



Centre for Public Policy
Indian Institute of Management Bangalore

Low cost Smart Cities

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Foreword

The Centre for Public Policy (CPP) at the Indian Institute of Management Bangalore is engaged in conducting research and imparting education in public policy and public service delivery. CPP focuses on capacity building in policy implementation and policy management through action research and training, dissemination through research through publication series, workshops and seminars with participation from policy makers and administrators. The Annual International Conference on Public Policy is a flagship event of CPP and it would be conducting its tenth Conference in Aug 2015. It also conducts periodically Public Policy Talk Series.

CPP was established in 2000 by IIM Bangalore with support from UNDP and the Department of Personnel and Training (DoPT), Government of India (GoI) with a mandate to provide policy research support to government and improve visibility of policy domain in India.

CPP Conducts research and action research in several areas like Urban Governance, Public Service Delivery, Inclusive Finance, Health Economics, Education, and Infrastructure and Utilities.

CPP has launched this Policy Discussion Series to bring out Policy Inputs Papers in areas of priority for government and public, and in the areas mentioned above. These papers will bring out comprehensively the issues, the evidences, the status, the debates and the alternatives. These papers also could emanate from research which are underway to help solicit expert views and public opinion. These papers will be presented to the policy makers, administrators, and members of civic societies. We hope this would improve the deliberations on the policies under consideration among the policy makers and concerned citizens and facilitate making of better decisions.

This Series on Low cost Smart City is a Continuum to the previous Discussion Series paper on Smart Cities: A Framework. This paper highlights scope for incorporating low cost solutions for building smart cities and lists various illustrative interventions implemented globally towards this purpose. We hope policy makers and administrators from the urban field would find this useful.

We welcome contributions to this Series from researchers in Public Policy.

G Ramesh

Chairperson

Center for Public Policy

Executive Summary

Various approaches and projects for developing Smart Cities are discussed in this paper. Some of the projects can be capital intensive and can make it unaffordable for ordinary people. In this context, we have tried to develop a framework for Low cost Smart Cities. We feel that at least the Tier 1 and Tier 2 cities should adopt low cost models, as megacities would require capital intensive projects like metros, and elevated corridors. This paper provides such a framework and enlists best practices in low cost infrastructure and service delivery globally. We have explored various caselets around the world which were successful in bringing in various smart and low cost interventions for the better functioning of cities. Through this paper we also propose that we need to look at developing alternate cities than focusing on the existing cities by ignoring its carrying capacities. The proposed low cost and efficient interventions with emphasis on environmental conservation can also help in the development of alternate cities without putting pressure on the existing resources.

We have analyzed caselets covering various sectors such as: citizen engagement & governance, mobility and transport, city decongestion, energy management, water management, storm water management, sewage management, solid waste management, smart buildings, health, education, environment and safety & security. Innovative, efficient as well as cost efficient practices in each sector have been analyzed with the help of these caselets. This study has given emphasize for various features such as conservation of natural resources and environment, participation of people in development, transparency, use of advanced technologies, inclusive planning , broad level planning with integration of various systems, use of decentralized and natural methods wherever possible, efficient management etc.

Based on the analysis of these caselets we have consolidated various interventions into a framework to facilitate possible interventions for each sector in the context of building Low cost Smart Cities. The various interventions are summarized in Table 1.

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1. Introduction

The resources of a City must be optimally utilized with least wastage of resources to be smart. Delivery of various municipal services and utilities has to be efficient and effective. The initiatives have to be affordable and inclusive. In this study, we have tried to explore various practices and scope for low cost strategies for a Smart City comprehensively.

In the Low cost City framework, we believe that the policy makers should be actually targeting optimizing usage of resources than maximizing provisioning of resources and services. We believe that the government should enunciate policies that encourage optimizing usage of resources like water, power, etc., minimizing need for mobility, minimizing generation of waste, etc. This can be achieved through more intensive participation of citizen. IT and transparency can be critical instruments of effective administration.

At the outset, this paper would like to make an observation. It is fashionable for all urban planners of cities to provide for rapid growth of their cities. They should concentrate more on developing alternative cities than pumping money into the same cities. Globally, the growth rates of cities have been coming down and we are one of those who are upbeat about taking the cities through rapid growth and to the neglect of developing alternative cities. Ideally, there should be a carrying capacity for each city in terms of mobility, water, space, environment, etc. but policy makers feel any available space is scope for development. Only way to ease pressure is to develop alternative cities.

1.1 Smart City: Areas of Interventions

Areas of interventions under the Low cost Smart Cities are discussed under various categories as below:

- Citizen engagement & Governance
- Mobility and Transport
- City decongestion
- Energy management
- Water management
- Storm water management
- Sewage management
- Solid waste management
- Smart buildings

- Health
- Education
- Environment
- Safety and security

Various smart and low cost practices and designs for Smart Cities were identified and discussed in the following sections. An analysis of these interventions have been consolidated and presented in Table 1 in page 48.

2. Citizen Engagement and Governance

In Smart Governance, participation from citizen has scope to increase the quality of service delivery with better transparency. Advances in Information Technology (IT) can help in achieve better governance through Open Data and effective coordination of various services among government departments themselves. In a Smart City, citizen participation and involvement in decision making are very critical components for achieving transparency in governance. In Smart Cities, ICT plays a major role in providing secured e-services and open data to the public which helps in improving the efficiency of city service provision, reduction of time and effort required for availing services and in making the system transparent.

2.1 Citizen and Government Interface

Various smart initiatives and programmes have been initiated globally targeting better governance system through effective citizen participation. Practices like participatory governance, decentralized governance, horizontal governance, performance assessment of governance, information sharing, transparent grievance redressal mechanism, etc. have helped in improvement of efficiency of governance. In this section, we have highlighted practice of these concepts which help make citizen smarter and governance better.

2.1.1 Horizontal Governance

‘Horizontal Governance’ refers to coordination among Ministries themselves in terms of its consultative process, accountability: collectively and severally, and institutional arrangements. This governance refers to institutional arrangement at various levels of hierarchies among departments. **Vertical Governance** is administrative mechanism within a Ministry. It can also include civic agencies and private sector partners wherever involved at various levels. In Horizontal Governance, the hierarchy is replaced by matrix structure and the emphasis

is on coordination, shared responsibility and the decision making is done in a collaborative manner. Some of the characteristics of horizontal governance include: Non-hierarchical structure, emphasis on common interests and partnerships, and coordinated government. Horizontal governance assures superior quality service delivery (Ferguson, 2009). Smart City should facilitate fostering of Horizontal Governance.

2.1.2 E- Government in Sri Lanka and Government Information Center - 1919

The e-Government strategy of Sri Lanka is considered as one of the best in Asia. The e-government in Sri Lanka is holistic in nature which has utilized ICT to connect all sectors of economy and society. The Information and Communication Technology Agency (ICTA) was created to implement 'e-Sri Lanka' and they coordinate and supervise the programmes under e-Sri Lanka. Programmes being implemented under e-Sri Lanka include ICT Policy, Leadership & Capacity Building; Re-Engineering Government; e-Society; ICT Investment & Private Sector Development; ICT HR Capacity Building; and Information Infrastructure. These programmes are further divided into various components and transform into projects and activities (Rainford, 2006).

'Government Information Center (GIC) – 1919' is one of the main projects under the Re-Engineering Government (Re-Gov) programme. The GIC programme has been initiated to help the citizen in gathering the correct and relevant information about citizen services provided by various government organizations. This service is provided through a call centre with the number '1919' and it is available in Sinhala, Tamil and English languages. The same information is made available also at the GIC website, "www.gic.gov.lk". This initiative has helped the government in organizing and presenting information related to various departmental services in a logical and citizen-friendly manner (ICTA, 2015). Information is made available about various sectors such as agriculture, livestock and fisheries; education and training; banking, tax and insurance; health, well being and social service; travel, tourism & leisure; housing, property & utilities; etc. (Government information Centre, 2015).

2.1.3 Sakala, Karnataka

The 'Karnataka Sakala Services act 2011' assures timely delivery of 669 guaranteed services to the citizens of Karnataka by the concerned government departments (Government of Karnataka, 2015). Sakala services covers various departments such as transport department, revenue department, commercial taxes department, Bangalore water supply and sewerage board, Karnataka housing board, commerce and industries department,

etc. (Government of Karnataka, 2015). The Sakala services can be availed with the help of an online platform as well as through telephone calls. The IT solution for transparent functioning of Sakala has been developed by National Informatics centre (NIC). The citizens can monitor the status of the service request online or through phone, with the help of an acknowledgement number which is generated while submitting the service request. The citizens get updates on the registered mobile number about the status of the application and there is a complaint redressal system which works with the help of a call centre. For any delay in the service provision, the citizens are also eligible to claim a compensatory cost per day which will be deducted from the salary of the concerned officer in charge (Government of Karnataka, 2015).

2.1.4 Municipal Performance Measurement Program, Ontario

Municipal Performance Measurement Program in Ontario is a comprehensive program in which the municipalities provide performance measurement information to the Ministry of Municipal Affairs and Housing and report the performance result to the citizens. This helps the municipalities in providing best quality services at an efficient cost with clear accountability. In such a system linked to performance and rewards for creativity, space for more innovative ideas arises and the performance of municipalities improves. In a scenario with performance measurement, citizens are able to take informed decisions about what level of services they want, since they are made aware about government's plans, actions, result and also the cost associated with each. The government is able to check whether expected service levels are being met and they can allocate realistic budget for each sector (Ministry of Municipal Affairs and Housing, Ontario, 2007).

2.1.5 Participatory budgeting: Cologne, Germany

Cologne in Germany has implemented Participatory Budgeting which involves its citizen's participation in budget. To increase the participation of citizens, they have also developed a mobile application. The introduction of mobile application attracts more younger and urban population in Participatory Budgeting. This system can be used for a variety of purposes like public consultations also (Manchester City Council, 2014).

2.1.6 Good governance: Kudumbashree in Kerala

Kudumbashree is a poverty eradication programme introduced in the year 1992 in Kerala and the programme is designed to reach out to the families through women participation. This programme functions with the help of hierarchical community groups created at various

levels which ultimately connects with the Local Government. Thus women are made part of all the development initiatives and also help in their empowerment through saving and credit system, enterprises development, participation in governance activities through the community groups, etc. The women above poverty line are also allowed to be part of this system. Kudumbashree is the largest women movement in Asia who has around 36 lakh members in it, who also represent equal number of families (C.J & M, 2013). Kudumbashree has helped in achieving a strong participatory governance system with the help of self help groups and Local governments which are transparent in their operations.

The three tier structure of Kudumbashree's Community Based Organization (CBO) is the back bone of Kudumbashree's success. The lowest tier known as the Neighbourhood Group (NHG) consists of 10-20 women members and all the NHGs in a ward are federated to form the Area Development Society (ADS) at the second tier. The activities of ADS are managed by elected representatives from each of the NHGs. All these ADS together at the Panchayat or Municipal level are federated to form the Community Development Society (CDS). These CDSs represent all the NHGs at the Panchayat or Municipal level and they work with the local self-government (LSG) in many activities such as community need assessment, implementation of various government programmes, information dissemination, etc. Some of the specific functions of CDS includes LSG liaisoning, community network strengthening activity, facilitating income generating activity, facilitating identification of poor for the purpose of LSG led development programmes, articulation of community demand for development, LSG plan intervention, facilitation of centrally sponsored schemes, etc. (Kudumbashree, 2015).

2.1.7 Seoul, South Korea

Seoul is one of the most tech-savvy cities in the world. Through the 'Smart Seoul 2015' initiative, Seoul is aiming to implement a lot of smart technologies and to improve the relationship between city and its citizens. Citizen and Governance is one of the areas which was given emphasis and some of the initiatives such as mobile Seoul , promotion of open governance, Content Management System (CMS) based home page of Government, online reservation system for public services, etc. have helped the city in improving the Governance system in a smarter way (Hwang & Choe, 2013).

The application "Mobile Seoul (m.Seoul)" provides a wide range of public information over the mobile with prioritization of most commonly demanded information. The range of information includes location of public facilities, climate alerts, hazards, real-estate listings, job opportunities, etc. and it also involves the citizen in participation in city improvement

plans through suggestions and 'yes/no' voting. CMS based home page of the Government helps in sharing of public information openly through a single platform. Open governance promotion and the government information sharing help the citizen and private sector in making use of the administrative information effectively. It encourages the private sector to come up with innovative solutions which suits the need of the public and it also helps the citizens in making use of the opportunities available in business, jobs, public services, etc. Another interesting feature of Seoul's smart governance is the online reservation system for public services which allows the citizens to use an integrated reservation system for searching, booking, and paying for public services instantly. Around 150 services are comes under this system which includes education, infrastructure, medical treatment, etc. (Hwang & Choe, 2013).

2.1.8 Bristol, England: Computer give away scheme

In Bristol city, the government has come up with a viable solution to increase the reachability of on-line services and other information like job and training opportunities to all sectors of the population. The government, along with a local partner refurbishes and distributes the used computers to deprived families, which otherwise will be discarded. Thus the poor families are also able to get the benefits and discount offers available online (You, 2013).

Bristol City Council started this scheme in the year 2010 to make sure that any citizen of the city who wants to have a computer should be able to get one and due to the popularity of this scheme, the demand exceeded the supply. The government then stopped the scheme for some time to refine and improve the scheme. They re-launched the scheme with some conditions such as people who are over 65 years of age, have a disability, have a child receiving free school meals, people with very low income, etc. only will be allowed to purchase a refurbished PC at reduced rate (Kevin, 2014).

2.1.9 Bangalore one

Bangalore one is an initiative of Government of Karnataka for the provision of integrated services with convenience, enhanced speed and accountability, to the citizens by using ICT. It is a one stop solution for a large number of services including water supply, electricity, telephone, railway ticket booking, bus services to name a few. Objectives of Bangalore one includes provision of more transparency, accountability, and responsiveness to citizens; cost effective service provision with speed; real time data availability for various departments, etc. The services of Bangalore one is provided through computerized Integrated Citizen Service Centers (ICSC's), electronic kiosks, internet as well as mobile phones. Productivity

of the administrative system improves drastically with the introduction of such a system for service provision (Government of Karnataka, India, 2015).

2.1.10 Direct Benefit Transfer (DBT), India

Direct Benefit Transfer (DBT) was introduced by the Government of India in the year 2013 to ensure that the benefits and subsidies given to people go to their bank accounts electronically. This reduces the procedures involved in the fund flow and ensures transparency. The payments reach the actual beneficiary on time without any delays. Around 28 schemes including the subsidy given on LPG cylinders for domestic use are included under DBT and it is implemented in stages in the identified districts (Ministry of Finance, India, 2015).

3. Mobility and Transport

Government has to veer away from simply making provision for more transport infrastructure to tackle the pressure of mobility. It should explore alternate policies like land use changes, promotion of e- connectivity, distributed growth nodes, satellite towns, etc. so that the need for travel itself reduces considerably on a daily basis. Also, policy regulations (eg: School admissions within certain km radius) can play a big role in reducing congestion. Promotion of public transport, well designed and safe pedestrian pathways, cycling tracks, promotion of electric vehicles, etc. can promote pollution free transportation and conservation of energy and money.

3.1 Interventions in Mobility and Transport

Mobility and transport is one of the key areas which need to be looked into, for ensuring efficient functioning of any city. Some of the low cost and smart initiatives in this sector have been discussed in this section, which includes parking management system using ICT, congestion pricing, promotion of bicycles, Bus Rapid Transit System, Traffic & Transit Management Centres, etc. Adoption of suitable interventions in this sector is of utmost importance to ensure smooth functioning of a city.

3.1.1 Vélib': Bike-Sharing in Paris

Vélib', the bike sharing system in Paris was launched in the year 2007 and it is one of the best bike sharing programmes in the world which has helped in reducing the traffic congestion in Paris. The users have to pay a daily or annual fee for using the bicycles and it has a large number of users including tourists. Employees have been assigned to do the maintenance

of these bicycles. This bicycle sharing system helps in provision of an economic mode of transportation with convenience in an eco-friendly manner (Asseraf, 2013).

3.1.2 Seamless Multimodal transport: Copenhagen, Denmark

Copenhagen, the capital city of Denmark has integrated sustainability into its development. The city's transportation sector has incorporated various interventions to achieve efficiency and sustainability. The city has developed physical as well as online integration among various modes of transport such as bus, train and metro services. This helps the passengers in moving seamlessly by using various modes. They have also integrated cycling into this public transport system by providing uninterrupted cycle lanes and easy transfer to public transport services. Some of the features of this integrated multimodal system include:

- Provision of real time information through digital signs and text messages about the arrival time of buses, delays in the train systems, etc.
- An online journey planner which helps in planning the journey from one point to another using various modes.
- Provision of bicycle parking at metro stations and train stations
- Keeping the traffic signal lights green if buses are approaching by use of GPS technology and radio which enables traffic controllers
- Text ticketing facility which allows the user to text the destination to receive a text reply which serves as a ticket.
- One ticket can be used in bus, train and metro with transfer between modes made free.

Integrated public transport with high reliability and efficiency has helped in reducing the traffic congestion and in making travel convenient with high mobility. This move has helped in the reduction in use of private cars, leading to reduced CO₂ emissions. This well integrated public transport network helps in saving time, money and leads to improved quality of life (City of Copenhagen, 2012).

3.1.3 Traffic Transit Management Centres (TTMCs), Bangalore

The Traffic Transit Management Centres in Bangalore have been developed with the aim to provide integrated transport facilities and related amenities for all the user groups. Bangalore has 10 TTMCs spread out at various locations in the city. Facilities provided at the TTMCs includes bus bays, platforms, seating, information systems, Bangalore One centers (one

stop solution for various services), ATMs, shops, etc. These centres help in reducing the congestion on the roads as well as make the transition to and from the terminals smooth and fast which eventually promotes the use of public transport (BMTC, 2015).

3.1.4 Bus Rapid Transit System (BRTS), Ahmedabad

Ahmedabad has around 89 km long Bus Rapid Transit System corridors. The BRTS was introduced here with the principle of connecting busy places in Ahmedabad by avoiding busy roads. The construction of BRTS ensured that the road space for other vehicles were not reduced and also provided a good transport service to the regular bus users. The BRTS in this city has created a city wide network which helped it in merging well with the city needs. The buses are privately owned and operated, but the bus design has to follow certain conditions to suit the bus stations as well as for convenience of people (Mahadevia, Joshi, & Datey, 2013).

3.1.5 The Delhi Metro

The Delhi Metro project was constructed to solve the increasing traffic issues of Delhi. Along with the population increase of Delhi, vehicular traffic was also increasing. The Delhi Metro has played a major role in relieving the transport issues faced by the citizens. The Delhi Metro rail Corporation Ltd (DMRC) which was responsible for the construction of Delhi Metro, formed consortiums for providing it with latest technology and to advise it on various aspects of the Metro project. The project is implemented in 4 phases and Phase 1 and Phase 2 are completed and fully functional. Due to efficient planning, project design and cooperation of all the stakeholders, the Phase 1 and phase 2 of the project was completed successfully on schedule and the next phases are also under progress. People living in a wider geographical area are able to utilize the benefit of Delhi Metro due to the well planned network (ICMR, 2006).

Metro feeder buses operated through contractors helps in connecting commuters with the Metro network in a convenient manner. The route length of the feeder buses were up to 5 km initially and then increased up to 10 km. These CNG buses are environment friendly and include safety measures such as fire extinguishers. The well managed control centres monitor the feeder bus movement across the city (DMRC, 2015).

3.1.6 Inter State Bus Terminals (ISBT), Delhi

There are three Inter State Bus Terminals (i) Maharana Pratap ISBT at Kashmere Gate; ii) Swami Vivekanand ISBT at Anand Vihar; and iii) Vir Hakikat Rai ISBT at Sarai Kale Khan in Delhi which are operated by the Delhi transport Corporation (DTC) . DTC operates intercity buses connecting Delhi with other states along with local bus services. These bus terminals are provided with amenities such as toilets, drinking water, shops, first aid facilities, cloak room, parking, bank, post office, etc. (Govt. of NCT of Delhi, 2015). Separate terminals for inter-city transport and segregation of the same from the local transport terminals can help in reducing the congestion to a large extent. But the connectivity of these terminals to other modes of travel such as railway station, metro rail, local bus stands, airport, etc. are of crucial importance in achieving the purpose of these Inter State Bus Terminals. Transport infrastructure cannot sustain individually without ensuring a seamless multimodal transport facility with proper linkages.

4. City Decongestion

Unplanned development combined with fast growth leads to congestion in cities. Future growth rate as well as direction of growth should be taken into account while bringing in decongestion measure in any city. Land use planning combined with transportation has a huge role to play in helping decongesting cities. Measure taken for decongestion should be able to sustain on a long term basis.

4.1 Interventions in City Decongestion

Some of the successful city decongestion measures have been analyzed in this section. These caselets have been included considering the fact that these emphasize measures which have combined land use and transportation to efficiently manage congestion in cities. This integrated approach can help in reducing the need to travel and it also helps in reducing the travel time.

4.1.1 Parking management

A major problem associated with urban mobility is the traffic congestion caused by vehicles looking for parking within city area, which also contributes to increased air pollution due to emissions. Efficient parking space management is necessary to tackle this issue and reduce congestion. ICT can play a major role in providing real-time data on parking space availability and route to the motorists so that they can select the shortest route to reach the

parking area. Information on parking slots availability can be captured on the basis of sold parking permits. Reservation of parking slots also can be done with the help of web based applications. The profitability of parking space management also increases with such well managed system where a nominal fee is charged for parking (SIEMENS, 2011).

4.1.2 Integration of Land Use and Bus System, Curitiba, Brazil

Integration of land use and transportation have helped in decongesting the city of Curitiba in Brazil. Promotion of linear growth along the structural axes of transportation helped in giving a direction for the growth in a planned manner. High-rise residential as well as commercial buildings are allowed close to the structural axis and the density reduces with increase in distance from the axis. Use of existing roads was redefined to suit the decongested development. The roads in each of the structural axes are divided into three, in which the central street is for public transport and local access with parking. On both sides of the central street there are one way streets for travelling away or into the down town area. Curitiba also has an express bus system known as Integrated Transportation Network which covers the entire municipality area through exclusive traffic lanes (Matsumoto, 2002). Success of decongestion measures in Curitiba can mainly be attributed to the well planned transportation system combined with the land use changes.

4.1.3 Congestion Charge in Stockholm, Sweden

Stockholm has imposed a congestion charge on majority of the vehicles as a traffic congestion and environmental tax. The congestion charge has been imposed in all the city centres. The system makes use of techniques such as wireless Radio Frequency Identification (RFID), Automated Number Plate Recognition (ANPR), transponders fitted in vehicles, etc. The income obtained through this system is used to finance building new roads. Exceptions are made for certain categories like emergency vehicles, buses, disabled persons vehicles, hybrid or electric cars, etc. and also for vehicles coming from certain areas which have no other alternate routes (roadtraffic-technology.com, 2015).

4.1.4 PARK & RIDE scheme: Singapore

Park & Ride Scheme in Singapore helps people in parking their car on the way and to make the remaining travel by taking public transport such as bus or train. This scheme makes travel faster, cheaper and convenient. The availability of parking sites can be searched using smart phones too, which makes it easier to find a parking space. These parking spaces

tend to be cheaper compared to the ones in the city centre, which helps in cost saving. This scheme encourages the public in taking public transport which eventually reduces the congestion in the city and also helps in saving the environment by minimizing air and noise pollution (LTA, 2015).

4.1.5 Decongestion: Bandra Kurla Complex in Mumbai

Bandra Kurla Complex is a good example for a smart solution for reducing congestion through spatial planning which helped in decongesting Mumbai city. The concentration of office spaces, hotels, convention complex, hospitals, staff quarters, club and other amenities in Bandra Kurla Complex reduces the pressure on other parts of Mumbai to a large extent and helps in reducing the need for transportation to a large extent (MMRDA, 2015).

4.1.6 Koyambedu Wholesale Market Complex (KWMC), Chennai

Chennai Metropolitan Development Authority (CMDA) shifted the wholesale markets for perishables to Koyambedu, which is at the periphery of the city. This decongestion measure helped in decongesting the Central Business District (CBD). Even though the market is at the city's periphery, it is easily accessible because of road connectivity. Development of the Chennai Mofussil Bus Terminus at Koyambedu and shifting of bus terminal from the CBD also has helped in decongesting the city (CMDA, 2008).

5. Energy Management

Power usage reduction possibilities should be explored with emphasis given on power conservation (eg: automated street lights) and power generation through non-conventional methods and renewable sources (eg: energy from waste, solar energy). Also government need to make policies for cost effective measures such as promotion of LED lights to reduce the cost considerably, eco-friendly and energy efficient buildings which require less energy, solar energy, etc.

5.1 Interventions in Energy

With rising energy requirement in cities, we need to identify smart energy utilization techniques with emphasis on energy conservation. In this section, we have discussed some of the smart energy concepts which can be adopted for Low cost Smart Cities. These caselets are about smart metering, Advanced Metering Infrastructure, energy conservation, renewable energy, etc.

5.1.1 Smart grid

The term Smart Grid Refers to advanced electrical power systems which utilizes information technology and communication for generation, delivery and consumption of electricity (IEEE Smart Grid, 2015). 'The Grid' refers to the networks of transmission lines, substations, transformers, etc. which are required to deliver the electricity to the consumers. An electric grid qualifies to be called as a 'Smart Grid' when it is automated and utilizes digital technology for two-way communication between the utility and its customers with sensing along the transmission lines. A smart grid is more reliable, efficient and capable of responding to the changing electric demand with the aid of automated control. Some other benefits of smart grid include, efficient transmission of electricity, faster restoration of electricity after power problems, reduced operations and management costs leading to lower power costs for the users, peak demand management, integration of renewable energy systems into the electric grid, better security, etc. (SmartGrid.gov, 2015).

5.1.2 Advanced Metering Infrastructure (AMI)

The term Advanced Metering Infrastructure describes the whole infrastructure and applications which enable real-time gathering as well as transfer of utility usage information related to energy, water and gas. AMI include remote meter reading to get error free data, problem identification in the network, energy audit, load profiling, etc. AMI helps in two way communication with the customers. Various components of AMI includes, smart meters, communication networks, Meter Data Acquisition System and Meter Data Management System. One of the benefits of AMI is the operational benefit due to the accurate meter readings, energy theft detection, etc. Financial benefits include reduction in equipment and maintenance costs, quick restoration of electric service during power outages, streamlined billing process with accuracy, etc. AMI helps the customers in managing their energy consumption with the help of time-based rate options. Enhanced monitoring mechanism in AMI also helps in increasing the security of the energy grid (ISGF, 2015).

5.1.3 Smart Metering

Installation of smart meters can help in reducing energy wastage and in conserving energy. Smart meters help in getting accurate bill for energy consumption. The user can keep a check on the energy usage and change the consumption pattern to conserve energy and money. Smart meters can also help in detection and prevention of theft of energy. Technical problems related to energy supply can be identified and resolved easily with

the installation of smart meters. Energy wastage is reduced with the introduction of smart metering (Consumer Focus, 2015).

5.1.4 Grid-connected SPV Rooftop systems

In the case of Grid-connected SPV (Solar Photovoltaic) Rooftop systems, the solar panels are installed on roof tops and the electricity generated is used for self-consumption with net metering or fed into the grid. The advantages of this system includes savings in transmission / distribution losses, reduced gestation time, saving of land since the solar panels are installed on roof tops, higher self-consumption of solar energy, etc. Installation of Grid-connected SPV Rooftop systems reduces the dependency on the grid power to a large extent with more reliability (Tripathi, 2014).

5.1.5 Local energy generation, Yokohama, Japan

Under the Yokohama Smart City project, efforts have been made to test the viability of local energy generation and to promote the same. In one such project, in a four storey building with 24 apartments, Household Energy Management System (HEMS) have been installed where the major source of power was 'ENE-FARM' (TERI, 2013). ENE –FARM is a residential fuel generation system. It utilizes a Polymer Electrolyte Fuel Cell (PEFC) to generate electricity from gas and it is also efficient in heating up water. It has high energy efficiency with low CO₂ emissions (TOKYO GAS, 2015). The system in this building includes 140 solar panels with a total output of 25 kW, 2 shared solar water heating systems, one nickel-hydrogen storage battery of 40 kWh and 10 number of 750 W capacity fuel cells. The heat generated during the electricity production is utilized for producing hot water for the households. The HEMS is an integrated control system which can predict the demand and supply of energy for the next day in the building including the electricity demand, hot water requirement and the solar electricity generation (with the help of weather forecast). Information is passed on to the users and they are given incentives to shift their peak hour energy demands. With the help of this system, almost 60% of the electricity demand and 90% of hot water demand can be covered during fine weather conditions (TERI, 2013).

5.1.6 Nagpur, India: Renewable Energy for Street Lighting

Most of the Indian cities are facing electricity shortages. Nagpur is emphasizing up on renewable energy and energy efficiency techniques to considerably reduce the conventional energy consumption. Nagpur is known as the first model Solar City in India. Energy efficiency measures taken by Nagpur between the year 2006 and 2007 includes, installation of solar

lights in Nagpur Municipal Corporation premises , high court premises and in gardens, parks, etc; installation of solar blinkers; and conversion of 70 watt High Pressure Sodium Vapour lights (HPSV) into 50 watt HPSV lights (Dowding-Smith, 2012).

5.1.7 LED Scheme India

The Prime Minister of India has launched a programme called ‘Demand Side Management (DSM) based Efficient Lighting Programme (DELP)’ in the year 2015, for the distribution of Light Emitting Diode (LED) bulbs in Delhi. LED bulbs saves energy and have around 50 times more life expectancy compared to ordinary bulbs. This is a strong move towards energy conservation through domestic consumers. A web based system helps the citizens in procurement of the LED bulbs under this scheme by registering the request. These bulbs are distributed at a subsidized rate. The government is planning to install LED lights in 100 cities, for domestic and street lighting purposes (The Hindu, 2015).

6. Water Management

Quality and quantity of water supplied is one of the critical factors which have a huge impact on the quality of living. Trend of water purification at household level should be reduced. Purified water distributed through a network can help in health cost reduction. Measures should be taken to minimize the water contamination. Minimization of water leakages through regular audits can help in water wastage reduction and in increasing the reachability of water supply. Emphasis has to be given on exploring reuse potentials of water which will eventually reduce the cost of water supply.

6.1 Interventions in Water supply

Water being a critical resource for the survival of any development, efforts are being made all over the world to use it efficiently. Water conservation measures in cities focus on leakage control along with awareness creation amongst the citizen to reduce usage and to avoid wastage. Some smart initiatives and interventions in the area of water supply have been discussed in this section.

6.1.1 Lake Rejuvenation

Lakes are one of the major sources of drinking water and irrigation. Lakes in urban areas are reducing in number due to improper planning of development. Various issues faced by urban lakes include pollution due to discharges from industries, sewage disposal, solid

waste disposal; eutrophication caused by farming practices using chemical fertilizers, etc. It is necessary to prevent the degradation of the lakes, rejuvenate them and manage them in a sustainable manner. Lake rejuvenation helps in storage of rainwater, flood management, ground water recharge and also helps in preserving aquatic bio diversity (iDeCK).

6.1.2 Australian Water Resources Information System (AWRIS)

Bureau of Meteorology, Australia is developing Australian Water Resources Information System (AWRIS) for providing water related information to the citizens. This system can receive, standardize, organize and interpret all the water data including river flows, ground water levels, water quality, water storage, water use and restrictions, etc., across Australia. This can help in better performance of water supply systems (Bureau of Meteorology, 2015).

6.1.3 Water management, Singapore

Singapore faced major issues due to water shortage, flood, water pollution, etc. But, it came up with efficient water management measures to tackle these issues. Its integrated approach with cost efficiency has helped in solving the water challenges. Its diversified water supply known as the 'Four National Taps' consists of local catchment water, imported water, highly-purified reclaimed water known as NEWater as well as desalinated water. Due to water shortage, Singapore imports water from Johor, Malaysia. To achieve water sustainability, Singapore is utilizing all available water sources efficiently. The source of local catchment water is the rain water. Rain water is collected with the help of a network of drains, canals, storm-water collection ponds, rivers and reservoirs. Thus urban storm water is collected and treated to use for drinking water supply. The NEWater which is the high grade reclaimed water produced from treated used water is utilized to meet up to 30% of the Singapore's water needs. The NEWater is purified using advanced membrane technologies and ultra-violet disinfection before using it for drinking water supply. Using Reverse Osmosis plant, Singapore utilizes sea water and almost 25% of water needs are met with the help of this. Singapore also has taken initiatives to manage the water demand and to reduce consumption with the help of programmes covering good water saving habits as well as Water Efficient Building Certification. Singapore's water management efforts have been done by engaging the citizens. People can give feedback and ideas to PUB, Singapore's National water agency. Awards are given to organizations and individuals for their contribution to water management. Thus Singapore has taken inspiration from the challenges in water sector to develop its capabilities to achieve water sustainability (PUB, 2015).

6.1.4 Rain Water Harvesting (RWH) in Tamilnadu, India

The state of Tamilnadu launched the rainwater harvesting programme in 2001 and made it mandatory to provide RWH structures in all the new buildings. This step taken towards RWH created a major impact in increasing the ground water table all over the state. Existing RWH structures were also revived under this movement. Vigorous campaigns and education programmes are conducted with people's participation to increase the awareness among the public (Government of Tamilnadu, 2015).

6.1.5 Sensors for plugging leakages: BWSSB

In the current scenario of water supply in Bangalore, almost 48 percent of the water supplied is unaccounted for. Bangalore Water Supply and Sewerage Board (BWSSB) has 2 projects in the pipeline for plugging the leakages. In one project, BWSSB is planning to install around 4, 000 sensors on the water pipelines in Bangalore. Installation of these sensors will help in detecting water leakages up to a distance of 150 meters with the help of acoustics. In the second project, leakage spots are identified using helium testing technology. In this, Helium gas will be pumped into the water pipelines and the leakage will be detected with the help of the gas leakage points (Ramani, 2015).

7. Storm Water Management

Rainwater harvesting possibilities should be explored and implemented to achieve a sustainable model for storm water management, to meet the water demand and for conservation of water resources. Depleting water table levels in city areas have mainly resulted due to lack of Rain Water Harvesting. Permeable surfaces around buildings should be increased with the help of policy regulations and incentives so that the water is allowed to percolate resulting in reduction of storm water runoff.

7.1 Interventions in Storm water Management

There are many smart and low cost concepts and ideas for efficient management of storm water in urban areas. Some of them include Low Impact Development, revival of natural drainage channels and water bodies for prevention of flood, rainwater harvesting, bio retention basins, green roofs, etc. In this section, we have discussed some of these low cost measures for implementation of low cost storm water management in Smart Cities.

7.1.1 Low Impact Development (LID)

'Low Impact Development' is an alternate approach to storm water management which helps in cost reduction and in reducing the pollution caused by storm water runoff. LID promotes storm water management through site design which promotes the use of natural systems for infiltration, and for reuse of rainwater which reduces the storm water runoff volume and intensity. LID techniques do not require hard infrastructures, but make use of natural drainage features, thus reducing infrastructure costs (EPA, 2015).

The basic principle of Low Impact Development is based on the nature's way of management of storm water. This distributed decentralized micro scale control helps in managing the rainwater at source itself. LID helps in infiltration, filtration, storage, evaporation and in detaining the run off at the source itself. The approach of LID differs from the conventional storm water management practices which involve conveying and managing storm water in large scale. LID manages storm water through landscape features known as Integrated Management Practices (IMPs). It explores the potentials of components of the urban environment such as open spaces, rooftops, streetscapes, parking lots, sidewalks, medians, etc. which have the potential to function as an IMP (Low Impact Development Center, 2015). Some of the techniques used in LID includes, redirecting waterspouts to vegetation, rain barrels or cisterns; bio retention with the help of grass strips, bioswales, rain gardens, tree box filters, etc.; use of water detention basins , green roofs , permeable pavers, etc. (City Creeks Division, 2008).

One of the advantages of LID is that it can be applied and integrated into existing developments, new developments, as well as revitalization projects with aesthetically pleasing effects. This method is not only environmental friendly which can reduce the harmful impacts of urbanization, but also economically sustainable. Adoption of LID for storm water management helps in enhancing the local environment quality, protects public health, and improves livability unlike the conventional storm water management technologies which fails to do so. LID also helps in ground water recharge and controlling the changes to the local hydrologic cycle. It also increases the urban greenery leading to improved air quality, heat reduction, better aesthetics, etc. Some of the cost benefits associated with LID come from its multi functionality, lower lifetime costs, additional environmental and social benefits, reduced off-site costs, functional use of open space, etc. (Low Impact Development Center, 2015).

7.1.2 Bio retention Basins

Bio retention basins or rain gardens are shallow landscaped depressions which help in retaining storm water before being infiltrated or discharged. They filter the retained water and treat it with the help of the shallow depression with soil topped with mulch. The suspended solids are removed and the pollutants are either filtered or absorbed by the soil layer and plants. Depending up on the need, these bio retention basins can be scaled up. In large scale requirements, pretreatment measures such as vegetated strips are utilized to capture sediment so that maintenance frequency of the basins is reduced. This method can be used in residential yards, commercial developments, parking lots, roadways, etc. The advantages include pollutant removal from the storm water, reduction in storm water runoff, increased bio diversity, etc. (University of Florida, 2008).

7.1.3 Green Roofs

Green roofs can be any building roof where there is a thin layer of plants growing on top of it. Green roofs have many advantages including, addition of green space to improve urban environment quality, temperature management of the interior of the building, etc. It is also a proven method for storm water management through reduction of storm water runoff leading to the reduction in quantity of the water being directed to the drains. Based on the type of plant variety and growing medium, green roofs can intercept the roof top runoff up to 90% and help in absorption up to 60%. Variations in temperature, wind, evapotranspiration rates, etc. affect the absorption rate of water (LakeSuperiorStreams, 2009).

7.1.4 Flood management: Singapore

Singapore has tackled the issue of flooding through landscaping. Singapore's Bishan -Ang Mo Kio Park was upgraded in such a way that it helps in flood prevention through natural landscape. Concrete drainage channels running through the park was converted into meandering natural river which functions as flood plains. This helped in creating new spaces for recreation and in bringing back a natural ecosystem. Safety measures like warning systems with water level sensors, warning lights, audio announcements, etc. are also there to inform people when the water level increases. This initiative is proved to be an environmentally and socially sustainable solution in flood control (Tunas, 2013).

7.1.5 Spokane Urban Runoff Greenways Ecosystem

Pollution due to storm water runoff combined with sewer overflows is one major reason for urban water pollution. The city of Spokane in Washington has developed a programme called Spokane Urban Runoff Greenway Ecosystem (SURGE) for controlling pollution from storm water runoff. Spokane river, a tributary of the Columbia river, runs through the city and polluted storm water and sewer over flows have led to accumulation of pollutants in the river. Under the SURGE program, curb and gutter systems will be constructed around the city by giving emphasis on Low Impact Development (LID) strategies which can help in natural hydrologic process of capturing storm water, infiltration, prevention of storm water runoff, etc. (EPA, 2012). The SURGE is a plant-based storm water system and ‘Storm gardens’ will be created between the curb and sidewalks in the city. Existing sidewalk, trees and plants are also included as part of this program (City of Spokane Wastewater Management, 2015).

8. Sewage Management

Centralized sewage treatment systems can be very expensive due to the infrastructure requirements in terms of sewage pipes network, power requirements for treatment as well as maintenance issues. Decentralized approach should be explored to decrease the load on centralized sewage treatment systems. Also this approach can help in serving areas which are not yet covered by sewage networks. Decentralized sewage treatment systems which make use of anaerobic digestion by microbes helps in conservation of power. This approach also helps in easy reuse of treated water at the site itself at reduced cost. But, it is also necessary to create awareness about safe reuse of treated sewage water. Maximum reuse of treated water should be established in case of any sewage treatment system in order to increase the efficiency and for conservation of environment.

8.1 Interventions in Sewage Treatment Systems

In this section we have discussed about some of the low cost and efficient practices in sewage treatment, which can be adopted in Smart Cities. These caselets have been selected considering the fact that they give importance for water recycling, cost reduction, easy implementation as well as people’s participation.

8.1.1 DEWATS (Decentralized Wastewater Treatment Systems)

Decentralized Wastewater Treatment Systems (DEWATS) is a technical approach to treat

waste water in a decentralized manner. This system functions in four stages which includes, primary treatment with the help of sedimentation and floatation, secondary anaerobic treatment using baffled reactors or anaerobic filters, tertiary aerobic treatment using sub-surface flow filters and lastly aerobic treatment in polishing ponds. Waste water treatment using DEWATS is proven to be of low maintenance with no power requirement. This system can be used for treating organic waste water from domestic as well as industrial sources with a treatment capacity of 1-1000 m³ per day. This is a cost efficient solution with low operation and maintenance cost (BORDA, 2015).

8.1.2 Water recycling in San Antonio, Texas

In San Antonio, waste water is converted into resources and the city reuses all the byproducts of waste water treatment. San Antonio Water System (SAWS), which is a public utility owned by the City of San Antonio does all the water management planning. Water is converted into recycled water, compost and biogas. The city has a pipe line network to deliver the good quality recycled water. The delivery system supplies water for commercial and industrial purposes, parks, golf courses as well as for the City's River Walk along the banks of San Antonio River. The compost generated out of the waste water treatment process is sold through local retailers and nurseries. The biogas generated is treated and is transferred to a commercial pipeline for selling in the open market. This waste water treatment model provides a sustainable solution to waste water treatment (SAWS, 2015).

8.1.3 Condominial Sewerage Systems in Brasilia, Brazil

Condominial sewerage systems were developed in Brazil during 1980s itself to tackle the issues associated with expansion of sewage treatment services to peri-urban neighborhoods. Condominium approach demands more community participation in planning and maintenance and helps in achieving substantial cost savings. In this approach, service is provided to group of dwellings or neighbourhoods which helps in reduction in length of networks. Also there is a closer relationship between the users and service providers, making it a social unit with collective decision making and community activities. Starting from the year 1993, lack of sanitation in peri-urban areas in Brasilia lead to condominium sewerage systems adoption at large scale. Being a low cost alternative to conventional sewerage system, it was extended to the affluent areas too. The case of Basilia proves that condominial sewerage systems are feasible at larger scale with substantial cost savings and without out having any issues regarding the operation and maintenance (Melo, 2005).

8.1.4 Decentralized Waste Water Treatment: Centre for Science and Environment, New Delhi

In Centre for Science and Environment (CSE), New Delhi, waste water is treated at the site itself with the help of decentralized waste water treatment method involving settler, anaerobic baffled reactors and horizontal planter filter. The total treatment capacity is around 8000 litres per day. The treated water is used to meet the horticulture and gardening needs of CSE. The water scarcity in this building is managed with the help of reuse of treated waste water (CSE, 2015).

9. Solid Waste Management

Drastic reduction of waste to be sent to landfill by means of recycling and reuse should be targeted to achieve efficient solid waste management with cost reduction. Also, composting facilities at household level as well as community level should be promoted in order to reduce the burden on transportation of wet waste to the common treatment areas. Possibilities of energy production from waste should be explored and segregation of waste into various categories should be made mandatory in order to increase the reuse possibilities and to avoid health hazards. Decentralized solid waste management systems can be more effective in terms of usage of energy from the waste as well as in issue resolution due to the manageable size of the population involved in each area. Ultimately we should be able to convert waste into resources.

9.1 Interventions in Solid Waste Management

In this section we discuss about initiatives in the area of smart handling of solid waste along with focus on efficient recycling and reuse. Some of the concepts such as use of Radio frequency identification for solid waste management, prevention of groundwater and soil contamination at landfill sites, e- waste management, waste reduction, recycling, reuse, etc. are discussed below.

9.1.1 Solid Waste management using RFID

Radio frequency identification (RFID) can enhance the efficiency of solid waste management with improved efficiency, economy as well as traceability. Use of RFID helps in cost reduction by automation of various activities related to waste management. This includes verification of container pick up, customer usage tracking, route efficiency measurement, etc. Route

optimization with the help of RFID improves service at reduced cost. With the help of RFID, service provision becomes easier and it is possible to increase the service level and quality (HID Global, 2014). Use of RFID combined with the use of GPS (Global Positioning Systems), GSM (Global System for Mobile Communications) and GIS (Geographical Information Systems) helps in efficient monitoring and management of waste bins along with weighing of waste during collection process. Scope for recycling increases in this system (Purohit & Bothale, 2012).

9.1.2 Prevention of groundwater and soil contamination at landfill sites

Improper management of landfill sites can lead to various environmental problems such as ground water contamination and soil contamination. These problems are mainly caused by the leachate generation from the landfill as well as improper design of the same with selection of unsuitable materials. There are techniques which are environment friendly as well as economically viable which can stop this contamination from the landfill sites. One such technique is use of clay linings to prevent contamination of ground water. Also, leachate collection pipes should be accommodated to drain the leachate to avoid infiltration and contamination. The leachate has to be treated before disposal. While selecting the site for landfills, it is better to avoid sites with low water table (Panthee, 2008).

9.1.3 Decentralized and Integrated Resource Recovery Centres

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) along with the organization 'Waste Concern' have promoted Integrated Resource Recovery Centres (IRRCs) which helps in transforming the challenges in solid waste management into opportunities by turning waste into resources. They are helping some of the cities in the Asia-Pacific region in managing the waste in cost effective and environmentally sustainable manner. The IRRCs promote various simple, non-mechanical techniques like composting, anaerobic digestion, refuse-derived fuel (RDF) and recycling, which operate at low costs. These techniques are labour intensive and thus create more job opportunities for the urban poor with stable income under safe working conditions. The amount of waste taken to the landfills reduces considerably and thus helps in reduction of greenhouse gas emission and environmental conservation. Solid waste management done at community level ensures people's participation and creates more awareness about minimization of waste volume (ESCAP, 2015).

9.1.4 E-waste management, Switzerland

Switzerland has an established e-waste management system which makes it convenient both for the producers as well as consumers in a very cost efficient manner. This system takes care of the entire electrical and electronic waste. This e-waste management system is managed by producer Responsibility organizations (PRO) that consists of manufacturers or importers of electric and electronic items. There are four PROs and each organization manages different types of e-waste. Different categories of e-waste managed by the PROs includes, waste related to ICT and consumer electronics; waste related to electrical appliances and electronic equipments; lighting equipments; batteries, etc. (e-waste : swiss e-waste competence, 2015).

9.1.5 Solid waste management, Japan

Solid waste management in Japan is very efficient and with the emphasis given on recycling technologies, they are able to turn a major part of the waste into resources and dispose only the remaining. Japan has a very efficient waste collection and transport system with waste transfer stations in between where the waste from small or medium sized garbage trucks is compressed and transferred to larger trucks. The larger trucks carry the waste to incineration plants or disposal sites. Efficient waste collection and transportation not only helps in providing good quality service to residents, but also helps in reducing the overall cost of solid waste management. Japan has safe and efficient waste incineration plants capable of high efficiency power generation without causing pollution. They incinerate the garbage using methods such as stoker furnaces, fluidized bed furnaces, and gasification fusion resource furnaces. They dispose the medical waste in environment safe manner with the help of technologies such as gasification furnaces, kiln furnaces and vertical furnaces which has the capability to burn the waste safely and completely. They treat and dispose the contagious waste separately. Under the 3R policy which promotes Reduce, Reuse and Recycle initiatives, Japan has undertaken various waste recycling measures. They collect the PET bottles, cans and food trays separately and recycle them to manufacture new products. They also have technology to recycle home appliances in ecologically safe manner. These appliances are sorted manually and compacted so that the purity of the recovered materials increases. The wet waste is used to generate electricity and fuel. The sewage sludge collected from the sewage treatment plants is also used to generate energy. Thus they are able to use this fuel obtained from sewage sludge instead of fossil fuel. Bio gas generated from sewage sludge is also utilized either by injecting directly into city gas

pipes or for using in gas production plants as a fuel for its operation. Japan utilizes farming, forestry and paper industry biomass for power generation (Japan Environmental Sanitation Center, 2012).

The non-recyclable waste is sent to landfills under three categories: controlled landfill, inert landfill, and isolated landfill. Waste which are non-harmful, but has the potential to pollute water, or affect the environment through the gas, odor, pests, etc. are disposed of at controlled landfill sites. Controlled landfills are semi aerobic in nature, which is environment safe. The semi aerobic landfills technique helps in stabilizing the landfills so that it can be used as parks and open space once the land completes its role as landfill. Materials such as plastic, rubber, metal, glass, bricks, ceramics, etc. which do not cause environmental pollution are disposed at inert landfill sites. Harmful waste containing heavy metals, Polychlorinated Biphenyl (PCB), etc. are disposed of at isolated landfill sites (Japan Environmental Sanitation Center, 2012).

10. Smart Buildings

Smart building should be designed as energy efficient and these should emphasize up on recycling and reuse of water, water usage reduction, rain water harvesting, onsite solid wastes management, etc. These should be designed in such a way that dependence on electrical energy for lighting, heating, cooling, etc. is minimized leading to cost reduction and environmental conservation. Also, the built in intelligence with automated control can be used to connect with other buildings and the service provisions can be managed efficiently.

10.1 Interventions in Smart buildings

There are many examples of smart buildings all over the world, which have achieved energy efficiency, utilized green building techniques and have contributed towards environment sustainability. In this section we have discussed some of the prominent smart buildings which have incorporated these smart and green techniques.

10.1.1 Green buildings

According to the United States Environmental Protection Agency, “Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction”. Green building practices addresses the concerns of building economy, utility, durability, and comfort. Green buildings

are designed in such way that the impact of the building on the environment and human health is reduced. They incorporate many sustainable materials for construction which are either recycled or made from renewable sources. Indoor environment quality is also increased due to minimal use of pollutants in the construction. Some of the features of Green buildings include efficient use of energy, water, and other resources; reduction and sustainable management of waste; reduction of pollution and environmental degradation, etc. (US EPA, 2015).

10.1.2 Leadership in Energy & Environmental Design (LEED) Certification

“LEED, or Leadership in Energy & Environmental Design, is a green building certification program that recognizes best-in-class building strategies and practices” (USGBC, 2015). It was developed by U.S. Green Building Council. To receive different levels of the LEED certification, projects have to satisfy the prerequisites given in the rating system. LEED can be applied to various types of projects and there are five rating systems to address different project types, which are: Building design and construction; Interior Design and Construction; Building Operations and Maintenance; Neighborhood Development; and Homes. Under LEED certification, there are four levels known as Certified, Silver, Gold and Platinum based on the number of points a project earn (USGBC, 2015). The LEED certification process considers various parameters such as water efficiency, energy efficiency, materials and resource use in the project, indoor environmental quality, site sustainability, etc. for assigning the rating (eiffelgres, 2015).

10.1.3 Zero Carbon Building, Hong Kong

‘Zero Carbon Building’, built by The Construction Industry Council, in partnership with Hong Kong’s Development Bureau is the first building in Hong Kong to completely offset the carbon foot print with the use of over 90 energy-conserving features. Almost 50% of the site is covered by landscaped outdoor space which includes eco-plaza, eco-terrace, eco-garden, outdoor exhibition area, and Hong Kong’s first urban native woodland. During the construction stage, construction wastage was minimized with the help of building information modeling technology and the construction utilized sustainable methods such as use of concrete made from pulverized fuel ash (a waste product from coal power stations), use of balanced cut-and-fill techniques, use of soil displaced by construction in the native urban woodland area, etc. The building also has exhibition and education centers consisting of an eco-office and eco-home which helps the public in understanding various sustainability procedures. The renewable energy generated by this building and surroundings is more

than the energy it consumes, making it energy surplus. The surplus energy is fed back in the local power grid (Asia Business Council, 2012).

10.1.4 Green building: The Solaire, New York

'The Solaire', a 27 storey residential tower with 293 units, situated in New York City has utilized green building techniques in the construction and operation. The building construction utilized recycled materials wherever possible and almost 60 percentage of the building is constructed using recycled materials. The building also has incorporated green roof and almost 75 percentage of the roof is covered with plants, helping in reducing heating and cooling loads in the building. Waste water is recycled and utilized in toilets, cooling towers and for irrigating the landscape. Water-efficient fixtures and toilets help in conserving water. Use of energy saving methods such as automatic dimming fluorescent lights, high-performance windows, maximum utilization of day light, etc. have helped in reducing the energy demand by 35 percent. The building also takes care of storm water management with the help of water retention layer at site, collection of storm water runoff in basement storage tanks, green roof, etc. Renewable energy possibilities are also explored with the help of photovoltaic power system. Indoor environmental quality is enhanced by monitoring and testing. The building has easy access to public transportation and it also has incorporated on-demand hybrid rental cars, electrical vehicle charging facilities, bicycle parking, etc. (NRDC, 2015).

10.1.5 Intelligent building: Duke Energy Center, Charlotte, North Carolina

The Duke Energy Centre in Charlotte, North Carolina is a U.S. Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) Platinum certified building which incorporated a lot of green strategies. This commercial building has succeeded in bringing in environmental conservation measures including conserving water, energy, reduction in green house gas emission, etc. This building saves around 30 million gallons of water per year with the help of rain water harvesting, purification of ground water and by reducing domestic water consumption. The building has achieved energy efficiency with the help of measures such as lighting controls, highly efficient HVAC systems, day light harvesting blinds, high-performance glazing on the exterior walls, green roof which cuts heating and cooling loads on the building, etc. The building encourages use of bicycles and low emission vehicles by the provision of secure bicycle parking, showers and changing rooms as well as preferred parking for low-emission vehicles. This building utilized almost 24% recycled materials for the construction (Environmental LEADER, 2010).

10.1.6 CII Sohrabji Godrej Green Business Centre, Hyderabad, India

CII - Sohrabji Godrej Green Business Centre is the first LEED Platinum rated green building in India, which has incorporated various energy and environment friendly features like solar power, high efficiency HVAC, wind towers for passive cooling , high performance glasses, rainwater harvesting , roof gardens, etc. With these initiatives this building is able to reduce 50% of its overall energy consumption along with reduction in portable water usage by 35%. Almost 80% of the materials used in this building have been sourced from recycled materials (Asia Business Council, 2012).

11. Health

In a Smart City which emphasizes up on cost reduction also, the health sector has to be more of preventive in nature to ensure better health of its citizens. Measures taken to improve the water quality, reduction in water pollution caused by storm water runoff, better solid waste management with emphasis on proper segregation, reduction of air pollution by promotion of more public transport and condemnation of old vehicles, a well-functioning public distribution system which ensures quality, adhering to the food safety and standards, etc. can help in preventive health care. Government hospitals should be upgraded to provide better health care so that the urban poor can get better health care facilities at low cost. Also, policy regulations have to be made to regulate the cost of health care to make it affordable.

11.1 Interventions in Health

Smart and low cost health initiatives such as E-health, Tele-medicine, Health Information Technology, etc. have been discussed in this section. Such initiatives help in increasing the reachability of healthcare facilities faster. Also, they increase the service delivery quality with the aid of ICT and helps in achieving better quality health care.

11.1.1 E –Health

E- Health or health care solutions provided by information and communication technology can help in the provision of more efficient healthcare facilities to the public. E-health solutions can create more awareness regarding health, diseases and life style, leading to cost efficiency and preventive health care. Quality of health care including diagnosis increases with the introduction of ICT measures into the health sector. Emphasis has to be given on

increasing awareness about e-health to medical professionals as well as the public to utilize the possibilities of e-health (ICT for Health, 2012).

11.1.2 Tele-medicine

According to the American Telemedicine Association, “telemedicine is the use of medical information exchanged from one site to another via electronic communications to improve a patient’s clinical health status” (American Telemedicine Association, 2015). Telemedicine utilizes a variety of applications with the help of telecommunication technologies such as videos, e-mails, smart phones, etc. Tele medicine can be efficiently used in hospitals, private clinics, work places as well as at home. Various services which can be covered under telemedicine include consultation through video conferencing, sharing of images, remote monitoring of vital signs, etc. These also include medical education, wireless applications in diagnosis and treatment, nursing call centers, etc. Tele medicine can be used in primary care, specialist referral services, remote patient monitoring and also for provision of health information to people (American Telemedicine Association, 2015).

11.1.3 Health Information Technology in Rwanda

Health Information Technology is a growing area in Rwanda especially in the areas of electronic health records and national reporting system. Active participation of the Government of Rwanda along with nongovernmental organizations and private sector partners has helped in integrating technology into the health sector. There are various programmes running in Rwanda, which have integrated health and information technology, leading to improved functioning of the health sector. Some of the e-health initiatives in Rwanda includes, an open-source medical records system for tracking the data related to patients, tracking of infectious diseases on a monthly basis, telemedicine, e-learning facilities for nurses, Health Management Information Systems, etc. (Frasier, May, & Wanchoo, 2008).

11.1.4 Smart Health India

‘Smart Health India’ is low-cost high-quality healthcare delivery system developed by George Institute researchers in India, Australia and the UK. This system helps in providing health care for common chronic diseases at very low cost with the help of community workers and doctors who utilizes simple and low-cost smart phone technologies. They use electronic clinical decision support systems which guide the health workers with personalized clinical decision support. This initiative helps people in preventing and managing serious chronic diseases at reasonable costs (The George Institute for Global Health, 2015).

11.1.5 Food Safety and ICT Traceability Systems: Japan

Food safety problems are increasing especially in urban areas and an efficient food traceability system has become very essential. Japan has used ICT in food traceability systems effectively and this has improved consumers' confidence in the products along with improved efficiency in the supply chain management. They have also collaborated public and private sectors which became a key to success. The use of ICT helps in quickly identifying the source of problems and in taking necessary actions immediately (Setboonsarng, Sakai, & Vancura, 2009).

12. Education

Smart education should aim at facilitating larger interventions. Provision of e-class rooms can be a solution to increase the reachability at reduced cost and in less time. Also, IT enabled safety systems installations can be used to ensure safety in the educational institutions at a viable cost. Smart education can help in creating study material pool which can be accessed easily by anyone. Also, visually attractive presentation techniques create more interest and helps in easy understanding. Also educational institutions have to adopt smart methodologies in managing their resources (eg: treatment of waste) with emphasis given on reusing so that it can have a positive impact on the society also in future.

12.1 Interventions in Education

Smart Interventions in the education sector is very important for the better functioning of a Smart City. It can help in increasing suitable resource availability, entrepreneurship development, as well as in increasing the quality of education. In this section we have discussed some of the interventions in smart education such as training and skills development, live and interactive classes, training for micro enterprises, etc.

12.1.1 Training and skills development: New Brunswick, Canada

New Brunswick in Canada faced issues of high unemployment rate, especially in the rural areas. This province has large numbers of people with low income combined with low skills. To tackle this issue, New Brunswick has created the Training and Skills Development (TSD) programme run by New Brunswick's Department of Post-Secondary Education, Training and Labour (PETL). Under this programme, under employed people are allowed to leave their work and receive financial assistance in availing training and skills development. Employment councilors help in assessing whether the trainings can help the employee

in getting better employment and the decision is made accordingly. Opportunities in the local labour market and return on investment are also assessed before authorizing the employees to quit due to underemployment. Skill development and training priority is given for people with seasonal employment, jobs under layoff possibilities and underemployment. There are Labour Force Development Officers funded by PETL who helps in connecting the government with the business. They work with the employers by providing them with advisory services, information and help them in improving their business plans. They help in connecting employers with the trained labour force (Wood, 2010).

12.1.2 Live & Interactive Classes in 1000 Government & aided schools

Indian institute of Management, Bangalore, along with Government of Karnataka has taken up an initiative to deliver quality education in Rural India with the help of ICT aided live and interactive class rooms. A Pilot project was conducted in Gubbi Taluk, Tumkur District for the academic year 2011-12 and SIT (Satellite Interactive Terminal) studio in DSERT (Department of State Educational Research and Training) was used to deliver the live classes. The classes were delivered to 3112 students of 8th and 9th grade for the subjects Mathematics, Science and English. This project was conducted with the help of satellite and advanced multimedia education. Thousands of students can learn simultaneously from expert faculties, and this can improve the quality of education. The positive impact of this project motivated to take up this initiative to a higher scale with 1000 Government and aided schools as beneficiaries. Around 1000 hours of live sessions by experienced teachers are planned for 5th to 10th grade students for the subjects Mathematics, Science and English. Skilled government school teachers will be acting as real time moderators to facilitate doubt clearance. (Naik & Basavaraj, 2015).

12.1.3 Training for Micro Enterprise under Kudumbashree, Kerala

Various trainings programmes are conducted under Kudumbashree programme by Government of Kerala, where emphasis is given on women empowerment and poverty eradication. Trainings related to micro enterprise development helps the members of Kudumbashree in starting new enterprises which eventually helps in improving their economic condition. The skill development training is a precondition for availing subsidies for starting an enterprise. Trainings are conducted by in-house teams of trained people and experts are hired when required. Types of trainings under Micro Enterprise Development Programme include General Orientation programmes, Entrepreneurship Development

Programmes, Skill Development Trainings and Performance Improvement Programmes (Kudumbashree, 2015).

13. Environment

Environment conservation is of utmost importance in a Smart City. Efforts such as, promotion of electric and CNG (Compressed Natural Gas) vehicles, dedicated bicycle tracks, condemnation of old vehicles, etc. can reduce the atmospheric pollution to a large extent. Also regulations have to be brought in for greenery conservation, relocation of factories outside the city, emission reduction, etc.

13.1 Interventions in Environment

Urban trees and forests have a huge role in improving the environmental quality. In this section we have discussed some of the green initiatives in urban areas such as urban trees and parks, urban community forest, promotion of pollution free infrastructure, air quality monitoring in urban areas as well as promotion of sustainable and healthy environment practices in educational institutions.

13.1.1 Urban Trees and Parks in improving Air Quality

Urban trees and parks play a major role in improving the air quality in urban areas, where air pollution is a major issue. The effect on environmental quality can vary significantly based on the amount of tree cover in parks and other open spaces. Parks help in reducing the temperature within and in surrounding areas, which have a significant impact on health of human beings. Air temperature reduction in nearby areas of the parks also helps in reduction in energy usage for cooling the buildings. Trees in the parks help in air pollution reduction by removing the pollutants. They also help in reducing the carbon dioxide from the atmosphere. Ultraviolet radiation reduction can also be achieved by absorption of the same by trees (Nowak & Heisler, 2010).

13.1.2 Air quality monitoring in Salamanca, Spain

Increasing air pollution is one of the main concerns in urban areas all over the world and pollution due to traffic is one of the main reasons for this. 'RESCATAME -Pervasive Air-quality Sensors Network for an Environmental Friendly Urban Traffic Management' project funded by the European Union through its LIFE program was introduced in the city of Salamanca to achieve sustainable management of traffic with the help of air-quality sensors

network and prediction models. These sensors are installed at critical pollution points and the pollution levels predicted by the models helps in taking actions in advance to control pollution in the city and it also helps in achieving sustainable traffic levels at any time. Two streets with major traffic flows were selected to install the sensors since they have an impact on the overall level of emission in the city. The sensors were installed at 35 points and measured the parameters , carbon monoxide (CO), nitrogen oxides (NOx), ozone (O3), fine particles (PM), noise, humidity and temperature. Real time data was collected at 10 minutes interval for a span of one year. The prediction models utilize this data to estimate the pollution levels and thus help the traffic department to take measures to control high pollution levels (European Commission , 2015).

13.1.3 Urban and community forest, Ann Arbor, Michigan

Ann Arbor's publicly-managed urban and community forest helps in improving the living condition in the city. This community forest comprises of vegetation in the public parks, institutional and private properties and alongside the city streets. They provide a lot of environmental, social and economical benefits to the citizens. The Community forest help in improving quality of air and water, reducing the storm water runoff and temperature moderation in summer. They also help in reducing utility costs and also help in improving the quality of life in the urban area. The greenery also plays a major role in improving the aesthetics of the city. But the management of this community forest faces challenges in terms of the city's budget as well as the staff resources. So, Ann Arbor has adopted an urban and community forest management plan for efficient management of the urban forest with more public engagement and outreach. The purpose of this plan is to provide a framework for efficient and sustainable management of the urban forest without compromising up on the needs and values of the community (City of Ann Arbor, Michigan, 2014).

13.1.4 The Center for Green Schools

The Center for Green Schools at USGBC (U.S. Green Building Council) was established to promote sustainable and healthy environment in schools. According to them, the promotion of green building concept for construction of schools and their operation and maintenance can make a huge impact on the health of students and environment; help in reducing school operational costs; and help in educating the new generation who can transform the future. For transforming schools into 'green schools' , this center works along with teachers, students , administrators , elected officials as well as communities directly and creates suitable programmes and helps in management of resources (USGBC, 2015).

According to 'The Center for Green Schools', various elements of a Green School includes energy and natural resource conservation, improved indoor air quality, use of daylight, improved acoustics , green cleaning practices, water conservation, waste management including recycling, etc. (USGBC, 2015).

13.1.5 IIT Bombay: Green campus initiative

IIT Bombay campus, located in Powai has an area of 550 Acres, and it is one of the first educational institutions in India which have attempted to create an environmentally sustainable campus. Measures taken up by the institute towards its Green Campus Initiative includes, dedicated no-vehicle zones in the academic areas, use of only electronic communication, proper disposal of e-waste, energy efficient ACs and solar water heaters, biogas plants for wet waste management, utilization of heat generated from AC to heat water, bikes that operates on a rechargeable battery, promotion of bicycles and CNG buses which transport people within the campus, recycling of paper, solar-powered streetlights, water recycling plants, etc. (Wadhwa, 2010).

14. Safety and Security

Safety and Security is one of the major concerns in all the cities. Violence against women and children is one of the focus areas which need immediate action. Providing security to the citizens against man made attacks as well as natural calamities are the responsibility of the government agencies. ICT can play a major role in providing increased safety and security in much efficient and smarter ways.

14.1 Interventions in Safety and Security

ICT is being used all over the world for managing the safety and security, especially in urban areas. It makes the communication efficient and fast and helps in taking timely actions. Here we have discussed some of the ICT interventions such as use of ICT for emergency services, tracking violence as well as for ensuring safety of women, which can be adopted in Smart Cities for ensuring better safety and security of the citizens.

14.1.1 Tracking of violence against children, Benin, West Africa

'Plan international', a global children's development organization, with the help of 'FrontlineSMS' a software for SMS reporting and communication, has created an SMS helpline for prevention of violence against children in Benin. This project is for violence

reporting with data protection related to the same and with an emphasis on risk reduction with the help of built in security in the design. The aim of this project is to strengthen and simplify reporting of any kind of violence against children. This project helps children as well as the public in actively participating in reducing violence against children by sending SMS. The data collected through this system is passed on to child care staff or concerned government agencies in order to respond to the incident and 'Plan Benin' makes sure that incident is investigated. The data collected through this process is analyzed later for understanding the reasons behind the occurrence of violence (Frontlinesms, 2011).

14.1.2 Himmat - Delhi Police Initiative for Women Safety

The Delhi Police have come up with an initiative called "Himmat" for ensuring women safety in Delhi. Women safety being one of the prime concerns in Delhi, this mobile application was launched in the year 2015. Women in Delhi are requested to register on Himmat Website to use this application for availing emergency services. The distress call or emergency message reaches Delhi police and it helps in taking immediate actions. This application helps the police in getting the location along with these alerts. To make it simpler, the application allows the user to send alerts by pressing the 'SOS button' or by shaking the phone or by pressing the power button 3-5 times. Activation of the application also invokes video and audio recording (Delhi Police, 2015).

14.1.3 Multi agency response, New Zealand

ICT can be efficiently used for the provision of emergency services to the public. New Zealand uses a software system called 'InterCAD' which helps the citizen in sharing essential information with the police, ambulance and fire service through the emergency number 111. This system helps in efficient coordination among various agencies and also makes it easier for the public to report emergency issues through a single window. The citizen needs to call the number only once, even if the issue is related to more than one agency. The response is much faster and coordinated since all the agencies have all the relevant information (SSC, 2015).

14.1.4 National Incident Management System, US

The National Incident Management System (NIMS) is developed by the US Department of Homeland Security for the purpose of effective management of any kind of emergency situation including natural calamities, terrorist activities, etc. This system provides a systematic approach for a broad spectrum of organizations in dealing with such situations

and helps in reducing loss of life as well as damage to properties and environment. NIMS acts as a template for dealing with different types of incidents while the National Response Framework (NRF) provides the structure and mechanisms for management of the same. Best existing processes have been integrated into a unified national framework for incident management (US Department of Homeland Security, 2008).

14.1.5 Urban security programme, Mexico City

Mexico City has launched the 'Ciudad Segura programme' in the year 2009 with the aim of increasing the crisis preparedness, reduction in crime rates as well as for improving multi agency coordination and efficiency (Thales Group, 2013). This urban security system has a widespread telecommunications network which is highly integrated which helps in collecting and managing the relevant information regarding city security. This system has around 8000 video cameras and sensors spread out in the city and they alert the concerned operators in case of any unusual events. Also, there are specially equipped mobile command centres connected to a central command centre which can be used in case of major emergencies (SecurityPark, 2009). This integrated urban security initiative has helped in making the city safer as well as efficient with reduction in crime rates, reduction in vehicle theft, reduction in response time with the help of multi-agency coordination, etc. Higher levels of public safety also help in making the city more attractive to the citizen as well as visitors and it also helps in attracting more investments and tourism (Thales Group, 2013).

15. Framework for sector wise interventions

Based on the analysis of the caselets in the previous sections, we have come up with a frame work for each of the sectors pertaining to a Smart City. We have identified the objectives for each of these sectors which will help in transforming a city to a Smart City. We have also identified various interventions required for achieving each of these objectives so that the transformation takes place in a cost efficient manner.

Table 1 Framework for sector wise interventions for a Low cost Smart City

Sector	Identified Objectives	Interventions
Citizen engagement & Governance	Transparent Governance	<ul style="list-style-type: none"> - Horizontal governance - Open data using ICT - Business process reengineering - ICT to play transformational role than just transaction role
	Participatory governance	<ul style="list-style-type: none"> - Service provisions made with people's participation which improves ownership and ensures that it reaches the actual beneficiary - Information sharing between citizen and government - A common platform for complaint redressal and enquiries related to service provision - Complaint redressal mechanisms made citizen friendly - Participatory Budgeting - Increased accountability in service delivery
	Citizen centric governance	<ul style="list-style-type: none"> - Inclusive governance with emphasis on poverty eradication, women empowerment, etc. - Bottom up planning - Resource allocation after assessment of economic condition of each sections of the society - Direct Benefit Transfer - Awareness creation about Government's ICT measures - Reduce the need for documentation in availing services - Minimum interface with public for service provision using ICT - Wi-Fi enabled service delivery - Provision of integrated services through one window using ICT

	Efficient governance	<ul style="list-style-type: none"> - Decentralization of administration and management - Reduce overall institutional cost and transaction cost of delivering services - Use of ICT to ensure service guarantee and connect all sectors of economy and society - Service level benchmarking with performance assessment which ensures quality of governance - Online platform for guaranteed service delivery - Seamless coordination - ICT for public service quality tracking
Mobility and Transport	Reduce the need to travel	<ul style="list-style-type: none"> - Creation of school districts within which children will be admitted - Creation of multiple business districts and satellite towns which are self contained
City decongestion	Seamless multi modal transport	<ul style="list-style-type: none"> - Provision of parking for private vehicles and cycles near the transit points which encourages and facilitates multi modal transport - Use of ICT in parking management - Bicycle sharing system - Traffic Transit Management Centres - Bus Rapid Transit System - Metro rail supported by an efficient feeder system - Multimodal transport with single ticket - Real-time communication about connected transport service
	Decongested city	<ul style="list-style-type: none"> - Shifting of wholesale markets and hospitals (except emergency services) to the periphery of the city to help in city decongestion - Restriction of long distance trucks and buses at the periphery of the city with improved connectivity of these transit points to the core city areas which helps in decongesting city by bi-passing the traffic
	Reduction in usage of vehicles in the city	<ul style="list-style-type: none"> - Land use planning to reduce the need to travel - Congestion charge in busy inner city areas which reduces inner city traffic volume - Dynamic and demand basis parking fee - Encourage shared services such as carpooling - Penalizing single passenger through tolls

	Increased usability of public facilities and services	<ul style="list-style-type: none"> - Parking facilities to encourage use of public transport/multi modal transport - Integration of land use, density and transportation planning
Energy Management	Energy Wastage reduction	<ul style="list-style-type: none"> - Smart Metering - Reduce transmission loss
	Increased Efficiency	<ul style="list-style-type: none"> - Smart grid with Advanced Metering Infrastructure - Promotion of energy saving methods such as LED lights, solar energy, bio fuel, etc.
	Energy conservation	<ul style="list-style-type: none"> - Renewable energy promotion by the government with the help of policy measures and incentives - Grid-connected SPV rooftop systems - Optimum micro grids - Local energy generation
	Commercial efficiency	<ul style="list-style-type: none"> - Maximize billing efficiency - Maximize collection efficiency
Water Management	Quality of water	<ul style="list-style-type: none"> - Ensure quality of drinking water supply, which will have a direct impact on the health and helps in the reduction of water purification at household level - Water directly drinkable from the tap (at least in public places)
	Water conservation	<ul style="list-style-type: none"> - Awareness programmes to reduce the usage , wastage and leakage - Plugging leakages using sensors
	Water sustainability	<ul style="list-style-type: none"> - Rain water harvesting should be made mandatory for all the buildings - Lake rejuvenation - Water Resources Information System - Efficient water management - Maximum reuse of water
	Commercial efficiency	<ul style="list-style-type: none"> - Maximize billing efficiency - Maximize collection efficiency - Increase in tariff for industrial and commercial uses for promoting use of recycled water

<p>Storm Water Management</p>	<p>Local management of storm water</p> <p>Prevention of storm water pollution</p> <p>Conservation of ground water table</p>	<ul style="list-style-type: none"> - Promotion of Low Impact Development (LID) to utilize the rain water and to reduce the issues associated with storm water runoff - Green roofs for reducing storm water runoff - Bio retention basins for retaining storm water - Measures have to be taken to prevent mixing up of the storm water with sewage - Revival of natural drainage channels and water bodies to prevent flood, for utilizing the storm water efficiently and for increasing the ground water table. - Rain water harvesting and ground water recharge
<p>Sewage management</p>	<p>Proper treatment of sewage</p> <p>Total reuse of sewage</p>	<ul style="list-style-type: none"> - Decentralized sewage treatment measures have to be explored in order to solve the issues associated with sewage at the local level - Condominial sewerage systems - Prevention of mixing up of sewage and storm water to reduce the load on sewage treatment system and to reduce the water pollution. - Decentralized sewage treatment measures to increase the reuse possibilities of recycled water - Water recycling and reuse of all the byproducts - Government should make water reuse policies in order to save water and to prevent use of drinking water for other purposes such as industrial use - Pipe line network to deliver good quality recycled water
<p>Solid Waste Management</p>	<p>Waste reduction by recycling and reuse</p>	<ul style="list-style-type: none"> - Complete segregation has to be achieved - Efficient collection and transportation with well-equipped waste transfer stations. - Radio frequency identification (RFID) for improved efficiency, economy and traceability in waste collection and transportation - Extended producer responsibility has to be made mandatory especially for e-waste - Community participation has to be promoted for solid waste management in order to increase the accountability and to reduce the quantity of waste

	<p>Efficient treatment of Solid waste</p> <p>Reduction in waste sent to landfill and proper disposal</p>	<ul style="list-style-type: none"> - Turn waste into resources by recycling by utilization of safe and suitable technologies which are ecologically safe - Government has to take policy measures and initiatives to improve the recycling percentage of the waste and for reducing the waste sent to land fill - Prevention of groundwater and soil contamination at landfill sites through proper design of the landfill site and by treating harmful waste separately
<p>Smart Buildings</p>	<p>Energy efficiency</p>	<ul style="list-style-type: none"> - Only 10% of the waste should reach landfills - Policy measures have to be taken to make energy efficiency mandatory for buildings above certain specified floor area - Awareness creation about energy efficient buildings and their long term gains
<p>Health</p>	<p>Reduce the impact of buildings on the environment</p> <p>Easy accessibility</p>	<ul style="list-style-type: none"> - Green buildings have to be promoted by means of incentives for construction as well as taxes - Promotion of Zero Carbon Buildings - E- Health - Tele-medicine including online consultation and remote diagnosis facilities - Electronic clinical decision support systems
<p>Education</p>	<p>From disease care to health care</p> <p>Increased reachability with quality</p> <p>Education based on the opportunities</p>	<ul style="list-style-type: none"> - Health Information Technology - Preventive healthcare with better nutrition and enhanced environmental quality has to be given more emphasis - ICT can be used effectively to establish online schools/ live & Interactive classes which can increase the reachability of education - Sustainable and healthy environment in schools - Training and skills development for employment generation and enterprise development

<p>Environment</p>	<p>Conservation of environment quality</p>	<ul style="list-style-type: none"> - Urban Trees and Parks for improving environment quality - Air quality monitoring with the help of sensors - Use of public transport has to be encouraged to reduce pollution - Promotion of cycle tracks with parking facilities which can improve the air quality and also help in energy conservation - Educational institutions should be encouraged to take up green initiatives like rain water harvesting, efficient solid waste management, energy efficiency, etc.
	<p>Increased quality of living</p>	<ul style="list-style-type: none"> - Development of Urban and community forest - Relocation of polluting industries outside the city and implementation of strict pollution control regulations - Promotion of green initiatives through continuous campaigns
	<p>Safety for citizens Convenient and efficient emergency response system</p>	<ul style="list-style-type: none"> - Multi agency response system - ICT for provision of emergency response systems - SMS helpline and mobile applications for prevention of violence against women and Children
<p>Safety & Security</p>		

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