Smart City for a Sustainable Future: Is Delhi Ready?

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Abstract: Cities are the geographic nodes around which people gather for their livelihood activities. Various factors like resources, technology, education, medical innovations and environmental developments have shaped modern cities. However, with rapid urbanization and population growth, many cities are facing the problems of degradation, pollution, diseases and a poor quality of life. The major challenges before the urban growth centers have necessitated the formation of smart cities. Sustainable future of a city lies in the development of transport, infrastructure, environment, energy, ICT and people with a sustainability approach. The Government of India has launched a scheme to create hundred smart cities across the country, among which the National Capital of Delhi is a frontrunner. This paper attempts to study the existing infrastructure and facilities in Delhi in order to assess its readiness to be a smart city. It also attempts to analyze the citizens' perception about Delhi as a smart city through a primary survey. Although there are limitations in the current scenario of economic and environmental performances and people's perceptions, Delhi makes a strong case for becoming a smart city.

Keywords: smart city, urban infrastructure, Delhi, sustainable development.

1. Introduction

Cities are the greatest of human inventions. With the history in backdrop, cities manifest our technological innovations, socio-cultural interactions, economic structures and political systems. Cities are often equated with the idea of progress of mankind because it is the city in which the concept of a citizen was born. Anonymity, social order, civil society, economic progress and the ability to produce and consume are certain attainments of a city which make its existence special to human beings. Starting from the early small size to house a few people, cities have grown to bigger areas with walls, boundaries, markets, production areas, streets, residential areas and civic facilities. With the rising population, almost half of the world's population lives in urban areas today (UN, 2011). The increasing urbanization rates suggest that people have looked at cities as places of leisure and work at a faster pace than ever before in human history. With the rapid growth of cities, there has arisen a variety of risks and problems in terms of resource scarcity, degradation, diseases and a basic quality of life. The situation has created an urgency to find 'smarter ways' to address the upcoming challenges. The search today is for sustainable pathways for growth and balance on the basis of experience and knowledge.

The most recent prescription for the sustainability of cities is to be 'smart'. This suggests the use of the best ideas to create an urban future that not only uplifts quality of life but continues to make cities vibrant, progressive and energetic spaces meant for citizens along with their interactions, production and communication processes. This needs to be done in a way that it is least costly to the economy and the environment. The concept of smart cities is essentially a manifestation of all such solutions towards urban problems centered around sustainability. It is important here to define as to what is a Smart City. While there is no single answer, there are certain multidimensional components and core factors which describe a smart city. There are a number of accepted definitions which attempt to define its framework and characteristics. According to Accenture, a Smart City delivers public and civic services to citizens and businesses in an integrated and resource efficient way while enabling innovative collaborations to improve quality of life and grow the local and national economy (NIUA, 2015). Smart cities are part of a process rather than a static outcome, in which increased citizen engagement, hard infrastructure, social capital and digital

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technologies make cities more livable, resilient and better able to respond to challenges. According to the British Standards Institute, smart city is the effective integration of physical, digital and human systems in the built environment to deliver sustainable, prosperous and inclusive future of its citizens. IBM defines a smart city as 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. CISCO defines smart cities as those who adopt scalable solutions that take advantage of information and communications technology (ICT) to increase efficiencies, reduce costs and enhance the quality of life (NIUA, 2015). Since smartness is dependent on the people's perception, smart cities should be more user-friendly and are required to adapt to the customized needs. A careful study of the successful smart cities of the world, as presented in Table 1, points at the following as the major factors that define a smart city: transport, infrastructure, environment, energy, ICT, people and an overall sustainability approach.

Table 1: Successful smart cities of the world (Source: Government of Singapore, 2009).

City	Core Areas	Achievements
Singapore	Transport Energy Environment Technology Community action	Urban transport system Widespread IT use Data sharing and open platforms Improved quality of life
Amsterdam, Netherlands	Technology Energy Transport People	Smart energy grids Smart cards (transport) Online car sharing system Smartphone apps
San Francisco, USA	Environment Transport Technology Data sharing People's participation	Parking projects for drivers Real time traffic data Safe mobility Making transit, walking, sharing preferable
Curitiba, Brazil	Transport Environment Community	BRT-integrated transport with land use planning

In a developing country like India with a change in rural-urban composition, cities are facing pressure in terms of resources, energy, infrastructure and opportunities along with problems of pollution, congestion, health issues etc. With the announcement of the Government of India to build up smart cities, it becomes essential to assess the present situation (GoI, 2014). This study attempts to study the existing infrastructure in Delhi in terms of the abovementioned parameters to know the 'readiness' of the city to be 'smart'. Since people are the most important stakeholders of this concept, a survey of people has also been done to know their preferences, perceptions, knowledge, the findings of which can be used as solutions and feedbacks to policy papers in future. The views can act as references for the planners for making better policy decisions which are directed towards betterment of people. Though the concept is at its 'conception' stage with very little information in the public domain, the analysis which is proposed here may act as a vital input to the government. The conclusion of the study therefore is more in the form of suggestions and recommendations, so that the city of Delhi is able to cope up with upcoming challenges with implementation of a successful model and continues to be sustainable in the long run.

2. The Delhi Megacity

2.1 The History of Delhi

The city of Delhi has a long political, social and cultural history which is a result of assimilation of different cultures through the centuries that the city has witnessed. The city dates back to the period of the Mahabharata and still stands testimony to the long past through the Sultanate rule, Mughal era and the British rule. The city has many famous monuments constructed by rulers with fine artistic taste and environmental relevance (Singh, 2008). Table 2 shows the evolution of Delhi over centuries whose traces can be found in many parts of the city till now.

2.2 Physiographic Features, Climate and Forest Cover

Located along River Yamuna in Northern India, between latitudes of 28°24'17" and 28°53'00" North and longitudes of 76°50'24" and 77°20'37" East, Delhi shares borders with the states of Uttar Pradesh and Haryana. Delhi has an area of 1,483 sq. km with the maximum length of 51.90 km and greatest width of 48.48 km. The physiography of Delhi is dominated by the Aravalli range, River Yamuna and the plains which are formed by the alluvial deposits. The Aravalli is covered with forest and is known as the Ridge, which acts as a barrier between the Thar Desert and the plains by slowing down the movement of dust and wind from the desert. The Ridge has 4 sections: Northern, Central, South-Central and the Southern, constituting the farthest stretch of Aravalli range. Often termed as the lungs of the city, this green belt has a moderating influence on the temperature and in maintaining an optimal environment (Singh et al., 2016). The average annual rainfall in Delhi is 714 mm, most of which falls in the months of July, August and September. Summers are hot with temperatures ranging 30-48°C.

Table 2: Chronological history of Delhi (Source: Jolly, 2010).

S.No.	Date	Name of Settlement	Founder(s)	Present Probable Site
1.	900 B.C.	Indraprastha	Yodhistra	Purana Quila
2.	1020 C.E.	Surajkund	Anang Pal	Suraj Kund
3.	1052	Lalkot	Prithviraj Chauhan	Near Qutub site
4.	1180	Quila Rai Pithora	Prithviraj Chauhan	Near Qutub site
5.	1301	Siri	Ala-ud-din Khilji	Near Hauz Khas
6.	1321	Tughlaqhabad	Ghiyasuddin Tughlaq	Tughlaqabad
7.	1325	Adilabad	Moh'd Tughlaq	Near Tughlaqabad
8.	1327	Jahanpana	Moh'd Tughlaq	Siri & Rai Pithora
9.	1354	Ferozabad	Firoz Tughlaq	Near Feroz Shah Kotla Stadium
10.	1530-33	Din Panah and Shergarh	Humayun, completed by Sher Shah Suri	Purana Quila
11.	1638	Shahajahanabad	Shah Jahan	Old Delhi (Walled city)
12.	1911	Delhi	British capital	North of walled city, Shajahanabad, Civil lines, Secretariat etc.
13.	1931	New Delhi	British (Lutyen, Baker)	Rashtrapati Bhawan, Connaught Place
14.	1947-date	New Delhi	Independent India	Present day New Delhi

2.3 Administrative Setup

The British presence in Delhi began in 1805 under the charge of Resident and Chief Commissioner of Delhi. In 1858, it was made a frontier province and transferred later to the newly formed Punjab province by the Lieutenant Governor. When the capital was shifted from Calcutta to Delhi in 1911, a separate Delhi committee was formed to oversee construction and management of civic affairs. After independence, Delhi became a part C state in 1951 with a council of ministers and legislature. The state reorganization commission in 1953 suggested its control under national government being the capital, with the formation of the Municipal Corporation of Delhi (MCD). Therefore, from 1956, Delhi as a union territory was administered directly by the President of India through a Chief Commissioner appointed under article 239 till the enforcement of Delhi Administration Act in 1966.

With the 69th amendment of the Constitution in 1991, Delhi was accorded a special status by designing it as the National Capital Territory of Delhi by insertion of Article 239AA providing for the creation of 70 member legislative assembly and 7 member council of ministers. Delhi was divided first into 9 districts (Fig. 1) and then subsequently to 11 revenue districts. A lot of changes have been introduced in the administrative structure (Singh, 2012). Delhi Transport Corporation has been transferred from the Central government to the Government of Delhi. Delhi Jal Board (DJB) is in charge of water supply and sewage disposal. The generation, transmission and distribution of electrical power in Delhi was under Delhi Vidyut Board (DVB) during 1997-2002. It was later unbundled into six successor companies: Delhi Power Supply Company Limited (DPCL), Delhi Transco Limited (DTL), Indraprastha Power Generation Company Limited (IPGCL), BSES Rajdhani Power Limited (BRPL), BSES Yamuna Power Limited (BYPL) and North Delhi Power Limited (NDPL).

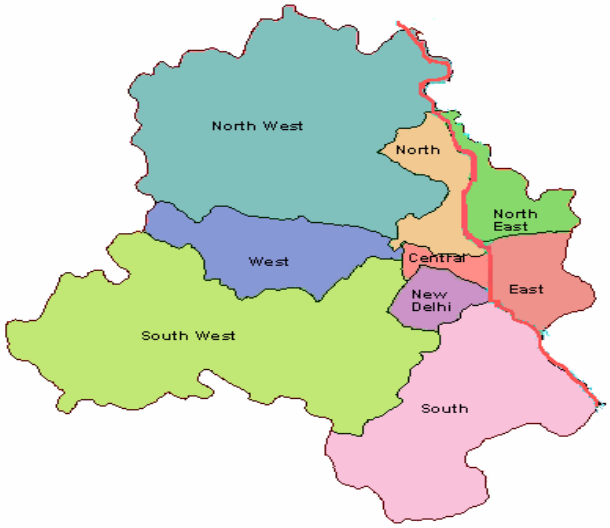

Figure 1. Nine administrative districts of Delhi (Source: delhi.gov.in, Accessed on 1 January, 2017).

3. The Smart Parameters of Delhi

Due to the immense opportunities, avenues and resources, the capital city of Delhi attracts a large number of people. The population of Delhi has grown at a rate of 21.2% over 2001-11 with a density of population 11,320 per sq. km

(Census of India, 2011). With the current population of more than 16 million, the city is facing multiple challenges. With rising demand for resources like land, water and energy, the future quality of life needs to be designed properly in harmony with the ecology. Smart Cities are conceived as solutions to the urban crisis. There are five major areas that are essential to be targeted for developing smart cities (Fig. 2). Smart people need to live in a smart city with smart transport, energy and water, information and communication technology and an above all a clean environment.

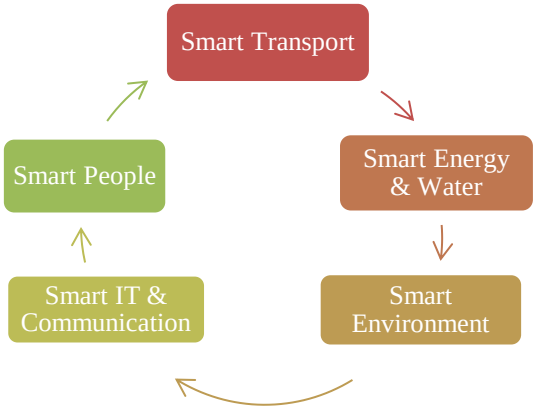

Figure 2. The smart connection.

3.1 Transport

Transport connects people. There are three major areas around which the transport sector operates: infrastructure installation, vehicles which run on these installations and operations including planning, financial issues etc. In order to sustain cities for a longer run, 'sustainable mobility' is required today in order to address its various challenges. While modes of transport need to be safe, comfortable and economical, these have to control pollution and congestion at the same time. Delhi has both public and private transport systems. The former includes bus, auto rickshaw, taxi, railways and Metro, owned by Government and/ or private players who operate in areas providing mass transport for people. Private transport means mode of transport owned by individuals or organizations largely for the private purpose like car, motor cycle, scooter, and cycles.

3.1.1 Bus

The bus service has been the largest and the oldest among the public transport system in Delhi. It is provided by Delhi Transport Corporation (DTC) since 1971. It operates in the city as well as across states. There are buses that ply between Delhi-Kathmandu and Delhi-Lahore. As a part of a green drive, all buses have been converted to the clean fuel Compressed Natural Gas (CNG) in 2003. With a minimum fare of Rs.5 (non-AC buses) and Rs.10 (AC buses), the DTC service caters to the largest share of the transport demand of the state. It has approximately 5,000 CNG buses, 45 depots, and 21 bus terminals. Steps have been initiated to make buses better by introduction of low floor fleets making them more citizen-friendly. The Government of Delhi also has plans to install passenger information system.

3.1.2 Metro Rail

The public transport sector of Delhi has witnessed a major achievement with the introduction and successful operation of the Metro in the city. The Delhi Metro Rail Corporation (DMRC) was formed with equity partnership from the Government of India and the Government of the National Capital Territory of Delhi. It is an excellent example of eco-friendly mass transit system after it was recognized by the United Nations as the first rail system to reduce greenhouse gas emission by reducing pollution levels by 6.3 lakh tones every year. The stations, parking spaces and upcoming expansions are likely to be developed as Green Buildings. It is also using rooftop solar power plants at certain metro stations. Delhi Metro has also become the first ever Metro and Railway system in the world to be registered with the prestigious Gold Standard Foundation, which is a globally accepted certification standard for carbon mitigation projects. Table 3 shows the clear advantage of the Metro as a green option as compared with the other modes of transport.

Table 3: CO_2 Emissions from different modes of transport (Source: delhimetrorail.com, Accessed on 1 January 2017).

Mode	Value	Unit
Passenger car	67	g-CO_2/km/passenger
Taxi (CNG)	72	g-CO_2/km/passenger
Two Wheeler (Petrol)	28	g-CO_2/km/passenger
Auto Rickshaw (CNG)	35	g-CO_2/km/passenger
Bus (CNG)	27	g-CO_2/km/passenger
Metro	20	g-CO_2/km/passenger

DMRC has a fine record of providing timely service, safe and comfortable journey, user-friendly practices of smart cards, travel information guides, online recharge systems, interactive maps, mobile apps etc. under the supervision of trained personnel. Beside the six functional lines at present, construction is going on for extending it throughout Delhi and NCT. The fare ranges from Rs.8 to Rs.100 according to the distance covered. The services are provided daily from 5.30 a.m. to 11.00 p.m. It covers a total length of 213 km with 160 stations through a fleet

of 216 trains of four, six and eight coaches. The daily ridership of the metro service is 2.4 million on an average. This great success of Delhi metro has attracted greater public attention and is to be followed up in other cities in India.

3.1.3 Auto Rickshaws

Auto rickshaws are three wheelers that form a significant part of public transport in Delhi. They are run on CNG and are cheaper than taxis. With the mandatory installation of fitted electronic meters and fare charts, the fare is regularized. The guidelines provide for mandatory uniform, badges, first aid box, and driving license to be possessed by the driver. Installing GPS devices is also under consideration. Around two lakh autos ply across entire Delhi. The government is also taking steps to make autos safer by providing training and hiring women drivers especially to ensure safe travel by women during nights. Introduction of Pink Autos targeting exclusively women, equipped with panic buttons is another effort towards women's safety. However, there is a parallel system of running autos by mutually agreeable rates without the fare meter which has become a problem for this mode. Besides the safety issue, auto rickshaws need to be made more accessible and regular. Further services need to be generated for booking rickshaws with payment options of cash or card. If implemented successfully, this sector can provide economical, comfortable, safe and accessible transport to a significant number of commuters.

3.1.4 Ring Rail

The ring rail is operated in the National Capital Region covering Delhi, with adjoining regions of Faridabad and Rewari in Haryana, Ghaziabad and parts of Uttar Pradesh. Started in 1975 by the Northern Railways to transport goods, it started as a popular option. As the name suggests, the railway runs parallel to the Ring Road covering important areas of the city in a circular fashion. It is run by using electricity on EMU and DEMU systems on a broad gauge track. The fare structures are as per the Indian Railways fare policy with minimum Rs.2 and maximum Rs.6. Less preference by passengers and operational failures contribute to the present poor state of suburban railways in Delhi. Mostly, it covers areas having less density centres which do not connect with other transport networks. It also has problems of irregularity, lack of hygiene etc. At present, these tracks are largely used as a freight corridor with some passenger services at peak hours. During the Commonwealth Games 2010, efforts were made to revive the ring rail network which did not sustain later. In view of its great potential, the ring rail needs to be restructured to make it an affordable, safe and comfortable option.

3.1.5 Taxi/ Cab

Another mode of transport common across Delhi is taxi/ cab. These are more popular among the tourists who are either outsiders or foreigners who hire taxis. Presently there are many private companies which dominate this field like Ola, Uber, Meru, Megacabs, Yo, Easy Cabs which are easily available and can be booked online. These are said to be pocket friendly with different deals, schemes and offers. However, these need to improve on their safety aspect after many incidents in the city. Fitting GPS track mechanisms and panic buttons, following stricter registration norms are some such measures to ensure quality service. Being comfortable and accessible, they provide services to cover greater distances and at all times, especially at night. Taxis registered with the Government run on CNG and can be booked by approaching the taxi stands. Delhi tourism provides taxi details, fares on their website. The vehicles, as per the radio taxi scheme 2006, call for mandatory display of boards, electronic meters, GPRS devices, verification of drivers, helpline numbers to make taxis economical, safe and comfortable.

3.1.6 Others

Apart from major public transport modes, there are other modes which fill up the gaps in this sector by providing last mile connectivity to areas where other public modes have no connectivity. These are pulled rickshaws, sharing vans, and e-rickshaws which are now widely accepted to complement the traditional transport sector. A pulled rickshaw is a human-powered transport in which the rickshaw is drawn by a cycle by the puller which seats 1-2 persons to travel short distances. Sharing vans are also popular in many stretches carrying 7-8 persons to major commonplaces like bus stands, metro stations, and market places. With lesser fares than a pulled rickshaw, their cost effectiveness is their major advantage as they run on a sharing basis. One major transformation came in the form of electronic/ e-rickshaws which are gaining popularity because of their low fuel cost, low fares, less human effort, electric motors and eco-friendliness. Efforts are made to regularize and register e-rickshaws by formation of policy which regulates their functioning.

3.1.7 Private Transport

Private cars and two-wheelers are largely used by individuals for private purposes. The increasing number of cars has become a major cause of concern. In order to tackle the pollution and congestion problems, the Government of Delhi has recently introduced the odd-

even car formula on an experimental basis. It has been a success and is going to be implemented again.

3.2 Energy and Water Resources

3.2.1 Energy

With rising population in Delhi, demand for energy is increasing rapidly. All sectors like industrial clusters, residential areas, office spaces, educational zones, transportation require energy. Energy consumption has increased from 19,666 million units in 2002 to 27,234 million units in 2013 with the per capita consumption of electricity being much higher than the national average. The domestic sector has the largest share in energy consumption at 44%, followed by industry at 25%, commercial 13% and agriculture 1%. The Government establishments and public works in the National Capital have a combined share of 17%. While the generation, transmission and distribution companies are responsible for the power supply to the city, Delhi Electricity Regulatory Commission (DERC) looks after regulatory matters, such as, rationalization of tariffs, transparency in subsidy policies and promotion of efficient and environmentally benign options. The state also has waste-to-energy plants with an installed capacity of 16 MW. It has 681 biogas plants with 90 solar photovoltaic pumps with present installed capacity of 2.53 MW. Although the energy sector is dominated by thermal power, alternative sources are under development. The net availability of power from the seven local power plants in Delhi is 1,213 MW whereas the central power projects supply 2,873 MW. With peak load during summer going as high as 5,653 MW, providing electricity to all is a serious challenge. Table 4 presents the peak load power demand of Delhi.

Table 4. Power Demand during peak load in Delhi (Source: DES, GNCT of Delhi 2014).

Year	Peak Load (MW)
2010-11	4720
2011-12	5028
2012-13	5642
2013-14	5653

The solution to this crisis is the development of alternate sources like solar power which the Government is considering. The outlay in annual plan in 2013-14 is Rs.100 lakh for promotion of energy efficiency and energy conservation. This includes promotion of solar energy by providing subsidy, mandatory adoption of energy conservation measures in buildings like building codes, smart grids etc. Awareness campaigns have also been initiated.

3.2.2 Water

With only one natural source of water, River Yamuna, Delhi sources its water from River Yamuna, Ganga, Beas and Ravi and Bhakra storage and Munak canal. There are five water treatment plants to distribute water across the city. Delhi Jal Board is responsible for procurement and treatment of allocated raw water and provide bulk supply of treated potable water. As per the Master Plan of Delhi, the water demand is around 1,380 million gallons per day (MGD) for the projected 23 million population (MPD, 2021, 2007). Water production on a regular scale is estimated around 1,290 MGD, thereby leaving a gap of about 90 MGD. The grim water situation of Delhi is reflected in Table 5.

Table 5: Water situation in Delhi (delhijalboard.nic.in Accessed on 1 January, 2017).

Year	Demand (MGD)	Production (MDG)	Shortfall (MGD)
2000	792	630	162
2005	918	650	258
2009	1020	810	210
2010	1080	845	235
2011	1380	1290	90

Apart from the scarcity, the state of River Yamuna is worrisome because of the increased pollution to an extent that the river has been declared almost 'ecologically dead'. This means there is now a greater dependence on groundwater and supply from neighboring states like Haryana and Uttar Pradesh. With greater exploitation of groundwater, the quality and quantity of water is not proportional to the requirement. The ground water situation in Delhi is alarming. With low water table in almost every region except central and north districts, the quality of water is also deteriorating. The water is polluted by the presence of heavy metals, calcium, magnesium salts and untreated sewage which render it unfit for drinking (Singh, 2012). Thus, the management and regulations will be critical in future to secure human and environmental health both of which are part of the millennium development goals.

Sustainable water management in Delhi requires optimized resource utilization, regulations banning withdrawal of ground water, storage of rain water in Yamuna and rain water harvesting. The Government is planning to build up additional capacity by constructing three new reservoirs and two new water treatment plants.

Dual pipe system for flushing purpose only will be implemented in all group housing societies and new colonies to be developed in the new urban extension areas by the DDA. Reclamation of sewage water following the North East Water of Singapore using ultra-filtration, reverse osmosis and UV treatment processes may be taken up. Reducing wastages through repair of supply pipes, using waste water for purposes like construction may also be introduced.

3.3 Environment

A Smart city must have smart environment so that it is able to cope up with the challenges and adversities it faces due to the natural and anthropogenic causes. Environment includes the natural environment comprising air, water, soil and forests as well as the built environment which includes buildings, parks and green spaces created or modified by people. It impacts indoor and outdoor physical environments and social environments and subsequently the health and quality of life.

3.3.1 Green Spaces

It is essential to have green spaces in an urban center. The Delhi Ridge, often termed as the 'lungs of the city', acts as a pollution controller, climate moderator, preventer of soil erosion and a habitat for birds and wildlife. The forest cover of Delhi is less than the prescribed 23% necessary for ecological sustainability. The city has more than 20,000 parks and gardens, 40 city forests, 5 ridge areas, 2 biodiversity parks and 1 wildlife sanctuary managed by development authorities and municipal corporations. Delhi Parks and Garden Society, registered under Societies Registration Act, 1860 has the objective of greening environment by identifying vacant spaces in coordination with local bodies. Delhi also has the presence of roadside greenery called green belts.

3.3.2 Green Buildings

An important aspect in a smart environment is to have sustainable urban designs under healthy urban planning. In order to have sustainable habitats, councils like GRIHA (Green Rating for Integrated Habitat Assessment) interact on scientific and administrative issues which are adopted by the Government of Delhi. It also provides ratings to buildings. The Government of Delhi has brought out an 'Action Plan for Implementing the Climate Change Agenda 2009-2012' with an aim "to reduce the energy consumption in existing buildings by 30-40% in relation to the conventional buildings, make at least 250 green buildings by adopting the green building standards and 50% buildings be retrofitted for this and another 50% new buildings be made."

The Government of Delhi has made mandatory implementation of the Energy Conservation Building Code (ECBC) in government buildings and building complexes (new construction) including buildings and building complexes of municipalities, local bodies, boards, corporations, Government aided institutions and other autonomous bodies of the Government of NCT of Delhi. It has been taking measures in site selection, orientation of buildings, rain water harvesting, using LED and solar lights, re-use of water and efficient waste disposal with major portion being recycled.

3.3.3 Pollution

Pollution is a major threat to life in Delhi. Along with the poor quality of water, the Air Quality Index also depicts a worrisome picture of Delhi. The high levels of PM 2.5, ground level ozone, carbon monoxide and SOx / NOx have made the city prone to health risks. The positive benefits of conversion to CNG are largely lost due to the ever increasing number of vehicles in the city. The figures in Table 6 reflect the huge pressure of vehicles on Delhi roads.

Table 6: Registered vehicle in Delhi (Source: DoE, GNCT of Delhi, 2014).

Vehicles (Number)	Private Cars	Two Wheelers	Taxis
2012-13	2474476	4962507	70335
2013-14	8293167	5297697	78686

Delhi is also facing increased noise pollution levels in Delhi/ NCR beyond permissible limits as formulated by the Central Pollution Control Board. The industrial and commercial areas as well as the congested roads are the hubs of the highest pollution levels.

3.3.4 Waste Management

A Sustainable Environment should also take care of its wastes generated from different activities because untreated and inadequate waste management leads to pollution, degradation and health hazards. Approximately 9000 million tonnes of municipal solid waste is generated daily in Delhi. Disposal of solid wastes has become a major issue with huge sanitation landfills causing air and groundwater pollution. Three of the four existing landfill sites have become over-full and fresh sites are not available with states forming boundaries around Delhi (Table 7). The municipal bodies and department of flood control are delegated with the responsibility of waste management. Debris from construction sites, non-biodegradable materials, e-waste in open areas and the

Yamuna causes major pollution and health risks. Sustainable waste management strategies require segregation, pre-treatment, followed by incineration/ autoclaving/ irradiation as per the waste with finally transportation to the landfill sites. There are waste management practices and rules according to the type of waste like bio-medical, e-waste which should be followed. Another aspect of waste management is to optimize the use of resources with the focus on reduce, reuse and recycle. The draft concept note of the Government of India on smart cities has also highlighted the importance of clean cities with appropriate waste management.

Table 7: Landfill sites and waste-to-energy capacity (Source: DoE, GNCT of Delhi, 2014).

Landfill Site	Waste (tons/day)	Power Generation (MW)
Okhla	1950	16
Ghazipur	1300	10
Narela-Bawana	3000	24 (yet to be functional)
Bhalaswa	500	-

3.4 Information & Communication Technology

The development of a 'digital city' within the 'smart city' ensures online presence of Government through websites, facilitating government-to-citizen interaction in terms of citizen charters, providing facilities like social networking, e-commerce, e-banking with emphasis on sectors like intelligent transport systems, education, health, administration, healthcare etc. These are the areas which Delhi needs to emphasize in order to improve the quality of life through smart information and communication technology (ICT). The department of information technology was set up in year 2000 to implement IT policy of the government in the National Capital Territory of Delhi. The aim was to put technology to its highest and best use through the government of Delhi in all departments and autonomous bodies to improve the administration of services and programs.

The state has implemented a Citizens' Charter with an aim to provide an efficient delivery of services in the most effective manner. The idea will also bring transparency and accountability on the part of government by building trust and confidence of the citizens. The IT policy of Delhi is governed by 6 E's, namely, e-governance, equality, education, employment, entrepreneurship and economy. Realizing the huge potential and application of IT in Delhi, the government has announced development of free public Wi-Fi access zones. Initiatives of compulsory computer labs, online student management systems, library management systems are emphasized by the government in this regard. The upcoming areas for the use of ICT are health, transport, tourism etc.

3.5 Smart People

All efforts are eventually meant for the best utilization of the human potential and facilitating a better life for the citizens. Smart dwelling requires optimal housing, education and health services along with optimal resource utilization, better communication and technological advances. While these are the necessary conditions for better living, the sufficiency condition is the attitude towards environmental protection, conservation of resources and preservation of heritage monuments. This stewardship can lead to intergenerational transfer of good living.

3.5.1 Housing

Like most megacities, Delhi has a wide range of residential facilities spread over various localities. There are highly developed residential areas in many parts of Delhi. However, people with limited means for housing often end up living in slums or unauthorized structures. A smart city cannot be visualized in this scenario. These slums are devoid of basic facilities like drinking water, sanitation, education and health. The growth of slums has resulted in environmental degradation as well as social tension and other problems. The general policy adopted by the government is two- fold. On one hand, no fresh encroachment shall be permitted on public land by the land owing agencies. On the other hand, the past encroachments in existence till 31st January, 1990 will not be removed without providing alternatives. This creates a dilemma in treating the current dwellers and the new comers. If a clean city is to be made, then clearing the slums is a challenge. Similar attention is paid to the rural villages in Delhi with the constitution of Rural Development Board for Delhi in 2004 to ensure integrated rural development. The board formulates plans with priority projects and schemes to implement the Rural Area Plan. The focus is to provide solutions to the problems of slums, villages and to restrict their growth in future. It also specifies that the new buildings or housing projects should be finalized in a way which optimizes the use of energy, water, space and environment.

3.5.2 Education

Education is considered to play an important part in realizing the full potential of individuals. Delhi records a literacy rate of 86.20% comprising male literacy at 90.90% and female literacy at 80.80%, both higher than the national average. The number of recognized schools

in Delhi is 5,453 with the number of enrolled students in schools as 43.95 lakh in 2013-14 with a student: teacher ratio of 32:1. Government schemes like Mid-day Meal, *Sarva Shiksha Abhiyan* (drive for universal education) have been able to increase the enrollment rate. Delhi also has the best institutions of higher learning in the country, namely, universities, colleges, technological, medical and management institutes. The sector needs to be coupled with technology to make education more effective which provides future opportunities for employment in different sectors. The city has 9 district employment exchanges with one online portal giving details about the upcoming jobs and preparation of employment manual by jobseekers who register at the employment portal. Therefore, applying the IT in these sectors can yield better results leading to improvement in quality of life.

3.5.3 Health

Being healthy is a right of every citizen which includes physical, social and psychological wellbeing. With congestion, changed lifestyles, and problems of pollution, citizens in the city are facing severe health problems like obesity, cardiovascular diseases, mental stress, respiratory disorders that inhibit individuals to realize their full potential. A megacity like Delhi has a greater burden. Being the capital city, people from neighboring states come to Delhi for getting better treatments. It has the location of major hospitals with specialized wards and clinics. There are 95 government hospitals, 1,451 dispensaries, 267 maternity homes and sub-centers with a total capacity of approximately 47,398 beds. The current state of the health sector needs improvements in terms of its functioning which is largely affected by overcrowding, especially at the government hospitals which are more economical. Units for women and child care also need improvement by enhancing public confidence through people-friendly approaches. Cleanliness is yet another issue which needs to be addressed. The health sector at present is largely dominated by private hospitals which are by far more costly. One transformation could be the use of ICT in this sector. Another aspect of better health implies a healthier life style, exercising, cycling etc. People should be encouraged to opt for bicycles to commute shorter distances by making cycling safe in the city. Ensuring cycling tracks will serve the dual purpose of healthy living and eco-friendly ambience. Walking as a practice is also helpful. This needs commitment by people to make efforts to have smart health.

3.5.4 Heritage Sites

Though heritage or monuments have greater historical significance and are a part of built environment, the fact that it is meant for people makes it significant. Delhi has a rich history and monuments are found all over the city. The city has a great potential for being developed as a 'heritage city' within the broader concept of smart city. The government alone cannot realize the idea in practice, it needs equal participation and support of citizens who should cooperate to maintain and preserve the present state of our heritage. As guardians of the city, they have to inculcate a habit of ensuring their cleanliness and a sense of stewardship towards the future citizens. Therefore, heritage is another aspect which needs to be taken care of in the proposed model of smart city. 'Smart people' is a two way approach. Along with government initiatives, it needs a citizen-centric view to make people feel a sense of ownership that will make their participation voluntary and broad-based.

4. Citizens' Perception: The Survey

A smart city should not only be a public policy, it should also be in people's perception. A survey was conducted to assess how the citizens of Delhi rate the status of transport, energy, water, waste, ICT, environment and awareness about being smart. A random sample of about 50 people from different groups of income, age and professions were chosen for the same. The findings of the survey are furnished below.

1) Knowledge about smart city: 60% of the respondents were aware and 40% were not. 2) Sources of knowledge: Newspaper, television, internet are the dominant sources of information as compared to magazines and radio. 3) Mode of transport: Ridership in metro 32%, bus 22%, auto rickshaw 14%, taxi 6%, car 9%, two wheelers 10% and others 7%. 80% of the respondents felt that metro and bus are cost effective, safe and comfortable modes of transport. Bicycle is not a preferred mode for the majority of the sample because of traffic congestion, inadequate cycling lanes and insecurity despite its environmental benefits. Among those owning vehicles, 37% of the households have at least one vehicle and 31% having 2 vehicles, of which around 41% of the vehicles are older than 10 years. 4) Energy use pattern: The electricity bill depends on the use of electrical gadgets and family size. More than half of the population surveyed pay a bill ranging between Rs.200 and Rs.3000 per month which they feel is justified. The dominant (73%) type of cooking fuel is LPG cylinders while 23% use piped gas and only 4% use firewood, kerosene etc. 5) Water availability: 83% of the total water use comes from the municipal supply, 15% hand pumps and the rest from water tankers. The average water bill is Rs.100-200 per month while a large section of the poor do not pay any charge. The duration of water supply in general varies between 6 to 16 hours per day. 6) Environment: 87% of the respondents

are aware of the problem of pollution in air, water, noise and soil. 11% of them felt that the solution is the responsibility of the state, 17% voted for the communities, 6% for individuals and 66% felt all agencies need to collaborate for mitigation of pollution. 7) Waste Management: Most people use dustbins for kitchen waste and general household waste. Newspapers and e-wastes are mostly sent to scraps and polythene is generally reused. Burning and open disposal were found to be very rare. 8) Heritage City: While everyone felt the need for protecting historical monuments, only 14% were in favor of strict laws, 26% for economic fines, 12% for individual awareness and 48% for all of these. 9) IT and communication: 84% of the respondents use the internet for various purposes. While 30% use it for education, 26% use for social networking, 25% for professional reasons and 19% for e-commerce and e-banking. 10) Miscellaneous: People revealed strong preference for government initiatives in areas of health and education. They showed willingness to install energy efficient devices and participate in citizen-friendly initiatives towards environmental protection. 11) Delhi as a smart city: 37% of the respondents felt that Delhi should be a smart city while the others are either ignorant or indifferent.

The citizens of Delhi have revealed reasonably good awareness about the concept of smart cities. The current scenario of water and energy resources is not at the expected level. The transport sector has problems of availability, safety, economy and pollution too. However, the people of Delhi have clean habits regarding the choice of fuel and waste management. They are exposed to the use of smart ICT and e-services. There is a definite need for improvement in the social sectors. The role of the government is also felt strongly. Those who are aware of the smart city concept are ready to participate in this new venture that the government has already initiated. With requirements for certain developments and some already initiated steps, Delhi can surely be visualized as a future smart city.

5. Concluding Remarks

5.1 Recent Developments

Delhi Government has announced to develop Rohini, Dwarka, and Narela areas as sectors of the smart city with improvements in water, electricity and Wi-Fi connectivity. Operational and business models of public bicycle sharing scheme is under process. Pollution will be reduced by 25% by repair of roads and broken footpaths. The plan includes grass to be planted on dusty patches with a plan to evolve a unified air quality monitoring system. The plasma gasification system and the water recycling model of Singapore is being studied for possible implementation. The National Green Tribunal (NGT) has planned to ban all diesel vehicles that are older than 10 years, construction activities on road and open burning of crop remnants in neighboring states of Delhi. The odd-even car formula is also in place to curb vehicular pollution. Companies have been invited to devise best practices of a smart city. Installation of roof-top solar panels is being promoted on a priority basis. The Union Cabinet has given nod for building 100 Smart cities after it was announced in the Union Budget 2014-15 with an outlay of Rs.48,000 crores. Each city will be given an assistance of Rs.100 crores per year for 5 years. "The mission is to recast the urban landscape of countries by making cities more livable and inclusive besides driving economic growth". The projects for future smart cities will also be invited through 'smart city challenge'.

5.2 The Draft Concept Note

The Government of India has prepared a draft note available in the public domain which discusses the scheme of setting up hundred smart cities. With its focus on the smart parameters, it tries to design a sustainable growth plan. Largely, it needs to prepare a master plan with a broad vision with small plans in its ambit so that each sector is focused in this larger approach. State Governments will be supplemented with financial resources for capacity building. This will be supplemented by building a program which encompasses training, education, database and personnel for effective implementation. The draft plan discusses the key strategies of the project encompassing the planning, organizing, and implementation of smart cities.

5.3 A Strong Case for Delhi

People make cities and thus smart people make smart cities. The city of Delhi is unique in terms of its history, heritage, demography and culture. Being the capital it has continued to attract people like any other city. With challenges posed due to the issues of urbanization, it has to strive towards making future goals of social and environmental sustainability, achievable with an aim to be economically competent. Therefore, it has to modify its present growth pattern and move towards the idea of a smart city. As observed from the secondary information, Delhi has high potentials to come up as smart city. Although the current state of resource use, transport systems, environmental standards etc. are not at par with the best international standards, there is a large scope to improve upon those and move towards a smarter solution. This micro-level study also revealed that the citizens of Delhi are ready to take part in this endeavour in every

possible way. The macro motive of building this city will serve the micro purpose of its stakeholders by providing a better quality of life. The smart city model has been successful in some major cities of world. With the proposal of the same in India, a city like Delhi represents a strong case. It has the crucial presence of infrastructure which has the potential to transform the scenario. From deficient resources to effective resources, from restricted to open access, from degraded to improved state of environment, from worse to better quality of life, all can be achieved with this visionary idea. This needs not only effective planning, finances, vision and implementation but also a constant support from the citizens who are the major stakeholders in any urban endeavour. The Government is the major actor which needs constant dialogue, interaction with people and cities that have previously been successful in this initiative. With the Government of Delhi taking a great initiative, a bright future is expected when Delhi will become a smart city with smart people living a smart life.

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