Planning for Low-Carbon Smart Cities in India

Athar Hussain and Alpana Gupta

Abstract A human greed is never ending which gives rise to social as well as environmental externalities. In the past decade, India's extraordinary urbanization has analogous growth in primary energy demand. With urban per capita scenario, commercial energy prompts three times higher energy demand than rural areas because urban areas are the foundation of energy and CO_2 emission giving rise to climate change. This paper will first review the traditional practices and approaches in the context of the low-carbon cities and related climate-resilient cities initiatives, as development strategies for addressing and highlighting urbanization challenges. An attempt has been made through this study to explore the major root causes and factors of climate change and variable ideas of low-carbon resilient cities. The article is an exploratory type, in which different practices worldwide for a low-carbon and resilient city model have been incorporated.

Keywords Urbanization · Low-carbon smart city · Greenhouse gases · Climate change · Resilience

1 Introduction

Urbanization is an important challenge facing today's developing countries. By 2030, 60% of the population will be responsible for urban residents with 60% of the population living in cities with 41% of the population of India and 87% of the population of the US urban centers being the key players in greenhouse gases (GHGs) [1]. Space agglomeration of activities leads to urban growth, while population, economic

A. Hussain (✉)
Department of Civil Engineering, Ch Brahm Prakash Government Engineering College, Jaffarpur, New Delhi 110073, India

A. Gupta
Master of Environmental Planning, School of Planning and Architecture, An Institution of National Importance, M.H.R.D., Government of India, Bhopal 462030, India

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activities and spatial models and built environments are the same concentrate. They are therefore posturized with increased risks as a result of floods, heat waves, the rise in sea level and other risks that many treaties are expected to complicate with climate change mitigation and adaptation. An international environmental treaty was adopted on May 9, 1992, and in Rio de Janeiro from June 3 to 14, 1992 the United States Framework Convention on Climate Change, (UNFCCC) [2]. They are aimed at "stabilizing GHG emissions to cut down emissions which rises due to anthropogenic interference." It sets non-binding greenhouse gas emission limits for individual countries and does not contain mechanisms for enforcement.

The concentration of CO_2 has increased since pre-industrial phase ranging from 280 to 379 ppm in 2005, according to India's National Action Plan on Climate Change. The elevation from sea level is between 0.18 and 0.59 m. That will have immense impact on freshwater level, productivity, flooding of coastal areas and increasing chart of diseases (National Action Plan on Climate Change, p. 13). Besides this, Indian economy has increased by 7–8% on average, with a large amount of confrontation in cities such as urbanization, migration openings, slums and squatters, infrastructure demands, road congestion, vehicular pollution, depletion of groundwater, depletion of non-renewable energy and alternative modeling and simulation that cities need. In order to address growing environmental concerns, the Global Environment Facility (GEF) Trust Fund was recognized on the eve of the Rio Earth Summit of 1992. Thirty-nine donor countries contribute GEF funding and are reviewed every four years. The World Bank is the trustee of the GEF and the mobilization of GEF funds.

1.1 Concept of Smart City and Climate Change

It is classified as an urban area with different types of electronic sensors for the efficient management of resources. The Smart Cities Mission is a new government of India initiative designed to foster economic growth and improve the quality of life of the population through local involvement and technological development.

Smart connections are connected and satisfy the needs of citizens by providing a range of links, including sustainable transport, online access, technological advancement (smart transport) and social inclusion. Innovative, enterprise-friendly and effective collaboration are promoted by smart economics which offers high paid jobs and enriched living standards. Smart people form a foundation for smart cities that have access to knowledgeable partnerships which embrace technology and innovation.

Smart living links people to good health, education and security. Management deals with sophisticated allocation of resources, such as safe drinking water, infrastructure and other resources, under budgetary constraints. The smart environment is a magnificent pillar that bridges or balance planning growth with protected resources (Fig. 1).

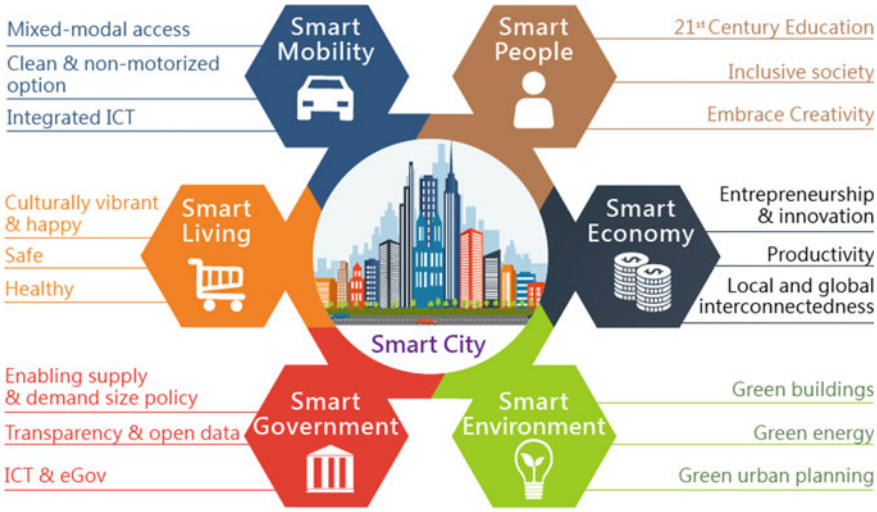

Fig. 1 Components of smart city [3]

Climate change refers to global climatic changes, a sudden apparent shift between the middle and the late twentieth century, largely attributed to the increased carbon dioxide produced by the increased use of fossil fuels.

1.2 Smart City and Benefits [4]

The smart cities facilitate the integration of public administration systems and processes and create transparency in the provision of better decision-making information. It is also useful for optimal use and resource allocation. The project also raises the population's satisfaction as it enables greater participation by civil society through the inclusion of technological instruments that help monitor public services, inform citizens and interact with the municipality in tackling particular urban issues. Singapore's National Secretariat for Climate Change (NCCS, 2012) enforces that it takes time to implement adaptation indications. The concept of risks and impacts of climate change for public health, energy demand and biodiversity should be identified and understood before supplementing policy initiatives which are useful in developing and implementing adaptive measures in the city.

The Government of Singapore has therefore encouraged and formulated a resiliency framework in the next 50–100 years that will promote and enhance its efforts to protect Singapore from the anticipated adverse effects of climate change. The framework is shown in (Fig. 2), and this is part of the national framework

Fig. 2 Resilience framework [5]

category. The framework represents the process for the Singapore Government to adapt to climate change. It covers the understanding of prevailing local climate conditions and evaluates vulnerability, uncertainty and impacts of climate change in order to identify adaptation options [5]. The options are then weighted, and the application prioritized. The options are properly evaluated, and alternatives are chosen. This is a platform for reviewing the strategy that constitutes the basis for local climate understanding. The Nanyang Technological University's Future Resilient Systems (FRS) research group reviews and adopts this approach to making cities resilient that involves dynamic interaction between infrastructures and social behavior.

2 Smart Cities Are Climate-Resilient

The world is developing, and by 2050, there will be over 6 billion people living in cities that are going to cross the threshold. The effects and threatening effects of climate change on the cities and risks to floods, droughts and heat waves increase. In addition, the IPCC refers to the insecurity and risk-facing India. The US-based World Resources Institute echoes historical and catastrophic events like the 2005 Mumbai floods and the recent paradoxical Srinagar disaster. When India blinds to the global intelligent city club, it will create work to integrate planning interventions and strong remodeling for the urban development ministry to help smart cities develop [6]. The new projects in India have enormous effort and potential. But local stakeholders and even the state plan to restructure and simulate cities in today's situation without taking into account the consequences of climate change. This is the right time to find alternatives to combat the terrain scenario. Smart cities are expected to lighten urban stagnation by restoring urban areas in line with the objectives of the smart city concept and remove them from the environmentally unsustainable areas.

2.1 Approaches Using Landscape and Nature-Based Adaptation

Natural solutions reduce the risk of flooding, droughts and urban heat, provide services to ecosystems and improve cities' live capacity. The soil–water green system should be considered as the basis for landscape adaptation. Co-creation with governments and local stakeholders is strongly needed when designing and implementing natural solutions. Adaptive circular cities and water-smart cities [7] established the cities simultaneously contribute to climate change mitigation, adaptation and resource efficiency. A transition from drained cities to water-smart cities is therefore needed to (re)design cities to restore the natural drainage ability of cities. Intelligent combinations of technical, civil engineering and nature-based climate adaptation solutions with the transition to water-smart city will generate great business and innovation opportunities.

2.2 Global Initiative for Low-Carbon Cities

There have been global initiatives in various sectors to improve quality of life and boost economic growth. On September 4, C40 City Climate Leadership Group (C40) and Siemens have reflected on 29 towns and 37 projects. For its tremendous efforts to promote green mobility, Bogota received urban transport awards [8]. Launched in 2000, the City's Rapid Transit Bus system achieved reductions in

emissions of more than 350,000 ton a year. Various sustainable approaches were adopted by shifting to hybrid and electric buses to cut down the emission by the end of year 2024.

Melbourne builds sustainable buildings that are energy-efficient. This is evident with the joint involvement of building managers with energy-efficient construction and water efficiency design. Tokyo has been at the queue for a program to reduce CO_2 emissions from large commercial and industrial buildings, which was launched in April 2010. Over 1100 facilities participated in a 13% reduction in emissions during their first year, a further 10% reduction was achieved the following year, bringing to more than 7 million tons of CO_2 total emissions reductions achieved. For the first time, Singapore has been known for the electronic price and congestion tolls for congestion and emission reduction.

2.3 Need for Low-Carbon City in India

The worst conditions prevail in Mega polis (Delhi and Mumbai). Mumbai is vulnerable to flooding, according to an article in 2012 which highlighted on climate change which is posing great threats to cities and also ranked Mumbai Sixth amongst 20 port cities. In November 2012, an article appeared in Times of India, [9] which stating that climate change and growing development are leaving Mumbai vulnerable to flooding, damage from high storm winds that rank Mumbai sixth in a list of 20 port cities worldwide. Mumbai is largely affected by the absorption of solar radiation by concrete, which activates the urban heat island effect. It reduced the permeability and additional stress on the creepy old drainage system was imposed by its high population density. The Mega Polis such as Mumbai, Delhi should be properly planned and managed. However, the urban low-carbon solution to combat climate change is becoming increasingly necessary. The article addresses all issues which highlight the gaps by means of urbanization scenarios, greenhouse gas emissions and CO_2 emissions causes. The concept of low-carbon cities is based on a Malaysian case study which reduces greenhouse gas (GHG) criteria and identifies carbon-reduction parameters using similar models for Indian cities.

2.4 Causes of Carbon Dioxide Emissions

In the transport sector, CO_2 emissions are driven by motors. Carbon emissions in corporate world is mainly through the running of offices and shops 24 h, which leads to increase in energy consumption. In the housing sector, areas have been

expanded as a result of the growth of nuclear families and single houses, the development of IT and increased size of household appliances, etc. The number of households is increasing [10]. Buildings and structures are also accumulating that are not energy-efficient or [10] low-carbon, since energy efficiency is lower than convenience, comfort and economy low-carbon emitting, since energy efficiency has lower priority compared to convenience, comfort and economy.

3 Indian Scenario of Urbanization

India accounts for 286 million people in 2001 and gains the second-largest urban population country [11]. According to the Indian registrar general and census officer, the urban population in India will increase by 38% during the next 25 years to reach 534 million by 2026 [12]. The problem is that the government is not capable of bridging the gap between large demands and supplies and that the mega projects will consume a large share of energy use. Thus, when low-carbon cities are simulated by energy-efficient buildings that encourage public transport in cities, a solution is required that will otherwise exacerbate the current urbanizing rate in future. India is the third-largest emitter of CO2 in absolute emissions. These emissions will continue to increase as the economy expands. India, as is the case in the usual business scenario, will increase its CO_2 emissions five times before 2050 while already relying heavily on fossil fuels. ICLEI South Asia., 2012.

3.1 Low-Carbon City

It can be defined as a city consisting of societies using sustainable green technology, green practices and relatively low carbon or GHG emissions in comparison with current practice [13], in order to prevent adverse impacts on climate change. The adoption of the Low-Carbon City Program was initiated by a resolution, which led to a strong desire for the 2009 National Energy Conference. The targets formulate low-carbon communities in both municipalities and counties over two years, six low-carbon towns over five years and four low-carbon towns, each of which will be completed by 2020 in the north, central, south and east of Taiwan [14]. Renewable energy, energy conservation, low carbon occupancy and green mobility were the major indices of low carbon development (Tables 1 and 2).

3.1.1 Keetha, Malaysia

Malaysia Low-Carbon City Framework formulates the need to study the local government plan on the ground and to implement it, which will initiate a reduction of carbon emissions to preserve the balance of the environment. The urban

Table 1 Low-carbon community promotion initiative [14]

Renewable energy and energy conservation	Low-carbon buildings	Green mobility
Renewable energy planning • Solar thermal energy • Bio-mass energy	**Low-carbon building management** Water conservation and waste reduction	**Low-carbon modes and sustainable modal choices** • Bicycle (electric bike) • Public transport system • E-rickshaws and other low-carbon modes
Energy conservation LED and compact fluorescent light installation	**Green building material** Evaluation of the lifecycle (production, process, use, demolition, disposal)	

Table 2 Indices planned for low-carbon smart cities in Taiwan include the following: [14]

Classification	Rural	Urban	Solid waste recycling rate	Wastewater recycling rate	Rural type
Major indices	Fossil fuel consumption	Greenhouse gas emissions			
Secondary indices	Ratio of total solid waste recycled			Ratio of total wastewater recycled	
Supplementary measures	Coping with local adverse conditions				
Low-carbon city classification	Renewable energy ratio increase		Conserving Energy		

environment performance criteria describe the extent and boundaries of urban planning by site selection, which includes different factors such as the urban base spring which focuses on the concept of infill development and the control of growth outside the green space boundary. KeTTHA, [13] which will initiate on reducing the carbon emissions, thus maintains the atmospheric balance. Urban transportation indicates the shift to low-carbon modes and other high transit capacities and encourages people to travel without motorization. Urban infrastructure provides wastewater management strategies. For green parks, outdoor areas, recycled water is suitable. Green building or energy efficient buildings have been adopted which made use of recycled materials. For example, in many government office buildings fly-ash has been used as green material as they are light weight. Green buildings also incorporates energy efficient appliances (5 star appliances) which leads to less energy consumption.

3.1.2 Programme Level

The Environment Program of the United Nations (UNEP), with a total budget of 2.49 million pounds, is now supporting low-carbon transport to India. There are also a number of models for the urban emission. The SIM-Air Model (simple interactive

models for improved air quality) is an integrated air pollution analysis tool that ranges from estimating emissions to pollution impacts for a given scenario. The other VAPIS model is the vehicle emission calculator to match and compare the emission inventory, including the emissions factor database repository [15]. Smart CART is an important model, which includes a simple carbon analysis calculator along a road corridor and a flexibility to expand to other pollutants. The air quality index, which is generally used in many cities around the world and designed to plug your data into AQI estimates in real time or forecast, is also an important parameter. Atoms Dispersion Model (The Atmospheric Transport Modeling System serves as a (FORTRAN language based) simplified Lagrangian dispersion model to generate transfer matrices for multiple source and multiple pollutant types; for direct input to the SIM-air model. *Fugitive emissions of dust by road vehicles are symbolic and simple to use V-Dust calculator* (urban emissions, Webpage).

3.1.3 Need for an Indicator

No management without measurement: While the Kyoto Protocol has elaborated on the methods to ensure allowable reduction of SGM, it remains for individual countries to decide how these mechanisms are to be used and what individual goals will they set at home. In 1995, the IPCC Working Group 13 concluded that there is an apparent human influence on the global environment. The ***GHG Indicator*** allows companies to meet this need.

4 Comprehensive Climate and Smart City Planning Model

Smart cities with resilience to climate and low carbon can be described as digitally linked to all sectors and features. It covers everything in connection with sustainable, resilient, circular, efficient and urban connectedness [16]. Climate change mitigation as well as adaptation goals are included at every step of planning process in urban governance.

4.1 Connectivity of Climate Change Actions and Plans

The increasing number and responses to climate change have identified the need for an integrated (3Cs) carbon-based model for smart planning that incorporates climate change mitigation policy goals at every stage of the process.

4.2 Benefits for Cities in Climate Change Action

There are at least four reasons why climate action is in the cities' best interests. First, there are very high costs of inaction. Urgent steps to guide building codes and practices, density and connectivity infrastructure will be necessary in rapidly growing cities. Secondly, green action's co-benefits often cover more than cost. Thirdly, the adoption of such a major global cause helps cities to position themselves in a group of leaders, access and learn through information and technology. Fourth, the best way for small and poor cities to access the best experience available from around the world is to take up and share global products and practices.

Cities are also good pilots of climate action and have key climate change responsibilities. Through screening of infrastructure and transport investment, financial, partnerships, energy suppliers regulation, cities can promote green growth. Practical approaches climate risk evaluation/city vulnerability study, which shows how the particular area is susceptible to hazards, is taken into consideration. Analytical hierarchical process should include adaptation and mitigation strategies. Landscape and nature-based adaptation strategies majorly focus on the adaptive practices of that area.

(i) Climate workshops/design workshops—The participation of parties involved can include advanced urban planning and design solutions.
(ii) The tool to support naturally oriented adaptation strategies focuses on developing cities in order to combat shocks and stress. In a situation, it is better to adapt rather than reduce it.
(iii) Modeling of urban heat stresses may very well be explained where the floor design is less permeable, absorbing heat that causes the surrounding heat waves to block.
(iv) Green health check concentrates on several parameters such as green mobility, green design and efficient construction.
(v) Water-sensitive urban design includes sensors for water saving to control the excess flow of water.

4.3 Climate and Disaster-Resilient Smart Cities

The smart city mission, which is India's largest urban development government effort, should unequivocally focus on urban climate resilience. The first 20 approved smart city plans are compared in a TARU Leading Edge study, and there is no explicit focus on climate change in any of the 20 documented city plans. The study was entitled "Climate Change and Disaster Resilience" in Indian Cities: the preparation of city governments and funding arrangements for development across the various sectors, as opposed to urban initiatives, and the sites examined are the

municipalities of Mumbai, Kolkata, Chennai, Surat, Indore, Kochi, Guwahati, Bhubaneswar, Aizawl and Panaji [17]. For example, climate resilience can be classified as a cross-cutting issue but does not form part of a plan.

4.4 Indices for Smart City Planning

The ecological stress framework suggests a new approach to evaluating community socio-ecological vulnerability to disasters. In order to study the diversity of ecological stress in these communities, remote sensing data are needed in combination with household surveys that document emotions and behavior and social practices. The City Prosperity Index needs to be introduced in the smart cities planning process, which states that resilience depends not only on physical assets but also on policies and social capital.

4.5 Mainstreaming Disaster Resilience for Sustainable Development of Cities in India

4.5.1 Case Study of Guwahati and Shillong

The case study emphasized mainly the need for disaster resilience to be integrated into city development plans. The HIGS Framework incorporates the four components of which relate to cities: hazard, infrastructure, governance and economic status), and GIS spatial analysis was used to carry out vulnerability and haze assessments in the cities of Guwahati and Shillong. The main component of the organization is governance and institutional framework [18]. The presence of multiple agencies which lead to issues of coordination, irresponsibility and inefficiency in service delivery generally causes a lack of governance in cities. Deficit in infrastructure is the result of growing greed and population growth. Sewage, solid waste and drainage infrastructure in both towns are poorly developed and out of date to cope with current urban demand. These are thus the indicative measures to incorporate the resilience plan into development plans, to protect both people's and nature's interests.

5 Smart City and Low-Carbon Digital Connections [16]

The preparatory models provide spatially and strategically urban growth while maintaining GHG emissions under control and reducing the pace toward climate change sensitivities, improving quality of life, in particular through the use of

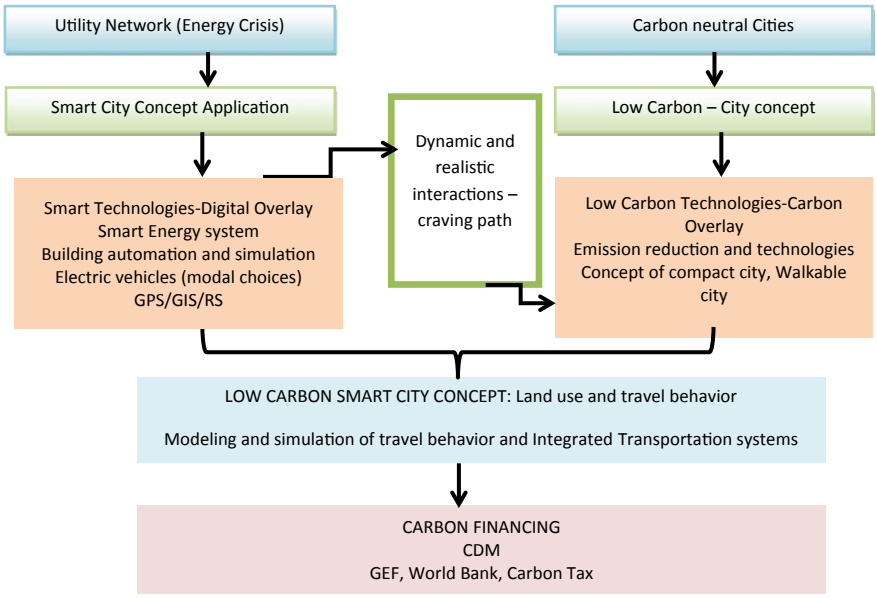

Fig. 3 Conceptual framework for low-carbon smart city

state-of-the-art automation and the development of Internet control technology [16]. With the help of growing ICT applications in specialized and growing areas, such as transport, land-use planning, energy, water, waste management and so on, the complex, spatial Web of a low-carbon smart city can be integrated in an integrated holistic approach via networking and information sharing (Fig. 3).

The concept of carbon overlay is a quantitative index. There are many green building ratings for efficient construction for each category. The results for every LEED loan depend on the carbon footprint analysis of the LEED building [16]. Carbon footprint is complementary to the construction and operation of gasoline gases, including:

- Building systems energy consumption;
- Embedded water emissions related to electricity used in water geysers;
- Embedded solid waste emissions
- Embedded material emissions indicating emissions from materials manufacture and transport.

Table 3 Government Initiatives under smart city

Policy/mission	Key focus area
INDC	Development of green mobility, climate-resilient urban areas
National sustainable habitat mission	Sustainable transport, waste management and energy-efficient construction
Smart city mission	To develop 100 smart cities
Atal Mission for rejuvenation and urban transformation	Revitalize 500 cities (basics, climate and green spaces policies)

5.1 National Policies Focusing on Sustainable Urban Development [19]

NDC majorly reforms cities into climate resilient to combat risks and uncertainties. There should be a proper corporate and official sector in each state to deal with climate agenda and plan according to the development goals. Various organizations are formed (5.1) that deal with climate hazards but are not planning accordingly; there is a need to have decentralized planning with an effective scale. Various initiatives were taken by GoI under smart city umbrella by setting up decentralized organizations for dealing or developing city as smart or eco-friendly (Tables 3 and 4).

Table 4 JNNURM, smart cities mission and AMRUT

	JNNURM [3, 20]	Smart cities mission [21, 22]	AMRUT [20]
Number of cites	65	100	500
Period	7 years (2005–2012)	5 years (2015–2020)	5 years (2015–2020)
Criteria	Class A cities will include populations over 4 millions per census for 2001), seven class B cities will include populations between 1 to 4 million per 2001 census), 28 class C cities will include religious/ historic towns, and 30 cities will be included in class A cities	Cities should meet the following requirements: master plan, GIS maps, public service online, IT-based platform, etc.	Towns with 1 lakh population, including some towns on the main river, some capital cities and major towns in hilly areas, islands and tourist areas
Central Government outlay	Allocation of Rs 66,085 crores	Allocation of Rs 48,000 crores	Allocation of Rs 50,000 crores

(continued)

Table 4 (continued)

	JNNURM [3, 20]	Smart cities mission [21, 22]	AMRUT [20]
Reform objectives	Transparent budgeting, planning and accountable management	Movability, provision of infrastructure, healthy environment and IT connectivity	Project-based approach: funding allocation, bye-laws, urban local authorities and central planning
Role of center	Central authority should sanction projects	City challenge competition	State shall present the central agency with plans

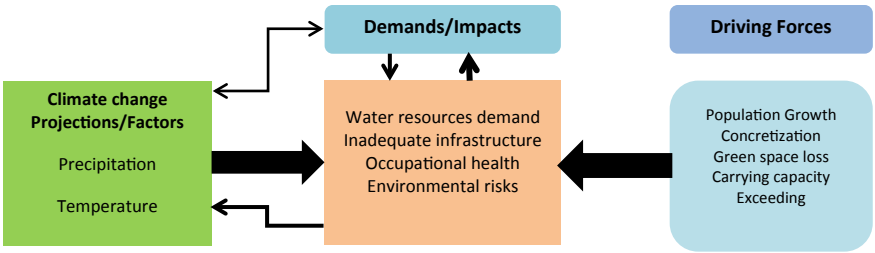

Fig. 4 Climate change vulnerability assessment

5.2 *Vulnerability Assessment*

Firstly, vulnerable factors affecting the specified location or area should be known. Vulnerability assessment can be done through remote sensing and GIS application. Various thematic and info graphics map can be prepared for better understanding of hot spots. Detailed analysis and inferences can be drawn, based on that policies can be framed and implemented by knowing the targeted groups. Vulnerability assessment can be best quoted from the climate change projection factors (Extreme temperature/precipitation) which will pose occupational as well as environmental hazards (Fig. 4).

5.3 *Mainstreaming Climate Change Resilience in Urban Development Plan*

Migration, slum growth, poor housing finance, poor local government, unexpected growth and restrictive zoning regulations all take into account India's urban challenges. For efficient resource-based planning, resource-based plans need to be incorporated into development plans as well as sufficient governance. Governance

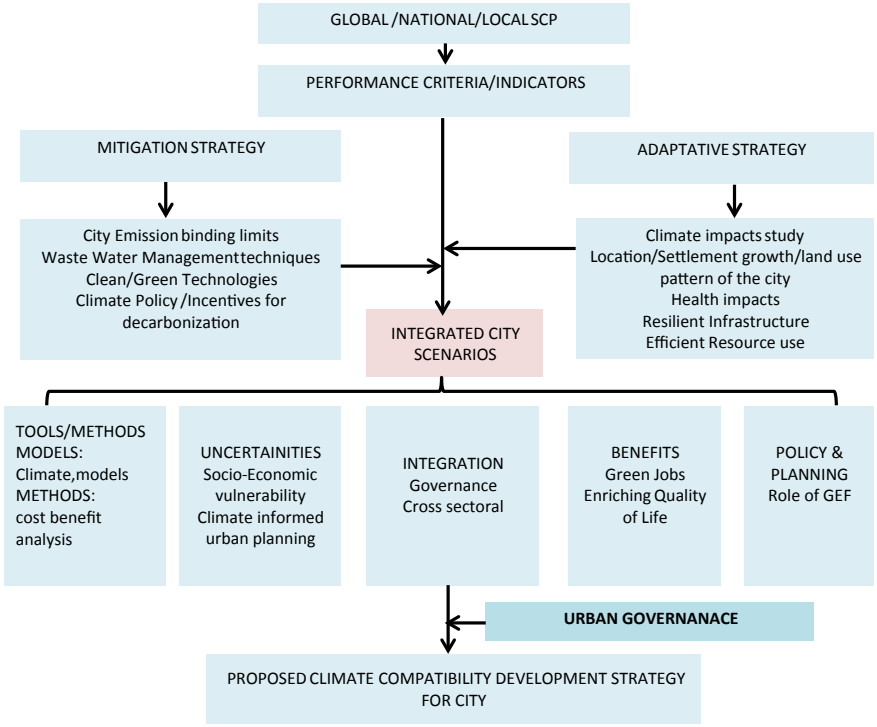

Fig. 5 Framework for climate change resilience in development plans

is an art of government leadership. The main components of governance are responsible, self-governing, provision, (Table 2) regulation, enabling and partnership. UNDP has listed different good governance parameters: participation, rule of law, transparency, responsivity, alignment, equity, efficiency, accountability, strategic vision (Fig. 5). Performance criteria are established for both mitigation and adaptation strategy. Climate compatible city development plan can be integrated with urban governance to check on performance indices.

5.4 Resilience Strategies

The capacity of a socio-ecological system to absorb shocks and stresses is defined as climatic resilience and in order to maintain the role that climate change places in the pace of external stresses [9] and to bridge the gap between adaptation and mitigation and evolve into more desirable configurations that improve the sustainability of the system (Fig. 6; Table 5). Resilience strategies can be adopted to combat environment risks such as proper land use planning, urban governance,

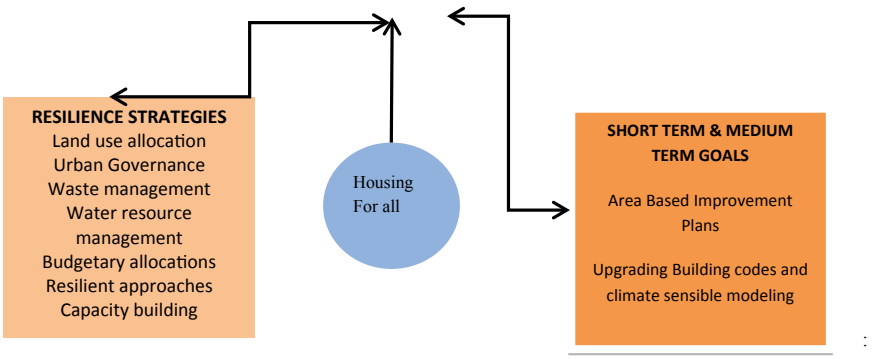

Fig. 6 Resilience strategies [21, 22]

Table 5 Urban governance approaches

Self-governing	Planning of buildings according to climate-resilient adaptation
Governing through enabling	Local governments should encourage local stakeholders and private actors to contribute their share in the pay of adaptation
Governing by provisioning	Warning systems and emergency planning
Governing by authority involving	Urban planning and other influential roles of local government

upgrading building codes, climate sensible modeling and capacity building. Good Governance approaches serves as the backbone for proper functioning of perspective plan.

6 Limitations of Climate Smart Cities

In these days, climate cities are always a big concern. The concept of adaptation and mitigation is much more comprehensible. The fourth evaluation of the IPCC shows that the urban resilience framework is emergent by the end of 2050. The key issue is the conflict of interest arising from the specificity of the project being undertaken in consultation with different stakeholders. In order to achieve stability, proper allocation and fair distribution of the budget should be made between all sustainable sectors. Megapolis as well as metropolis are planning according to Master plans. But in great need of Master plan, settlements and their are growing at a very fast pace, which needs to be checked upon. Master plan must incorporate a sustainable vision of growth of city in eco-friendly manner. The plan should be strengthened, focusing on public involvement and adaptation and mitigation goals in order to enhance the town's resilience.

7 Conclusions

In India, disaster and climate resilience framework can be integrated into the cities' development plans, with missions such as Smart City, AMRUT and HRIDAY. Geospatial and remote sensing techniques can be used to make city climates resilient, allowing for vulnerability and hazard assessment. Capacity building, the appropriate institutional framework and programs (decentralized planning) are needed for better coordination of cities at all levels to cope with climate change. In order to tackle current urbanization challenges, it is also necessary to integrate the low-carbon smart city concept.

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