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Smart Sustainable Cities: A Need for 21st Century

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Abstract— The sustainable city is a relatively recent concept which has gained increasing attention the last decades both through the international community and through grass root movements. "A smart sustainable city is an innovative city that uses ICTs and other means to improve the quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects." Smart, sustainable city transformations are complex and difficult, requiring a holistic approach, encompassing long-term planning, partnership and engagement. But with the right foundations, cities can put themselves on the path to sustainability and Return On Investment (ROI), not only in traditional financial terms, but also in the so-called triple-bottom-line dimensions of economic, social and environmental sustainability. Creating a smart, sustainable city is a continuous process, requiring vision, ongoing measurements and constant rebalancing of complex, often competing needs. To ensure the best chance of success, those shaping the future of cities must lay a solid foundation for transformation, based on purpose-driven planning, networked governance structures, organizational capacity building, broad stakeholder engagement and effective long-term partnerships..

Keywords— Sustainability; Innovative; Transformation; Planning; Stakeholders

I. INTRODUCTION

Just half a century ago, only one-third of people lived in urban areas; now it is over half, and by 2050, the united nations (UN) expects worldwide urbanisation to reach 70%. Given that both rapid urbanisation and strong population growth are concentrated in poorer countries, the un estimates that cities in emerging markets will see their populations more than double to 5.2 billion by 2050, from 2.5 billion in 2009. India's urbanization levels will also increase up to 70 per cent from 30 per cent in 2011. India will have 68 cities with population 1 million or more than 1 million, 13 cities with more than 4 million people, and 6 megacities with populations of 10 million or more, at least two of which (mumbai and delhi) will be among the five largest cities in the world by 2030 (source: indian urbanization econometric model, mckinsey global institute analysis report). Adverse effects will also increase along with urbanization. Increasing populations at such a fast rate will only exacerbate the numerous problems in urban areas like increase in slums, air pollution, water shortages, energy shortages, traffic congestion, waste water and sewage and industrial waste. 21ST century has brought with it a new requirement of "smart sustainable city" and this concept requires a swift review of the existing cities. A smart city is the integration of technology into a strategic approach to sustainability. In general, "sustainability" refers to a harmonious relationship between human and environmental systems. "a smart sustainable city is an innovative city that uses information and communication technologies and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects"(source : itu–t focus group). Smart sustainable cities are to empower urban residents to make their cities capable of providing sufficient food, water, energy and waste management within their local vision. When these resources access will become decentralized, local level will promote a community mind-set of self-sufficiency and encourage towards independence from the destructive and dangerously unsuitable dominant system. The key attributes of smart sustainable cities are sustainability, quality of life and intelligence. Sustainability relates to governance, pollution, climate change and other factors. Quality of life refers to the financial and emotional well-being. Intelligence is the implicit or explicit ambition to improve economic, social and environmental standards.

II. DEFINITION

"When investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance" (Allwinkle & Cruickshank (2011, p. 500)). "Smart" in this case is a feature rather than taking as a criterion for performance. Smart is seen here as a prefix representing a special category of products, services and product-service systems. "Sustainable development" is development that meets the needs of the present without compromising the ability of future

generations to meet their own needs. It contains within it two key concepts: the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs. (Bruntland report). “Cities” is the object to which both smart and sustainable are combined. It is used here as to designate the types of human structures and environments where smart solutions for sustainable development may be found. The most important feature of smart sustainable cities are Compactness, Sustainable Transport, Population Density, Mixed Land uses, Diversity, Passive Solar Design and Greening the area. A Smart Sustainable City is a city that fulfils the needs of its present generations with consideration for future generations to meets their necessities and requirements of resources, and thus, within local or global environmental limitations with the help of ICT. So the Smart Sustainable Cities (SSC) should be seen as an aggregate concept. As shown in Figure 1, this means that all three parts need to be present for an entity to qualify as a smart sustainable city; if not, the entity is instead a smart city, a sustainable city, a case of smart sustainability – or something else. The Sustainability Plan acts as an adjunct to the City’s Comprehensive Plan and will cover three broad areas: Environment, Economic Prosperity and Social/Community initiatives. It tries to balance the environment, economy and social good, recognizing that a healthy environment underpins economic and social well-being. For example- Frankfurt is the leading smart and sustainable city of the world securing first place in the list of most sustainable cities. Frankfurt increased the green percentage of the city by establishing parks, planting trees along the roads and woodlands and 52% of the total city area is dedicated to open spaces and water bodies. The city council has employed certain planning and design techniques to protect the climate such as passive housing, expansion of cogeneration facilities, efficient and effective use of electricity etc. A sustainable city is a city that is taking an intelligent, long-term collaborative approach to tackling the economic, social and environmental challenges that arise when more and more people come together in dense, compact areas, stretching already scarce resources. Applicable across a vast array of industries, including automotive and transport, health, education and banking, sustainable city modelling solutions come in a variety of shapes and sizes. Take for example intelligent buildings that utilize connectivity for security, energy and climate monitoring and are net producers of renewable energy, Or disaster and management solutions that use remote sensors to alert people at risk of severe weather or natural disasters. Smart meters can give consumers the knowledge they need to control their energy costs Or food initiatives where it’s possible to choose healthy and appetizing food with a low carbon/water footprint, and plan meals to avoid waste.

III. SCOPE

Urbanization presents one of the most pressing and complex challenges of the 21 century. How cities are designed, managed and used is likely to shift substantially based on demands created by two powerful trends. One trend involves a growing awareness of a threat to the sustainability of the Earth’s natural environment; the second is the rapid rise in the number of people moving into and living in cities. Combined, these trends call for massive development of new buildings and infrastructure, along with new social and cultural institutions, to accommodate vast numbers of city dwellers without irreparably harming the natural environment. Human development since the Industrial Revolution has had serious impacts on the environment, and the growth and destructive actions of human society have resulted in negative impacts on the Earth’s sub-systems (Steffen et al. 2011). We are therefore facing a systematic sustainability challenge (Ny et al. 2006), wherein human behaviour cannot continue on the same course without having significant negative impacts on future generations’ ability to meet their needs (O’Brien 1999). Reaching sustainability will require significant and widespread changes in human behaviour. The global urbanisation trend is creating an urgency to find smarter ways to manage the accompanying challenges (Nam and Pardo 2011). Sustainable cities have become a highly desired goal for future urban development. For the scope of this thesis, we focus on the concept of smart cities, defined as cities where “investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance” (Caragliu, Del Bo and Nijkamp 2011,). Smart cities highlight important aspects of sustainability, such as the need for responsible resource management, energy efficiency, and citizen engagement. However, the smart city concept can only help a city to reach sustainability if it allows it to function within the natural boundaries of the Earth. Given the present day understanding of the smart city concept, it is unclear whether it holds the necessary characteristics to ensure that sustainable development can occur. Smart cities are highly complex and interdependent, since they are built from large, interconnected systems. Studying them would therefore require an approach that works well in complexity.

Sustainable cities have become a highly desired goal for future urban development. However, there are several differentiating descriptions of what exactly a sustainable city should look like. According to the think-tank Sustainable Cities International (2010), a city should adopt city-specific sustainable development strategies in order to foster innovation and advancements within

infrastructure and technology, whilst also increasing efficiency gains. Bulkeley and Betsill (2005) address how strongly cities and local governments actually can influence the challenges of sustainability.

IV. DIMENSIONS OF URBAN SUSTAINIBILITY

Sustainable development has been described as the intersection between social, environmental and economic goals. Sustainability has performed more of a balancing act than promoting any real change of direction to development. The most pressing problem with this model is that it offers relatively little understanding of the inherent trade-offs found in the simultaneous pursuit of these goals. Coupled with this, the picture it provides is too abstract to appreciate how sustainable development unfolds at the urban level, but also to acknowledge the political dimension of the process. By definition, cities are not sustainable, urban dwellers and economic activities inevitably depend on environmental resources and services from outside their built-up area.

A. Economic sustainability is understood as the capacity and ability of a practice to be able to put local/regional resources to productive use for the long-term benefit of the community, without damaging or depleting the natural resource base on which it depends and without increasing the city's ecological footprint. This implies taking into consideration the full impact of the production cycle.

Social sustainability refers to the fairness, inclusiveness and cultural adequacy of an intervention to promote equal rights over the natural, physical and economic capital that supports the livelihoods and lives of local communities, with particular emphasis on the poor and traditionally marginalized groups. Cultural adequacy means, in this context, the extent to which a practice respects cultural heritage and cultural diversity.

B. Ecological sustainability pertains to the impact of urban production and consumption on the integrity and health of the city region and global carrying capacity. This demands the long term consideration of the relation between the state and dynamics of environmental resources and services and the demands exerted over them.

C. Political sustainability is concerned with the quality of governance systems guiding the relationship and actions of different actors among the previous four dimensions. Thereby, it implies the democratization and participation of local civil society in all areas of decision-making.

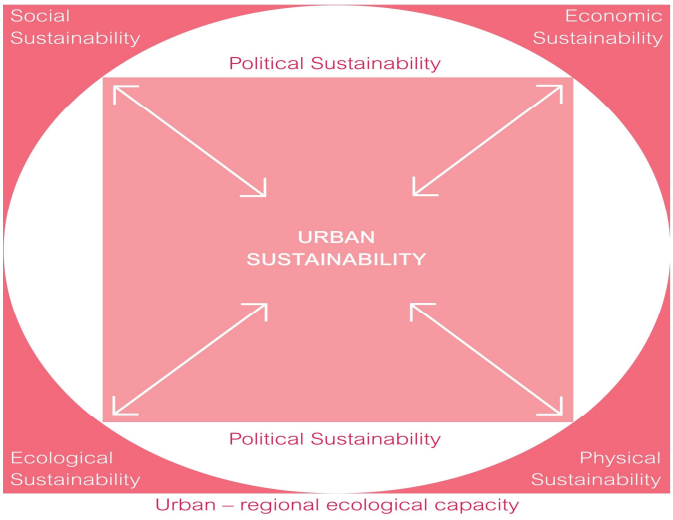

Figure 1: Urban sustainability

V. SUSTAINABILITY INDICATORS

To translate sustainability into practice is a problematic phase. It is therefore important to identify the elements of sustainability. This is especially important to decision-makers due to the different interpretations of the concept of sustainability. One way is to assess and measure sustainability by applying Sustainability Indicators (SI's). The indicators can be viewed as variables in order to make sustainable development applicable. The ideal indicator should be able to reduce large quantities of data to its simplest form of where it still retains the essential meaning of the questions asked of the data**.** The process of selecting SI's is important in the progress to integrate sustainable development in concrete action plans. Important functions with SI's are;

A. Assess conditions and trends,

B. Be comparable across places and situations,

C. Assess conditions and trends in relation to goals and targets,

D. Provide early warning information,

E. Anticipate future conditions and trends; such as air pollution indicators

Sustainability indicators have been focused on quantitative data which restricted the concept of sustainable development to numerical variables. But indicators can also be ordinal variables or ranks. The *foci* on quantifiable data of national states or local governments are due to the means and capacity; to conduct the necessary measurements and statistical analyses that are required to develop these indicators. Just as well as the Gross Domestic Product alone can't assess the outcome of economic development, the concept of Sustainable development can't be confined in numerical data. When selecting indicators the nature of the indicator as well as the hierarchal level has to be considered in order to make a right analysis. Another implication of sustainable development reports today is how specified the data presented should be. Since a more simplistic presentation could allow for a comparison. Another aspect that is important to include is the fact that the indicators are inter-linked; within and between systems. Most research is based on a national basis not on a city-level which is why it is difficult for cities to address the sustainability problem. Time and spatial scale which needs to be included in the conception of sustainable development are neglected, partly due to the lack of capacity and skills which have been prominent in the case of urban-level indicators and could explain the low priority given to assessing sustainable development at different spatial scales. A spatial design of sustainable development is crucial if the concept should work in practice and in the policy process. The temporal aspect is also important due to the dynamic in the process of sustainable development. Often cities lack well-coordinated environmental management strategies for sustainability. Introducing SI's would not only manage the environmental impact of urban growth but also ensure that growth is not on the expense of nature or ecological integrity locally or elsewhere. Key indicators are air and water quality standards, particularly for cities where large concentrations of people live. These indicators have a considerable effect on the quality of life and the living standards. These are useful indicators as most cities are more likely to monitor some aspects of air and water quality. However, little effort has been made in understanding the process of tracking the effects it has on the urban environmental quality. It is more likely that urban governments adapt sectoral approaches in the monitoring of the urban environmental quality.

VI. METHODOLOGY

A. Compact cities

Area of cities generally should not exceed 50 to 100 km^2, enabling ease of mobility, economic activity and better management of physical and social infrastructure.

B. High population density

Affordability in a city can be achieved with high population densities ranging between 100 and 150 persons per hectare in the city which will result in more economical cities.

C. Mixed land use

Mixed use developments including three or more significant revenue-producing uses including retail/entertainment, office, residential, hotel, and/or civic/cultural/recreation, in well planned cities are mutually supporting. Mixed use developments also signify physical and functional integration of project components and thus a relatively close-knit and intensive use of land, including uninterrupted pedestrian connections and development in conformance with a coherent plan that frequently stipulates the type and scale of uses, permitted densities.

D. Transit oriented development- polycentric cities economize on transit cost and time

Transit oriented development (TOD) helps in integration of transport networks with land use and development rights and potential. It implies a polycentric city structure, enables local employment centres and reduces the pressure on CBD's by optimizing commuter costs and time. Supported by public transit, TOD is inevitable for sustainable development.

E. Connected

ICT networks when integrated into a sustainably developed City helps better service delivery making the City a Smart City. It becomes an enabler for integrating and documenting data pertaining to various forms of usage in all segments of infrastructure delivery.

F. Green infrastructure

1) *Transit First:* A City provided with mass rapid transit system; enable real time travel planning, E–Bus Rapid Transport (GPS enabled), Mass Rapid Transit (metro-mono rail), Smart Parking, Multi-modal transit integration.
2) *Pedestrian First:* Good cities allow 'eyes on the street' (applying the legendary Jane Jacobs in India); Inclusive streets that incorporate the vast informal sector in an organized spatial manner supports economic activity, provides safety, security and strengthens social capital of cities in India. Technology will help coordinate pedestrian mobility with vehicular.
3) *Green streets:* Defining street networks in urbanized areas as an integral part of the ecological network of cities, streets can incorporate a wide variety of design elements including bio - swales, water- retention and detention ponds for ground water recharge, infiltration trenches, green parking spaces and lots; Green Streets achieve multiple benefits, such as improved water quality and more liveable communities, through the integration of storm water treatment techniques which use natural processes and landscaping; ease of traffic movement is supported by fine grid of street hierarchy; Permeable pavements for structural support, runoff storage, and pollutant removal through filtering and absorption.
4) *Intelligent street lighting:* It is known as adaptable smart street lighting system, dims when no activity is detected, but brightens when movement is detected. This type of lighting has a working which is different from traditional, constant illumination, or pre-determined dimmable street lighting.
5) *Waste to energy:* It facilities offer a safe, technologically advanced means of waste disposal while also generating clean, renewable energy, reducing greenhouse gas emissions and supporting recycling through the recovery of metals and brining environmental benefits. The recent trends include-Getting Bio-fuel from Garbage, Turning wastewater into Ethanol, Converting waste heat to electricity etc. At the unit level, a decentralized under-ground waste collection and processing system will reduce the transmission of waste to the landfill to 20% of the total collection.
6) *Renewable energy:* Using either of solar, wind and tidal for of infrastructure to generate resource for another constitutes generation of renewable energy. For example, generation of power from installation on high tension lines or along complex structures which will link to the power grids. The present contribution of renewable energy sector to the power sector requires to be enhanced from 10% to 20%, thereby having parallel positive implications on employment and better environment and health.

G. Access (distance and space standards) to social infrastructure

Social infrastructure can be built at various levels of disaggregation, macro, meso and micro, for health, education, open spaces and other social amenities in a manner that ensures per capita space and distance based access. The ICT network shall supply to these in order to integrate service access and delivery to the end user.

H. Low carbon footprint: Infrastructure, buildings

To evaluate extent of greenhouse gas emissions in various production systems for cities is mandatory to accompany master plans/ development plans for cities in India by using 'Life Cycle Analysis'. Carbon foot print can be evaluated in two phases construction and operation phase. Modern building materials consume higher embodied energy and can cause bigger carbon footprints. Conducting LCA for production systems for engineering infrastructure (water, sewerage, roads, power, drainage, solid waste) and typologies of buildings (vernacular, glass encased, predominantly concrete) is essential to defining codes and practices for sustainable development.

I. Security systems

Safety ensured through ICT network based systems (supply to public realm, public spaces in private realm); ICT network can provide more secured and smart interface/ environment solution to security systems.

J. Welfare

Various welfare schemes like insurance, subsidies, cash transfers, loans etc., can be delivered with help of services enabled through ICT based networks.

K. The Informal Sector: Lateral thinking

India's economy comprises a vast majority of the Informal Sector which not only is engaged in informal economic activity but also occupies space informally, consumes infrastructure informally and is structured on the basis of social mutual trust, bringing

resilience. The Smart Sustainable City must incorporate inclusive streets and rental housing. It also must devise place specific barters that support the informal sector. For example, the Latin American cities provide better access to the favelas through public transit and have launched a programme of 'food for garbage' scheme, thereby lowering crime rates. The ICT system can enable measuring effectiveness and outcomes.

L. Finance

Sustainable structure towards revenue generation; regulations that support natural urban renewal and continual levying of development charges; ring fencing for effective management of resources: Revenue generation is a crucial area in making the local government self-sustainable. Other than taxes many times the urban local bodies are unaware about their land bank due to old mapping techniques, less interaction with revenue department etc. These all can be rectified by building common interface at local level which will enable real time data on tax collection and reflection impact by smallest deviation in tax and land resource restructuring.

M. Governance

Multiple software application tools like mygov.in can be accessed by public and private stakeholders for all sectors; the Urban Local Body as the Nodal Agency for Brown Field Sites and the SPV as the Nodal Agency for Green Field Sites.

N. Stakeholder engagement

The five major stakeholders are the public authorities, private agencies, non-government organizations, professional's bodies, residents' welfare associations and the elected representatives form the key stakeholders of a city. The bottom up approach will enable negotiation between symbiotic groups and help prioritize the services/ facilities required. Social network can be one of the best methods to involve various stakeholders for involving them in decision making with the help of ICT.

O. Integrated City Plan Implementation

Resource optimization in deployment of construction management linked to planning and city management, for Urban Local Bodies and Special Purpose Vehicles. ICT will assure the optimum utilization of resources available.

P. GIS – MIS based management through effective M&E systems

GIS-MIS based management will assure seamless connection between special and non-special data. This will also reflect how any finical decision taken will affect special parameters of the city.

VII.KEY DRIVERS FOR ACTION

A. Strategic policies, legislations, rules and regulations

Smart and sustainable cities have to be planned, designed, implemented, and managed effectively. Also, the benefits of smart cities are not automatic. These require strategic policies and innovative thinking about 21st century technological advancements in the sustainable urbanization agenda. More, it is important that the development of a smart city is understood not as the final aim of city administrators, but as a way to reduce costs of public services, enhance access to and quality of these services, enhance regulatory compliance, and help enhance the transparency and accountability of public agencies. All these require smart governance that recognize complementary assets and linkages of urban and rural areas, advance partnerships and bottom up approaches inclusive of stakeholders.

B. Innovative, responsive urban planning and design

Planning and design from the planned city extension perspective focuses on: public space layout that minimizes transport needs and service delivery costs while optimizing the use of land; street patterns that enhance mobility and space for civic and economic activities; open spaces that provide areas for recreation and social interaction enhancing quality of life; and, block typology that facilitates private investment in defined and serviced areas. There is a need to re-evaluate existing approaches and instruments, identify good practices suited to local contexts, ensure alignment with international standards, and promote integrated approaches across government ministries and sectors (transportation and communication networks, green buildings, inclusive and efficient human settlements and service delivery systems, improved air and water quality, disaster preparedness and response toward urban resilience).

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C. Robust financial planning

Smart city approaches require robust financial planning and investments, thus need to be informed by knowledge anchored in local context. This requires inclusive governance marked by stakeholder engagement -- harmonizing public and private sector priorities and ensuring civil society participation, including marginalized and vulnerable groups, in local public decision-making processes. Financial models also need to be well designed, focused on cost-effective and sustainable solutions and conducive to foreign investment. This aspect focuses on developing a realistic and implementable financial plan that is crucial to the successful implementation of planned city extensions and infill (PCE/I).

D. Coherence

There is need for international consensus on what "smart and sustainable city" means, and deeper understanding of how approaches labelled as "smart" advance the new urban agenda. The assumption that the application of ICTs in planning, design and management of urbanization and cities will automatically result in improved outcomes needs to be addressed. This is a long term process and cannot be achieved overnight. Transitioning or building a city into a smarter, more resilient, more sustainable city is a journey and every city is likely to have different pathways. This is a long term process of actions that would not only allow for comparability but would also promote sustainable development along with each city being able to quantity improvements. Cities are accountable for continuous improvement to strengthen its effectiveness for the future. Therefore the process should be able to adapt to the dynamic, evolving and complex nature of cities and be able to continuously update the vision as required.

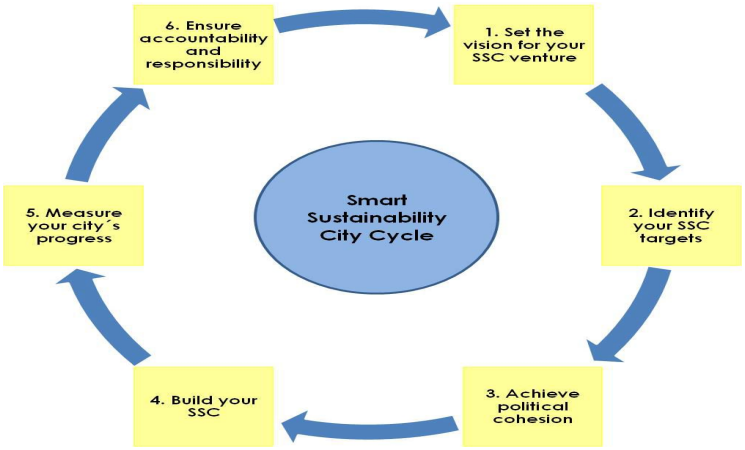

Figure 2: Smart sustainability life cycle

VIII. MODEL SMART SUSTAINABLE CITIES

1	Frankfurt	11	Sydney	21	Houston	31	São Paulo	41	Doha
2	London	12	Toronto	22	Philadelphia	32	Mexico City	42	Moscow
3	Copenhagen	13	Brussels	23	Tokyo	33	Dubai	43	Jeddah
4	Amsterdam	14	Manchester	24	Rome	34	Abu Dhabi	44	Riyadh
5	Rotterdam	15	Boston	25	Washington	35	Shanghai	45	Jakarta
6	Berlin	16	Paris	26	Kuala Lumpur	36	Istanbul	46	Manila
7	Seoul	17	Melbourne	27	San Francisco	37	Johannesburg	47	Mumbai
8	Hong Kong	18	Birmingham	28	Los Angeles	38	Buenos Aires	48	Wuhan
9	Madrid	19	Chicago	29	Dallas	39	Beijing	49	New Delhi
10	Singapore	20	New York	30	Santiago	40	Rio de Janeiro	50	Nairobi

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Set the vision for the city venture	Identify the targets	Achieve political commitment	Build the city you want	Measure the city's progress	Ensure accountability and responsibility
Identifying -- a city vision that is in line with the city's identity and long-term development strategy; relevant stakeholders and mechanisms for multi stakeholder involvement; the existing governance and organizational mechanisms for city solutions.	Developing city infrastructure (e.g.; Internet of Things); Identifying and developing smart and sustainable city services.	Local governments should obtain the necessary political approval and backing to ensure that the strategic programme is pursued. This includes the adoption of the programme/targets through consensus.	The existing traditional infrastructure may be improved on by integrating ICT applications or a new infrastructure must be built from scratch; developing an action plan; establish Public Private Partnerships programmes; ensuring long term services via good operation and maintenance.	Consists of monitoring and evaluating a work programme required to achieve the targets. Internationally approved KPIs can be utilized to help city administrators map their city's progress.	Involves evaluating, reporting and learning from city process and related experiences. The reflective process of evaluation will feed into a process of continuous learning, which in turn will influence and inform the development of the future vision and strategy for smart and sustainable cities.

A. Frankfurt

Frankfurt is the leading smart and sustainable city of the world securing first place in the list of most sustainable cities in the world. Frankfurt increased the green percentage of the city by establishing parks, planting trees along the roads and woodlands and 52% of the total city area is dedicated to open spaces and water bodies. Frankfurt was one of three finalists to be awarded European Green Capital 2014. Furthermore, the city has been recognised as the European City of Trees 2014 – not only is every tree registered and monitored; the information is also publicly available online. Frankfurters can also enjoy Germany's largest city forest with more than 8,000 hectares or one third of the city. Since 1990 Frankfurt has already decreased its CO_2 emissions per capita by 15% while increasing its economic power by 50% and office space by 80%. The electricity and gas in the city is manufactured using bio-waste that has been collected from the residential areas and from around public places, hence the city achieved the goal of reducing carbon emissions. The pleasant and compactness of the city is the main reason, so that 15% of all commutes are already done by bicycle.

B. London

London is a city with a great international profile, widely regarded as one of the top cities in the world as evidenced in the Sustainable Cities Index securing 2nd place in the list of most sustainable smart cities in the world. The management of London's passenger and road transport systems is amongst the most advanced in the world. Innovations include: Congestion Charging using number plate recognition. The London Data Store is an open data platform that provides over 500 datasets. It's designed to help citizens, businesses, researchers and developers to understand the city and develop solutions to London's problems.

C. Copenhagen

Copenhagen is ranked 3rd among the list of most sustainable cities in the world, Copenhagen can set the path for developing smart cities to follow. Copenhagen has also been recently named as the 2014 European Green Capital. Making its citizens educated and aware, the city has negligible amount of air pollution as 50% of its citizens use bicycle as their mode of transport. This has also

made city on low carbon emissions making it the first carbon neutral capital in the world. Copenhagen is also a zero waste city that recycles all its waste and reuses it. The city also employs cycles of cleaning harbour water through mechanical, biological and chemical waste water plants which has improved the marine ecosystem. To help saving water, several initiatives have been taken: installation of individual water meters, price mechanisms, awareness campaigns, and other solutions. Because of these efforts, water usage from 1987 to 2010 went from 171 liters to 108 liters per capita per day

D. Amsterdam

Amsterdam is ranked 3rd among the list of most sustainable cities in the world. Amsterdam Smart City initiative which began in 2009 includes 79 projects collaboratively developed by local residents, government and business. It main purpose of the project is to reduce traffic, save energy and improve public safety. An example of a resident developed app is Mobypark, which allows owner of parking spaces to rent them out people for a fee. The other projects are flexible lighting System allowing authorities to control the brightness of street light and monitoring traffic and analysing and broadcasting to motorists by helping them to determine the best routes to travel.

IX. IMPLEMENTING THE CONCEPT OF SUSTAINABLE SMART CITY IN INDIA

Cities must adopt sustainable development policies as soon as possible because today's infrastructure investments will be locked in for hundreds of years. This is all the more urgent in developing countries like India that are rapidly urbanizing. Making a city smart and sustainable is quite challenging because the first step towards making a city sustainable and smart is to engage the citizens, government and business as a whole unit. The Sustainability Plan seeks to build community resilience in the face of such challenges as peak oil, climate change and economic crises. It is designed to engage our community to create an inspiring local way of life that can withstand the shocks of rapidly shifting global systems. The focus area of the smart cities in India would be improve air quality, improve groundwater/drinking water quality, improve surface water quality, improve storm water management, increase water conservation, prevent solid waste from entering landfill and restore and maintain natural habitat. Policies that correct environmental issues may have negative or positive side-effects, leading to either tradeoffs or synergies. For instance, a transportation policy that decreases congestion improves inhabitants' well-being, enhances economic attractiveness, reduces inequalities in accessibility among neighbourhoods, and lowers air pollution. On the other hand, reserving urban land for public parks or green spaces without providing compensatory measures may lead to reduced population density, increased greenhouse gas emissions from transport, and higher land prices. These conflicts create implementation problems, while synergies offer opportunities for win-win solutions. To identify and capitalize on these opportunities, cities and their partners can

A. Address Knowledge Gaps There are massive gaps in terms of knowledge, analytics, indicators, and local government capacities, particularly for dealing with complex issues on multiple timescales. The lack of institutional capacity will be especially limiting when it comes to choosing among technical packages, negotiating with suppliers of so-called green technology, and ensuring community participation when understanding of the global "bads" remains minimal.

B. Foster Participation A city's metabolism (the flow of materials and energy into and out of a city, results from the interactions of many stakeholders, including city officials, inhabitants, non-governmental organizations (NGOs), and businesses. Sustainable urban policies will depend on the contributions of both public and private actors, and on incentives to guide individual private action, including funding, innovative new technologies.

C. Seek Behavioural Change Most importantly, sustainable development calls for changes in individual and corporate behaviour. Influencing human behaviour is possible—for instance, through the provision of information on energy cost-saving measures. Cities can set their long-term objectives (for example, reduce 20 per cent of energy consumption over 20 years) and help private actors plan and contribute to these objectives. The role of the private sector is particularly important in supplying greener goods and services, retrofitting buildings, and enabling cities to increase density and improve the efficiency of service delivery. The above interventions require strong institutions and an effective regulatory framework. To motivate these institutions and policies, however, an economic case needs to be made for sustainable cities.

X. CHALLENGES TO THE SMART CITIES

A. Five Challenges for Smart Sustainable Cities

Smart Sustainable Cities is an underdeveloped concept. In the previous section, we suggested a definition for it. In this section we present five challenges that need to be addressed for smart sustainable cities to materialize.

1) *Strategic Assessment:* Once Smart Sustainable Cities are defined, it is evident that assessments in relation to that meaning become necessary. Methods and practices need to be developed and implemented. Methods are required that can be used to identify which solutions are needed, and that take a systems perspective on evaluating the effects of the proposed solutions. Without this, "Smart Sustainable Cities" risks becoming just a label without validated content. In developing assessment methods, it is important to keep in mind that in practice it is the assessment, or the indicators included in an assessment, that defines the important characteristics of a smart sustainable city. As mentioned, it is also important to consider how to prioritize between different objectives in case of conflicting interests. Such conflicts may arise between sustainability dimensions (e.g. the conflict between biofuel and food production) or within them (e.g., the conflict between biofuel production and biodiversity).
2) *Mitigating Measures:* Historically, infrastructure development and investment have led to substantial improvements in wellbeing and wealth. Through the implementation of systems for transport, power, water and sewage management, life for billions of people has been improved. As a part of this, infrastructures have also made it possible to create and develop more efficient systems for trade and businesses of various kinds. Infrastructure development is in many ways a backbone of modern society. However, infrastructures have also made it possible to ruin ecosystems and exploit natural resources to an extent that threatens the existence of that same modern society. ICT is in this sense functioning in the same way as other infrastructures; today it plays an increasingly important role in maintaining and developing society and has the potential to support a resource-efficient sustainable society. But it also has the capacity to be used to make modern society an even more efficient machine for over-exploiting the earth. An example of this is using ICT to increase traffic flows in cities. If measures are implemented that make it easier to travel, travel will increase along with its negative environmental impacts. Therefore, the improvements in traffic might need to be paired with other measures. Similarly, counter-measures may be needed to realize the sustainability potential of ICT in other cases as well. Cities must craft mitigating measures at the same time as they encourage technology for efficiency improvements, and they must closely follow how ICT is shaping society.
3) *Top-Down and Bottom-Up:* The actual products, services and systems of the smart sustainable city may originate as large-scale suggestions from big companies such as Cisco, Ericsson, IBM or Siemens. One potential benefit of such top-down solutions is that these giants have the economic capacity to fully implement the assessments called for above, and they can function as concrete suppliers of the tools and services that city administrations may want to implement. However, there is also a risk that the strength of the corporate giants can enable them to monopolize smart sustainable city development to the extent that it kills creativity. The bottom-up approach can be represented by hacker communities and other types of grassroots or small-scale initiatives. Many cities have great expectations on the potential for innovation through involving people in formulation and solving of problems. A weakness of this approach is that it can be very difficult to take the solutions to the next level, thus leading to many fragmented small-scale solutions without the power to actually make a big change. Another weakness of this approach is that it can be very difficult to assess the actual outcome. It may be argued that supporting many initiatives will increase the chance of yielding successful ones. This may be true, but it is also likely that others will turn out to be bad from a sustainability perspective.
4) *Competence:* As mentioned in the previous challenge, initiatives from big enterprises can be very effective. They may also be efficient ways of implementing good solutions. However, currently ICT knowledge among companies is so much higher than among city governments that the cities become weak customers. They do not have the capacity to adequately specify their needs or to properly evaluate the offers they receive. This can lead to either bad investment decisions or paralyzed decision making. It is probably in the interest of both city administrations and ICT companies to increase city administrations' competences with regard to ICT solutions for Smart Sustainable Cities. This need has been recognized by the EU Smart Cities Stakeholder Platform, which has developed guidelines for public procurement for smart cities.
5) *Governance:* Smart sustainable city subsides for connecting devices as well as several organizations which should be involved in the planning and governance of the city. Moreover, for the diverse ICT in the city to work through concerted action, a coordinating body must play a role. This is also important from the perspective of sustainability because of the aforementioned need to strategically assess and evaluate the effects of ICT investments. Lee et al. propose a "dedicated smart city team formed with diverse roles and skills to promote smart city development also recognized by other city's agencies". With a focus on Smart Sustainable Cities, this team could then be given the assignment to promote smart sustainable city development. Over time, such a body could also develop the competence needed to scrutinize offers from ICT companies as well as play a role in balancing top-down and bottom-up approaches.

XI. CONCLUSION

Smart Sustainable Cities is an aggregate concept. In this chapter we have shown that each of the constituent concepts – smart, sustainable, and cities – is important in its own right. Cities can be made sustainable without the use of smart (ICT) technology, and smart technologies can be used in cities without contributing to sustainable development. Smart technologies can also be used for sustainable development in venues other than cities. It is only when all three aspects are combined, when smart (ICT) technologies are used to make cities more sustainable, that we can speak of Smart Sustainable Cities (SSC). Indeed, the concept of Smart Sustainable Cities is not relevant for all actors and perspectives. For example, from a sustainability perspective it could be argued that whether or not a city uses ICT is a rather unimportant issue as long as it becomes more sustainable. Therefore, the concept of a sustainable city would be enough. And from an ICT industry perspective it could be argued that industry works with smart solutions, while the sustainability part is not their business, and therefore the concept of the smart city is appropriate and sufficient. Those standpoints are valid, but from a more holistic perspective, the concept of Smart Sustainable Cities is needed, exactly because of the two standpoints above. Connecting the concepts of sustainable cities and smart cities may also raise awareness about the potential of using ICT to promote urban sustainability among planners, IT companies and policy makers. The concept of Smart Sustainable Cities can thus be used as a common framework or joint vision for elaborating new collaborations, business models and ways of carrying out urban development. This in turn highlights the need to avoid getting caught up only in the technological challenges of developing Smart Sustainable Cities and rather taking a proactive approach to actor networks, governance, and policy innovations. Defining Smart Sustainable Cities is also important because of the ongoing competition on how to interpret this concept. It has become a concept with positive connotations and thus it is seen as good to be associated with it. In practice, this can lead to a loss of power for the concept the concept losing its power. By focusing the definition, ICT development based on sustainability concerns can get a competitive edge. By simultaneously emphasizing both smart and sustainable, ICT development could be driven more by sustainability problems, instead of by a pure technical development in which newly developed “solutions” may not actually be solutions to any specific problem. Some challenges for the practical use of the concept would remain:

Assessment methods need to be developed and used in order to ensure that cities identified as Smart Sustainable Cities are in fact sustainable

Mitigating measures will most likely be needed for implementing policies for Smart Sustainable Cities. Otherwise, rebound effects may well cancel out the positive effects

The relationship between top-down and bottom-up initiatives needs further exploration

Strategies for strengthening city governments’ competences are needed

Governance models for smart sustainable city development must be considered.

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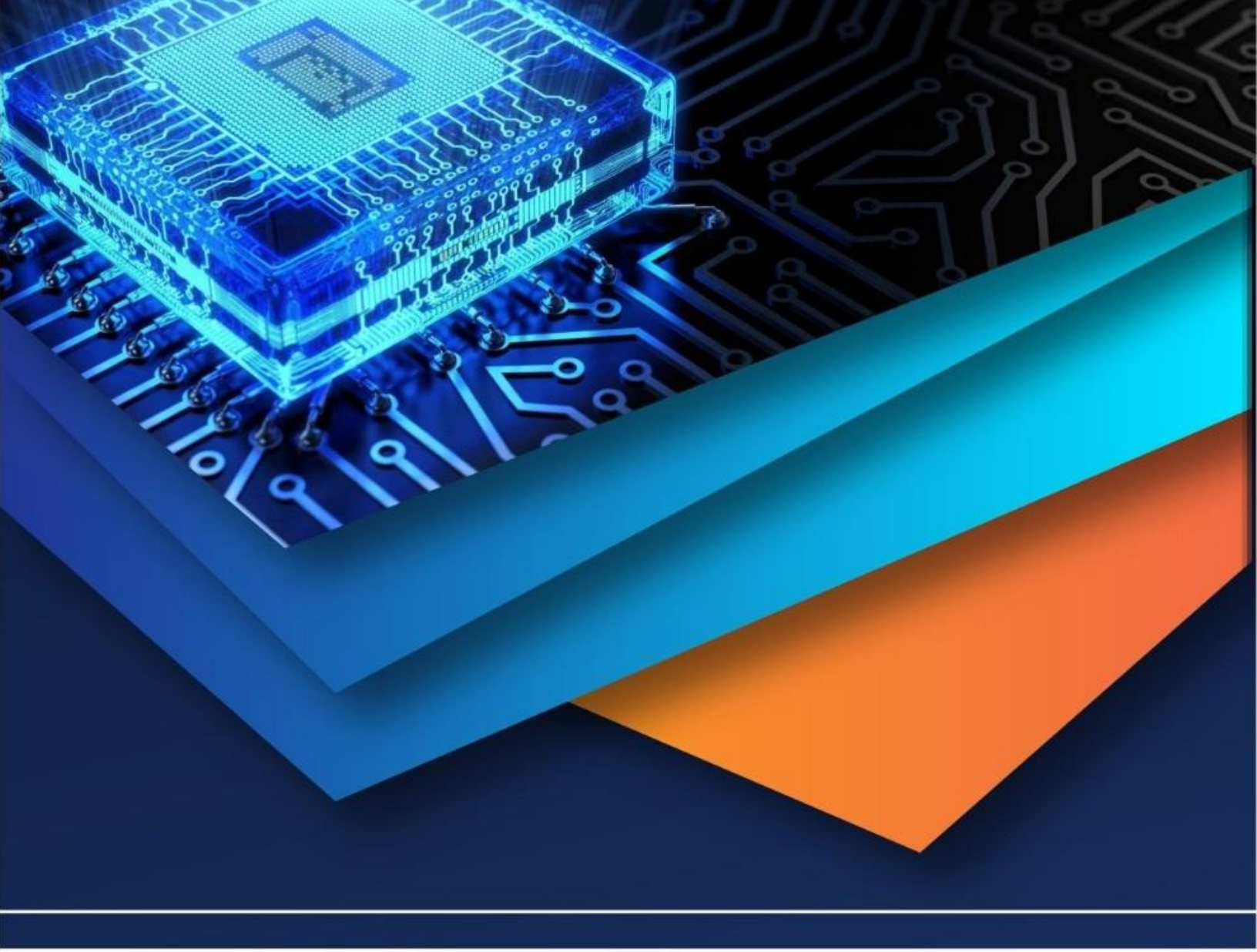

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