SMART CITY AND URBAN SUSTAINABILITY

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SYNOPSIS

The statistics speak for themselves. The world's population is urbanising and expanding faster than ever. By 2050, well over half the planet's estimated nine billion people will be living in cities or urban centres. If we don't "smarten" up our urban infrastructure, daily life could slowly ground to a halt. This in turn means we cannot afford to live the way we are living today, especially in urban areas where resources are already constrained. This is a threat in itself but at the same time an opportunity too to face the challenges through a plethora of initiatives. In the recent literature, the concept of "smart", "intelligent", or "cognitive" cities has gained increasing attention as an approach for addressing the challenges of urban management. The premise of a smart city is that by having the right information at the right time, citizens, service providers and city government alike will be able to make better decisions that result in increased quality of life for urban residents and the overall sustainability of the city. It is, therefore, stipulated that information resulting from a smart city implementation has a two-fold impact: first, it shifts the social behaviour of citizens towards a more efficient and sustainable utilization of city resources (bottom-up) and second; it allows service providers (such as utilities and transit companies) and city government to provide more efficient and sustainable services (top-down). There is an explicit need to understand the impact of smart cities on urban environmental, social and economic sustainability from a holistic perspective, especially in a country like India where cities are characterized by dense population, bleeding infrastructure, lack of basic amenities and existence of slums.

Keywords: Governance; Smart City; Sustainable Behaviour; Sustainable Planning, Urban Sustainability

1. Introduction

Cities are facing unprecedented challenges as the pace of urbanization is increasing. Every day, urban areas grow by almost 150000 people, either due to migration or births. Between 2011 and 2050, the world's urban population is projected to rise by 72% (i.e. from 3.6 billion to 6.3 billion) and the population share in urban areas from 52% in 2011 to 67% in 2050. In addition, due to climate change and other environmental pressures, cities are increasingly required to become "smart" and take substantial measures to meet stringent targets imposed by commitments and legal obligations. Furthermore, the increased mobility of our societies has created intense competition between cities to attract skilled workforce.

Needs of cities differ strongly but the main three pillars of development remain the same and these are economic, social, and environmental sustainability. A city cannot promote a thriving culture without these three pillars. This will only be made possible by improving a city's efficiency including the carrying capacity. Obviously, this requires the integration of infrastructure and services.

While the availability of smart solutions for cities has risen rapidly, the transformations will require radical changes in the way cities are run today. Thus developing smart cities is not only just a process whereby technology providers offer technical solutions and city authorities procure them. Building up smart cities also requires the development of the right environment for smart solutions to be effectively adopted and used.

The development of a smart city requires participation, input, ideas and expertise from a wide range of stakeholders. Public governance is naturally critical, but participation from the private sector and citizens of the community are equally important. It also requires a proper balance of interests to achieve the objectives of both the city and the community at large. The following diagram depicts the various components of a Smart City in general.

There is no single trend, solution or specific approach for smart cities. Regional trends illustrate that there are divergent urban growth patterns among major regions with different levels of economic development. Significant disparities in the level of urbanization can be observed across different countries across continents including in cities within a given state or a country.

2. Environmental Parameters

Effective implementation of the smart cities requires an integrated and interdisciplinary approach. To ensure a low carbon, a low water and low ecological footprint with infrastructure designed to adapt to the present and future impacts of climate change, developers need to consider the following at the very design and planning stage of the project:

2.1 Land Use Planning

Efficient land use would be a major concern due to limited land size, high population density and economic growth. Land use planning in a Smart City would have to be done to ensure that:

- The most sustainable sites are used for development and that quality of life is enhanced through proper zoning and siting of activities;
- Environmentally sensitive areas are conserved;
- Key ecological assets e.g. rivers, wetlands, lakes, forests may be valorized and development carried out around the specific asset;
- Development is appropriate to the local context and supports a sustainable community.

2.2 Green Buildings and Energy Conservation

The main objective would be to decrease CO_2 emissions. Buildings being responsible for 40% of our carbon emissions, promoting sustainable buildings would be a central challenge. The following needs due consideration.

- Design of buildings must be sustainable and efficient by passive means. This means, the longest façade of a building may be oriented towards the North and South to minimize heat gain inside the building from the rising and setting sun along the east-west axis. This would reduce cost of cooling.
- Building roofs may be finished to have high emissivity and reflectivity (‘Cool Roofs”) in order to comply with the requirements
- Natural lighting may be utilized during day time by providing appropriately sized/shaded windows.
- Buildings may use energy efficient lighting.
- Trees on the north and west of the buildings may be used for providing direct shading. Sun breakers may be sized in addition to surrounding masks to protect openings of the buildings from direct solar radiation.
- Local materials for constructions may be used.

2.3 Use of Renewable Energy

In order to encourage the use of renewable energy within a Smart City, the following may be adopted:

- Buildings may be fitted with solar heating system.
- Based on the latitude of a given city, solar collectors may be oriented to maintain system performance.
- Solar panels may be encouraged for residential and commercial areas, bus stop, traffic light, advertisement, road signage and street lighting.

2.4 Disaster Risk Reduction

The objective is to ensure that developments take into consideration the flood/flash flood and earthquake risks. The following measures are suggested.

- Storm water harvesting and water storage into natural/artificial lakes/wetlands/ponds for disaster risk reduction by reducing floods and damage to infrastructure through reduced peak flows.
- Sustainable drainage measures such as porous surfaces (grasscrete, gravel), grass swales and attenuation ponds may be used to manage the rates of surface water runoff.
- Wastewaters may be canalized to onsite treatment plants and the treated water may be used for irrigation of common areas.
- A minimum of 20% of the plot area may be under soft landscaped areas, particularly on sloped lands.
- Drainage channels may be utilized for aquifer recharge.
- Existing natural drains may be re-routed as appropriate. They must not be simply filled in.
- For buildings with basements, measures should be in place to prevent accident in case of flooding.

2.5 Water use efficiency and recycling

The objective is to manage water resources sustainably by reducing consumption of clean water for non-potable uses and to manage the rain water runoff from the site. The following measures may be adopted.

- Buildings may be fitted with water efficient plumbing and appliance e.g. faucet water aerators.
- Water meters may be installed in buildings;
- Provision may be made of leak detection facilities and monitoring within water infrastructure.
- Species with low water requirement may be planted so as to form at least 50% of the vegetated area
- Storm water harvesting and storage into natural or artificial reservoirs/ponds may be considered;
- Rainwater harvesting systems may be integrated in the design of buildings and the water collected may be used for purposes other than drinking.
- Rainwater harvesting and the overflowing water from storm water ponds may be recuperated in an underground tank for re-use.
- Grey water i.e. water from baths, showers, washing machines and wash-hand basins may be captured and recycled within a building. The treated water may be reused for non-potable use such as toilet flushing or garden irrigation.

2.6 Waste Management

The cities being major producers of waste, smart cities must focus on reducing the volume of waste based on the 3'Rs' (Reduce, Reuse and Recycle) approach, involving a complete shift in the mindset of users from simple waste disposal to waste avoidance and prevention. The following steps may be taken.

- Waste segregation at source, down to household and commercial levels by providing separate bins for recycling (non-biodegradable) and composting (biodegradable) purposes.
- Composting of organic wastes may be encouraged both at household and community level by providing separate collection for organic waste.
- A centralized collection facility may also be provided for e-wastes such as batteries, electronic appliances, computers and other hardware.
- For commercial developments, provision may be made for the collection, segregation and safe storage of hazardous wastes/containment of spillages through the use of oil separators and grease traps.
- Adoption of "plastic bottles and bags free" policies need to be adopted within the smart cities.

2.7 Sustainable Transport

The transportation sector is one of the highest contributors of GHGs. The Smart cities would require sustainable transport to improve access and mobility while decreasing congestion. This may be achieved through the following measures.

- Walking and cycling may be encouraged as a mode of travelling by providing the necessary facilities:
- Provision of an integrated and network of pedestrian and cycling paths within and between developments;
- Provision for cycle storage may also be made;
- Electric bicycles for short everyday journeys around the city can be introduced.
- Dropped curbs will have to be provided at crossings to facilitate access for the elderly/disabled people.
- The safety and security of pedestrian and cyclist must be a priority in order to encourage users to shift from automobile usage to walking or cycling.
- Use of electric/hybrid vehicles may be promoted by planning support facilities such as service station.
- Carpooling/sharing may be promoted.
- An Integrated Public Transportation System may be designed to economically move people on time. It is important to have a good network to connect public transportation within the cities in order to ensure a better connection and reduce waiting time.
- To reduce reliance on private transportation through promotion of " hop on hop off" LPG or electric driven public transportation covering strategic places of residence, work, and commercial areas.
- A park and ride system may be introduced at the peripheries of the smart cities.

2.8 Greening and Biodiversity

The residents of smart cities must have greenery around. This helps to reduce heat effect, provide carbon offset, conserve biodiversity and enhance the aesthetics. The overall objective would be to ensure that there is no reduction in biodiversity due to development and wherever possible, a net gain. The following measures may be taken:

- The ecological value of a development site may be conserved and enhanced, maintaining biodiversity and protecting existing habitats, which contribute to and enhance the amenity of a particular area.
- Capitalise on storm water harvesting to allow for the creation of artificial lakes/wetlands/reservoirs to give way to greeneries for enjoyment and nature;
- Continuous green belts, parks, open space, endemic gardens and biodiversity corridors may be created and maintained for human enjoyment of nature, open air activities and sports.
- Natural features, landscaped spaces and greeneries as a form of value creation may be incorporated within the master plan.
- Green agriculture with roof top gardening may be considered.
- Overall, the development must be based on the Garden City Concept with necessary ingredients.

2.9 Community

Sustainable communities depend upon the effective delivery of community infrastructure. The objective is to ensure that development encourages and supports a vibrant, diverse and inclusive community, which can integrate with the surrounding communities. To achieve this, the following measures may be taken.

- Development may be planned around a key asset of the site, which would be the focal point where people will be able to meet and socialize to create socially inclusive communities.
- Developers may capitalize on the presence of an Environmentally Sensitive Area such as a river, lake, forest as an opportunity to enhance the same as a focal point for recreational/sports/social/eco-tourism activities within or near the smart city.
- The set up should allow for social interaction and conviviality amongst citizens, irrespective of their social class and ethnicity while converging towards or passing by this vibrant pole of attraction.
- The Smart City must be able to integrate people of all social fabrics including those within the surrounding areas through job creation.
- The development may ensure that there are available facilities within the neighbourhood, which are appropriate to the existing and new communities that will be developed.

3. Quality Standards

Standards are necessary to ensure interoperability of technologies and the transfer of best practices. But standards are not yet adapted to the level of technology integration we require. Standard bodies still operate in sectorial parallel silos, developing standards which are not easy to understand by non-specialists, particularly city managers. Standards are facilitators for city planners, and they need to incorporate standards in planning and procurement. In order to ensure quality of goods and services and overall living condition, the following standards will have to be established and adhered to.

- Drinking water Standards
- Environment Standards for Noise
- Standards for Air
- Standards for Effluents for use in Irrigation
- Standards for Effluent Discharge

4. Impact of the Smart City Paradigm on Urban Sustainability

In order to achieve multi-dimensional urban sustainability, both bottom-up citizen behaviour and top-down government decision-making must become more efficient, effective and sustainable (Cutcher-Gershenfeld et al., 2004). It is necessary that officials (who work based on established rules and standards) report and respond with fairness and consistency to the concerns of residents. During this process, all residents, including the poor, should be able to play an essential role in decision-making. Public employees should have access to basic entitlements necessary to make a living.

All residents should have access to low-cost, understandable and relevant information, from which effective accountability and clear laws, regulations and policies can be provided (De, 2010). Meanwhile, the interconnected systems of land use, water, energy and transportation systems that comprise the urban infrastructure all affect the decision-making process. Finally, the implementation of socioeconomic and environmental policy affects the decision-making process for sustainable cities (Minne et al., 2011).

4.1 Sustainable Citizen Behaviour

Human behaviours such as excessive breeding and overconsumption cause major environmental threats, including global warming and ozone layer destruction (Oskamp, 2000; Giord, 1999). Accordingly, behaviour change is required to achieve the goals of sustainability. Teachers can play an essential role in helping citizens to adopt sustainable patterns of living and enhance their contributions to the environmental, economic and social aspects of sustainability (Oskamp, 2000; McKenzie-Mohr, 2000a; Vlek and Steg, 2007). Since human behaviours are rooted in social situations, institutional contexts and cultural norms (Shove, 2010), individual adaptation and change as well as personal agency are also embedded within those socio-structural networks. Social structures shape rules and resources to organize, guide, and regulate human actions. Meanwhile, human activities create, implement, and alter social systems.

Within this dynamic, personal agency and social structure operate “as interdependent determinants in an integrated causal structure rather than as a disembodied duality” (Bandura, 2004). Human behaviour change is a must to achieve the goals of sustainable urban development at the same time conserving the environment. Actors include officials, inhabitants, non-governmental organizations (NGO), activity groups, religious groups, community-action groups, private sector firms, women and experts. In practice, the role of these local communities and groups in protecting the environment is more significant than the government's role (While et al., 2004).

In smart cities, the usage of new information and communication technologies (ICT) facilitates smart administration and good governance using tools such as e-governance and e-democracy. This, in turn, enhances effective political participation among residents and officials (Fertner et al., 2007). ICTs strengthen freedom of speech and improve access to public information and services (Partridge, 2004). Citizens prefer online participation and discussion, due to the relative lack of nonverbal politics in an online environment. Inequalities stemming from race, gender and disability are decreased in online communities. In fact, the medium of the web might serve to increase citizens' political participation and the power they can wield in their communities (Sotarauta, 2001).

4.2 Sustainable Planning

New urbanism, smart growth, and the ecological city are three sustainable urban development approaches. Smart growth refers to natural resource protection, regional collaboration, and economic development based on local capacity and resident participation. New urbanism addresses itself more to” architecture of community” focusing on the structure of places/open spaces to improve the quality of life. In the eco-city, land-use policies reflect the use of renewable energy, diverse transportation options, short travel distances, and urban density (Jepson and Edwards, 2010). For planners, the city should be considered a complex system consisting social, economic and environmental sub-systems. Thus, planners require tools to manage natural resources, pollution, information, and trade (Campbell, 1996).

In order to achieve urban sustainability, government in a smart city would have to employ information technologies, including internet and mobile computing, to enhance its relationship with citizens, businesses, and other governmental sectors. This would enable delivery of more services to citizens, improved interactions with businesses and more efficient governmental management. Other benefits of e-government would result in less corruption and cost along with greater transparency, convenience and revenue growth. Meanwhile, citizens themselves are empowered by this improved access to government information and services (Palvia and Sharma, 2007; Yildiz, 2007). Implementation of other socio-economic and environmental policies also affects the decision-making process in sustainable cities (Minne et al., 2011).

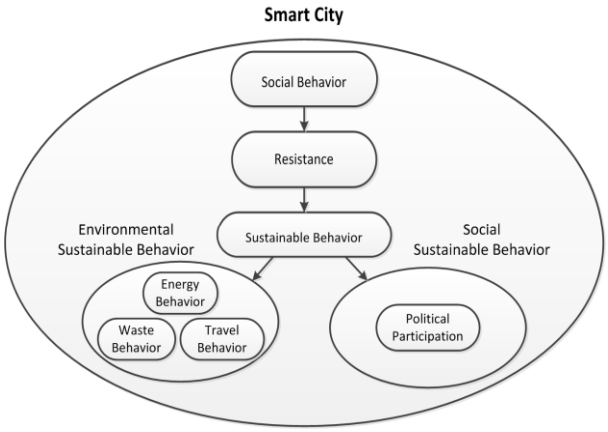

Figure 1: Impact of smart city on sustainable behavior

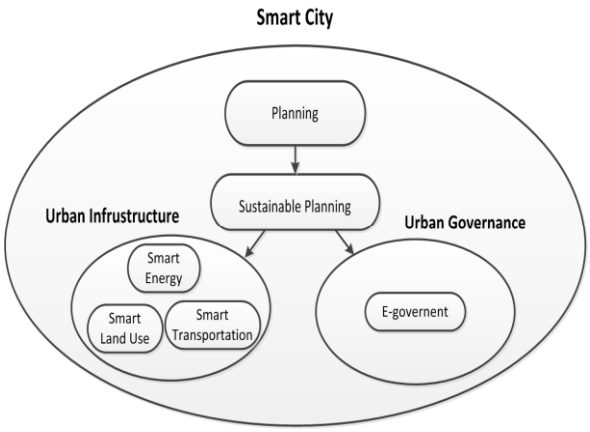

Figure 2: Impact of smart city on sustainable planning

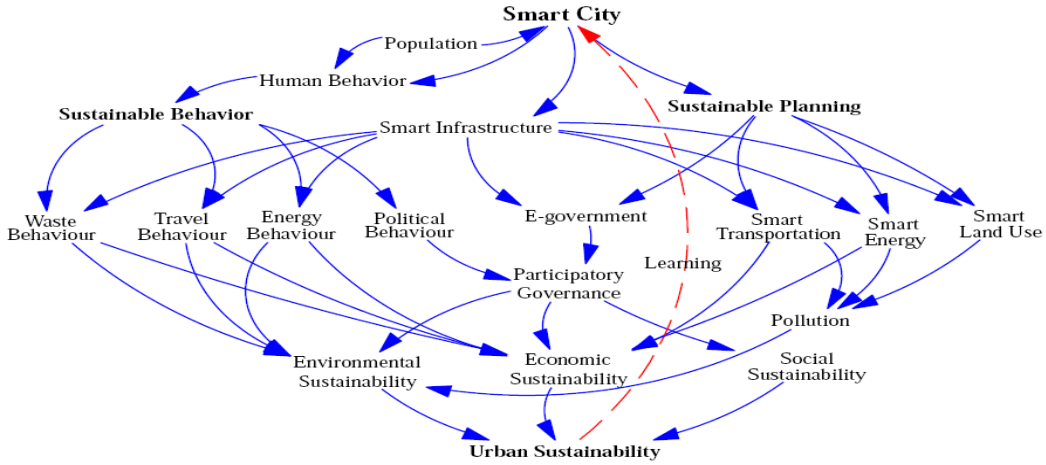

Figure 3: The process of achieving urban sustainability

5. Conclusion

Smart cities are necessary not only to reduce emissions, but to handle the rapid urbanization growth that the world is experiencing. Inefficiencies in urban areas bring large negative environmental and social impacts. City infrastructures are the backbone of the cities, delivering the necessary services to the population and creating the conditions for citizens to develop their professional, social and cultural activities. Infrastructures are also quintessential in guaranteeing the city's resilience to environmental risks. Until now city infrastructures have been built independently and operated separately in parallel silos. Furthermore, the citizen has mainly been a consumer of services with little direct influence on the system. In a smart city, this needs to change. First of all, efficiency requires that infrastructures are appropriately interlinked horizontally. Secondly, citizens are becoming producers and service providers. With smart systems, goods owned by citizens can be active in improving efficiency. Smart meters and electric cars can interact with the grid, data produced by the smart applications of the citizens can contribute to traffic control, improve emergency response, etc. Citizens can also use the technologies to sell new services. This change in cities needs to be accompanied by enabling conditions, which means reforming the ways cities are governed and financed, i.e. administrative reforms and new financial systems. Access to the right information at the right time allows citizens, service providers and city government to make better decisions that result in increased quality of life for urban residents and overall sustainability of the city.

To achieve multidimensional urban sustainability, citizens' behavior and government decision-making must each become more efficient, effective and "sustainable". This would shift the social behaviour of citizens towards a more efficient and sustainable utilization of city resources, while allowing service providers and city government to provide services more efficiently and sustainably. In other words, smart cities will require innovation when it comes to planning, management and operation of their infrastructures and resources if they are to cope with the future demands of their citizens (Naphade et al., 2011). Smart cities are thus capable of altering the environmental and social behaviours of citizens, whether this means providing information about mechanisms for reducing energy consumption, or updates on travel routes. In addition, they would facilitate smart governance and political participation among citizens and officials through the use of ICTs like e-governance and e-democracy. However, in making use of these technologies, cities must deal with challenges related to privacy, security and government surveillance. In practice, residents will live in a "surveillance society"; that is, where societies are connected but completely unknown to one another (Alusi et al., 2011). Only time will tell what this would result in. Yet another challenge facing smart cities is to properly model and understand human behaviours through psychology, user experience design and social computing (Naphade et al., 2011). The other challenge for a country like India would the integration of slum areas into the proposed smart cities. The task though daunting, is not impossible.

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