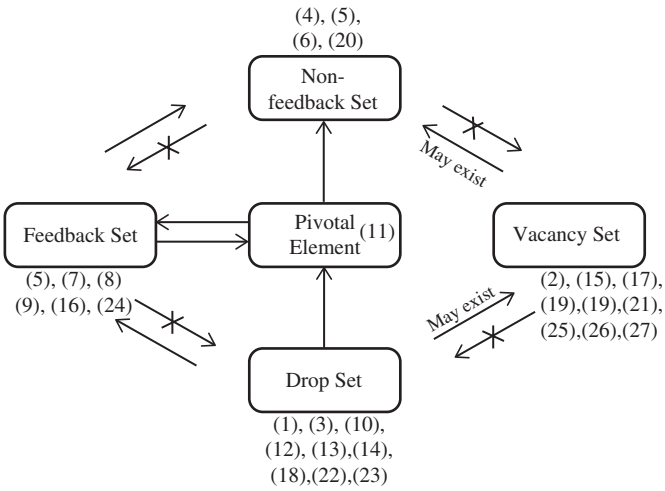

Fig. 7.5 Scanning method to develop reachability matrix (ISM) – Varanasi

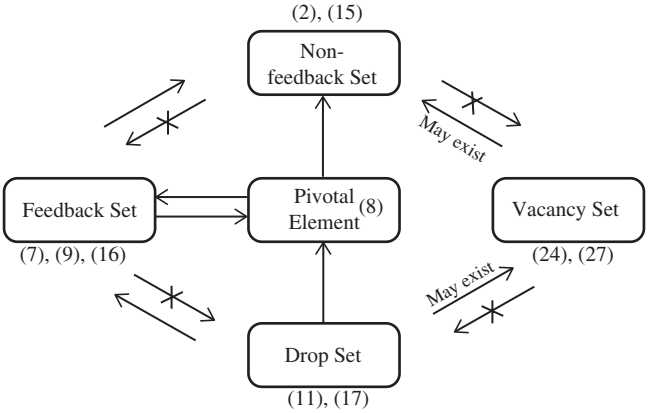

Fig. 7.6 Scanning method to develop reachability matrix (ISM) – subcomponent: Varanasi

includes 27 (19 generic and eight city-specific) parameters. It can be concluded from here that for smart city development, computer literacy, affinity to internet usage and access to information, is essential but only in combination with smart human networking and participatory development. It can be deduced from this model that after the aforementioned steps, policies can be channelised to boost land-river interface-based economy also. This should be followed by policies supplementing spiritual knowledge dissemination and augmentation and regularisation in spiritual tourism economy. The paper further proposes detailed development of structural models based on the already developed interpretive structural models.

For Varanasi-specific approach, 'creative economic systems' have been chosen as the pivotal element (Figs. 7.5 and 7.6). Initially seven levels were obtained (Fig. 7.7.). As Level 4 had ten elements in it, so the same technique was applied on those

	Reachability Matrix																															Reachability Set	Antecedent Set	Intersection Set	Level
	4	5	6	20	7	8	9	16	24	11	2	15	17	19	21	25	26	27	1	3	10	12	13	14	18	22	23								
4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5	4,6,7,8,9,16,24,11,1,3,10,12,13,14,18,22,23	4	2
5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	4,5,20,7,8,9,16,24,11,17,21,1,3,10,12,14,18,22,23	5	**1**
6	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,6	6,7,8,9,16,24,11,17,27,1,3,10,12,13,14,18,22,23	6	3
20	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,20	20,7,8,9,16,24,11,15,17,19,21,1,3,10,12,13,14,1,8,22,23	20	2
7	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5,6,20,7,8,9,16,24,11	7,8,9,16,24,11,1,3,10,12,13,14,18,22,23	7,8,9,16,24,11	4
8	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5,6,20,7,8,9,16,24,11	7,8,9,16,24,11,1,3,10,12,13,14,18,22,23	7,8,9,16,24,11	4
9	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5,6,20,7,8,9,16,24,11	7,8,9,16,24,11,1,3,10,12,13,14,18,22,23	7,8,9,16,24,11	4
16	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5,6,20,7,8,9,16,24,11	7,8,9,16,24,11,1,3,10,12,13,14,18,22,23	7,8,9,16,24,11	4
24	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5,6,20,7,8,9,16,24,11	7,8,9,16,24,11,1,3,10,12,13,14,18,22,23	7,8,9,16,24,11	4
11	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,5,6,20,7,8,9,16,24,11	7,8,9,16,24,11,1,3,10,12,13,14,18,22,23	7,8,9,16,24,11	4
2	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2,19,21	2,14,18	2	4
15	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	20,15,17,19,21	15,17,19,1,3,13,14,18,22,23	15,17,19	4
17	0	1	1	1	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5,6,20,15,17,21	15,17,19,1,3,13,14,18,22,23	15,17	4
19	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	20,15,17,19,21	2,15,19,21,3,14	15,19	5
21	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	5,20,19,21	2,15,17,19,21,1,3,13,14,22,23	19,21	3
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	25	25,26,27,1,3,12,13,22,23	25	1
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	25,26	26,27,1,3,12,13,14,22,23	26	2
27	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	6,25,26,27	27,3,12,22,23	27	4
1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	1	1	1	0	1	0	1	1	0	4,5,6,20,7,8,9,16,24,11,15,17,21,25,26,1,3,10,13,18,22	1,3,14,18,22	1,3,18,22	7
3	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	4,5,6,20,7,8,9,16,24,11,15,17,19,21,2,5,26,27,1,3,10,12,13,18,22,23	1,3,14,22	1,3,22	8
10	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0	4,5,6,20,7,8,9,16,24,11,17,10,12,18	1,3,10,12,14,18,22	10,12,18	5
12	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	0	0	1	1	0	0	1	0	0	4,5,6,20,7,8,9,16,24,11,25,26,27,10,1,2,18	3,10,12,22	10,12	6
13	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	0	0	0	0	1	0	1	0	0	4,5,6,20,7,8,9,16,24,11,15,17,21,25,26,13,18	1,3,13,14,22,23	13	6
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	0	1	1	1	1	1	4,5,6,20,7,8,9,16,24,11,2,15,17,19,21,26,1,3,10,13,14,18,22,23	14,12,23	14,22,23	8
18	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	0	1	0	0	0	1	0	0	4,5,6,20,7,8,9,16,24,11,2,15,17,1,10,18	1,3,10,12,13,14,18,22	1,10,18	5
22	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	4,5,6,20,7,8,9,16,24,11,15,17,21,25,2,6,27,1,3,10,12,13,14,18,22,23	1,3,14,22,23	1,14,22,23	8
23	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0	0	0	0	1	1	0	1	1	4,5,6,20,7,8,9,16,24,11,15,17,21,25,2,6,27,13,14,22,23	3,14,22,23	14,22,23	7

Fig. 7.7 Reachability matrix and level assignment (ISM) – Varanasi

Reachability Matrix											Reachability Set	Antecedent Set	Intersection Set	Level
	2	15	7	9	16	8	24	27	11	17				
2	1	0	0	0	0	0	0	0	0	0	2	2,7,9,16,8,11,17	2	1
15	0	1	0	0	0	0	0	0	0	0	15	15,7,9,16,8,11,17	15	1
7	1	1	1	1	1	1	0	0	0	0	2,15,7,9,16,8	7,9,16,8,11,17	7,9,16,8	2
9	1	1	1	1	1	1	0	0	0	0	2,15,7,9,16,8	7,9,16,8,11,17	7,9,16,8	2
16	1	1	1	1	1	1	0	0	0	0	2,15,7,9,16,8	7,9,16,8,11,17	7,9,16,8	2
8	1	1	1	1	1	1	0	0	0	0	2,15,7,9,16,8	7,9,16,8,11,17	7,9,16,8	2
24	0	0	0	0	0	0	1	0	0	0	24	24	24	1
27	0	0	0	0	0	0	0	1	0	0	27	27	27	1
11	1	1	1	1	1	1	0	0	1	0	2,15,7,9,16,8,11	11	11	3
17	1	1	1	1	1	1	0	0	0	1	2,15,7,9,16,8,17	17	17	3

Fig. 7.8 Reachability matrix and level assignment (ISM) – subcomponent: Varanasi

ten elements again (Figs. 7.6 and 7.8). Finally, ten levels are obtained for Varanasi (Fig. 7.9) where Level 1 is the final level.

7.9 Conclusion

Smart city as an urban experiment is a highly contextual and subjective especially in Indian scenario which will vary according to the identity, needs, potential and resources of the city. An attempt to formulate a generic model resulted in a level-wise emphasis in the realms of smart community planning parameters. The approach of ISM-based modelling helped in generating two simultaneous aspects, that of generic and specific cases. The generic case dealt with the parameters which would be common to any typical city which has to be transformed into a smart entity. The case of Varanasi was taken for generating specific model. This included all the parameters from the generic model and those criteria which are attributed to the uniqueness of this city and will make an impact while decision-making in the planning procedures.

Policy wise, it could be implied from above that ‘smart community planning’ should be the foremost step in making our cities smart and everything else follows it. This would result in policies which will integrate people centric approach with smart solutions to achieve the desired result. Another important component which would be vital to the process is intra-government synchronisation and citizen-government coordination.

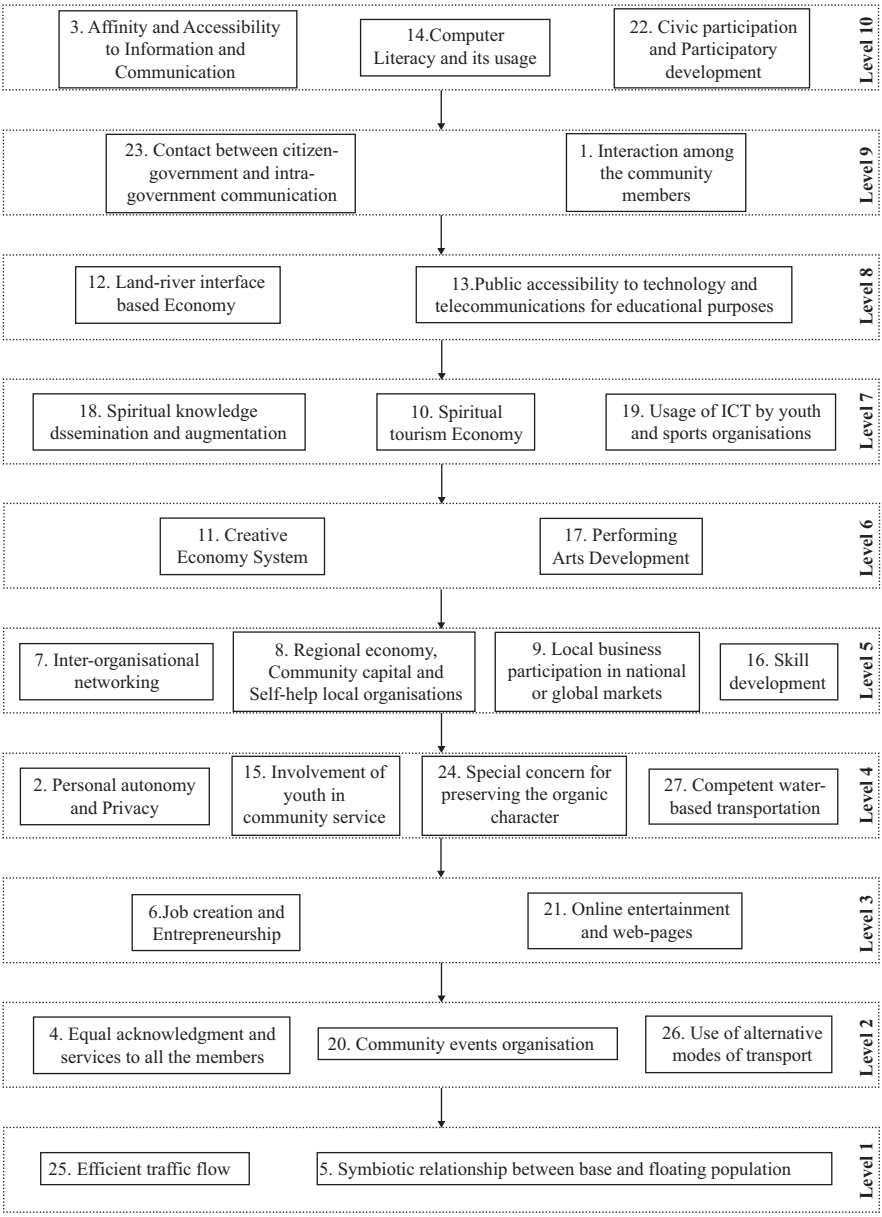

Fig. 7.9 Hierarchy model for smart community – Varanasi

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Chapter 8
Smart Cities and Disaster Resilience

Neha Bansal, Mahua Mukherjee, and Ajay Gairola

Abstract Most of the present cities are characterized by low-density urban sprawl, fragile infrastructure, low resilience, and people's poor coping capability to disasters. Further with the increasing unplanned rapid urbanization, the disasters (in terms of frequency and numbers) and their impacts are increasing, which is primarily associated with badly planned and managed urban development, degraded ecosystems, and poverty. According to a study by the United Nations, almost 890 million people (60 %) across the globe live in cities that are at risk from at least one major natural disaster, including floods, droughts, cyclones, or earthquakes. Disasters eventually wipe off years of development and cause death, injury, economic losses, and environmental and urban systems' degradation. Since a city is an integration of complicated urban systems like transportation, water supply, sanitation, housing, and other urban infrastructure and services, strengthening these systems will increase the resilience and help in disaster management in urban areas. On the other hand, smart cities use information and communications technology (ICT) to involve people, improve city services, and enhance urban systems which in turn will improve disaster resilience. To make cities disaster resilient right at the inception stage, the efficiency in urban planning can have a major impact on communities' preparedness and capacities to recover. Smart growth strategies like creating flexible land-use policies, targeting public investment, and engaging the entire community in making decisions can help communities recover from a disaster, rebuild according to a shared community vision, and be better prepared for a disaster. This paper tries to explore through various examples those aspects of smart cities which build and assist in disaster resilience of cities. The study clearly indicates that the relation between smart development and disaster resilience is strong, where the smart growth, smart urbanization (smart grids, eco-cities, compact development), and low-carbon footprint strategies have been used and are some of the most needed consideration to deal with the present scale of disasters in urban areas.

Keywords Smart cities • Disasters • Resilience • Urbanization • Smart growth • Carbon footprint

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8.1 Introduction

Most of the present cities are characterized by low-density urban sprawl, fragile infrastructure, low resilience, and people's poor coping capability to disasters. Further with the increasing unplanned rapid urbanization, the disasters (in terms of frequency and numbers) and their impacts are increasing. These cause increased losses and have huge economic implications. According to a study by the United Nations, almost 890 million people (60 %) across the globe live in cities that are at risk from at least one major natural disaster, including floods, droughts, cyclones, or earthquakes. Thus people and development are getting more vulnerable and exposed to disasters, which will eventually wipe off years of development and cause death, injury, economic losses, and environmental and urban systems' degradation. In addition to the projected estimation of 100,000 lives lost each year due to natural hazards, the global cost of natural disasters is anticipated to top $300 billion annually by the year 2050 (UNISDR, WSSD, 2002). Since a city is an integration of complicated urban systems like transportation, water supply, sanitation, housing, and other urban infrastructure and services, strengthening these systems will increase the resilience and help in disaster management in urban areas.

It has been rightly said that, "The 21st century is the century of the cities and of urbanization" (Kötter 2004). As the process of urbanization is irreversible and unstoppable, we need to tap its potential and be adaptive for sustainable development of cities. The statistics by the State of World Population 2001 indicate that the total population is increasing by 280,000 people per day (Kötter 2004). Nearly three-quarters of them will be inhabitants of the developing world (Doytsher et al. 2010). The rapid urbanization and growing number of megacities cause great ecological, economical, and social problems and risks across the globe leading to serious issues like climate change, disasters, and environmental degradation. Despite being faced with urbanization, emerging cities do have advantages. Cities are engines of economic growth and advanced technology. Thus planned and smart urbanization strategies in cities can reduce energy usage, strengthen infrastructure, reduce/shift urban sprawl, and reduce adverse environmental effects, climate change, and disasters. The low-density urban sprawl in most of the cities is primarily responsible for the increased exposure to natural disasters. Therefore high-density compact development with smart growth principles will help in disaster management twofolds. First, it will reduce exposure; secondly the smart growth will enhance resilience in terms of preparedness and recovery. Smart cities, smart development, and smart growth are a new concept in today's time. These have emerged due to the need for sustainable development in light of disadvantages of rapid urbanization, increasing disasters, and climate change. Thus integrating disaster preparedness and recovery approaches with eight key principles of smart growth can dynamically change the disaster management in cities. The literature indicates, the eight key features of a smart city a—smart economy, smart buildings, smart mobility, smart energy, smart information communication and technology, smart planning, smart citizen, and smart governance. Thus, more specifically these will

act as an efficient tool for disaster management—first at pre-disaster stage by reducing the sprawl, as a result, reducing exposure to disasters; second, at the stage of disasters, improving the adaptation and resilience by strengthening the infrastructure; and thirdly improving the post-disaster management by improving the efficiency in communication which in turn will allow emergency management and mitigation with immediate effect. Some of these smart growth methods that are tools for disaster management have been identified in this paper.

8.2 Smart Growth as a Tool Toward Disaster Resiliency

A resilient city is low risk to natural and man-made disasters. It reduces its vulnerability by building on its capacity to respond to climate change challenges, disasters, and economic shocks. Urban resiliency to disasters can be achieved more efficiently through smart growth and smart urbanization. This section tries to discuss the urban resiliency toward disasters with respect to eight key features of smart growth and identify the key principles of smart growth that will improve resiliency. These can be discussed in four categories*(1) Pre-disaster stage smart planning tools* (like compact development, smart infrastructure, and transportation), *(2) Emergency disaster response* using smart planning tools (smart communication, emergency response services based on smart technology), *(3) Post-disaster stage smart approach* (this stage gives an opportunity to rebuild smartly and fill the gap of lack of urban resiliency needed for disaster management, thus development of smart cities, use of renewable resources, etc. are looked upon in this section), *(4) Smart strategies at policy level for disaster resilience*.

8.2.1 Pre-disaster Stage Smart Planning Tools

(a) *"Urban resilience" can be increased by using high-density compact development adopted from smart planning.*

Since cities offer opportunities, they need sustainable development (UNDESA 2013); the rapid urbanization can be easily used for reducing greenhouse gas emission, retrofitting and upgrading of facilities and network in existing urban centers, and delivering high-quality energy services, energy-efficient transportation, and enhanced electricity transmission (Wagner.nyu.edu 2014; Falconer and Mitchell 2012). All these will improve the resiliency of the city. One of the key aspects is the high-density development aspect of smart growth which can be used as a tool for urban resilience, because it specifically directs land use (location and concentration of economic and social activities) (TERI 2010) and optimizes transportation systems. The study found that the more compact land use saves about a third in capital and operating costs for roads, transit services, water and wastewater, emergency

response, recreation services, and schools. This not only indicates the economic savings but also the savings that would be achieved in terms of land usage (Litman 2004, 2011). Compact development reduces urban sprawl (UNESCAP, UNISDR, 2010) which reduces the population's exposure and vulnerability to natural disasters by directing growth away from known flood-risk areas, earthquake zones, landslide areas, etc. (Emerine et al. 2006; Bansal et al. 2012). This improves overall quality of life on the reservation and improves access to resources, services, and amenities by reducing distances. There have been many initiatives taken up by world organizations. The most prominent and recent are the Environmental Protection Agency (EPA)- and Federal Emergency Management Agency (FEMA)-collaborated projects. Some of these are Safe Growth Strategies for the San Francisco Bay Area, Flood Resilience and Recovery Assistance for the State of Vermont, Preparing for Sea Level Rise in Coastal North Carolina (the Wilmington and New Bern City projects), and Land Use Planning Assistance for Spirit Lake Nation.[1] These can be referred in detail in the literature.

(b) *Smart infrastructure development.*

Urban resilience can be achieved by making wise decisions for locating new infrastructure by selecting adaptive technologies that do not fail during disasters and by making the infrastructure resilient enough to not collapse during or after disasters. "Smart Seoul 2015" project extends the use of smart technologies and mobile-web applications to provide citizen-centric services and infrastructure. These are more adaptive, faster, and resilient to impact from climate change and disasters. The report refers to a smart city as an improvement in today's city both functionally and structurally, using information and communications technology (ICT) as an infrastructure. ICT is used as a communicating element connecting physical infrastructures, transmitting data by way of sensors. Thus it brings about a convergence of processes that enables a smart city to function as a giant, independent intelligence unit highly informed and adaptive to unexpected situations (Hwang and Choe 2013).

Alternatively strengthening the existing urban infrastructure will serve the dual purpose of first catering the new development requirements, reduction in infrastructure costs and energy usage, and second creating greater resilience (Bansal et al. 2012). In an example, the National Institute of Standards and Technology (NIST)[2] research focuses on the impact of multiple hazards on buildings and communities and conducts post-disaster studies (like Joplin Tornado, 2011; The Witch Fire, California, 2007) to provide the technical basis for improved standards, codes, and practices to help communities improve the resilience of their buildings and

[1] EPA- and FEMA-collaborated projects under the MoU in 2010 using smart growth as a tool for urban resilience (http://www2.epa.gov/smartgrowth/smart-growth-strategies-disaster-resilience-and-recovery)

[2] National Institute of Standards and Technology (NIST) founded in 1901, and now part of the US Department of Commerce, is one of the nation's oldest physical science laboratories (http://www.nist.gov/disaster-resilience/).

infrastructure systems. This is based on several efforts like Community Resilience, National Earthquake Hazard Reduction Program (NEHRP), Fire Protection and Wildland-Urban Interface (WUI), Wind Engineering, Progressive Collapse, and Disaster and Failure Studies.

(c) *Smart transportation can further improve resilience.*

Cities' transportations have been a leading driver behind globalization: shrinking distances in the emergence of entire new economies and improving the quality of life for millions of people. But at the same time, the transportation sector is responsible for the majority of greenhouse gas emissions such as CO_2 resulting from the combustion of petroleum-based products, like gasoline. The transport sector is responsible for almost 25 % of global CO_2 emissions (IISD 2004). Transport emissions are growing at approximately 2.1 % per year worldwide and 3.5 % per year in developing countries (IEA 2002). These impact climate change which in turn affects the frequency, magnitude, and intensity of disasters especially hydro-meteorological disasters like flooding, extreme temperature, high and intense rainfall, etc. (Saxena and Banister 2008). "Growing Cooler," a study published in 2008 by the Urban Land Institute and EPA, examined the research on compact development, using two parameters—(i) vehicle miles traveled and (ii) carbon dioxide emissions, to determine the more efficient development patterns. The study estimated that compact development could reduce CO_2 emissions by 7–10 % in 2050. Another aspect of smart transportation is the use of smart means and choices. These include aspects like advanced driver-assistance systems, advanced safety control systems, intelligent traffic lighting system, battery technology, charging stations, vehicle tracking system, etc.

Another important aspect is the shift from personal automobiles to better and faster public transportation means. This shall reduce carbon emissions as well as traffic chaos which is the biggest problem during and after the disasters. "Transportation for America," a project of Smart Growth America, identifies that nationwide, the cost and time lost from traffic congestion would be 15 % worse without public transportation service.[3] In another example, a significant step is taken by England to measure its risk reduction by using smart and sustainable transportation. In 2004, England Government's Department for Transport, published a research report "The Effects of Smarter Choice Programmes in the Sustainable Travel Towns: Research Report" based on "Sustainable Travel Towns," a project carried in three towns—Darlington, Peterborough, and Worcester. The implementation of the program, measured from 2004 to 2009, intended to reduce car use. Under this the government spent £15 million to boost public transportation and travel awareness campaigns and to promote walking and cycling, and public transport marketing; some policy reforms were also taken. Impacts in relation to social, eco-

[3] *Smart Growth America* is the American National organization dedicated to researching, advocating for, and leading coalitions to bring smart growth practices to more communities nationwide. It advocates for people who want to live and work in great neighborhoods (http://www.smartgrowthamerica.org/issues/transportation/).

nomic, and environmental objectives indicated car driver mileage by residents fell by about 5~7% which helped reduce congestion and improve journey reliability; it resulted in an annual per capita carbon savings of roundly 50 kg of carbon dioxide in 2008, compared to 2004. In most cases, the implied reductions in risk per kilometer were comparable to or greater than the implied reductions per kilometer occurring nationally. Thus, smart growth transportation strategies are more efficient and reduce congestion by providing multiple routes and multiple types of transportation. When streets are connected in a complete network, choosing from many different routes to get from point A to point B can be faster and easier. Further comprehensive integrated development using smart growth principle of providing mixed land uses reduces vehicle dependency.

8.2.2 Emergency Disaster Response using Smart Planning Tools

Smart cities can improve the emergency and response primarily by responding quicker and faster and being more advanced. This will minimize all types of losses anticipated and potential losses in a disaster event. The compact planning and mixed land-use principle of smart cities optimizes and reduces the emergency services' response times due to the fact that fire departments, emergency responders, and police stations are closer to the areas they serve and have more route options, easy accessibility, and immediate ability to respond to emergency calls (EPA 2010; Bansal et al. 2012).

The second-most significant aspect stated in many researches and by many research organizations is the transportation management (access to transportation routes and reach abilities) during emergencies. Intelligent transportation system (ITS) technologies provide transportation service and public safety agencies with the ability to communicate and coordinate operations and resources in real time. The examples of successful applications are Emergency Transportation Operations (ETO),[4] the United States, since 2004; and the use of ICT for mobility, cloud, and big data solutions in Indonesia, Disaster Management 2015[5], ICDMS—an intelligent cloud-based disaster management system for vehicular networks (Alazawi et al. 2012). Another example is Smarter Cities emergency management solutions (by International

[4] *Emergency Transportation Operations (ETO)*—a collective effort among Federal Highway Administration (FHWA), National Highway Traffic Safety Administration (NHTSA), and Federal Transit Administration (FTA) that was launched in 2004, the US Department of Transportation across many cities in the USA

[5] *Fujitsu Asia Conference*—held on November 11, 2014, in Jakarta, Indonesia, aimed at a future vision for Asia using ICT to overcome social challenges in Asian disaster management (http://journal.jp.fujitsu.com/en/2014/11/18/02/)

Business Machines (IBM) Intelligent Operations Center[6]) designed to collect and aggregate existing and future data—from historical event information to sensor data to system status to video, allowing data sharing across organizational boundaries, putting information where it is needed when it is needed. Rio de Janeiro is transforming its emergency response system by using IBM solutions. The New York Real Time Crime Center, Lancaster's predictive modeling also uses this concept.

8.2.3 Post-disaster Stage Smart Approach

(a) *Smart growth approaches and models—smart city models.*

Smart growth models of cities give an insight of one or more applications of smart growth that can be efficiently used in pre-disaster mitigation strategies. Chinese smart city model: in China, as many as 18 cities (according to a Lux Research report) have been announced with smart city plans. These include some of the biggest cities such as Beijing and Shanghai and a number of small to medium-sized cities, such as Ningbo, Wuxi, Chengdu, Wuhan, Kunming, Foshan, Shenzhen, and Guangzhou. Ningbo is a seaport city in Zhejiang province, not too far from Shanghai since 2008, when a 33 km cross-sea bridge was built, allowing travel to Shanghai in less than two hours, with a population of 7.6 million inhabitants. Ningbo released its action plan for developing as a smart city (2011–2015), and soon it will hold the "China Smart City Technology & Applications Expo." According to the smart city plan, RMB 40.7 billion will be invested in projects in the next 5 years (12th Five-Year Plan period). The plan addresses five "speedups:" speedup construction of international strong port, building a modern metropolis, industrial restructuring, building a smart city, construction of ecological civilization, and improvement of quality of life. There are 87 individual projects covering logistics, manufacturing, public services, energy, social administration, traffic, healthcare, residential site management, and entertainment services (Appleyard et al. 2007). For example, IBM Smart Logistics Center, Ningbo Branch Corporation of Tata of India, BT Cloud Computing Center, and Shuguang Cloud Computing Center have come to settle in.[7]

Another example is of a European smart city model: Since 2007, the TU Wien (University of Vienna) team works on the issue of smart cities. In cooperation with different partners and in the run of distinct projects financed by private or public stakeholders and actors, the European smart city model was developed. Basically it provides an integrative approach to profile and benchmark European medium-sized cities and is regarded as an instrument for effective learning processes regarding

[6] *IBM Intelligent Operations Center* synchronizes and analyzes information gathered from diverse data-collection systems. It primarily takes initiatives toward Smart Planet initiatives focus on smart innovative solutions (http://www.ibm.com/smarterplanet/us/en/public_safety/nextsteps/solution/M573313P64918R78.html).

[7] https://ict4green.wordpress.com/2011/08/30/ningbo-a-leading-chinese-example-of-smart-city/

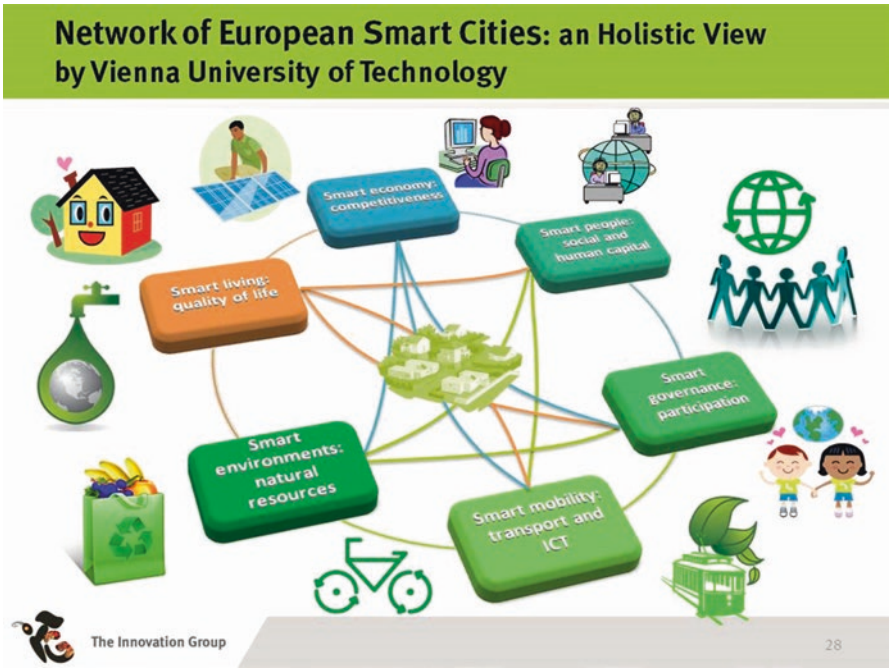

Fig. 8.1 Network of European smart cities, as given by Vienna University of Technology

urban innovations in specific fields of urban development. Currently, the third release (2014) of the smart city model is already available. As per the model, a smart city is a city well performing in six characteristics, built on the "smart" combination of endowments and activities of self-decisive, independent, and aware citizens.[8] The smart city network model of European cities is shown in Fig. 8.1.

(b) *Use of renewable sources of energy to improve resilience and efficiently mitigate in disaster situations.*

Most natural disasters such as hurricanes, earthquakes, and floods commonly cause utility grid failures. Backup renewable power systems can serve as an insurance against collapse of electrical systems. One solution to prevent collapse of electrical system during disasters is to back up utility grids with renewable power systems, alternatively using portable systems, following disasters to assist response crews and victims. Solar electricity or photovoltaics (PV) is the most used for these applications.[9] An example of both the aspects is witnessed in Operation Fresh Start,

[8] http://www.smart-cities.eu/model.html

[9] *Operation Fresh Start* is a project of the National Center for Appropriate Technology (NCAT). It began in 1997 with support from the Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) in response to the 1997 flooding in Red River, North Dakota (http://www.freshstart.ncat.org/articles/enrgsyst.htm).

a US Department of Energy project, that has been successfully implemented in cities of New Pattonsburg, Missouri, Rhineland, Missouri, Soldiers Grove, Wisconsin, Valmeyer, Illinois, and Kinston-Lenoir County, North Carolina. Further the literature identifies the significance of community disaster resilience. The "*resilience refers to the ability of a community – its systems, institutions, and residents – to adapt to changing conditions or to recover from an emergency event or disaster*." There are numerous strategies at local governance level that enhance community resilience and being complimentary to solar development or vice versa. Examples of this are "Solar Outreach Partnership" projects in the United States.[10]

Another aspect is the smart implementation of renewable resources (Erec and Greenpeace 2010). Technologies can generate reliable "base-load" power in electrical systems. This can be done by the use of grid-scale battery storage to support renewable energy expansion, by the development of enhanced geothermal power potential, and by the acceleration of the development of advanced nuclear power technologies. For example, according to New York Times 2011, the Federal Department of Energy financed a solar map of the city, an innovative approach which identified that two-thirds of New York City's rooftops are suitable for solar panels and that together they could generate 5847 megawatts, enough energy to meet half the demand for electricity during peak periods and 14 % of the city's annual electricity use.

(c) *Smart transportation networking—used for early warning, emergency management, and post-disaster evacuation routes.*

In emergencies, transportation networking can be extremely useful in directing the evacuation routes. As a long term benefit smart transportation networking reduces the carbon emissions also. This is more significant with the present scenario of greenhouse gas emissions. Transport-sector represent 23 % CO_2 emissions (globally) and 30 % in OECD Countries (OECD- ITF Joint Transport Research Committee's Working Group 2010; Bongardt, Breithaupt, and Creutzig 2010; UNDP 2011). Many researchers have studied the application of intelligent transportation networking and have identified transportation evacuation strategies based on VANET Disaster Management System (Alazawi et al. 2012). The basic concept of ITS is the inter-connectivity of different transportation systems using cloud computing systems.

The intelligent transportation systems (ITS)[11] is the application of information technology to surface transportation in order to achieve enhanced safety and mobil-

[10] *Solar Outreach Partnership (SolarOPs)* is a designed solar energy adoption on the local level by providing timely and actionable information to local governments. Funded by the US Department of Energy (DOE) SunShot Initiative, SolarOPs achieves its goals through a mix of educational workshops, peer-to-peer sharing opportunities, research-based reports, and online resources (http://solaroutreach.org/resource/resilienceresourcehub/#.VgOo3N-qqko).

[11] *The Intelligent Transportation Systems (ITS)*: ITS is the product from the Joint Program Office (JPO), Research and Innovative Technology Administration (RITA), and the US Department of Transportation (USDOT), by Noblis, Inc., with cooperation from the USDOT's John A. Volpe National Transportation Systems Center (http://www.its.dot.gov/standards_strategic_plan/).

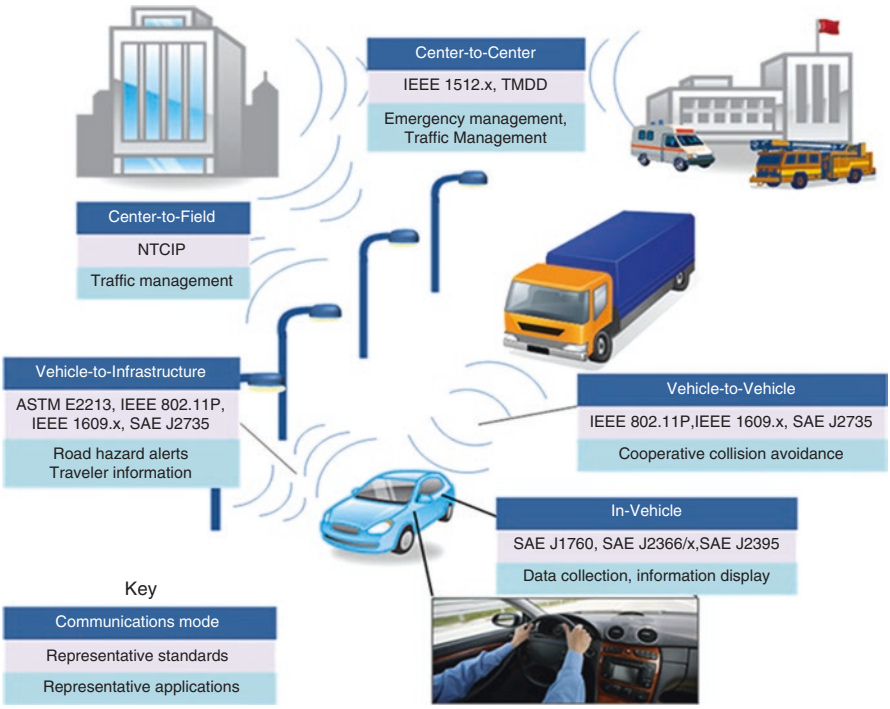

Fig. 8.2 A series of graphics that represent general elements of the transportation systems in the intelligent transportation systems (ITS) (http://www.its.dot.gov/standards_strategic_plan/stds_strat_plan_fig3.htm#sthash.dRRoDIQo.dpuf)

ity while reducing the environmental impact of transportation taken up under the ITS Strategic Research Plan, 2010–2014. Figure 8.2 indicates the intelligent transportation systems (ITS) graphically.

(d) *Smart grids to improve energy use can optimize the accidents and infrastructure failures in cities during disasters.*

The smart grid is a relatively new concept. The literature says, "*A smart grid is a digitally enabled electrical grid that gathers, distributes, and acts on information about the behavior of all participants (suppliers and consumers) in order to improve the efficiency, importance, reliability, economics, and sustainability of electricity services.*" Smart grid policy is organized in Europe as Smart Grid European Technology Platform.[12] The energy systems of the twenty-first century are likely to be characterized by cheap and abundant use of information and communications technology (ICT), enabling more efficient energy use and integration of renewable energy through an integrated energy network. A smart grid is a modernized electric system that uses sensors, monitoring, communications, distribution system automa-

[12] http://deepresource.wordpress.com/2012/04/03/smart-grids/

tion, advanced data analytics, and algorithm for anomaly detection to improve the flexibility, security, reliability, efficiency, and safety of the electricity system.

For example, the Provincial Electricity Authority (PEA) is a government enterprise under the Ministry of Interior. The PEA Smart Grid is utility information and communications technology to manage, monitor, and control the generation, transmission, and distribution of electrical energy. The PEA Smart Grid enables distributed generation from alternative clean energy sources and maximizes profit from asset utilization with a new management system. The PEA Smart Grid also enables the use of electric vehicles and provides connection services to the electrical network through smart metering. Finally, the PEA Smart Grid will provide efficiency, security, safety, reliability, and international standards of power quality to meet customer needs in the twenty-first century.[13]

(e) *Smart communication for early warning and preparedness.*

Challenged by a natural disaster, smart cities can use faster and more sophisticated ICT infrastructure and analytical capabilities that enhance and synchronize the information flow between multiple public sectors. Even with the simplest technology of mobile networks, a city municipality can reach the majority of its citizens at short notice. Cities can enhance from the experience of Japan, where the federal government launched an emergency warning system in February 2007, providing its municipalities with a plan and a solution to respond to natural disasters.

8.2.4 Smart Strategies at Policy Level for Disaster Resilience

All the efforts and initiatives that are at incubation stages need to be incorporated in the future in our living systems. This needs planning and implementation of smart strategies at all the levels of development, involving each and every actor and stakeholder in the process. Thus some initiates at policy level have been identified. The US Green Building Council (USGBC), the Congress for the New Urbanism (CNU), and the Natural Resources Defense Council (NRDC) have come together to develop a national set of standards for neighborhood location and design based on the combined principles of smart growth, new urbanism, and green building. In 2009, the Leadership in Energy and Environmental Design (LEED) rating system decided to certify development projects that perform well in terms of smart growth, new urbanism, and green building (Welch et al. 2011). Projects may constitute whole neighborhoods, fractions of neighborhoods, or multiple neighborhoods. The goal of this partnership is to establish these standards for within the rating framework of the Leadership in Energy and Environmental Design (LEED) Green Building Rating System (Ibm.com 2014).

[13] http://www.powergenasia.com/conference/smartmeter.html

8.3 Conclusion

As our present cities are generally characterized by high urbanization rates, and the world is undergoing changes due to globalization, urbanization, and technological advancements, it forces us to think and change our ways of living, especially in the cities of developing countries which are just not able to cope urbanization pressure. This challenge has been addressed many times by the economists and researchers by the development of "smart" technologies, which target the potential transformation of our cities into more responsive and self-sufficient smart cities. Smart cities use information and communication technology (ICT) to involve people, improve city services, and enhance urban systems that result in an improved integrated urban system which altogether improves disaster management intelligently. To make cities disaster resilient right at the inception stage, the efficiency in urban planning impacts communities' preparedness and capacities to recover from natural disasters. Other aspects of smart growth that focus on more efficient land-use patterns that reduce the spatial extent of the city though high-density compact development are needed. The smart growth strategies like creating flexible land-use policies, targeting public investment to catalyze private investment and engaging the entire community in making decisions about the future can help communities recover from a disaster, rebuild according to a shared community vision, and be better prepared for the next natural disaster. Numerous studies indicate that smart growth can reduce public infrastructure and service costs, providing savings on roads, water, sewage, garbage collection, utilities, school transportation, delivery services, and parking facilities. This also serves in the development of a strong economy.

These aspects identified here are just the basics which need a deep exploration in order to deal with disasters in a smarter way. The major challenges associated with the concept are that, first there are no laws to support this type of planning; secondly more research needs to be done in this area to understand the various positive and negative implications. Third, these technologies shall yield fruitful results only with public participation and "inclusive approach" which at the moment is a huge challenge. The people need to own the problems in order to participate in meeting their solutions. The lesson we learn here is that though there are many technologies being developed, it is very important to select the appropriate technology based on the available resources and adaptability level of people, in any city to achieve smart and sustainable built environment for efficient disaster resiliency.

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WSSD (World Summit on Sustainable Development) (2002) Convened from 26 August to 4 September 2002, in Johannesburg, South Africa, reaffirmed the international community's commitment to 'full implementation' of Agenda 21, alongside achievement of the Millennium Development Goals and other international agreements. The Johannesburg Plan of Implementation (JPOI), adopted at WSSD, sets out new commitments and priorities for action on sustainable development

Chapter 9
Indian Smart Cities and Their Financing: A First Look

Kuldeep Kavta and Pramod Kumar Yadav

Abstract The extant international literature on smart cities, which are conceptualized and designed to enhance the quality of well-being, fails to provide a homogeneously unifying definition of smart city. This lack of comprehensive knowledge manifests into a critical policy challenge to policy managers responsible for creating and managing complex contours of evolution of smart cities. Smart cities, however, are increasingly becoming a subject to public debate worldwide, which appears to be a strong value-enhancing approach to managing future cities. This paper critically reviews the existing definitional conceptualization of smart cities and their changing frames in global setting across a range of criteria borrowed from literature. Further, the research maps a potential Indian smart city (case of GIFT City) on comparable framework of global smart cities with an objective of developing insights into planned efficiency of smart cities in India. The study also examines different strategies of smart city development with a spatial approach and understanding the way in which these strategies can fit into India's urban scenario. The second part of the paper delves into financing of smart cities in India. Having taken into account India's budgetary plans to develop 100 smart cities, we assess the scale and effectiveness of the plans. Given the potential economic profiles of such cities and associated financial outlays, we also explore likely sources of financing for smart cities with a strong focus on risk-return trade-offs.

Keywords Smart cities • Smart city finance • Smart city mapping • Definition • Strategy

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9.1 Introduction

The urban population of the world has raised from 29 % in 1950 to 50 % in 2008 and is expected to increase further to 70 % by 2050 (Nations 2008). While the current urban population in India is around 31 % of the total population, contributing 60 % of country's GDP, it is projected that urban India will contribute about 75 % of the national GDP in the next 15 years (GOI 2014). With an urban population of 31 %, India is on the verge of transition where the pace of urbanization will boost up. It is in this context that the government has decided on developing 100 "smart cities" in the country. In the financial budget of 2014, the finance minister rightly said "Unless, new cities are developed to accommodate the burgeoning number of people, the existing cities would soon be unliveable" (GOI 2014). The study is broadly done in two parts: the first part is conceptualizing smart cities and the second part is about financing of smart cities. This lacks a standardize definition, and the understanding of smart cities formed the motivation for the first part of the research which initiated with working definitions of smart cities worldwide and understanding it. The research further proceeds with mapping different smart cities of the world on the European Union (EU) reference frame and preparing the logic behind the development strategy of cities. The second part of the study is about financing smart cities given the existing plans and budgetary allocation for 100 smart cities by the Government of India.

9.2 Defining Smart City

Extant academic literature and policy studies fail to provide a homogeneously unifying definition of smart city. The conceptualization and definition of smart city is structured around different names, different circumstances, and different policy outcomes in different countries. Table 9.1 summarizes worldwide working definitions of smart city by different firms, governments, and NGOs.

9.2.1 Grouping the Definitions

Based on the keywords mentioned in different definitions, the definitions were classified in different domains, namely, technology stressed, broader definitions, and unclear. Based on the classification of definitions based on different domains, the inferences were extracted out (Table 9.2).

Table 9.1 Smart cities definition

Institute/firm/group	Definition
The UK (business, innovation, and skills)	"Smart cities a process rather than as a static outcome, in which increased citizen engagement, hard infrastructure, social capital and digital technologies make cities more liveable, resilient and better able to respond to challenges" (GOI 2014).
IBM	"One that makes optimal use of all the interconnected information available today to better understand and control its operations and optimize the use of limited resources" (GOI 2014).
British Standards Institute	"The effective integration of physical, digital and human systems in the built environment to deliver sustainable, prosperous and inclusive future of its citizens" (GOI 2014).
CISCO	"Smart cities are those who adopt scalable solutions that take advantage of information and communications technology (ICT) it increases efficiencies, reduce costs and enhance the quality of life" (GOI 2014).
Accenture	"A smart city delivers public and civic services to citizen and businesses in an integrated and resource efficient may while enabling innovative collaborations to improve quality of life and grow the local and national economy" (GOI 2014).
Natural Resource Defense Council	"A city striving to make itself smarter (more efficient, liveable, equitable and sustainable)" (NRDC 2015).
Smart city council	"A smart city is one that has digital technology embedded across all city functions" (council 2015).
European Union	"A city seeking to address public issues via ICT-based solutions on the basis of a multi stakeholder, municipally based partnership" (POLICIES 2014).

Source: Author's own compilation from various sources

Table 9.2 Grouping the definitions

Domain	Definitions	Keywords	Outcome or deliverables
Technology stressed	IBM	Interconnected information	Control operations, resource optimization
	CISCO	Information and communication (ICT)	Efficient, cost reduction, improved quality of life
	EU	Information and communication (ICT)	Solution provider
	Smart city council	Digital technology	Digitally embedded
Unclear	Accenture	Innovative collaborations	Quality of life, growth in the economy
Broader definitions	NRDC	Process, livable, equitable, sustainable, efficient	Efficient, livable, equitable, sustainable
	BIS	Hard infrastructure, digital technology, social capital, citizen engagement	Livable, resilient, better response to challenges
	BSI	Physical, digital, human systems	Sustainable, prosperous, inclusive future

Source: Author's own compilation from various sources

9.2.2 Preliminary Definitional Analysis

Technology-stressed definitions are mostly given by those companies that are in ICT business. Smart city council is a US-based organization that has led partners such as Microsoft, CISCO, Qualcomm, etc., which are dominating companies in IT sectors. Accenture definition is very generic which does not give a clear idea about the character they expect from smart cities. It fails to articulate the nature of innovative collaborations – whether collaborations are IT related, hard infrastructure, economics, or finance related. Broader definitions are given by Natural Resource Defense Council (NRDC) which is a nonprofit organization based in New York. Business, innovation, and skills (BIS), British Standards Institute (BSI), and Wiki are not engaged in any IT-related business and their definitions are also broader.

9.2.3 Government of India Definition

Government of India's concept on smart cities does not have a definition in words but has components that will form definition. The major difference in GOI's concept vis-à-vis the ones listed in the above table is the inclusion of employment as a critical outcome of smart cities. The concept note says that a large number of people migrate to urban areas in search of jobs, and smart city should cater this demand. Each smart city should have a unique competitive edge of providing employment and economic activities. What is required to achieve the competitive advantage is a clearly defined policy agenda that can be implemented to create and strengthen institutional, social, physical, and economical infrastructure.

9.3 Mapping the Indian Smart City in Global Frame

In the concept note on smart cities, the Government of India has declared the criteria of smart city selection, and what is expected to follow is the announcement of the final list of 100 smart cities. Gujarat infrastructure finance technology city (GIFT) is a city under construction in Gandhinagar. GIFT is a potential city being developed as smart city by the Government of Gujarat and private player IL&FS.

Since the concept of smart city is quite new to India, it is of critical importance for policymakers and stakeholders to understand the potential positioning of Indian smart cities with respect to the global landscape of smart cities. This first requires a deep understanding of technology and development frontier of smart city against which Indian cities can be assessed. Similar exercise has been carried out in the European Union to map smart cities in the EU context. We borrow the methodological framework from the EU study and modify it to appropriate Indian context and specificities.

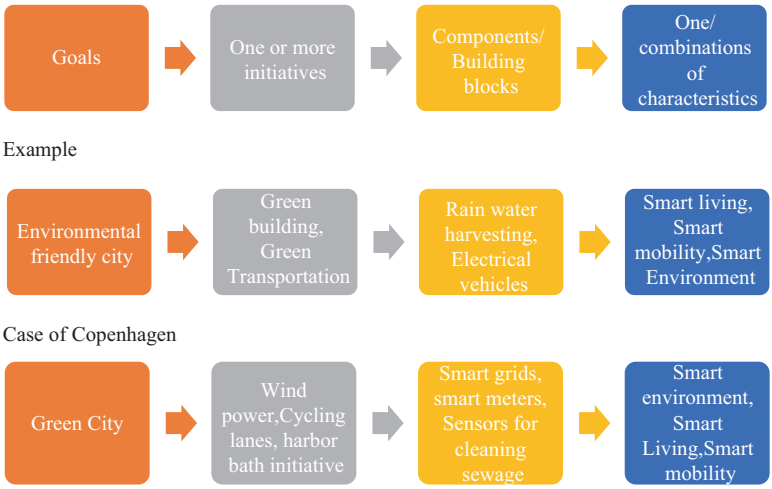

Image 9.1 Relation between initiatives, components, and characteristics (Source: Author's own compilation)

9.3.1 Methodology to Mark Smart Cites

9.3.1.1 Understanding Smart Cities in European Context

European Union describes a smart city that shows at least one of the characteristics of smartness, namely, smart governance, smart Europe, smart mobility, smart environment, smart people, and smart living. The city showing more number of characteristics is smarter than the city showing fewer characteristics.

9.3.1.2 Relation Between Initiatives, Components, and Characteristics (Image 9.1)

The city decides to attain certain goals or missions. For achieving the goals, the city takes certain targeted initiatives. The initiative is divided into smaller tasks, processes, or activities which are components of that initiative. In other words components are building blocks. Characteristics can be identified from these components or directly from the initiative.

Example: Amsterdam (Table 9.3)

Thus, Amsterdam took six initiatives with average 3.33 characteristics per initiative (POLICIES 2014).

Table 9.3 Amsterdam initiatives and characteristics

Initiatives	Characteristics	Initiatives	Characteristics
SC platform	LIV, MOB, ENV, GOV, PEO, ECO	Common 4U	GOV, ECO, MOB, LIV
Citadel	GOV, ECO	Digital cities	GOV, LIV, PEO
NICE	ENV, PEO	Open cities	PEO, LIV,ECO

ECO economy, *ENV* environment, *GOV* governance, *PEO* people, *MOB* mobility, *LIV* living
Source: POLICIES (2014)

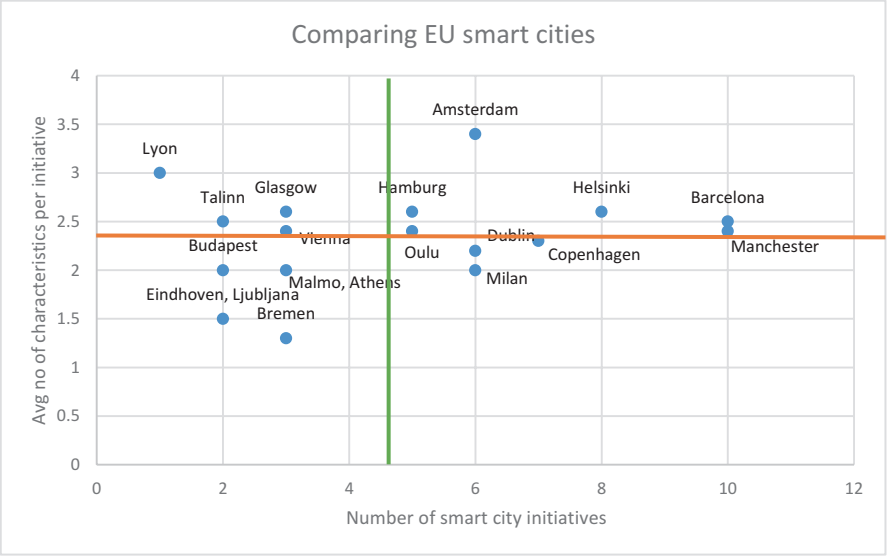

Image 9.2 Comparing European smart cities (Source: (POLICIES 2014))

Table 9.4 Grouping the European cities

Group	No. of initiative	Variety of characteristics	Cities
1	High	Great	Amsterdam, Helsinki, Barcelona, Hamburg, Oulu
2	High	Few	Copenhagen, Manchester, Dublin, Milan
3	Low	Great	Glasgow, Vienna, Tallinn, Tirgu Mures, Lyon
4	Low	Few	Malmo, Athens, Budapest, Eindhoven, Ljubljana, Bremen

Source: POLICIES (2014)

9.3.2 Mapping the Cities (Image 9.2, Table 9.4)

The cities are classified in basically four classes: a high number of initiatives with great variety of characteristics, a high number of initiatives with few varieties of characteristics, a low number of initiatives with great variety of characteristics, and a low number of characteristics with few varieties of characteristics.

It was important to understand the logic behind cities taking a number of initiatives and characteristics in each initiative.

The logic is explained by Image 9.3.

Explanation of the below figure:

High initiative: Since "city of zero pollution" is a broad goal, it needs to take initiative related to green transportation, initiative for governance to monitor industrial pollution, initiative related to waste management, etc., resulting in a large number of initiatives.

Low initiative: A city wants to be a "cycle city." It takes a very much focused initiative to make a "cycle city" like free GPS-based cycle at major location. This goal would not require initiatives related to energy, water, heating, etc. It may also be observed when available resources in the city are less, resulting in taking initiatives in few sectors only (phase wise).

Great characteristics: An initiative is "transport integration." It can be achieved by having intelligent transport system (smart transport), transport apps (smart governance, smart people), etc.

Few characteristics: An initiative is simple, for example, "wind power" which Songdo smart city took covered only smart environment as its characteristics since it will have nothing to do with smart mobility- or smart people-like characteristics.

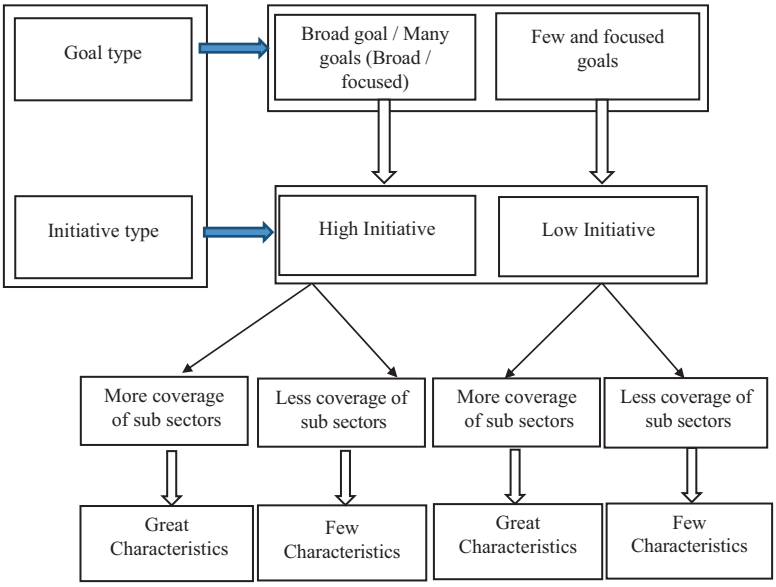

Image 9.3 Logic for initiatives and characteristics (Source: Author's own compilation)

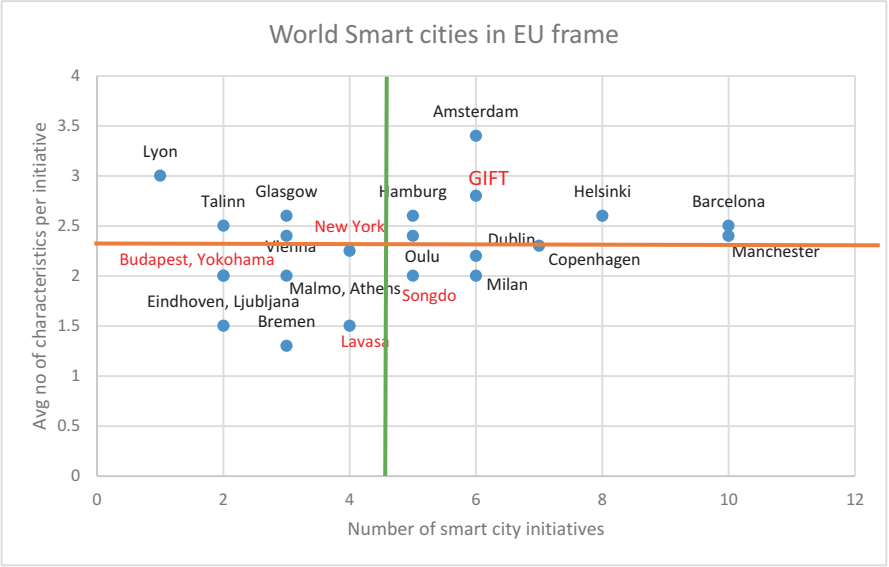

Image 9.4 Mapping smart cities of the world in EU (Source: Author's own compilation)

9.3.3 Inference After Plotting World Smart Cities

The city takes initiative based on its availability of resources, the goal that they seek, the size of city, and many other factors. The cities in the same country do not necessarily have the same initiative and characteristic pattern, e.g., India (Lavasa and GIFT) and Europe (Amsterdam, Budapest, Glasgow, etc.). The number of initiatives and characteristics is highly case sensitive and hence can't be fitted in definite frame. India's plan to develop 100 smart cities should also be a city-centric approach where the initiatives and characteristics depend on the city of subject.

9.4 Smart City Finance

9.4.1 Introduction to Government Plan for Smart City

The government plans to make 100 smart cities in the country. The ambitious project of smart cities requires a large amount of investment which demands huge financing. Such financing is not going to come easily and cheaply to us especially in the light of weaker credit markets. To achieve this gap of funds, it requires a study for understanding different models of finance considering the existing financial condition of the nation.

9.4.1.1 Existing Budgetary Plans for Smart Cities

Per capita the cost for developing 100 smart cities comes out to be INR 43,383 per year for the next 20 years which will include water supply, sanitation, transport, and other infrastructures. If an average figure of 1 million is considered, the fund requirement for the next 20 years will be of INR 35,000 crore per year. So, the total cost for the next 20 years will be INR 7 lakh crore. The majority of contribution from GOI would be in the form of viability gap funding (VGF) (GOI 2014). Initially an investment of INR 5000 crore will be required for preparing a framework for city engagement, city development plan based on GIS mapping, master plan, etc.

9.4.1.2 How Is Smart City Finance Different from Normal City Finance?

Traditional financing is financing of the physical infrastructure of a city or urban renewable projects in which either the cash flow from assets are expected to be used for meeting credit obligation on off-balance sheet basis or existing asset of firms are used as collateral by banks for financing the projects. Smart city finance is different than traditional city financing due to the addition of technology perspective to it. The technologies planned for smart cities are new and still being developed. The use of technology like cloud technology, internet of things, green technology, etc. requires a different type of financial model. These technologies will not be financed by banks as in the case of standard physical infrastructure, and hence innovative modes of finance and business models are required for this purpose. Also smart city is made of innovative start-ups which need to be financed separately. The mode of financing such new idea which cannot be financed by traditional model has also to be new which will be discussed further.

9.4.2 Potential Sources of Financing Smart Cities

Smart city financing can be broadly arranged from debt markets, multilateral financial institutions, and equity markets.

9.4.3 Debt Market

Debt refers to fixed obligation a project or firm owes to a variety of credit providers. It can be raised in the following markets.

9.4.3.1 Banks

Banks have served to be the most promising tool for financing infrastructure projects traditionally, but now it faces severe issues to finance long-term infrastructure projects. To date, the debt financing has been significantly contributed by banks which with significant infrastructure assets already on books are approaching fast toward their debt limit. The total gross nonperforming assets (NPA) of all banks may rise to 4.1 % in Q1, FY 2015 as per ICRA report (ICRA 2013–2014) which is a serious concern for economy, and it is increasing due to bad loans (e.g., Kingfisher, which was declared as a defaulter, had outstanding loan of 3000 crore). The infrastructure sector is a major reason for NPA increase. The sector NPA was 4.66 % in March 09 which raised to 17.43 % in March 13 of the total advances of banks' NPA (Dr. K.C. Chakrabarty, 2013). So, banks are already heavily burdened due to infrastructure projects. Also, banks face a problem of asset-liability mismatch since banks borrow money from retail customers that look for a short tenor of 2–3 years and banks lend money to long-term infrastructure projects which have a period of mostly greater than 10 years causing asset-liability mismatch.

9.4.3.2 Pension Funds, Insurance Funds, and Infrastructure Debt Funds

Market now looks to life insurance companies and pension funds which are well capitalized and looking for long-term returns. As per ASSOCHAM, pension fund market in India is about 20 lakh crore with annual CAGR of 10 % which has a potential to be channelized in long-term infrastructure projects (ASSOCHAM 2012). Similar case is for insurance funds where the government is training to raise funds by allowing 49 % FDI in insurance against formerly 26 % which would result in large inflow of money from FII. Infrastructure debt funds also remain a prominent tool to solve the asset-liability mismatch issue of bank financing of infrastructure. Infrastructure debt fund (IDF) has got a good response with leading infrastructure companies and banks entering the business. The government has also given tax exemption to these funds for attracting the investors. For example, Larsen and Toubro infrastructure debt fund is an infrastructure fund in which LIC is a partner leading to raise funds for financing infrastructure project. It also refinances the infrastructure projects setting bank money free so that those money can be pumped back in new infrastructure projects.

9.4.3.3 Bond Market

Bond market offers fixed income opportunities to investors which have potential to prove efficiency in India. The USA and Canada have raised significant capital through bond market which was used for various urban infrastructure projects. These bonds get matured when a certain fix goal which was fixed is achieved by the money raised by bonds. The interest rates for these bonds are higher than the

interest rates by banks. Municipal bond market has also remained underdeveloped in India except few successful cases like Ahmedabad municipal bond which was a first bond by a municipal government which raised 1000 million to implement water- and sewer-related projects in 1998 (IL&FS 2005). The interest rates given were 14 % semiannually, whereas bank interest rate at that time was 13–14 % only[1], resulting in a large number of bond buyers and easy fund-raising. Innovative bonds are there for innovative concepts like smart city and "climate action bond" type of bonds which were issued by the European[1] investment bond to raise funds for projects related to renewable energy and others that concern the climate change. This bond was based on green projects, raising funds for green projects which are usually financial not viable.

9.4.4 Multilateral Financial Institutions

The Government of India also accesses financial assistance in the form of loans/credits/grants from various multilateral agencies. The World Bank and the Asian Development Bank (ADB) are the leading multilateral institutions for availing external assistance by India. The World Bank's new strategy proposes a lending program of $3 billion to $5 billion each year over the next 5 years, with 60 % of this funding going to government-backed projects (Ministry 2015).

9.4.5 Equity Investment

9.4.5.1 Venture Capital

Smart cities are conceptualized as a platform for innovative ideas and start-ups, and venture capital can serve as an important tool for start-ups in smart cities. Smart cities have tremendous opportunities for technology, and digital infrastructure presents a high-risk, high-return opportunity for global venture capital into innovative companies. Multinational corporations along with traditional ventured capital firms are aggressively increasing their investments to drive the smart city industry in the world, e.g., TATA investment in new start-ups like "snap deal" and "blue stone." Venture capital can be "corporate venture capital" or government small-medium enterprise support. In 2015, the budget finance minister declared 1000 crore for start-ups which are high-risk investments (Budget 2015).

[1] https://www.sbi.co.in/portal/web/interest-rates/benchmark-prime-lending-rate-historical-data

9.4.5.2 Alternate Smart City Vehicles

There are various options for investment by overseas investors into India including FDI, foreign venture capital investment, or foreign portfolio investment (FPI). Depending on smart city vehicle nature (i.e., infrastructure, real estate, technology, etc.), investment can be made through different routes like FDI, FPI, etc. "Make in India" allows 100 % FDI inflow in different sectors like renewable energy, construction, etc. which are principal sectors of smart cities.

9.4.5.3 Real Estate Investment Trust

Smart city development requires a significant real estate investment, which is globally structured and regulated differently than infrastructure. Currently, 100 % FDI is allowed in Greenfield property projects. GOI and SEBI have approved rules for the creation of real estate investment trusts (REITs) for fund-raising understanding the appetite of retail investors who want to invest in real estate projects but can't do due to the high cost of investments. REITs will provide a new source of funding for developers as well as dividends for investors and also satisfy the financial requirement of the real estate projects. To encourage REIT development, the government has provided tax pass through status so that large investment can flow in through REIT route.

9.4.6 Financial Models and Tools for Smart Cities

The financing sources of smart cities described above will be accessed to arrange finance in multiple ways. Project financial structuring includes the ways in which funds will be deployed and will depend on models used and tools to support these models. The following are the potential financial structuring approaches for smart cities.

9.4.6.1 Debt Equity-Based Leveraged Structure

Debt and equity form the capital structure in project financing. Leverage of project is driven by the proportion of debt and equity in capital structure. This structure is the most significant model of project financing. Typically, the debt part comes from banks. Equity is an ownership right that can be claimed by the private player, public, or combination of promoters. Equity consists of shareholder agreement between different shareholders. Debt-to-equity ratio depends on the type of project and risks involved in the project. A higher-risk project will have lower debt-to-equity ratio and vice versa. Such leveraged structure may not be the most efficient vehicle for smart city financing as the ability to correctly forecast and model cash flows in such cases is highly constrained on the account of the lack of experiential data and case studies.

9.4.6.2 PPP

Smart city following PPP structure in infrastructure benefits because of the formal alignment of government and industry capacities, technology, assets, and capital. PPP which is also known by the name of project finance initiative has witnessed a mixed rate of success in the past. Recent economic survey of the Government of India (Subhramanyam 2015) said that PPP models have to be restructured as a lot of them are struck. The failure of a PPP is often due to the lack of realistic objective, financial management, project governance, and equity in the risk management level of risk equitably shared between the parties, e.g., the Delhi Metro Airport Line where interests of private player and the government were not aligned and led to failure to achieve the deadline of project (i.e., commonwealth games) and eventually resulting in the suspension of services for 6 months. The nature of the concession agreement between the government and developer is another key area to PPP success. Proper framing of concession agreement based on the risk of project, type of project, etc. can prove to improve PPP success ratio. Forming a proper PPP model which satisfies the interest of private party and the government can be a key to raise large funds.

9.4.6.3 Tax Tool

Favorable tax treatment for global companies is an important tool and has the potential to be an extremely effective policy tool for encouraging urban development beneficial to all citizens. For example, the policy support for clean energy can make clean energy projects more viable for private players to invest. Moreover, tax increment financing (TIF) is a funding instrument that may be used to develop smart cities. Funds raised from taxes are used to develop infrastructure, clean energy projects, and revive properties back to productive use. Proper collection of tax can help municipalities to raise good amount of fund which they can pump back in the system for operation and maintenance.

9.4.6.4 Innovative Business Model

Traditionally public sector has worked with business on city projects with conventional methods. This approach could prove to be insufficient for smart city projects. Innovative businesses are tools to help the financial model success. The innovative models include “cloud city services,” “crowd financing,” “payment enabler,” etc.

9.4.7 World Smart City Financial Model Cases

As mentioned previously, the lack of studies on smart cities in India, partly due to being a new concept, compels us to identify and review sources and models of financing smart cities in global setting. Table 9.5 shows the application of different tools, models, and sources of finance used worldwide.

Table 9.5 Cases of worldwide use of different sources

Tools/model/source	Case	Description
Debt		
Banks	Smart development: Belgium	The European Investment Bank (EIB) and Belgium Bank raised € 400 million for the project
Bond	World Bank: green bond. Rio de Janeiro's urban rail transport	The World Bank Group has raised $6.7 billion in green bonds which enjoys AAA rating. These would be used for low-carbon projects. Smart city projects satisfying low-carbon criteria get this funds (Worldbank 2009)
Infrastructure debt fund	L&T IDF financed PPP project of NH7 Nagpur-Hyderabad	L&T IDF is a fund raised by L&T and LIC to finance the infrastructure projects that require funds to get viable and give banks to release fresh funds for projects
PPP	Rio de Janeiro: Brazil. PPP for developing city for Olympics	35 % of investment was by private party. IBM was a partner for center of operation. Also, Olympic Park was built by private money
Equity		
Real estate	Dublin raised € 300 million through REIT	First green REIT raised € 300 million and second REIT raised € 365 million from investors which were used for real estate in Dublin smart city
Venture capital	Siemens sponsored Sunverge	Sunverge is a California-based company started in 2009 with vision of integrated solar storage with smart controls. Sunverge investors include Southern Cross Venture Partners and Siemens Venture Capital (Siemens 2009)
FDI	Amsterdam smart city	According to the research of PWC, Amsterdam achieves significantly in attracting FDI. It attracted about 95 projects of investment through FDI by providing proper policy frame
Tax	Seattle, Washington	Tax breaks are given to business in green technology and also to the residents who keep their property green

(continued)

Table 9.5 (continued)

Tools/model/source	Case	Description
Innovative models		
Cloud-based services	CISCO cloud service Chicago	CISCO and a wide range of stakeholders public and private in the city of Chicago are advancing a series of Smart + Connected Community initiatives
Payment enabler	MasterCard Long Island cashless service	Long Island urban mobility is a cashless service provided by MasterCard where the entire ticket payment of modes of transport was done by e-ticketing by MasterCard
Crowd financing	Denver city: the USA	Denver raised $12 million in just one hour it needed. It was oversubscribed and the authority had to give back 375 orders. Unlike mini-bonds, which often sell for $20,000 or more each, Denver's mini-bonds were just $500, and investors couldn't buy more than $20,000

Source: Author's compiled from various sources

9.4.8 Strength and Weakness of Each Source

The strength and weakness of every source need to be understood to understand its suitability under different risk conditions and thereafter the type of infrastructure it suits. Table 9.6 shows strength and weakness of each source.

9.4.9 Financial Analysis Summary

As discussed earlier, the source of finance depends on the risk nature of the particular infrastructure. After understanding the strength and weakness of each source, it was possible to broadly list the type of source based on the infrastructure type. This finding can serve as an initial push to the policy of smart cities. Based on the type of the city and type of risk in the infrastructure, the findings can help to identify the best source of finance. Table 9.7 shows major infrastructure of the city and their best suitable mode of finance based on the financial study done.

Table 9.6 Strength and weakness of sources

Type of finance	Strength	Weakness
Debt		
Banks	Healthy completion among banks	Debt given is governed by interest rates causing uncertainties, high NPA, asset-liability mismatch
	Good liquidity	
Bond	Definite yield, easy fund-raising	Rating sensitive, not easily tradable in the secondary market
	International fund-raising	
	Guarantee by IIFCL and RBI derivative CDS	
Infrastructure debt fund, pension and insurance funds	Long-term funds hence suit infrastructure projects, huge cash piles, interest in diversification, feeder funds, refinancing	Highly governed by policy causing uncertainty. IDF-NBFC decides the projects to invest
Equity		
REITS and InvIT	Satisfies hunger of real estate investment, direct public participation in infrastructure projects; success rate is high globally	Depends on project mix of particular funds, still in draft stage; system needs to be updated
Venture capital	Finances high-risk projects	Mostly suits for small investments only, owner and VC conflict of interest
	Start-ups	
	Innovative projects	
FII, FDI	Enabling provision by rupee bonds	Swings in the market, potential threat for national importance sectors, policy sensitive
Multilateral finance/ bilateral finance	Gives grants, helps in capacity building	Western dominance

Source: Author's compiled from various sources

Table 9.7 Financial modes and best sources to finance

Particulars	Finance modes	Case
Real estate	REIT	Dublin raised € 300 million through REIT
	FII	Amsterdam attracted about 95 projects of investment through FDI by providing proper policy frame
Physical amenities (SWM, water supply, sanitation)	Bonds	Ahmedabad municipal bond raised 1000 crore for water supply and sewer projects
	Infrastructure investment trust	NA
Smart	Multilateral financial institution, PPP	OECF Japan gave 56 % of the total fund requirement in Delhi Metro
Mass rapid transit systems		L&T Hyderabad metro project
Start-ups/new ideas (e.g., ICT business)	Ventured capital, crowd financing	Siemens sponsored Sunverge
		Denver city: the USA raised $12 million in just one hour it needed

(continued)

Table 9.7 (continued)

Particulars	Finance modes	Case
Roads, electricity, public spaces	Bonds, IDF, InvIT, PPP	L&T infrastructure debt fund financed PPP project of NH7 Nagpur-Hyderabad. L&T IDF has LIC as lead promoter
Education, health care, and Hospitality	PPP, PE, banks	The UK has 130 PPP projects in health care (e.g., St. Bartholomew and London Royal). 5 star Shilparamam hotel, Hyderabad. Model schools PPP
Smart grids	Multilaterals	World Bank finance smart grid Vietnam
	PPP	FINSENY project EU
Cloud-based computing	ICT companies	CISCO cloud service Chicago
Payment enabling	Payment enabler company	MasterCard Long Island cashless service

Source: Author's compiled from various sources

9.5 Summary and Conclusion of the Research

Smart cities are widely considered to be the new form of cities that allow for sustainable investment and consumption. Such cities are viewed as a new engine of growth, characterized by resource efficiency, economic effectiveness, environmental improvements, and other value-enhancing aspects. A close and careful look at the timeline-based evolution of smart cities worldwide points out that the need for such smart growth engines has arisen on the account of different antecedents and reasons in different countries and circumstances. This variance appears to exist because of the possible versatility of attributes that define and make up smart cities. Extant research studies acknowledge this and fail to provide a homogeneously unifying definition of smart city. The conceptualization and definition of smart city is structured around different names, different circumstances, and different policy outcomes in different countries.

Definition is the building block of city planning as it lays out a broad contour of development of smart cities. Arriving at a definition that works well in a specific context, therefore, is indispensable to further the development of smart cities. India is yet to articulate a clear definition of smart cities, although a concept note on developing 100 smart cities is already in place. Using the concept note to understand dimensions of smart cities in India in relation to an exhaustive definition of smart cities worldwide shows that India's definition of smart cities is more holistic and inclusive rather than focusing overbearingly on technology alone. Overall concept note by the Government of India talks in broader sense rather than having a technology-stressed approach.

Furthermore, the comparative analysis of the concept note with other smart cities worldwide, in the context of India's socioeconomic landscape and political economy, suggests that focus should be directed toward adopting a city-centric approach to developing smart cities instead of a centralized national approach. A city-centric approach offers flexibility of setting in the plan around local socioeconomic-

behavioral contextual specificities which simply cannot be completely captured by a single national approach. Authority and power should be bestowed upon states to come up with their own smart plans, and then center should select from those cities based on some completion parameters.

This recommendation, however, poses governance challenge which needs to be recognized and accounted for at the time of prescribing such policies. India is a federal democracy where the power of constitution and legislation is divided between states and center. Also the administration of different sectors like transport, power, urban development, etc., is governed by different ministries and departments of government. Many infrastructure projects have been halted due to regulatory and permission delays by other departments. For example, railway overbridge construction projects get delayed due to the dispute between railway and road department. Purely from governance viewpoint, a series of reform need to be initiated to push policy impetus on improving interdepartmental and intergovernmental cohesiveness and collaborative operating efficiencies. This is a precondition for developing smart cities in India.

Developing 100 smart cities in India necessitates copious financial requirements. Given our recommendation of a city-centric approach, it is not too difficult to see that the capacity of states and cities will be quite constrained when it comes to raise finances for smart city development. Therefore, innovative economic and financial structuring needs to be employed to augment the smart developmental process. Various sources of finance have been identified and compared in order to understand their characteristics, more specifically their strengths and weaknesses in the context of assets need to be funded. A broad analysis is conducted to understand what works best for what kind of infrastructure in smart city parlance. The finding can serve as stepping stone to understanding what type of initial policy push is required to facilitate financing of smart cities. It can help policymakers to identify the potential financing sources based on the type of the city and type of risk in its infrastructure.

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Chapter 10
Evaluating the Effect of Building Envelope on Thermal Performance of Houses in Lower Himachal Pradesh

Amitava Sarkar and Shivashish Bose

Abstract Buildings are the major component of built environment. Creating comfortable indoor living environment for users is the primary objective of building design. The building envelope plays a crucial role of both protecting its occupants from external environment and controlling the indoor environment. Hence, selection of building envelope materials is critical in maintaining indoor thermal comfort condition and its energy performance. The main aim of present-day building design should be eliminating the need for mechanical heating and cooling equipment. The climate in Himachal Pradesh, India, varies with increasing altitude from "subtropical" to "cold-desert" climatic condition. The study area, Hamirpur town of Himachal Pradesh, has "subtropical" climate with hot summers and cold winters. Field studies of naturally ventilated residential buildings with different building envelope materials found in Hamirpur were conducted in winter months of 2013 and 2014 to evaluate their impact on indoor thermal condition. The optimum indoor comfort temperature in winter months for naturally ventilated residential buildings in Hamirpur (HP) is found as 16.5 °C, with thermal comfort temperature range 15.7–16.9 °C. Based on this study, suitable building envelope materials for houses are recommended to maintain indoor thermal comfort and energy efficiency for holistic sustainability of built environment.

Keywords Residential building • Himachal Pradesh • Building envelope • Thermal mass effect • Thermal comfort • Building thermal performance

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10.1 Introduction

The built environment is mostly consisted of different types of buildings such as residential, commercial, official, industrial, etc. All the buildings consume considerable energy both during its construction and its operation; hence, they are a great source of CO_2 emissions to the atmosphere. In India, the building sector causes about 33 % of electricity consumption with commercial and residential sector accounting for 8 % and 25 %, respectively (BEE 2009). The improvements in living standards and growth in population will cause increased energy consumption in the building sector (BEE, 2008).

The building envelope – also called building enclosure, shell or fabric – is the boundary or physical separator between the unconditioned or conditioned interior of a building and the outdoor environment. The building envelope, consisting of external walls, roofs, ceilings, floors, windows, and doors, regulates the flow of energy between the exterior and interior of the building and plays a crucial role of both protecting building occupants from external environment by providing them comfort and by enhancing their productivity. Ventilation and daylight requirement of the building must be considered while designing the building envelope to provide thermal and moisture protection suitable to the climatic conditions of the location. Hence, building envelope components act as weather, thermal, air, and noise barrier by providing reflective, capacitive, and resistive insulation.

Local climate and function of the building are the two foremost important parameters affecting building envelope design. The thermal loads of residential buildings are primarily external (from the sun). The efficiency of building envelope design is significantly affected by the building configuration and by its footprint as well. India is divided into five climatic zones as per the National Building Code of India (BIS 2005), namely, hot-dry, warm-humid, temperate, composite, and cold climates, all of which suggest different design strategies. Acknowledging this, the Bureau of Indian Standards (BIS) has published a series of codes (BIS 1986, 1987), based on the studies done at the Central Building Research Institute (CBRI) in Roorkee, addressing thermal performance and energy efficiency issues of buildings and recommended design guidelines for different climatic regions in India. Further, to mitigate the implication of growth in building sector on energy resources of India, the Government of India has introduced the Energy Conservation Building Code (ECBC) in 2007 and made further addition in the code in 2008 to provide minimum requirements for energy-efficient design and construction of buildings and their systems (BEE 2007).

The principal aim of building design and construction at present should be a judicious selection of building envelope materials to eliminate the need for mechanical heating or cooling. This paper will present the study about the effect of various building envelope materials, used in walls and roofs of naturally ventilated residential buildings in Hamirpur, Himachal Pradesh (HP) with “subtropical” climate during winters, on thermal performances of buildings through field survey. The result of the analysis will be useful to suggest appropriate building envelope for residential buildings in Hamirpur (HP) to develop and maintain sustainable built environment.

10.2 Literature Review About Building Envelope Performance

The materials and construction techniques used in building envelope widely differ between developed countries like Europe and the USA and developing countries like India, China, etc.

As per the report published by the International Energy Agency (IEA 2013), the following building envelope technologies are being used in the developed countries with hot climate:

(i) Architectural shading.
(ii) Very low-solar heat gain coefficient (SHGC) windows or dynamic shades/windows.
(iii) Reflective walls and roofs.
(iv) Advanced roofs featuring building-integrated photovoltaic (BIPV).
(v) Optimized natural and mechanical ventilation.
(vi) Existing buildings are also retrofitted with appropriate high-performance building envelope materials.

The developed countries with cold climate have adopted the following building envelope technologies:

(i) Highly insulated windows
(ii) Passive heating gain through architectural features/dynamic glass/shades
(iii) Insulated shades and other insulating attachments like low-e films
(iv) Exterior insulating wall systems
(v) Interior high-performance insulation

Whereas, in developing countries, like India, the following building envelope technologies are in practice:

For hot climate:

(i) Exterior shading and architectural features
(ii) Low-SHGC windows
(iii) Reflective roofs and wall coatings
(iv) Optimized natural and mechanical ventilation
(v) Natural ventilation
(vi) Low-cost window films

For cold climate:

(i) Insulated windows, possibly double-glazed with low-e storm panel
(ii) Passive heating gain through architectural features
(iii) Optimized low-cost insulation and air sealing
(iv) Cavity insulation, with lower-cost, e.g., expanded polystyrene, interior insulation

A number of systematic studies have been done based on laboratory experiments, to examine discomfort caused from heated ceiling panels, which are being used for room heating in cold climates (Munro and Chrenko 1949; Chrenko 1953; Koenigsberger and Lynn 1965; McNall and Biddison 1970; Griffiths and McIntyre 1974; and Fanger et al. 1980). ASHRAE Standard 55 (ASHRAE 2004) recommends ceiling temperature should not be allowed to be more than 5 °C warmer, but wall surface temperature may be up to 23 °C warmer than the other surfaces. Discomfort may also be caused by the floorings that are too cool or too warm. Hence, ASHRAE Standard 55 also recommends that floor surface temperatures stay in the range of 19–29 °C in room spaces where occupants will be wearing lightweight shoes.

Chandra (1980) defined thermal performance index (TPI) of wall and roof sections, developed from peak heat gain and inside surface temperature for conditioned and unconditioned buildings, respectively, based on the study conducted in hot-dry climate of India. The TPI values for typical wall and roof sections, calculated by Chandra (1980), are included in the Bureau of Indian Standards code SP: 41 (S&T), 1987 (BIS 1987). Suman and Saxena (1992) calculated the effect of roof treatment on thermal performance of buildings under hot conditions based on the unsteady-state harmonic method. Kabre (2010) proposed a thermal performance index for dwelling roofs in warm-humid climate based on the study done at Trivandrum and Pondicherry in India.

10.2.1 Bureau of Indian Standards (BIS): Thermal Performance Index (TPI)

The BIS has published two relevant documents, the *Handbook on functional requirements of industrial buildings (lighting and ventilation)* (BIS 1986) and the *Handbook of functional requirements of buildings (other than industrial building)* (BIS 1987). Thermal performance of a building is an outcome of the process, whereby the design, layout, orientation, and construction materials of the building modify the prevailing outdoor climate to create the indoor climate. This is generally perceived by the occupants in a building in terms of the sense of warmth in cold winters and sense of coolness in hot summers, considering the amount of heating and cooling required maintaining comfortable indoor thermal conditions. Thermal performance can be expressed in quantitative or numerical terms in many ways.

The U-value or air-to-air thermal transmittance is the most widely used property for building envelope components like walls and roofs. But, this commonly used steady-state property (U-value) alone cannot provide a satisfactory basis to assess thermal performance in tropical climates. Hence, the BIS has prescribed air-to-air thermal transmittance (U-value), thermal performance index (TPI), thermal time constant (T), and thermal damping (D) for roof and exposed walls in different climatic zones of India (BIS 1987), for nonindustrial buildings, like houses, hospitals, schools, and office buildings, wherein no mechanical cooling or heating aids, such

Table 10.1 Thermal performance standard for roofs and walls

Building components	Hot-dry and hot-humid zone				Warm-humid zone			
	U max	TPI max	T min	D min	U max	TPI max	T min	D min
	W/m^2K		h	%	W/m^2K		h	%
Roof	2.33	100	20	75	2.33	125	20	75
Exposed wall	2.56	125	16	60	2.91	175	16	60

Source: BIS (1987)
U = air-to-air thermal transmittance, TPI = thermal performance index, T = thermal time constant, D = thermal damping

as air-conditioning plants, are used (Table 10.1). The thermal performance index (TPI) of a non-air-conditioned building element is given by the equation

$$\mathrm{TPI} = \left\{\left(T_{is} - 30\right) \times 100\right\} / 8 \tag{10.1}$$

where T_{is} = peak inside surface temperature. It is expressed in percentage. A temperature of 8 °C has been considered over a base temperature of 30 °C. TPI depends upon the total heat gain through the building section both by steady and periodic part and is a function of outside surface temperature. Thermal time constant (T) is the ratio of heat stored to thermal transmittance (U-value) of the structure and is expressed in hours. Thermal damping (D) is calculated from the equation

$$D = \left\{\left(T_o - T_i\right) / T_o\right\} \times 100 \tag{10.2}$$

where T_o = outside temperature range and T_i = inside temperature range. It is expressed in percentage.

10.3 Methodology of the Study

The field study was conducted in Hamirpur town of Himachal Pradesh during winter months of December 2013 to February 2014 to find out the thermal performance of the building envelope materials commonly used for house construction. Thirty naturally ventilated houses were selected representing both present-day houses designed by architects and the traditional dwellings. The limited accessibility to the residences was a hindrance in the study. The thermal performance of building envelope materials used in the buildings of the study area during summers will be presented in future work.

During the field study in winter months, spot measurement of the surface temperatures of walls, floorings, and ceilings and the indoor environmental temperature was recorded between 7.00 am and 9.00 pm as per the class II protocols of ASHRAE Standard 55 (ASHRAE 2004). Indoor surface temperatures, air temperatures, relative humidity (RH), and air velocity were measured with calibrated digital instruments like infrared thermometer, thermo-hygrometer, and anemometer, respectively.

Rooms, with walls and roofs exposed to the winter sun, of the houses were selected for the measurement of thermal parameters. The outdoor climatic data is collected from the state meteorological department and other secondary sources.

Building dwellers can act as measuring meter of their surrounding environment. Hence, a thermal comfort survey was conducted with 100 persons, 57 were male and 43 were female aged between 18 and 50 years, residing in 50 naturally ventilated houses (including 30 houses mentioned earlier) to collect data about their subjective thermal comfort responses, measured on ASHRAE's 7-point thermal sensation (TS) scale with values *hot (3)*, *warm (2)*, *slightly warm (1)*, *neutral (0)*,*slightly cool (−1)*, *cool (−2)*, *and cold (−3)*, along with their thermal preferences (TP), measured on ASHRAE's 3-point scale with values *a bit cooler (1)*, *no change (0)*, *and a bit warmer (−1)*, and their acceptance of the thermal environment (TA), measured on ASHRAE's 2-point scale with values *acceptable (2) and unacceptable (1)* (ASHRAE 2004), during winter months. The data on clothing and activity of the residents of the buildings was recorded during the field survey. The total clothing insulation value (in "clo") and activity level (metabolic heat output in Watt/m^2) are calculated as per the ASHRAE Standard 55 (2004). The questionnaire for the thermal comfort field survey was prepared as per ASHRAE Standard 55–2004 *Informative Appendix E-Thermal Environment Survey* (ASHRAE 2004).

Firstly, the occupants of the residential buildings, who participated in the field study and the thermal comfort survey, were informed about conducting this survey to collect data for thermal comfort performance evaluation of their houses. They were also told that the result from this survey data will help in identifying good and bad thermal performance aspects of the buildings and will give important feedback about improving the indoor thermal environment of present-day buildings. The thermal comfort survey questionnaire includes questions covering the following aspects: (i) personal information about the participant like name, age, sex, height, weight, and years of stay; (ii) position of the residents with respect to the floor plan; (iii) residents' thermal sensation, thermal preference, and acceptance of the thermal environment; (iv) residents' feeling about natural air movement and humidity; (v) residents' activity in the last 15 min; (vi) residents' clothing; and (vii) residents' action during under-heating in winter months. The thermal comfort survey was conducted between 7.00 am and 9.00 pm with a minimum 2-hr interval between consecutive surveys. It took 15–20 min to conduct the comfort survey with a participant. Recording of indoor environmental data was carried out concurrently to validate the subjective questionnaire survey data during analysis.

The variation in indoor surface temperatures and other environmental temperatures measured in the houses with different building envelope materials is compared for analysis to develop the related recommendation.

10.3.1 Location and Climate

The study area is located in Hamirpur town (31.68° north latitude, 76.52° east longitude, and average altitude of 800 m above mean sea level), the headquarter of Hamirpur district in the Indian State of Himachal Pradesh (HP).

Table 10.2 Average climatic data for Hamirpur town (HP)

Months	Average monthly maxima[a] (°C)	Average monthly minima[a] (°C)	Average monthly mean[a] (°C)	Mean total rainfall[b] (mm)
January	18.9	6.7	12.8	43.1
February	21.0	8.5	14.8	57.1
March	26.0	12.8	19.4	50.9
April	34.6	18.8	26.7	34.8
May	38.8	23.3	31.1	36.7
June	39.6	26.2	32.9	157.1
July	34.9	26.1	30.5	295.4
August	32.9	24.8	28.9	373.3
September	33.4	23.4	28.4	139.2
October	32.0	17.7	24.9	12.8
November	26.4	11.6	19.0	4.4
December	20.7	7.4	14.1	19.9

Source: [a]http://www.yr.no/place/India/Himachal_Pradesh/Hamirpur/statistics.html
[b]http://www.agricoop.nic.in/…/HP/HP3-Hamirpur-31.12.2012.pdf

The climatic zones of Himachal Pradesh vary according to its elevation above mean sea level and related biogeography. Hamirpur town has "subtropical" climate as per "Köppen climate classification" (Kottek et al. 2006) with hot summers and cold winters and receives good amount of average annual rainfall. The daytime maximum temperature in May–June reaches up to 42 °C, while the minimum temperature in winter months falls even below 5 °C. The intensity of solar radiation received by Hamirpur (HP) ranges from 3.45kWh/m^2/day in January to 7.42kWh/m^2/day in May. Table 10.2 presents the average climatic data of Hamirpur town (HP).

10.4 Indoor Thermal Comfort Condition

Thermal comfort is defined as "that condition of mind which expresses satisfaction with the thermal environment" (ASHRAE 2004). Comfort may also be defined as the sensation of complete physical and mental well-being of a person within a built environment (Givoni 1967). The comfort zone is defined as the range of climatic conditions within which the majority of people would not feel thermal discomfort, either of heat or cold. The comfort conditions of individuals depend on various physiological and environmental conditions. Literature reviews of thermal comfort standards suggest that most people are comfortable in the temperature range between 18 °C and 30 °C with air velocity 0–2 m/s and relative humidity conditions between 30 % and 70 % mentioned as "comfort zone" on the psychrometric charts. Four environmental variables, namely, air temperature, relative humidity (RH), mean radiant temperature (MRT), and rate of airflow, and two physiological variables, namely, clothing and activity level (metabolic rate), identified by Macpherson

Table 10.3 Conditions for indoor thermal comfort in India

	For non-air-conditioned buildings as per TSI		
Seasons	Air temp (°C)	RH (%)	Air velocity (m/s)
Summer	25–30	50	Nil
Winter	18–22	50	Nil

Source: BIS (1987)

(1962), are used by Fanger (1972) to calculate the indoor thermal comfort condition for humans, based on heat-balance equation. Also age, gender, state of health, cultural conditioning, acclimatization, and expectations of different people affect the "comfort limit" by influencing their tolerances to the discomforts.

The field studies by Humphreys (1976), Auliciems (1981) Nicol and Roaf (1996), Baker and Standeven (1996), and de Dear and Brager (1998) have established the dynamic "adaptive thermal comfort model," which shows that wider range of comfort temperature is accepted by the residents of naturally ventilated buildings, mainly because of physiological (acclimatization), psychological (expectation of the season), and behavioral adaptation (activity, clothing, and use of environmental controls) by the inhabitants. Adaptive comfort model is most suitable for free-running naturally ventilated buildings where mechanical cooling and heating are not present and residents have total control on the operable windows. This model relates the indoor comfort temperature to outdoor mean air temperature through linear regression analysis.

Handbook of Functional Requirements of Buildings (other than industrial buildings) (BIS 1987) has recommended the conditions for indoor thermal comfort (Table 10.3). The recommendations for naturally ventilated buildings are based on the study of Tropical Summer Index (TSI) by Sharma and Ali (1986) done at the CBRI, Roorkee.

10.4.1 Results of Thermal Comfort Field Survey

In this study, the indoor comfort temperature for the naturally ventilated residential buildings at Hamirpur (HP) is calculated by linear regression analysis between subjective thermal sensation vote (TSV) with indoor air temperature (T_a), shown in Fig. 10.1. Air motion inside the houses is reduced to nil by keeping the windows and doors closed. The relationship found through regression analysis is:

$$\begin{aligned} &\mathrm{TSV} = 0.669 * T_a - 10.983; \\ &(R^2 = 0.8472, \text{correlation coefficient } R = 0.92) \end{aligned} \tag{10.3}$$

Figure 10.1 shows optimum indoor comfort temperature in winter months for naturally ventilated residential buildings in Hamirpur (HP) as 16.5 °C (corresponding to "0" vote on ASHRAE TS scale). The thermal comfort temperature range is

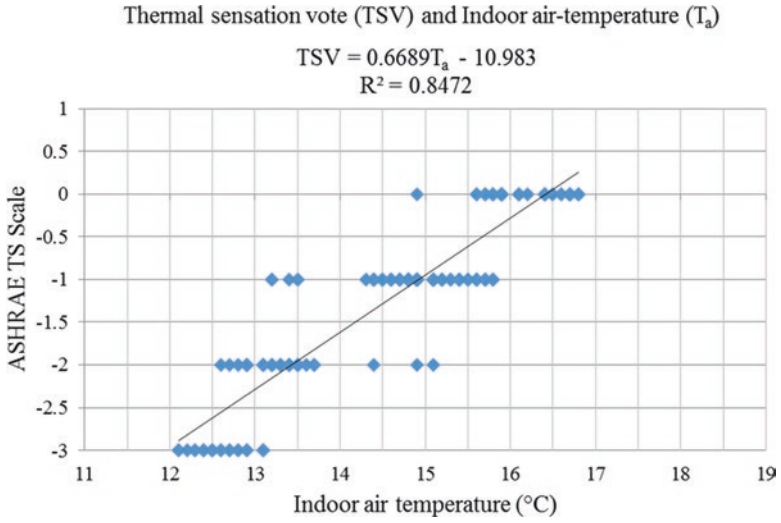

Fig. 10.1 Indoor thermal comfort temperatures for the naturally ventilated residential buildings at Hamirpur (HP) during winter months

found as 15.7–16.9 °C (corresponding to "±0.5" vote on ASHRAE TS scale), and minimum acceptable indoor temperature (corresponding to "−1.0" vote on ASHRAE TS scale) is found as 15 °C from the linear regression analysis. The regression Eq. (10.3) also shows that thermal sensation vote (TSV) changes with 0.7 °K change in indoor temperature.

The thermal comfort survey also revealed that about 65 % of residents of modern present-day houses have preferred higher indoor temperature than at present during winters. Further, 60 % of residents of modern houses, participated in the thermal-comfort survey, have expressed their acceptance of indoor thermal environment during winter months, while, 70 % of residents of traditional houses are found satisfied with the indoor thermal environment. The residents are found wearing heavy garments, inner thermals, cotton full-sleeve shirts, heavy trousers, sweaters, jackets, woolen socks, and shoes during the thermal comfort survey in winter months to keep themselves warm, especially during night with chilly condition; the total clothing insulation is calculated to be 1.10–1.40 clo as per the ASHRAE clothing insulation chart (ASHRAE 2004).

10.5 Building Envelope Details of Houses in Study Area

The houses surveyed in Hamirpur (HP) are of one-, two-, and three-storey high, with a floor height of 2.4 m in traditional houses and 3.1 m in present-day houses. Out of 30 houses that are surveyed, ten houses are of traditional construction. In those dwellings, walls are made of 45 cm thick adobe sun-dried bricks with mud

plaster on both sides, and pitched roofs are constructed of slate roofing on timber rafter with attic and ceiling made of timber planks. The flooring is made of cowdung finish, on layers of mud and dry leaves, supported by timber planks or bamboo splits on timber joists. The remaining houses represent present-day construction methods. The most common form of construction found in Hamirpur (HP) at present consists of 23 cm burnt brick external walls with cement plaster on both sides, 11.5–12.5 cm reinforced cement concrete (RCC) roof with waterproofing bitumen coats on top, and 10 cm RCC floor slab with tile/marble floorings.

Another common practice at present, surveyed in five houses, is the use of pre-painted CGI sheet for roofing on steel truss, with attic and ceiling of timber board on top floors. In two of these houses, walls are constructed of 20 cm thick cement concrete block. In three houses, roofing is done with layers of mud phuska and brick tiles on 11.5 cm RCC slab, whereas in another three houses, roofing is done with layers of cinder and brick tiles on 11.5 cm RCC slab. Two houses are surveyed with inside insulations on walls and below RCC roofs and with carpets on floorings. Figure 10.2 shows the views of the modern and traditional houses surveyed at Hamirpur (HP). Further, Figs. 10.3, 10.4, and 10.5 show the details of walls, flat roofs, and pitched roofs, respectively, found in the houses at Hamirpur (HP) during the field study.

Fig. 10.2 Views of the modern and traditional houses surveyed at Hamirpur (HP)

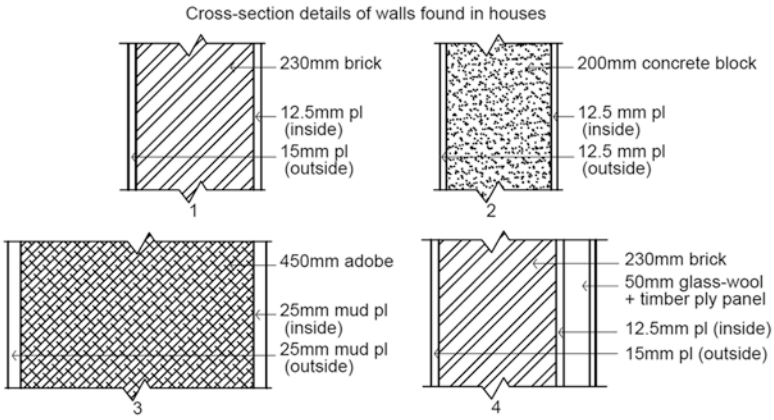

Fig. 10.3 Details of walls found in houses at Hamirpur (HP)

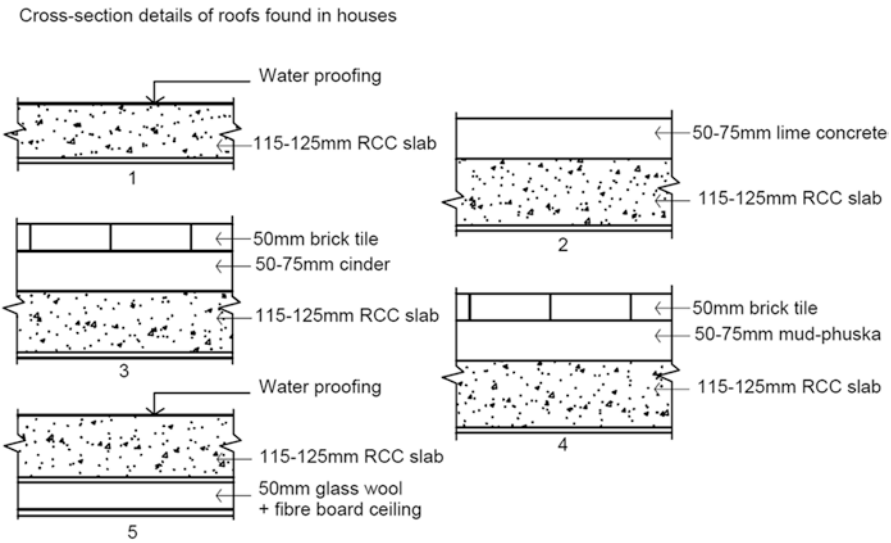

Fig. 10.4 Details of flat roofs found in houses at Hamirpur (HP)

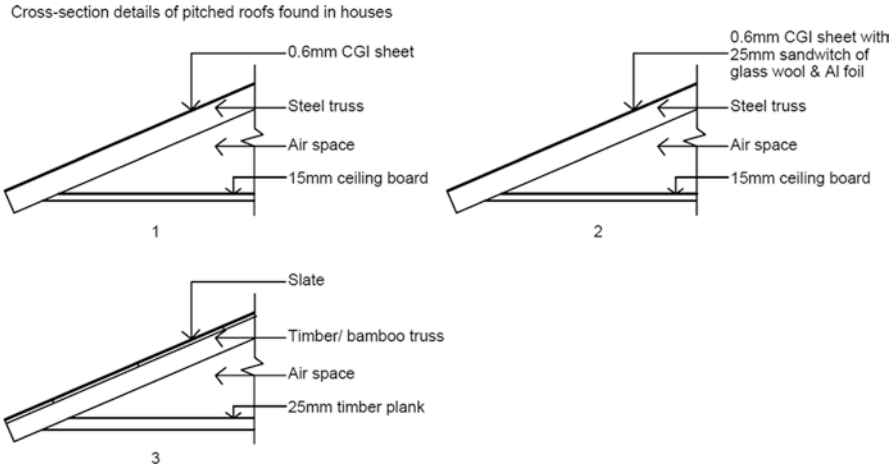

Fig. 10.5 Details of pitched roofs found in houses at Hamirpur (HP)

10.6 Results and Discussions

10.6.1 Thermal Performance of Building Envelope Materials

Sarkar (2013) has proposed design guidelines for buildings in Hamirpur (HP) based on bioclimatic analysis, which recommended use of heavy walls and roofs in buildings with more than 8 h time lag. Time lag is the time difference between the occurrences of temperature maximum at the outside and inside when subjected to periodic condition of heat flow. It is expressed in hours. The floors should be also of heavy construction for the climatic condition in Hamirpur (HP), where wall and roof materials with large thermal capacity are suitable to maintain indoor comfort condition by resisting the high diurnal and seasonal variation in external climatic conditions. Table 10.4 presents the thermal properties of the building envelope materials used for construction of traditional and present-day houses in Hamirpur (HP), in terms of their U-value, thermal damping, thermal performance index (TPI), and thermal time lag. For the selection of wall and roof construction in buildings of Hamirpur (HP), the following parameters should be followed: low U-value, high thermal damping percentage, TPI value less than 100, and thermal time lag of more than 8 h.

10.6.2 Surface Temperatures of Building Envelope Materials

To understand the thermal performance of building envelope construction, surface temperatures of walls, ceilings, and floors of houses, which are surveyed in Hamirpur (HP), are measured during winter months. The values measured in January, the

Table 10.4 Thermal properties of wall and roof materials used in houses at Hamirpur (HP)

Sl. No.	Wall construction (from outside to inside (ref. Fig. 10.2)	U-value (W/m^2K)	Damping (%)	TPI (%)	Time-lag (Hours)
1.	15 mm cement plaster + 230 mm brick + 12.5 mm cement plaster	2.13	78.8	93	8
2.	12.5 mm cement plaster + 200 mm concrete block 12.5 mm cement plaster	2.09	75	102	8
3.	25 mm mud plaster + 450 mm adobe brick + 25 mm mud plaster	1.35	90.9	61	11
4.	15 mm cement plaster + 230 mm brick + 12.5 mm rough plaster + 50 mm glass-wool + 12 mm timber ply panel	0.85	92.4	82	11
	Roof construction (from outside to inside (ref. Fig. 10.3)				
1.	Water proofing + 115 mm RCC slab + 10 mm cement plaster	3.3	30	184	3
2.	50 to 75 mm lime concrete + 115 to 12 mm RCC slab + 10 mm cement plaster	2.78	71	131	4.5
3.	50 mm brick title + 50 to 75 mm cinder + 115 to 125 mm RCC slab + 10 mm cement plaster	2.07	81	90	≥7
4.	50 mm brick title + 50 to 75 mm mud-phuska + 115 to 125 mm RCC slab + 10 mm cement plaster	2.31	87.3	97	≥7
5.	Water proofing + 115 to 125 mm RCC slab + 10 mm cement plaster + 50 mm glass-wool + 15 mm fiber-board ceiling	0.62	83	61	≥8
	Pitched roof construction (from outside to inside (ref. Fig. 10.3)				
1.	0.6 mm CGI sheet + air space + 15 mm fiber-board ceiling	2.0	39	111	≥8
2.	0.6 mm CGI sheet + 25 mm sand-witch of glass-wool and aluminium foil + air space + 15 mm fibre-board ceiling	0.93	21	90	≥8
3.	Slate on timber/bamboo truss + air space + 25 mm timber plank	2.0	39	111	≥8

Based on: BIS (1987) and Koenigsberger et al. (1984)

coldest month, are given in Table 10.5. It is evident from the table that the modern houses constructed with wall and roof insulation provide resistive insulation, whereas the traditional houses constructed with thick adobe wall provide capacitive insulation to maintain warmth inside the houses during winters.

10.6.3 Indoor Thermal Environmental Conditions

Indoor environmental temperature is the simplest indicator to evaluate the thermal performance of buildings, including indoor thermal comfort conditions, which is being recognized in all international standards (ASHRAE 2004; and CIBSE 1979).

Table 10.5 Indoor surface temperatures of building envelope materials in January

Type of Construction	Traditional houses with adobe wall, pitched roof, timber/mud flooring			Modern houses with brick wall, RCC roof, tiles/marble flooring			Modern houses with wall and roof insulation, carpet		
	Walls	ceilings	floors	walls	ceilings	floors	walls	ceilings	Floors
Surface temperature range in °C	14.5–16.0	15.0–16.0	14.5–15.5	12.0–16.0	12.0–16.0	12.0–16.0	16.0–18.0	16.0–18.0	16.0–18.0
Outdoor temperature range in °C	Max. = 16 °C								
	Min. = 4 °C								

Table 10.6 Indoor air temperatures in houses with different building envelope materials in January at Hamirpur (HP)

Type of construction	Traditional houses with adobe wall, pitched roof, timber/mud flooring	Modern houses with brick wall, RCC roof, tiles/marble flooring	Modern houses with wall and roof insulation, carpet
Indoor air temperature range	14.5–16.5 °C	12.0–16.0 °C	16.0–18.0 °C
Outdoor air temperature range	Max. = 16 °C		
	Min. = 4 °C		

Table 10.6 shows the comparison of indoor air-temperature range found in the surveyed houses with different construction materials and techniques at Hamirpur (HP), during winter months. It is found that the modern houses constructed with wall and roof insulation keep the indoor air temperature very close to the comfort temperature range for winter months prescribed by the BIS. Next best option to maintain thermal comfort is to construct the houses with walls and roof having high thermal mass. Indoor relative humidity is found within the range of 50–70 % in all the houses, which is within comfort range.

The hourly variations in indoor air-temperature range during a day in winter month (January), observed in the houses, with different building envelope materials, being studied at Hamirpur (HP) are shown in Fig. 10.6. It clearly displays that in modern houses, constructed with wall and roof insulation materials, almost the full day, indoor temperature remains above 16 °C, which is good for indoor thermal comfort. Next, in traditional houses, constructed with walls and roofs having good thermal capacity and large time lag, indoor air temperature remains above 15 °C, for about 12 h in winter days, especially the indoor air temperature at night is found acceptable by the occupants. The duration of indoor air temperature above 15 °C in present-day houses, with common construction practice, is found to be for 4–5 h during winter days, and after sunset during nights, indoor temperature becomes unacceptably low.

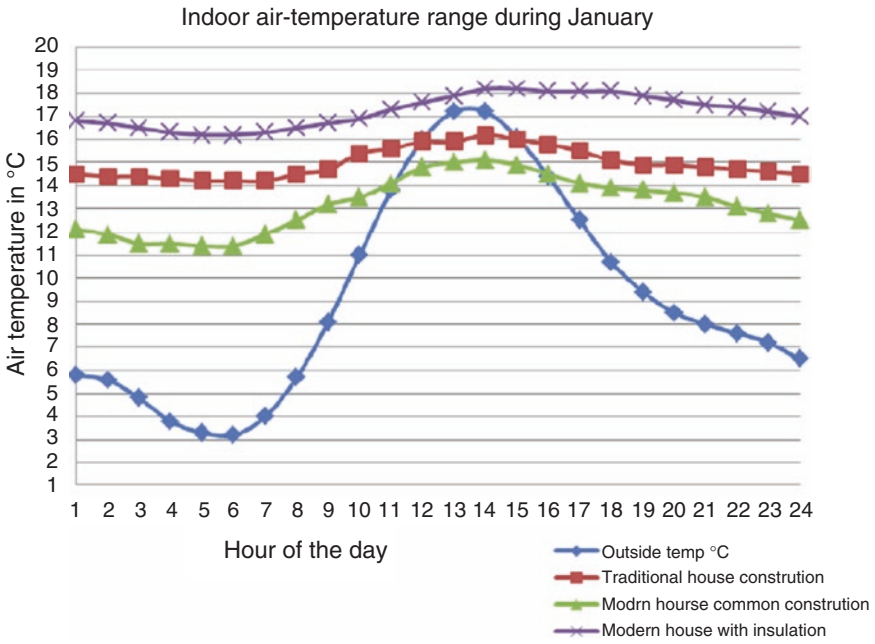

Fig. 10.6 Hourly indoor air-temperature ranges found in houses with different envelope material during January in Hamirpur (HP)

10.7 Conclusion

The study has highlighted the effect of building envelope materials and construction techniques found in naturally ventilated houses of Hamirpur (HP) with "subtropical" climate, on its thermal performance during winters. The analysis has presented the thermal properties of different types of wall and roof construction techniques to enable the architects, building designers, engineers, builders, and mostly occupants to select judiciously and wisely to achieve economy and comfort in their houses.

The optimum indoor comfort temperature in winter months for naturally ventilated residential buildings in Hamirpur (HP) is calculated as 16.5 °C, with thermal comfort temperature range 15.7–16.9 °C, from the linear regression analysis. The minimum acceptable indoor temperature in winters for naturally ventilated residential buildings at Hamirpur (HP) is found as 15 °C.

By analyzing the empirical data obtained from the field survey, this study recommends the use of either insulation materials on walls and roofs, like glass-wool, expanded polystyrene (EPS), extruded polystyrene (XPS), etc., or the wall and roof construction with high thermal mass having more than 8-hr time lag, for the naturally ventilated residential buildings at Hamirpur (HP) to keep the building interior comfortable for almost throughout the year, without using any mechanical cooling and heating, by damping the large daily and annual variation in temperature range.

However, care should be taken to use vapor barrier during installations of wall and roof insulation to mitigate the problem of condensation.

Buildings constitute the major part of the built environment. By adopting suitable building envelope materials according to the local climate and its use, the comfort and efficiency of the building can be enhanced which will further contribute to the overall holistic sustainable development of the built environment by reducing carbon emission as well. Policy makers should also develop guidelines to ensure the practical and economical application of the proper building envelope materials to enable the public to adopt them conveniently and wholeheartedly.

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Chapter 11
Eco-City or Environmentally Sustainable Villages

Nikhil Vaiude, Gajanan Deshpande, and Ashish M. Deosthali

Abstract Urban population in India stands at 31.16% as per the 2011 census. Today India has the world's second largest urban population after China. The urban population is expected to grow by another 400 million by 2050 (United Nations 2014). This would manifest majorly in two ways: organic growth of megacities and emergence of new urban areas. These megacities demand huge infrastructural investment on basic services. On the contrary the new growth centers emerge due to various economic, political, and institutional incentives. Infrastructure development around these new growth centers remains largely neglected to a point in time where proper planning is very difficult.

This paper tries to highlight the initiative of the Government of Maharashtra (GoM) to address the issue of disorganized development in potential growth centers and preset the *vision*, *process*, *outcomes*, *and limitations* of the initiative over the last 5 years.

The "sustainable village" initiative by the GoM focused on the development of a comprehensive "environmental development plan" based on predetermined parameters. The selected villages were categorized as nodal villages or potential urban centers with population ranging from 5000 to 35,000 (GoM, GR Dated 24 August 2011, Preparation of EDP for villages with population greater than 5000 people. Rural Development and Watershed Management Department, Mumbai, 2011) per village. The primary objective of the project was to address development-related issues at microlevel, at the stage when it is still manageable (terms of reference for preparation of environmental development plan. Maharashtra Pollution Control Board (MPCB), Mumbai, 2011).

Keywords Infrastructure development • Urbanization • Rural reforms • Environmental development • Eco-cities • Smart villages • Reform-led development

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11.1 Introduction: Vision of Eco-Village

Infrastructure development has taken place in Indian cities without any comprehensive planning for the past 50 years. Post independence, JnNURM has been the country's first national flagship program of this nature and size for the urban sector (Grant Thorton 2011). The mission was a comprehensive development plan-based approach to bring about change in infrastructure and services and improve governance of the city. The year 2015 marked the completion of 10 years of JnNURM period.

The urban population is expected to grow by another 40 crore peoples by 2050 (United Nations 2014). This would manifest majorly in two ways: organic growth of megacities and emergence of new urban areas. While JnNURM and upcoming Smart Cities project focus on big cities, the villages of India do not get due attention in the infrastructure and a sustainable planning of resources. Infrastructure development in these new growth center areas remains largely neglected to a point in time where proper planning is very difficult. It is therefore necessary to make villages more ecologically and economically sustainable.

The subsequent sections in this paper will discuss the vision, the process of implementation adopted by GoM, the outcomes, and limitations of this visionary eco-village project.

11.2 Vision of Eco-Village

Eco-village concept sets a goal of making communities socially, economically, and ecologically sustainable within their local settings. Eco-village communities have to strive for achieving supportive environmental and socioeconomic developments to reduce over reliance on external energy and economic resources. Thus, eco-village concept promotes a conservation of natural habitat and a lifestyle that has minimal ecological impact. Ecological planning, sustainable waste management practices, alternate agriculture practices, and the use of renewable energy sources are some of the aspects that need to be adopted for the development of eco-village communities (GoM 2010).

The principle of eco-village seeks a sustainable lifestyle for its inhabitants through infrastructural independence based on the latest available technologies within the local setting. These include:

- Maximize respect for existing natural and man-made surrounds: landscape, nature, agriculture, local culture and heritage, infrastructure, and local economy.

- Preserve biodiversity and habitats in the surrounding landscape; strive for the protection of the surrounding landscape and its natural elements.
- Establish measures to avoid unplanned future extensions of settlements in order to conserve the much-needed agricultural areas
- Optimize interaction within the natural environment: reuse of wastewater, reuse/recycling of solid waste, use of renewable energy sources, organic farming, etc.

11.2.1 Key Areas for Intervention, Scope, and Methodology

The concept was primarily focused to identify and support areas for social-cultural-ecological development in select villages with the active participation of targeted communities and integrating relevant ongoing government programs. The scope is explained in Fig. 11.1. There are several programs aimed at development of rural areas. However, there is a need to converge these programs to address environmental issues as part of economic, social, and environmental development of the village which will eventually contribute to the improved and sustained quality of life for rural population.

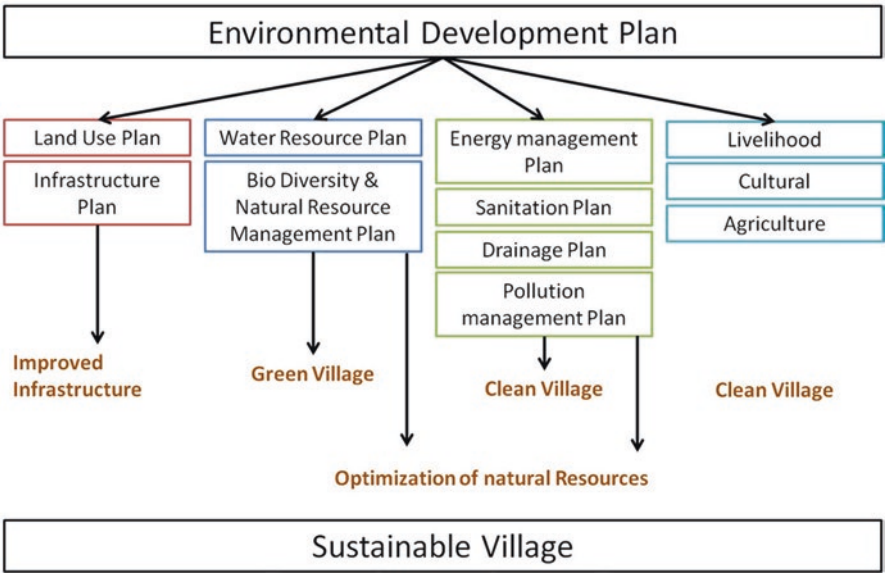

Fig. 11.1 Eco-village goals (GoM 2010)

11.3 Process Adopted by GoM

Considering all these issues, the Government of Maharashtra launched the eco-village program to celebrate golden jubilee year of the state on 2 October 2010. The Rural Development Department (RDD), Government of Maharashtra (GoM), with the technical assistance from the Maharashtra Pollution Control Board had institutionalized an ambitious scheme for transforming villages in the state of Maharashtra into "Environmentally Sustainable Village Program: An Eco-Village" (MPCB 2011).

The MPCB and RDD laid down reform-oriented guidelines (Table 11.1) for the selection of villages who would become eligible for the preparation of a comprehensive environmental development plan (EDP). The villages which were able to fulfill the reforms for all the 3 consecutive years were selected for preparation of the EDP (GoM 2011). The agency for preparation of the EDP was selected from the empanelled agencies through competitive bidding.

Table 11.1 Guidelines for selection of villages for preparation of EDP (RDD GoM 2011)

Reforms laid down by RDD	1st year	2nd year	3rd year
Trees-to-population ratio	50 %	100 %	
Open defecation free ratio	60 %	75 %	100 %
Tax recovery percentage	60 %	80 %	90 %
Sant Gadge Baba scheme[a]	Action plan	50 % marks	60 % marks
Pollution prevention measures	Plastic ban in the village	Plastic ban in the village	Plastic ban in the village
Use of nonconventional energy	Action plan	50 % street lights on solar/CFL/LED	100 % street lights on solar/CFL/LED
		10 % HH to have biogas plants	25 % HH to have biogas plants
Solid waste management	Action plan	Collection of 100 % waste	Collection of 100 % waste
		50 % of the waste converted to compost	75 % of the waste converted to compost
Wastewater management	Action plan	Treatment of 50 % of the wastewater	Treatment of 75 % of the wastewater

[a]Sant Gadge Baba Gram Swachhata Abhiyan is a rural sanitation scheme initiated by GOM in 2008

11.3.1 Implementation Methodology

The preparation of the EDP report required four major activities: (1) collection of secondary data, (2) village-level assessment, (3) preparation of GIS (Geographic Information System)-based maps, and (4) environmental sampling of the village (MPCB 2011). The detailed methodology is described in Fig. 11.2.

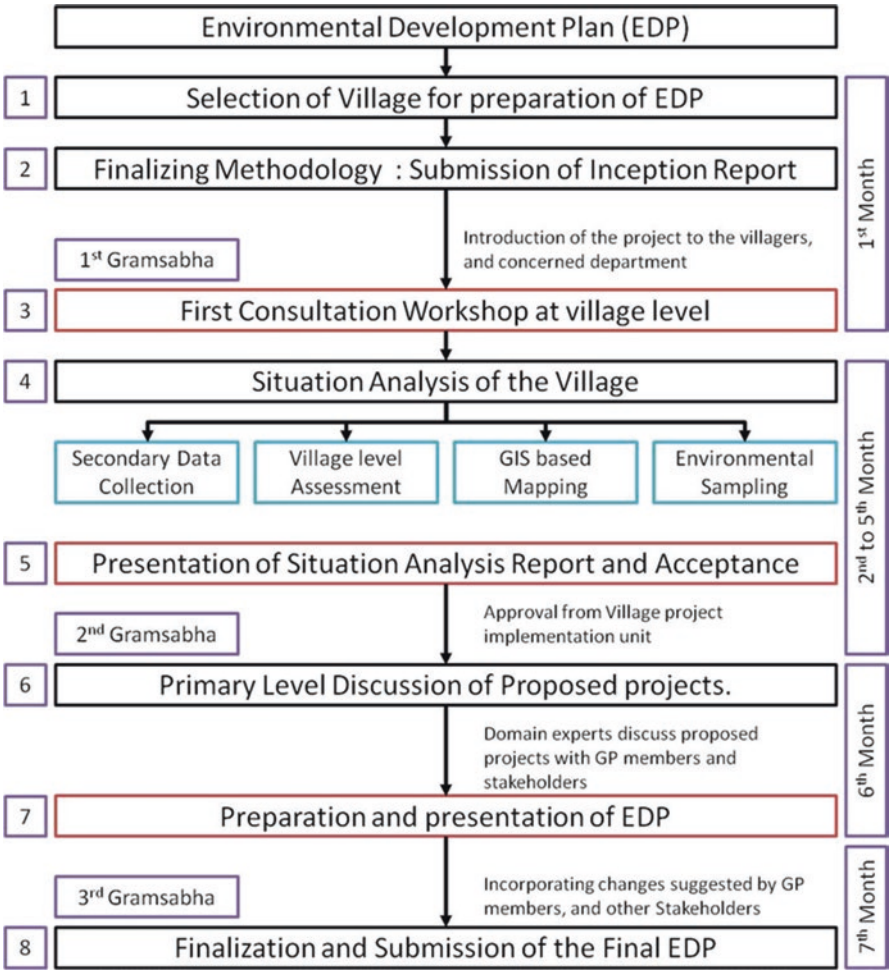

Fig. 11.2 Methodology adopted for preparation of EDP

11.3.2 Collection of Secondary Data

- Socioeconomical: physical profile, demographic profile, economic activities, sociopolitical environment, decision-making processes, vulnerable groups, and their participation
- Ecological: natural resources, land use pattern, agricultural practices, resource requirements (water for domestic, agriculture, fisheries, etc., energy requirements), and conservation practices
- Development: general infrastructure development (road, buildings), water supply, sewerage, solid waste management, waste management and recycling practices, and sanitation (toilets, public toilets, open defecation practices, etc.).
- Cultural: religious and cultural norms-events-practices, environment around religious places, activities of local groups, participation of youth, etc.

11.3.3 Village-Level Assessment

Following surveys and consultations were conducted to elicit the baseline scenario:

- Surveys for physical development and land use
- Infrastructure-related surveys for water supply, toilets, sewerage, and solid waste management including their condition assessment, conservation of water, plants, and agricultural practices
- Social surveys mapping demographic, religious, and cultural profile of the village

11.3.4 Preparation of GIS-Based Base Maps

A 0.5 m resolution satellite (MPCB 2011) imagery was procured from the National Remote Sensing Agency (NRSA) which was then used to prepare GIS-based existing land use maps and other thematic maps.

11.3.5 Environmental Sampling on the Village

Samples were collected for water (drinking and waste), solid waste, and air at various locations in the village.

Table 11.2 Key intervention areas of the EDP (MPCB 2011)

Key interventions	Target areas	Planning interventions
Sanitation and health	Water supply	Identify improvements required in each of the target areas
	Sanitation and sewerage including recycling	
	Solid waste management	(Water supply, sanitation, solid waste improvement plans)
	Awareness and hygiene promotion	
Energy conservation	Applications of renewable energy – solar and wind	Identify potential for use of renewable energy technologies
Environmental conservation	Water conservation	Identify conservation potential and necessary activities
	Conservation of plants and forests	
Conservation of local heritage and culture	Sanitization of local heritage sites and religious places	Plan for sanitization of heritage and religious places
Industrial and commercial area improvement	Industrial and commercial area management	Identifying the status and requirements
Capacity building	Capacity building	Identifying the status and skill set and support required

11.3.6 Planning Activities

Based on the data obtained and the analysis carried out, preparation of eco-village plan was undertaken. This is an important step in the eco-plan development where communities were treated as a partner to this process. Individuals, community groups, and formal community structures such as Panchayat, etc., have been involved and consulted in various planning issues. Participatory approach of planning was adopted for decision-making, and it ensured participation of all groups in the community. Appropriate community structures (e.g., eco groups) were set up in the villages to lead and facilitate consultations and participatory processes in the selected villages.

Planning process primarily focused on key interventions areas (Table 11.2) and identified improvements required as well as interventions of new technologies and management involved. Cost estimates were done for infrastructural improvements and are consulted with communities for their ability to manage their operations.

11.3.7 Finalization of the EDP

Eco-village plans were discussed in a workshop involving Zilla Panchayat (ZP), local community members, and other resource persons for seeking comments and suggestions. In incorporating comments and suggestions of this workshop, plans were finalized and submitted to the Zilla Panchayat for further review, approval, and financial support for implementation.

11.4 Outcomes of the Process

The execution of the sustainable village scheme was a participative planning process. There was a series of consultations held in the respective villages. These consultations at village level sought suggestions from the Gram Panchayat Office, and therefore local knowledge regarding sustainable use of local resources received due importance. These consultations also exposed the Gram Panchayat functionaries to various best practices of infrastructure management being implemented elsewhere.

After its inception the first six EDP were completed in 2011 under the technical guidance of MPCB. Once the desired outcome was achieved, the entire process from selection to finalization of EDP was handled by individual ZP. Till today a total of 330 villages had been selected for the preparation of EDP, of which 174 EDP were prepared in the first phase. The remaining villages were taken in the second phase.

These EDP reports proposed broad cost estimates for preparing the management plan for each subtheme and a total cost estimate for the development of eco-village as per the proposals. It was envisaged that the implementation shall be led by Zilla Panchayat through a Project Monitoring Unit (PMU).

11.5 Findings of the Study

- This EDP project has created a database for 174 villages across 34 districts of the state. The project has furnished the current status and future capital investment required for these villages in a holistic manner.
- The process of EDP gave preference to the development through the process of community participation.
- EDP varied in terms of uniformity regarding proposed projects and capital investments envisaged for the villages. The proposed capital investments for each village varied from 30 million to 120 million per village.
- The satellite images had to be procured from the DigitalGlobe through the National Remote Sensing Agency (NRSA), Hyderabad. The process of placing image requisition, getting required approvals, and receiving the image from NRSA usually took more than 4 months, which led to the delay of the project cycle.
- Although the data is presented on GIS platform, the technical expertise of ZP and GP official for analyzing and utilizing this data was found to be inadequate.
- There was a lack of institutional clarity on the source and criteria for funding of the projects proposed as part of the EDP.
- Many EDP have primarily focused on projects of high visibility – moderate impacts such as infrastructures like internal village roads, underground drainages, and street lights in place of environmentally positive projects.

- The aspect of capacity building and institutional strengthening at the village level needs to be better analyzed in the big schemes like these keeping in view the importance of these villages as potential urban centers.

11.6 Conclusions

The eco-village project mobilized professional expertise from various government departments such as Agriculture, Health, Public Work Department, Irrigation Department, etc., in the selected villages. This technical manpower worked with the project-implementing agency and the village-level committees to prepare a comprehensive development plan for the village. As the plan was prepared through a consultative process, there was a sense of ownership among the villagers regarding the various constituents of plan and a need to implement the same in the future.

Due to the eco-village initiatives, the GoM has the unique opportunity where it has the database of almost 300 villages across 34 districts in Maharashtra. The government has a firsthand information. This database included GIS-based land use maps, existing infrastructure status, gaps and future demand for basic infrastructure, socioeconomic activities, and environmental background and issues of the village. Such a database gives the decision-makers an in-depth understanding of the scenarios and the issues of villages in various districts. These planned growth centers would grow into.

These villages hence present an opportunity for comprehensive and sustainable planning of future eco-cities in a sustainable and phased manner.

Acknowledgments We acknowledge this opportunity provided to us by Shri Ramanath Jha, Director General, All India Institute of Local Self Government (AIILSG), to present our learnings of working on environmental development plan in this prestigious conference.

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Chapter 12
Potential of Energy Saving at the City Level Through Energy-Efficient Buildings: A Study in the Context of Ahmedabad City

Aditya Singh

Abstract The building sector consumes about one third of the total energy consumed in India. Moreover, the commercial building sector is the fastest growing sector. Only 33 % of the commercial floor area that would exist by 2030 is currently (2010) built. This presents a huge potential of energy saving in the commercial building sector. A study to calculate the probable saving potential would help decision-makers to further exploit it.

The research attempts to estimate the current energy consumption pattern in the commercial building sector at the city level along with a broad study of the predominant building characteristics. Consequently, it tries to assess future energy consumption patterns, based on business-as-usual (BAU) scenario and two energy-efficient (EE) scenarios. The results show that by employing EE building envelope, an annual maximum saving of 202 MWh can be achieved for Ahmedabad city. Also, it should be noted that the difference in savings between the two EE scenarios is not significant. The study proves, with hard numbers, the possibility of significant future energy-saving potential that the building sector holds. It also puts light on the fact that delay in implementation of EE measures locks-in a considerable amount of energy-saving potential.

Keywords Building envelope • Energy-saving potential • Energy efficiency • Commercial building sector • ECBC enforcement • Climate change

12.1 Introduction

In India, the residential and commercial sector consumes 47 % of the total final energy consumption (International Energy Agency (IEA) 2007). The consumption is growing at the rate of 8 % per year (Rawal et al. 2012). A rapid urbanisation will result in a very high growth rate of the commercial sector that will have to provide

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jobs and services to a huge population. As stated by a few research papers, only 33 % of the total floor space area that would exist in 2030 is present currently. Commercial sector is growing at a tremendous rate of 13 % per year (Mewada et al. 2013). This provides the commercial building sector with a huge potential to save energy. If proper measures are taken and if Energy Conservation Building Code (ECBC) is followed, a building can save as much as 40 % of its actual energy consumption (Rawal et al. 2012).

The research question that this study raises is, what is the energy-saving potential at the city level through commercial building sector: if a more efficient design of building envelope is enforced on new constructions and/or existing buildings are retrofitted to increase the envelope's efficiency?

12.2 Rationale of the Study

The study helps identify and quantify the potential of energy saving in the commercial sector. The built-in characteristics of the buildings, which include building envelope characteristics, orientation, etc., are the most difficult to change once constructed or retrofitted. These lock-in a certain amount of efficiency potential with themselves and hence should be prioritised for EE, considering the ease of enforcement as well as the long-term energy-saving potential (Rawal et al. 2012). A study to calculate the probable saving potential is anticipated to help decision-makers to further exploit it. Specifically building envelope is chosen because it is that part of the building that stays with the building for life, unlike HVAC systems or lighting systems that have a relatively very small lifespan and also incur a greater amount of maintenance cost. Also, changes done towards efficiency in the core structure of the building, which includes the building envelope, give the best lifetime energy savings (Rawal et al. 2012) for the buildings, especially in warm and humid, composite and hot and dry climates (Manu et al. 2011). Additionally, enforcement of EE through building envelope is easier to enforce through urban local body (ULB). This is because the envelope design can be checked when building drawings go for approval to this body, before commencement of construction. This is unlike HVAC or lighting systems which are chosen and installed just before the occupancy of the property.

12.3 Methodology

The methodology followed to perform the study consists of two distinct parts (Fig. 12.1), which merge during the final steps assisting each other to produce the desired results. The first part operates at the building scale. In this part, commercial buildings from around the city of Ahmedabad were surveyed for various properties

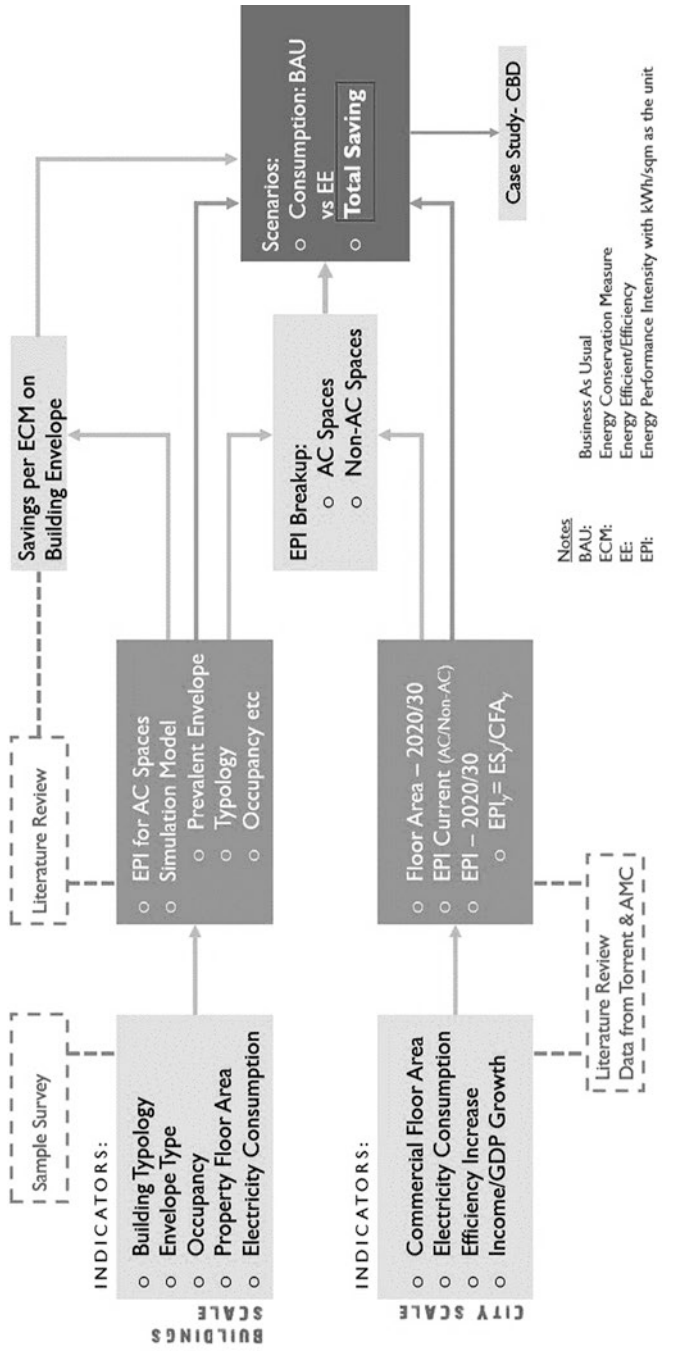

Fig. 12.1 Graphical representation of study methodology

including building typology, envelope type, energy[1] consumption, type and quantity of equipment used, occupancy type, etc. The buildings surveyed were picked up from the commercial strips in the city that showed newest constructions, as these would give a more representative value for future commercial developments. The data collected from these surveys was then analysed to get the required data including energy performance index[2] (EPI), type of envelope, etc. The EPI hence gotten was used as a representation of energy consumption for air-conditioned (AC) commercial buildings of the city. Further, help was taken from literature study in addition to collected data to calculate energy savings per unit floor area, per energy conservation measure (ECM). These ECMs were based on the building envelope modification solely.

In the second part of the methodology, data was collected at the city level. The indicators, for which the data was collected, include the total commercial floor area of Ahmedabad city, the total electricity consumption in the commercial sector, the anticipated increase in appliance efficiency, etc. Using these indicators, EPI for base year (2011) was calculated. Further, future projections for probable EPI were done for the years 2020 and 2030 to assess future consumption of energy. These projected EPI numbers were calculated using projected data for income, efficiency and commercial floor area at the city level, through literature study.

The last step of the methodology was to build various future scenarios. These scenarios were for the years 2020 and 2030. The scenarios were based on the degree of enforcement of EE measures over the commercial floor area and is summarised in the Table 12.1. The scenarios described in the Table 12.1 were based on the 'Interim Report of the Expert Group on Low Carbon Strategies for Inclusive Growth' published by the Planning Commission of India (Planning Commission 2011).

12.4 Data Collection and Analysis

A total of 39 commercial properties were surveyed. The following table (Table 12.2) gives an overview of the data collected through sample survey.

The following figures show further analysis of the data. Figure 12.2 shows distribution of EPI over months in a year, and Fig. 12.3 shows the regression of energy consumption with respect to BUA. The figures clearly indicate a relationship of BUA and season of the year with energy consumption pattern. Additionally, the calibrated energy savings per ECM have been represented in the Table 12.3.

At the city level, the data collected came from literature study as well as through various urban bodies like the municipal corporation. Table 12.4 shows the growth and projections of the commercial floor area of Ahmedabad city.

[1] In the paper, the word 'energy' represents electricity, because in commercial buildings, the energy consumption is mostly the electricity.

[2] EPI gives a measure of intensity of energy consumption of buildings and is a ratio of total annual energy consumed by the property to the total floor area of the property.

Table 12.1 The scenario conditions

Business as usual (BAU)	Determined effort (DE)	Aggressive effort (AE)
Past growth trends of floor area will continue	Past growth trends of floor area will continue	Past growth trends of floor area will continue
15 % of buildings coming up between 2010 and 2020 will have ECBC compliant envelope	25 % of buildings coming up between 2010 and 2020 will have ECBC compliant envelope	35 % of buildings coming up between 2010 and 2020 will have ECBC compliant envelope
65 % of buildings coming up between 2020 and 2030 will have ECBC compliant envelope	100 % of buildings coming up between 2020 and 2030 will have ECBC compliant envelope	100 % of buildings coming up between 2020 and 2030 will have ECBC compliant envelope
No retrofitting will happen to the existing building stock	25 % of buildings before 2010, and 25 % of buildings between 2010 and 2020, not complying to ECBC get retrofitted envelope by 2030	25 % of buildings before 2010, and 50 % of buildings between 2010 and 2020, not complying to ECBC get retrofitted envelope by 2030
All ECBC compliant buildings by 2030 will have envelope that will remain at prescribed energy performance boundary	10 % of ECBC compliant buildings by 2030 will have envelope that will surpass prescribed energy performance boundary by 10 %	25 % of ECBC compliant buildings by 2030 will have envelope that will surpass prescribed energy performance boundary by 10 %

Table 12.2 Sample survey details

	Unit	Average	Maximum	Minimum	Standard dev
Annual energy consumption	kWh	19,641	62,016	6,379	11,225
Built-up area (BUA)	m^2	374.53	2700	80	478.98
Occupancy	Persons	33.08	165	8	26.99
Wall-window ratio (WWR)	Ratio	0.34	0.50	0.25	0.07
HVAC	TR	12.89	81	4	12.37
Equipment power density (EPD)	kW/m^2	33.45	66.06	2.03	18.20
EPI	Index	89.2	149.9	39.1	31.8

To estimate the future consumption of energy, along with the projected floor area, projected EPI would also be required. To project the EPI, two indicators were used, the growth rate of household income and the anticipated increase in appliance efficiency. As suggested by literature study, as income increases, so does the EPI, whereas, with advancement in technology, the efficiency of appliances would increase. An efficiency increase of 9 % was taken for the year 2020 and 18 % for 2030 (Planning Commission 2011). The household income was assumed to be growing at 14 % with a correctional factor of 0.71 (Annez et al. 2012). Using these two indicators, the EPI for 2020 and 2030 came out to be 140.79 and 311.21, respectively. These EPI were further broken down into AC EPI and non-AC EPI based on base year proportion (Table 12.5).

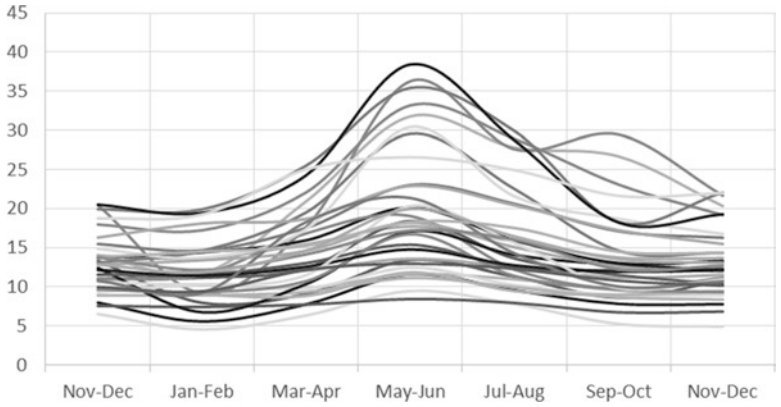

Fig. 12.2 Monthly distribution of EPI

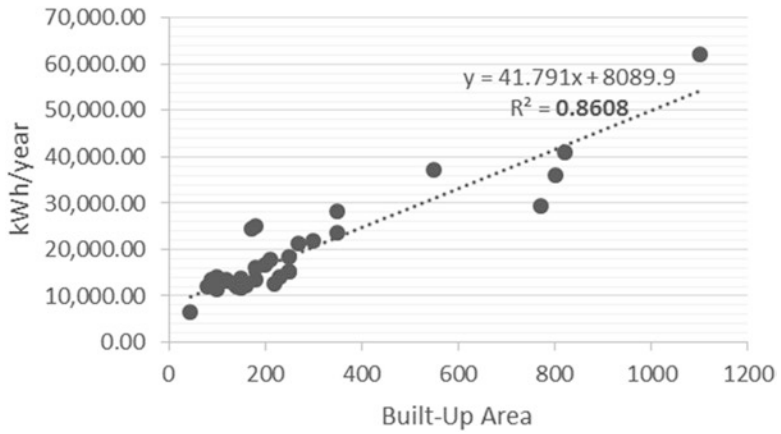

Fig. 12.3 Annual electricity consumption

Table 12.3 Savings per ECM (Rawal et al. 2012)

Savings (kWh/sqm)	Literature review	Calibrated
Element	(For 225 kWh/sqm)	(For 89.24 kWh/sqm)
Envelope insulation	7.80	4.86
Windows/glazing	39	13.98
Shading	7.33	2.63
Total	**54.13**	**21.47**

12.5 The Results

The final results obtained after following the methodology, for the created scenarios, are represented as follows (Fig. 12.4). The energy consumption numbers were

Table 12.4 Growth of commercial floor area (Munshi 2013)

	1980	1990	2000	2010	*2020*	*2030*
Total (million sqm)	6.12	9.04	12.31	17.43	*22.09*	*26.05*

Table 12.5 AC and non-AC EPI break-up

Non-AC EPI	AC EPI	Mean	Year
47.80	89.24	68.52	Base
217.10	405.32	311.21	2030

obtained by multiplying the floor areas with the respective EPI as per the conditions of the respective scenario.

12.6 Key Findings and Conclusion

The key findings of the research can briefly be noted as follows:

- As the amount of air-conditioned floor area at the city level will increase with passing time, lock-in of potential energy saving would also increase.
- By employing energy-efficient building envelope, an annual maximum saving of 202 MWh can be achieved (for 2030).
- Going from determined effort scenario to aggressive effort scenario does not produce significant improvement, yet gives a noticeable change.
- If the floor area is allowed to expand without any energy-efficient intervention, a significant amount of mitigation potential will be locked in.

The study reveals some very positive outcomes. The results may not be shocking per se, but they give a good backing to some of the well-known possibilities, through hard numbers. It also answers the 'how much?' question in a very satisfying manner. It can now be said with confidence that there lies a huge potential of energy savings through measures like having an energy-efficient building envelope.

It can also be concluded that as the air-conditioned floor area increases over the time, the potential of savings increases exponentially. It can be said that the proportion of air-conditioned space would actually increase, with rising income, and this makes it even more urgent for the relevant stakeholders to take active participation in the process of energy efficiency. The recommendations of the paper would be to utilise the available potential as soon as possible; only then can the maximum profit be achieved.

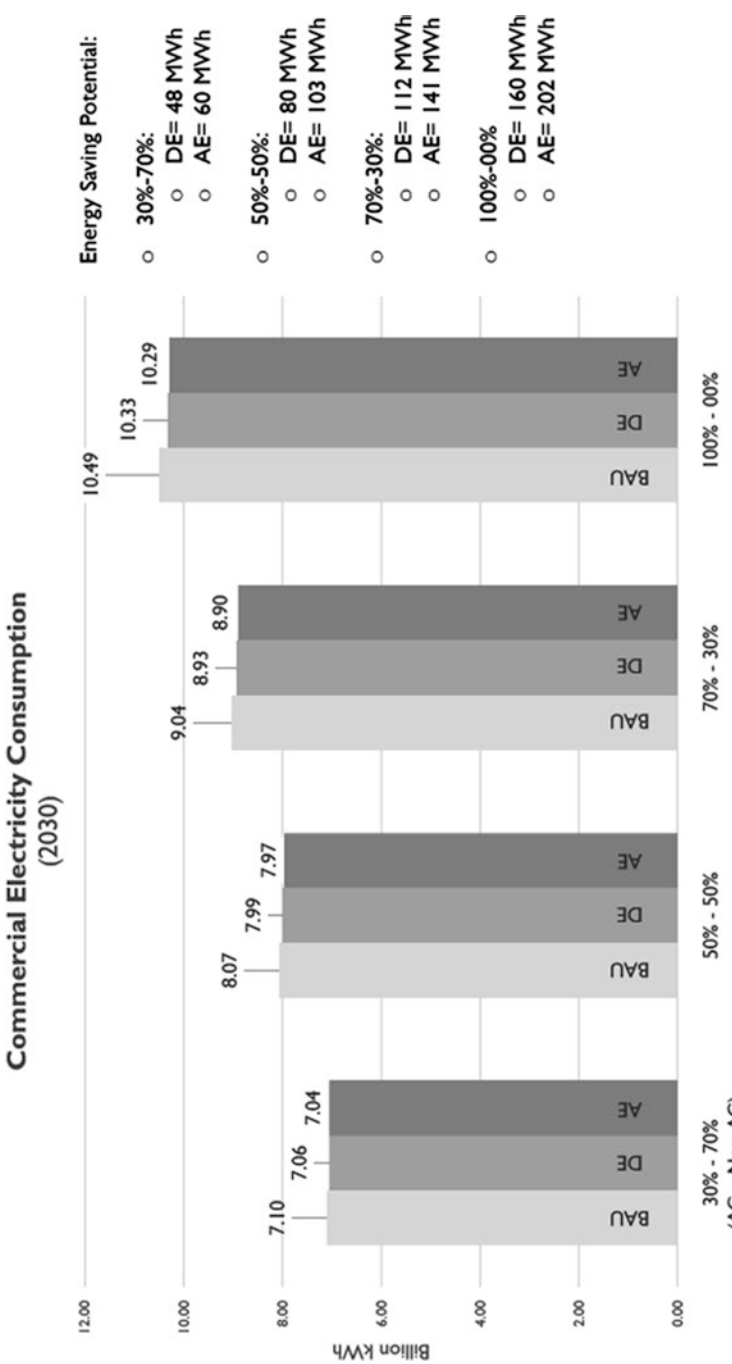

Fig. 12.4 Comparison of the final scenarios

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