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Criteria for being Climate Resilient

Debalina Chakravarty*
Post-Doctoral Research Fellow
Economics Group
Indian Institute of Management, Calcutta
Kolkata 700104
Email: debalinac@iimcal.ac.in
(* Corresponding Author)

Runa Sarkar
Professor
Economics Group,
Indian Institute of Management, Calcutta
Kolkata 700104
E-mail ID: runa@iimcal.ac.in

URL: https://www.iimcal.ac.in/faculty/publications/working-papers/archive/2018

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Debalina Chakravarty*
PDRF (Economics Group),
Indian Institute of Management, Calcutta

Runa Sarkar
Professor in Economics,
Indian Institute of Management, Calcutta

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Abstract

The response of a city towards climate change mitigation and adaptation is crucially linked to how the city operates. Broadly such 'operations' are manifested as 'smart cities' in the literature. However, the indicators vary to a large extent. Climate change is identified as one of the many types of shocks and stresses that urban and regional economies face. Problems arising from rapid urbanization lead to a loss of basic functionalities of a city to be a liveable place. The aim of the paper is to review how the operation 'Smart City' is conceptualised in the existing literature and to identify as well as assess the criteria which lead smart cities to be capable of formulating and achieving low carbon targets. The smart city mission in India has been initiated in 2015 by the Government of India with an objective to provide core urban infrastructure for a decent quality of life. This includes a clean and sustainable environment for inclusive development and application of 'smart' solutions such as information & communication technology interventions for e-governance and online government services to ensure efficient and least-cost core services. This paper attempts to synthesise findings from a number of theoretical studies from the last 6 to7 years. Though the methodology of each existing study is different in nature, the current study threads them together using a common analytical perspective. In order to contribute to long-run urban sustainability, efforts to promote urban resilience to climate change need to be bundled into a smart city mission. Integration of all pillars of sustainability becomes essential if a 'Smart City' has to play important role in achieving the stringent climate change targets such as limiting global average temperature rise to1.5°C. The research highlights the importance of challenges such as a lack of awareness of citizens, disjoint strategies between different governing bodies, lack of proper incentive schemes for the end-users, missing links between different stakeholders, an absence of a proper business model and foresight and absence of adequate expertise. This paper provides insights for policymakers, micro-consumers, service providers and developers as to how climate resiliency might be addressed in an urban context.

Keyword: smart city, climate resilience, sustainability, technology

JEL Classification: P25, Q01, Q54, R00

***Corresponding Author.**

Email: c.debalina12@gmail.com/debalinac@iimcal.ac.in

1. Introduction

Cities are seen as ecosystems dominated by human beings, which they are at an unprecedented level of urbanization (Dirks *et al*., 2010). Ten per cent of the world population lives in the top 30 metropolitan cities, and 25% in 600 cities (Dobbs, 2011). Cities are primarily responsible for climate change as they account for more than 70% of global CO_2 emissions (UNFCC, 2018). They consume almost three-quarters of the world's natural resources, although cities occupy less than two per cent of the landmass of the earth (Marceau, 2008). UNDP (2015) identified resilient cities as one of the 17-millennium development goals as world cities account for 60-80 per cent of energy consumption and 75 per cent of carbon emissions. Problems arising from rapid urbanization indicate a loss of basic functionalities to be a liveable place: for example, difficulty in waste management, scarcity of resources, air pollution, human health concerns, traffic congestion and inadequate, deteriorating and ageing infrastructures (Borja, 2007; Toppeta, 2010; Washburn, 2010). Urban areas are significant contributors to climate change, severely vulnerable to the impacts of the same, while at the same time they are the sources of the compelling set of opportunities towards innovation and strategizing future climate-related actions (IPCC, 2007; UNDP, 2011; IPCC, 2014). To prevent the rapid urbanization from creating a crisis-like situation, there is a need to operate cities in an innovative way. Making a city smart is, therefore, a new approach to urban development. The popular view is that the smart city approach is emerging as a way to solve urban problems inherited from rapid urbanization. While in literature, initially the technological aspect of smart cities are emphasised, its sustainability aspects have not been given as much attention. The meaning of smartness in the urban context not only indicates utilizing cutting-edge information and communication technologies (ICTs) but also incorporating sustainability and moreover climate resiliency. Furthermore, the adoption of technology is not an end in itself, but the means to enable cities to be resilient to climatic shocks. Therefore, deeper the emission cut target is, more significant will be their roles in achieving the goals.

A study of several failures of urban adaptation and mitigation policies from the past have identified the need for a strong information network and system as a necessary intervention (Nam and Padro, 2011). Basic economic theories also suggest that with perfect and full information in the economy, market policies will achieve the highest success (Hanley *et al*., 2007). This stream of literature, eventually identifies urban areas especially, cities with improved information system as ‘Smart Cities' (Nam and Pardo, 2011; Batty *et al*., 2012). The Fourth Assessment Report by IPCC (2007) and the subsequent publication of Global Report of Human Settlements by UNDP (2011) broadened the concept of ‘Smart City' by incorporating the concept of sustainability and defining its role towards climate change mitigation. Gradually the concept was improvised to a sustainable city with advanced information systems (Ahvenniemi *et al*., 2017; Liacuna *et al*., 2015; Jong *et al*., 2015; Giuseppe *et al*., 2014). The proposed approach includes the management of administrative procedures, integration of non-conventional energy in the housing, commercial and institutional sectors in the smart city and digital control.

The objective of this study is to review how ‘Smart City' is being conceptualised in the existing literature and to identify as well as assess the criteria which lead smart cities to become important drivers for the achievement of low carbon targets in the context of India. The study is unique in

the sense that the study tries to find out the criteria for smart cities to be climate resilient, which has not been adequately discussed in the literature.

This study has been organised in six sections. Section 2 briefly discusses the theoretical discourse about over the concept 'Smart city' based on past literature. Section 3 describes the economic basis of smart city-related policy and practice. The criterion for climate resiliency has been discussed next. The complementarities of the smart city mission and climate resilience in the context of the Indian economy is discussed in section 5. The last section summarises and concludes.

2. The Theoretical Discourse over 'Smart City'

The concept "smart city" was introduced in 1994 (Dameri & Cocchia, 2013) but it took till 2010 for smart city projects to take shape with the support of the EU. This also led to the emergence of an academic interest in smart cities and contributed to the literature (Jucevicius *et al*., 2014). Researchers from different fields identified the need to exploit the idea. While this concept is now widely used in research and practice, a consistent understanding of the concept is still not anonymously accepted in the literature (Angelidou, 2015; Chourabi *et al*., 2012; Caragliu *et al*., 2011; Hollands, 2008; Marsal-Llacuna *et al*., 2015; Wall & Stravlopoulos, 2016). A common understanding is that the implementation and use of improved technologies to achieve sustainability in cities is a key feature of smart cities (European Commission, 2012). The concept was focused on the intersection between energy, transport and ICT. Marsal-Llacuna *et al*. (2015) present that the criterion for a smart city is based on "the previous experiences of measuring environmentally friendly and livable cities, embracing the concepts of sustainability and quality of life but with the important and significant addition of technological and informational components". Even if both policymakers and academia have recognised the use of modern technologies as an inseparable aspect of smart cities, a great number of definitions with slightly different angles have emerged. There exists an extensive literature which studies how the use of ICT and modern technology are key drivers of smart cities (Gonzales & Rossi, 2011; Harrison & Donnely, 2011; Hung-Nien *et al*., 2011; Jucevicius *et al*., 2014; Paroutis *et al*., 2013; Washburn *et al*., 2010). One part of the smart city literature focuses mainly on technical and environmental aspects of a city. According to Lombardi *et al*. (2011), most definitions of the smart city identified that the use of modern technology in daily life can lead to efficient use of energy, green infrastructure development and innovative transportation system. A broader understanding of smart cities also highlights the use of modern technologies but sees them more as enablers for a better quality of life and decreased environmental impacts (IEEE, 2014). As an example, Marsal-Llacuna *et al*. (2015) suggest that the objective of smart city initiatives is to "provide more efficient services to citizens, to monitor and optimise existing infrastructure, to increase collaboration amongst different economic actors and to encourage innovative business models in both private and public sectors" by using improved data and information technologies. On the other hand, the definition of Angelidou (2014) highlights the role of ICT to achieve prosperity, effectiveness and competitiveness. Another body of literature highlights – in addition to new technologies – the role of human capital in developing smart cities with improved economic, social and environmental sustainability (Neirotti *et al*., 2014; Giffinger *et al*., 2007; Hollands, 2008; Nam

& Pardo, 2011). This more holistic understanding suggests that smart cities bring together technology, government and society to enable a smart economy, smart mobility, smart environment, smart people, smart living and smart governance (IEEE, 2014).

The concept of 'Smart City' was gradually improvised from sustainable city to ICT equipped sustainable city in the literature, as mentioned in the previous section (Ahvenniemi *et al*., 2017; Liacuna *et al*., 2014; Jong *et al*., 2015; Piro *et al*., 2014). 'Smart cities' are also linked to the efficacy of different sectors -energy sector, transport sector, residential sector, health sector etc. These efficacies are often strongly related to the efficiency of energy use. Other features such as employment generation, awareness generation, governance and citizen's participation are also identified in the literature as indicators of smart cities (Angelidou, 2014; Nam & Pardo, 2011). Broadly, a 'Smart City' can be defined as a city which can gives access to "all available and upcoming wireless technologies, while enforcing, at the same time, ubiquitous and secure applications in many domains, such as, e-government and public administration, intelligent transportation systems, public safety, social, health-care, educational, building and urban planning, environmental and energy and water management applications" (Piro *et al*., 2013). The proposed approach includes the management of administrative procedures, integration of non-conventional energy in the housing, commercial and institutional sector in the smart city and digital control thereof. Integration of non-conventional fuel in the traffic sector and its control, energy efficient buildings, creating a new job or business opportunities and efficient waste management are the features of a smart city. The Joint Programme on Smart Cities by the European Energy Research Alliance (EERA) highlights the environmental sustainability aspects of smart cities suggesting that smart cities are "expected to move the energy system towards a more sustainable path. This will require an integrated systems view as well as innovative, intelligent approaches to the design and operation of urban energy systems." (EERA, 2013).

Other than sustainability and technological aspects, there are aspects identified by the literature- for examples human capital (Ahvenniemi *et al*., 2017), good governance (Caragliu *et al*., 2011), improved infrastructure (Correia and Wünstel, 2011), urban services (Belanche *et al*., 2016 ; Lee *et al*., 2014), participatory service design and open data movement (Lee *et al*., 2014). In addition, soft factors like participation, security/safety and cultural heritage (Lombardi *et al*., 2011) are also aspects of a smart city.

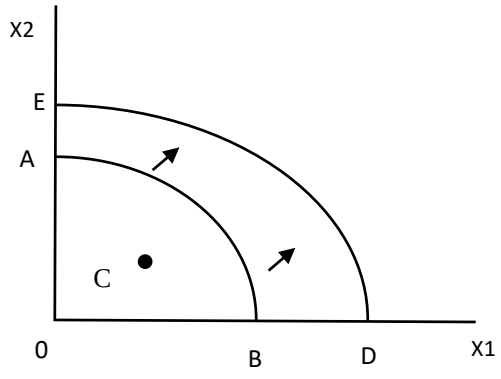
Literature also identifies the deployment of intelligent infrastructure, a robust incentive system and centralised governance as ways to accelerate smart city strategies. Other metaphors used to categorise smart city views are top-down vs. bottom-up initiatives (Calzada&Cobo, 2015) and supply vs. demand-driven approaches (Angelidou, 2015). Smart city performance assessment systems have been developed by Giffinger *et al*., (2007), Albino *et al*. (2015), Lazaroiu and Roscia (2012) and Lombardi *et al*., (2012) to assess cities' development towards the wanted direction. Debnath *et al*., (2014) and Garau *et al*., (2016) identified transportation sector-specific indicators for smart cities.

In essence, it can be summarised that there are two mainstream approaches towards smart city conceptualisation- 1) the ICT and technology-oriented approach and 2) the sustainability approach

to creating a climate resilient cities. The strategies range from energy efficiency and technological advancement of the city's hard infrastructure (i.e. transport, water, waste, energy) to those focusing on the soft infrastructure and people (i.e. social and human capital, knowledge, inclusion, participation, social innovation and equity) (Angelidou, 2014), A careful analysis of the concept identifies three broad criteria: first, advanced information technology and system (March, 2016), second, efficacy of different production and consumption sectors with significant emphasis on energy efficiency (Khansari, 2014; Debnath *et al*.,2014) and third, effective societal governance and citizen precipitations (Vanolo, 2016; Joffe and Smith, 2016; Baldascino and Mosca, 2016). These three components, although three pillars of 'Smart City', are often discussed in a mutually exclusive manner. But if a smart city is conceptualised based on only one concept, then it will be difficult to achieve strict low carbon targets (Daikin and Raid, 2016). In fact, integration of these three pillars is essential if a 'Smart City' has to play an important role in achieving the stringent climate change targets such as 1.5°C global average temperature rise (Cohen and Munoz, 2016; Vollaro *et al*., 2014).

3. Economic Underpinnings of the "Smart City" Initiative

The objective of smart city initiatives across the world is to provide core infrastructure, a decent quality of life, and a clean and sustainable environment using 'Smart' technological solutions. The whole concept of the smart city is based on the allocation of core resources efficiently. A production possibility frontier (PPF) approach shows the maximum possible output combinations of goods or services an economy can achieve when all resources are fully and efficiently employed. Curve AB in Figure 1 illustrates the location of a PPF for a city before the smart city initiative, with the point C demonstrating where the city is at present. As it is evident, in this scenario, the resources are not fully utilised or inefficiently utilised by the economy. The smart city initiative works in two ways; first the PPF shifts outwards to DE because of the possibilities of better resource utilisation, and second, the city's economy is now enabled to move towards DE from the point C.



The shift of Production Possibility Frontier (PPF) after an increase in economic efficiency, where X1 and X2 are a set of goods and services.

Figure 1: PPF approach for smart city concept

The prime objective of the smart city approach is to achieve the best possible production frontier with the given resources by reducing risk and uncertainty from the economy with the help of information technology. However, any kind of technological advancement with perfect information in all sectors requires bulk investment. A large amount of social investment in all sectors of the economy pushes the economic growth path into new higher growth path. Investment in low carbon environmental activity and sustainable development activity requires technological efficiency improvement as well as bulk climate finance. The *Big-push theory* suggests that underdeveloped countries require large amounts of investments to embark on the path of economic development from their present state of backwardness (Rosenstein-Rodan, 1961; Murphy, 1989; Sachs, 1999; Vishny, 1989). According to the theory, the social marginal product and the private marginal product of an investment is different from each other. If a group of industries come together and plan investment as per their social marginal productivities then the overall economic growth is bound to be higher. Smart city approach provides a common platform for the group of industries to realise such marginal productivities.

At the micro level, especially in the context of developing countries, *Sens' Capability Approach* provides the theoretical background to the principles of smart city concept. The approach suggests that well-being is 'what the individual can do or can be' in relation to the ability of people to transfer the means and the resources available to cities. The main principle of the perspective is to identify the dynamics of deprivation and impoverishment and appropriate social protection required for empowering the citizens with a special focus on the needs to the stakeholder's ability to act (Sen, 1985, 1993). The capabilities approach focuses on human life rather than material possessions such as income or goods. On similar lines, the smart city approach aims to empower the citizen by providing the core means necessary to create an overall well-being. The smart city concept also emphasises the notion that other than creating material resources, often private goods and society should focus on core basic needs like education, health, environment etc.

4. Climate Resilience

Climate change is one of many types of shocks and stresses that cities face, and climate change-related shocks typically occur in combination with other environmental, economic, and political stresses (Ernstson *et al*., 2010; Maru, 2010; Coaffee, 2008; Sherbinin *et al*., 2007). Therefore, cities must become resilient to a wider range of shocks and stresses in order to be prepared for climate change; and efforts to foster climate change resilience must be bundled with efforts to promote urban development and sustainability (Leichenko, 2011; Ayers, 2011; Bahadur and Tanner, 2014; Tyler and Moench, 2012; Atteridge *et al*., 2012; Ali *et al*., 2013). Urban resilience to climate change generally refers to the ability of a city or urban system to withstand a wide array of shocks and stresses (Leichenko, 2011; Reed *et al*., 2013; Ayers, 2011; Bahadur and Tanner, 2014; Tyler and Moench, 2012; Atteridge *et al*., 2012). Building urban resilience to climate change will thus require cities to become resistant to a wide range of overlapping and interacting shocks and stresses (Tanner *et al*., 2009; Hardoy and Pandiella, 2009). A common definition of climate resilience is, therefore, "*… the capacity of a system to absorb disturbance and reorganize while undergoing a change so as to still retain essentially the same function, structure and feedbacks, and therefore*

identity."(Turner, 2010). The concept propounded in ecological theory defines it as an adaptive system that returns to the initial equilibrium after an external shock. Literature advocated the need to couple resilience with the concept of transformation in order to incorporate issues of political & socioeconomic structure and trade-offs that determine risk and vulnerability (Bhaduri and Tanner, 2014).

Developing criteria for climate resilience in smart cities will equip local governments with information to actively engage in training, capacity building, and capital investment programs more effectively. Primarily, the local governments need to identify the "hot spot" risk and vulnerability issues and accordingly prepare the tools and strategies for resource allocation. A gradual assessment of challenges could help in addressing the hindrances. These would be most relevant for cities who have just started to think about climate resiliency as well as those who already have well-established policies, institutions and strategies in place.

Four main principles for climate resilience identified in the literature (Roy *et al*., 2018; Roy *et al*., 2009; Eriksen *et al*., 2010) are:

- recognise the context for climatic stress and vulnerability,
- acknowledge that different stakeholders have different values and interests towards climate resiliency
- integrate local knowledge (traditional and cultural) with modern know-how;
- incorporate potential challenges into strategy development

In the context of vulnerability, there is a need to identify the sources and components and types of climatic stress (Eakin, 2009; Ziervogel *et al*., 2006; Leichenko and O'Brien, 2010; Eriksen and Lind, 2009; Tschakert and Dietrich, 2010). The underlying social, economic, institutional and cultural conditions that contribute to a wider context for resiliency need to be understood, in order to identify the direct and indirect consequences of actions/efforts. One has to be sensitive to the spatial and temporal effects of such efforts.

Recognizing the potential value and conflicts of interest can help to identify how prioritization of climate resilience related activity may be different for different groups, which may affect the other groups as well as the urban economy. Strong vested interests within particular strategies may act as a barrier to or strengthen the strategy. Evidence shows that leveraging traditional and cultural practices are least or no cost mechanisms to strategizing the resiliency (Roy *et al*., 2018). For example, the tradition of using electric streetcars or tram in many cities in the world show historic climate resiliency that may be leveraged.

Evidence shows the role of incentive structures for building climate resilience (ADB, 2010). Incentives are necessary to encourage the investment towards climate resilient actions over existing investment portfolio rather than finding new ways to develop climate resilience.

Key criteria for evaluating climate resilience would include informed strategies, legislative structure, constant monitoring and continuous knowledge updates. Although resilience can be measured in many different ways, common parameters are populations, neighbourhoods, and systems including diversity, flexibility, adaptive governance and capacity for learning and innovation (Rose, 2007; Cutter *et al*., 2008; Klein *et al*., 2003). These are also key characteristics of cities that are at the forefront of technological innovation and efforts to develop sustainable

urban infrastructure (Ernstson *et al*., 2010). Therefore, in order to evaluate resilience, once must see evidence of the broader development policies and plans incorporating efforts to promote urban resilience to climate change, including both adaptation and mitigation strategies (Sperling *et al*., 2008; Duxbury *et al*., 2007; Seto *et al*., 2009; Bahadur and Tanner, 2014,). Table I summarises the main principles to be used for identifying climate resilient cities. There is a need, however, to identify specific parameters under these criteria, which may be developed from specific case studies of cities.

Table I: the Main criterion for climate resilient and smart cities

Principles	**Reference**
Data for risk and uncertainties	Roy *et al*., 2018; Roy *et al*., 2009; Eriksen *et al*., 2010
Tools and strategies for resource allocation	Eriksen *et al*., 2010; Eriksen and Lind, 2009
Assessment of challenges	Maru, 2010; Eakin, 2009
Integrated strategy and incentive design	Eakin, 2009; Ziervogel *et al*., 2006; Leichenko and O'Brien, 2010; Eriksen and Lind, 2009; Tschakert and Dietrich, 2010

5. Smart city Mission in India and its Climate Resiliency

The Census of India (2011) states that about 32% of India's population lives in urban areas and this could reach 40% in a decade and 50% in about 30 years from now. 70% of the GDP can be attributed to urban areas, while the country invests just 0.7% for urban development (Madakam & Ramaswamy, 2015). It has been predicted that India needs to create 500 new urban agglomerations in the coming 20 years to host 700 million more city dwellers by 2050 as it has been found that an average of 30 people migrates each minute from rural to urban areas of India. Indian urban agglomeration is often confronted with a multi-faceted core problem like unplanned development, informal real estate markets, inevitable population growth, lack of infrastructure, inadequate transport facilities, traffic congestion, poor power supply, incompetent health services and lack of basic services. This is the case for both within the city and in the suburban areas. Poor natural hazard management in overpopulated areas, a prevalence of crime, and water, soil and air pollution (as exemplified by the Delhi smog; Barry, 2016) add to the concerns. Climate change and poor governance have led to urban populations living in conditions of persistent stress (Madakam and Ramaswamy, 2013).

The nation started addressing urban developmental issues from 1979 onwards with the introduction of the Integrated Development of Small and Medium Towns (IDSMT) scheme by the central government. The objective was to improve the economic and physical infrastructure of urban settlements with a population under 500,000. A total of 1854 towns were under this scheme, but outcomes of the scheme were not satisfactory because of the lack of implementation capacity, non-availability of the investment portfolio and unencumbered land for the projects (Planning Commission of India, 2014). In 1993, a Mega City Scheme (MCS) was introduced for five mega

cities in India with a special focus on infrastructure development. These two schemes continued till 2005 after which insufficiency of investment funds led to the scheme becoming dormant. (Aijaz and Hoelscher, 2015). From 2005, the Government of India initiated a comprehensive scheme – Jawaharlal Nehru National Urban Renewal Mission (JNNURM) for infrastructure development and providing improved basic services with a special focus on the transportation sector for the urban poor in sixty-five mission cities. The mission achieved some successes and many failures due to lack of capacity, funds and insufficient planning. In 2015, a more comprehensive, transparent, inclusive and participatory scheme was launched as Smart city Mission in India. The Smart City Mission of the Government of India (2015), promotes cities that provide core infrastructure with a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' solutions. Such smart solutions include ICT interventions for e-governance, online government services, and improving the efficiency of core services at a relatively lower cost. The main focus of this mission is on sustainable and inclusive development and to create a replicable model which will act as a lighthouse to other aspiring cities (Ministry of Urban Affairs, Government of India, 2015). Of a total of around 4000 cities and towns (Census, 2011), proposals from 90 cities were considered as winners (till June 2018) under this mission. The urban population expected to be impacted under this scheme is 25% of the total urban population of India and 2.5% of the total urban population of the World.

According to the mission guidelines, the state and central Governments are expected to invest equal amounts in the chosen cities. The total cost of this project is Rs.189,256 crores (20% for pan-city solutions and 80% for area-based development) over five years (2015-2020). The essential features of the scheme are:

- bottom-up planning based on citizen participation
- complete autonomy to states and local municipalities in preparation of projects
- selection of cities on a competitive basis
- convergence of all urban schemes to enable integrated planning and efficient utilization of resources
- a special purpose vehicle (SPV) headed by CEO and comprising central, state and local government nominees, to take conducive plans and programs of city-specific proposals and projects, as well as execution either through joint ventures subsidies or public-private partnerships (PPP).

On the other side, to address climate change, countries including India adopted the *Paris Agreement* at the COP21 in Paris on 12 December 2015. In the agreement, all participatory countries committed to work to limit global temperature rise to well below 1.5 degrees Celsius. The Paris Agreement enters into force on 4 November 2016. India is the fourth largest emitter of greenhouse gases and is responsible for 5.3% of global emissions. However, the emissions intensity of India's GDP reduced by 12% between 2005 and 2010. In October 2015, India, therefore, committed to reducing the emissions intensity of its GDP by 20-25% from its 2005 levels by 2020 and by 33-35% by 2030. The role of the Paris agreement was essential to meet the UN Sustainable Development Goals (SDGs) of 2015 to provide affordable, scalable solutions to reduce emissions and build climate resilience. The Government of India has also adopted

a National Action Plan on Climate Change (NAPCC) to address this issue directly, as well as a National Mission for Green India from 2009. These national schemes are complemented with missions like solar energy, enhanced energy efficiency, sustainable habitats, water and sustaining the Himalayan ecosystem (Ministry of Environment and Forest, Government of India, 2010). In 2013, Rockefeller foundation selected four Indian cities (Pune, Bhopal, Surat and Chennai) to identify physical, social and economic challenges for becoming climate resilient. The cities will be provided with resources such as climate strategies and solutions necessary to develop a roadmap to resilience. Almost 1800 concrete actions and initiatives have been identified to create a resilient city.

Popular literature says it is still possible, using a wide array of technological measures and changes in behaviour, through institutional and technological intervention to be on the low carbon growth path (IPCC, 2017). Therefore there is a possibility of a strong linkage between the smart city mission and climate resiliency of cities in the country. A careful analysis of the concepts of smart city mission in India shows that they are essentially attached to three criteria, namely, advanced information technology and systems (March, 2016), efficacy of different production and consumption sectors with significant emphasis on energy efficiency (Khansari, 2014; Debnath *et al*., 2014;), and effective societal governance and citizen's participation (Vanolo, 2016; Joffe and Smith, 2016; Baldascino and Mosca, 2016). Table II attempts to map the components of the smart city mission of India with elements of climate resilience.

Table II. Smart city mission components and climate responsive actions therein

Components	**Climate Responsive Actions**
Smart Transportation	Public Transport through Rail; Electric Bus use; E-rikshaw use; Non-motorised mode of transportation through bicycle for last mile transportation; BRT system.
Smart Water	Smart Water metering for the household sector; Rainwater harvesting; Wastewater recycle.
Smart Waste	Waste Segregation; Covered Sewage system.
Smart Buildings	Green Rooftop; Vertical Gardening; Green Building Materials eg. Ash Bricks.
Smart Energy/ Grid	Solar rooftop; Micro-grids with renewable energy.
Smart Governance &public Security	Led Street Lighting; Improved Traffic signalling system; Climatic condition monitoring system.
Smart Health & education	Green Open Space; Reduction in water-borne diseases & Malaria, Dengue; Generating environmental awareness in the curriculum.
Smart Employment	Green Employment
Smart Digital Citizens	Access to weather & Climatic information
Smart Manufacturing	Monitoring pollution with improved technology
	Source: Authors compilation from smart city proposals, Government of India

Although the extent of overlap of the smart city concept and climate resilience in existing initiatives at the implementation stage is minimal, there is still some hope. Evidence shows there are existing policies aimed at addressing urban environmental problems, such as housing in risk-prone areas that can be adapted to promote climate change resilience at little or no cost (Hardoy *et al*., 2009; Prasad *et al*., 2008). Essentially, climate-resilient smart strategy implies a simultaneous improvement in productivity, adaptive capacity of the economy with less greenhouse gas emission. Smart city mission strategies and embedded actions are showing resilient interest in India, but the goal and mission can only be achieved by simultaneous inclusion of the actions and the effectual address of the criteria for the resilient city.

Evidence says the progress of transformation from city to smart-city is quite unsatisfactory. Out of the total sanctioned amount, only 7% had been utilised so far, according to ministerial data. This is primarily due to poor policy implementation, incomprehensive institutional effort, lack of accountability and transparency. Therefore there is an exigency for a review of the mission. It is recommended that the government should strengthen the key institutions and policy implementation through multi-level governance which will ensure the efficacy of the mission. Further, this should be looked at as an opportunity to improve the design and operations of resilient actions and/ or strategies and integrate them into the smart city mission within a broad policy context.

6. Discussion and Conclusion

The aim of this review is to unpack the logic and rationale behind smart city mission and climate resilience discourse, so as to understand the viability of low carbon urban economies. Within this literature urban agglomeration is considered as a complex adaptive system and climate events are regarded as shocks or stressors that affect them. Therefore, the emphasis is placed on enhancing the capacity of cities, infrastructure systems, and urban populations and communities to quickly and effectively recover from both natural and human-made hazards. Since the core problems of urbanization are social, political and organizational in nature and therefore the smart city strategies for innovation must reflect these considerations. Although it is difficult to define the smart city, the conceptual clarity of the smart city mission is recommended to create guidelines for stakeholders in achieving the goals. It is universally recognised that meeting the needs of all citizens is an essential component of city planning and development, along with providing core infrastructure and a clean sustainable safe environment, creating employment, and enhancing incomes especially of the poor and disadvantaged to ensure inclusive growth. In India, the concept of a smart city is perceived as a use of advanced technology, something more suited for new infrastructure development. It entails the application of sustainable solutions to overcome critical climatic and environmental problems with the use of improved technology and system mostly created by the private sector. Many experts, therefore, feel the mission would benefit private entities and fundamental problems may be overlooked.

A careful analysis of the concepts of smart cities in the existing literature shows that they are essentially attached to three criteria-advanced information technology and system, the efficacy of different production and consumption sectors and effective societal governance and citizen

participation. These three components are also essential for ensuring climate resiliency. However, to be a climate resilient smart city these criteria should be addressed in an integrated manner. In literature, however, they are often discussed in a mutually exclusive manner. A systematic understanding of criteria or principles could play a central role in decision framework towards forming a resilient smart city in India.

Climate resiliency and smart city are closely interlinked concepts. The main difference is that the focus in climate resilience aspect is on outcomes related to climate change adaptation and mitigation, whereas the focus for the smart city is on outcomes related to improved technology and ICT. All cases of climate resilience invariably turn out to be cases of smart city as climate resiliency comprises higher productivity and efficiency with less emission. A strong strategy identifying the criteria and challenges of the resiliency could result in rapid urban economic growth. Actions taken to improve resiliency may often have significant co-benefits, but they may also have higher upfront costs (e.g. installation cost, skilled-labour costs). Therefore, identifying appropriate ways to incentivise the uptake of climate-smart alternatives is a key priority. In many countries, smart strategies/ actions are inextricably linked with economic support for urban economies. There are increasing possibilities for low-income countries to orient production along pathways that are both more sustainable and more productive. Research and development partners have a key role to play in identifying and promoting climate-smart practices that strengthen urban agglomerations, improve livelihoods and employment, and avoid negative social and environmental impacts. While there is a potential for the smart city mission to incorporate climate resiliency, considering the lacklustre performance of the smart city mission so far, the mission needs to be reviewed, and climate resilient actions should also be incorporated into the mission.

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