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Research paper

Urban climate resilience in Indian cities: current practices and challenges in mainstreaming adaptation to climate change

Maulsri Jha *

Assistant Professor, Amity School of Architecture and Planning, Amity University, Noida
**Corresponding author E-mail: jha.maulsri@gmail.com*

Abstract

The urban population in India is expected to increase by about 500 million in the next 50 years, which would catapult Indian urban regions towards climate change related disasters such as extreme temperatures and precipitation, droughts, river and inland flooding, storm surges and coastal flooding, sea-level rise and other environmental risks. Large gaps exist in the demand and supply of infrastructure and services in urban regions. A radially outward approach is necessary for cities to integrate mitigation and adaptation policies into their urban design and planning philosophy. Municipal authorities are already grappling with shortages in basic infrastructure and therefore, mainstreaming adaptation and resilience is not high on the priority list of government bodies in the country. There is a need to adopt a pan-sectoral approach to upgrade mitigation and adaptation policies and to motivate actors from different sectors for a holistic integration of urban resilience into the design and planning fabric of urban regions in India. Urban climate vulnerability of India is not only a technical challenge, but is also deeply rooted into the social and cultural ethos of the country; we must realize that resilience building in the nation cannot be merely a physical planning exercise but has to be socially equitable as well. Through this paper, an effort has been made to examine the current structure and practices which are in place in Indian cities for the purpose of mainstreaming disaster adaptation. For this purpose, the paper analyses emerging lessons, experiences and limitations of resilience design and planning in select cities of Asia associated with the Asian Cities Climate Change Resilience Network (ACCCRN), a network which is dedicated towards identifying vulnerabilities and mainstreaming agendas associated with resilience design and planning and disaster mitigation and adaptation. Several Indian cities are a part of this network as well. Internationally, commendable and exhaustive work has been done for mainstreaming adaptation to climate change in the primary design and planning of cities, and this is indeed helpful for formulating suitable standards which could be applicable to the architectural policies for a resilient urban India. Additionally, this paper would also analyse and examine various challenges and roadblocks that are faced by urban governance in strengthening management and mitigation practices in India to deal with hazards. Finally, the paper would end by describing possible adaptation frameworks for encouraging efficient resilience architecture and planning in urban India.

Keywords: *Climate Change Resilience; Disaster Mitigation; Sustainable Development; Urban Planning.*

1. Introduction

Large number of metropolitan hubs strung along the South East portion of Asia present serious challenges to their planners and decision making bodies mainly because of their recent rate of growth, but also because of their sheer complexity and level of informality. The process of evolution of most of the Asian cities in the last century has been chaotic and unstructured because of different aspects such as colonialism, wars, intermittent economic crises and unstable regimes. Furthermore, with the retreat of colonialism in the last decades, a trend has been observed in major Asian cities wherein the major focus lies in catching up to global economic and business standards without approaching a holistic and structured urban developmental approach. Also, it cannot be denied that rural to urban migration has been at its zenith in the last few decades, so much so that many megacities have ceased to be recognized as individual cities but have, on the contrary, come to be identified as urban agglomerations and mega-urban regions, for which there is decent amount of literature present.

Asia is home to about two-thirds of the global population, with China consisting of 1.4 billion alone. Indonesia has a population of 230 million and Japan has 127 million. Further, Philippines has 92 million inhabitants, Thailand has 68 million, Korea has 48 million, Malaysia has 28 million, Taiwan has 24 million and Singapore has 5 million. Altogether, Asia has an urban population of 1.6 billion [1]. Different Asian countries have urbanized at different rates, with Japan, Korea and Taiwan being more economically advanced, where more than half of the population resides in urban areas. In comparison to this statistic, countries such as Indonesia, Malaysia, China and Philippines have a large chunk of rural and semi-urban population but they are also on the trajectory of massive urbanization in the near future. Interestingly, contrasting patterns are revealed in the UN projections of city populations in 2025 [2]. Seoul and Tokyo will increase in population but not more than 1 million, but in contrast, cities such as Shanghai, Manila and Beijing will see an addition of about 3 million inhabitants.

Table 1: Source: United Nations (2010) World Urbanization Prospects: the 2009 Revision (File 12). New York: Department of Economics and Social Affairs, Population Division

City	Population 2010 (million)	Projected Population 2025 (million)
Tokyo	36.7	37.1
Shanghai	16.6	2.0
Beijing	12.4	15.0
Taipei	2.6	3.1
Seoul	9.8	9.8
Honk Kong	7.1	8.0

Singapore	4.8	5.4
Kuala Lumpur	1.5	1.9
Jakarta	9.2	10.9
Bangkok	7.0	8.5
Manila	11.6	14.9

2. Global risk and resilience

Cities can be impacted by different calamities and catastrophes which can be immediate and sudden, or can have a slow onset with equal or maybe greater devastation. Some recent examples of extreme weather events are the devastating earthquake of Tangshan in 1976, the tsunami of 2004, and the hazardous earthquake and tsunami of 2011 which occurred in Fukushima Prefecture in Japan, triggering a nuclear accident scare. Additionally, countries such as Taiwan, China and the Philippines are in constant danger of deadly typhoons; Tokyo and Beijing lie on existing seismic faults; and several Indonesian islands are at the risk of volcanic eruptions and hazardous flooding. Additionally, most of these countries also grapple with the threat of terrorism which leads to various social and physical setbacks, crippling the social and economic well-being, and also presenting a herculean post-conflict resurrection challenge. Moving on, it is imperative to remember that not all the setbacks and calamities are immediate in nature. Several catastrophic events are a result of minor build-ups over a longer time period, or a culmination of several turbulent episodes. It can be argued that globalization in itself is increasing the economic vulnerability of Asian cities, as they are now being widely exposed to the risks and fluctuations of the global economy; a critical example of which can be observed during the great financial crisis (GFC) of 2008-09. It is worth noting that climate change is adding on to the already considerable amount of risk that many Asian cities face, bringing them face to face with difficulties and situations that they have never before encountered, and in some cases, not even anticipated or imagined. However, if we go back to the basic definition of resilience, we may recall that it is "….the ability to absorb disturbances, to be changed and then to re-organize and still have the same identity (retain the same basic structure and ways of functioning)" [3]. Many Asian cities have indeed been able to bounce back to their ordinary way of functioning despite suffering massive setbacks in recent years because of manmade and natural calamities, and this is some consolation. However, further planning, development, modernization and urbanization cannot and must not continue on this assumption and optimism alone, as it is only a matter of time before the entire organizational framework of the urban fabric and government processes may come undone because of said factors. Therefore, the need of the hour is to safeguard cities against unforeseen extreme events, and adapt the cities suitable by inculcating and including social and communal participation at the political, financial and infrastructure level. In this regard, it is worth mentioning that economically advanced cities have a better mitigation mechanism in place as compared to economically disadvantaged cities; for instance, Singapore and Hong Kong have better adaptive capacity and mitigation safeguards in place as compared to Jakarta and Manila, which are also mired by corruption and poor interventions of governance and planners. This establishes the fact that poverty leads to an increase in vulnerability and hinders the ability to prepare for future extreme events, both foreseen and unforeseen. [4] aptly describes the fourfold approach for enhancing resilience in such cases with special emphasis on moral instead of actuarial planning; community involvement in resilience planning; recovery planning from the bottom up; and preparation of effective hazard mitigation plans. This paper also attempts to shed some light on governance, or the lack thereof, in select Asian cities, highlighting the fact that often there is a lack of proper communication and exhaustive collaboration between the different levels, resulting in inefficient organization and ground work. It is common to find in many cases that the state and central governments do not want to grant sufficient power to urban local bodies for efficient operation; in such cases it is imperative to realize that global issues of climate change and extreme weather events cannot be handled by one layer alone, but requires efficient collaboration and co-operation between hierarchical orders. Cities such as Tokyo, Seoul, Taipei and Singapore are heavily concerned about maintaining their world city status and therefore, aim to strengthen their economic development and infrastructure, and comparatively fewer efforts are made for upgrading and reforming the quality of urban environment on the whole. Additionally, it is safe to say that poly-nucleated cities, which are self-sufficient with respect to urban housing, services and employment, have a better resilience and mitigation structure [5]. The poly-centric form of development has many proponents among western planners and scholars, as they reason that the space between the main urban centre and dense surrounding nuclei can be used for creating green belts, open areas and also may be useful for peri-urban agriculture. There is a need of a paradigm shift from the practice of "regional government" to "regional governance"; wherein the former presents a rigid hierarchical structure with an almost authoritarian approach by the government with set strategies and goals, whereas the latter aims towards a more fluid and flexible relationship between different actors and existing institutions [6]. Asian mega-cities are often disturbed due to fragmented governance, decentralized unstructured authority, and inequitable distribution of economic and technical resources. There is tension between rigid authoritative bodies and aware citizens who want to play a greater role in understanding and planning their own city, and a beneficial and productive way ahead can be established by balanced effective public participation in local planning processes and place-making [5].

3. Tier ii cities in Asia and risk resilience – acccrn

At this juncture in the paper, a suitable background has been established which has provided the reader with insights about the present situation of Asian mega-cities with respect to climate change mitigation and risk resilience. It is common to conjure up images of mega-cities such as Mumbai and Bangkok concerning urban resilience and risk factors, but according to [7] it is tier II cities in Asian countries which showcase the existing urban reality. It has been projected that about 60% of the increase in urban population between now and 2050 will take place in Asia, and about half of this increase will occur in cities which have a current population of about 500,000 inhabitants (mid-size or tier II cities) [8]. Since tier II and tier III cities already have strained limited institutional capacities and finances, they struggle daily to provide basic services and infrastructure to their inhabitants. There are very few effective planning models for lower tier cities and because of this reason, capacity building and risk resilience measures may seem overwhelming in such cases. However, their safeguarding is of utmost importance because they have most of the planning decisions ahead of them. Lack of planning models in such cases should not be seen as a handicap, but as an opportunity because these cities provide a fresh slate for comprehensive interplay of climate change and urban development in the present, while keeping future demands in consideration. As a special emphasis on tier II and III cities, the Rockefeller Foundation launched the Asian Cities Climate Change Resilience Network (ACCCRN) in 2007, which aims to develop a conceptual model and practice base across a range of elements. It also aims to spearhead efficient funding, attention gaining and ensuring complete vulnerability robustness of economically weaker neighbourhoods in such cities.

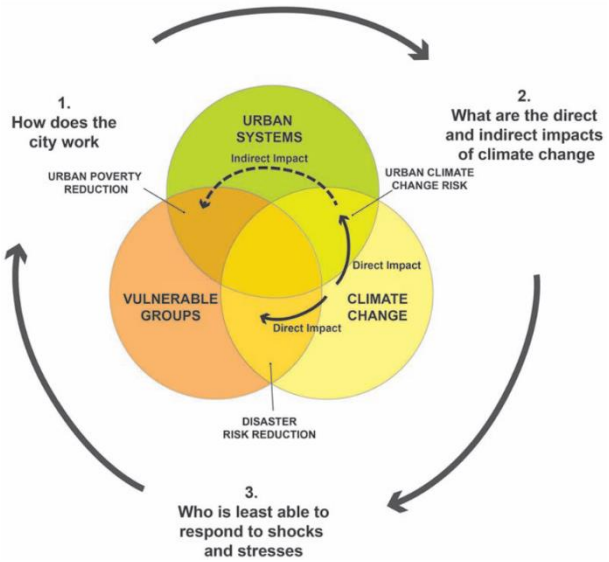

Fig. 1: Climate Impacts: A Compound Effect Combining Direct Impacts, Indirect Impacts and Pre-Existing Vulnerabilities. Source: Da Silva, J, S Kernaghan and A Luque (2010), "A Systems Approach to Meeting the Challenges on Urban Climate Change", International Journal of Urban Sustainable Development.

A system of interdependencies among a range of actors and concepts has been propagated by the Rockefeller Foundation along with its partner organizations: Arup's International Development Team and the Institute for Social and Environment Transition (ISET); emphasis has been laid on the relevance of urban governance, engagement of varied stakeholders, consideration of different spatial and temporal processes, and to develop mitigation measures into an evolving process. In the context of urban climate change resilience, the aspects of geographic spread and development are crucial to realizing the connections between development, density, land and profiles of risk and vulnerability. It is crucial to produce a vision that is not limited to daily pressures and strains, but looks towards the impending struggles of the not so distant future. For example, several Indian cities in the Indo-Gangetic plains experience unpredictable levels of water logging and flooding, leading to large outbreaks of water-borne diseases. In particular, low income residents in squatter colonies and informal settlements are particularly susceptible to such challenges, including dengue fever, Japanese Encephalitis and malaria. In such scenarios, it becomes very difficult for the local governance to adopt a long term vision, as the main emphasis lies on mitigating the present problem at hand.

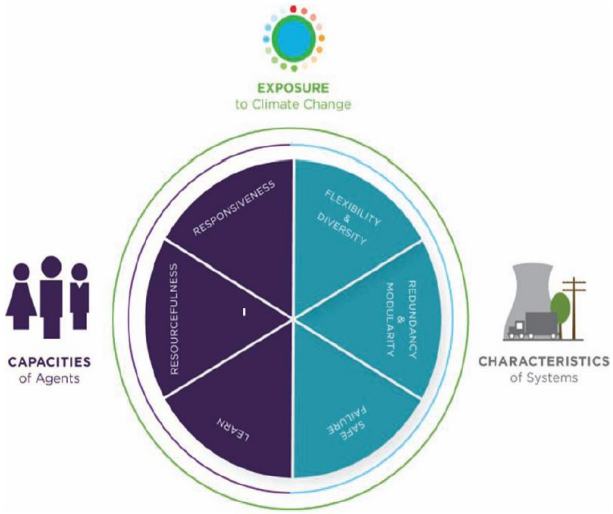

Fig. 2: System Resilience and Agent Capacity [9].

As a result of a broad range of intervention ideas, 10 crucial Urban Climate Change resilience action areas emerged, which aimed at helping cities to strengthen their participatory ability and preparedness towards sudden and slow impact events. They have been summarized as follows:

a) Climate Sensitive Land Use and Planning

The changing profiles of local weather patterns, hydrology and rainfall in an urban area affect how urban land use is developed and used, along with topography, population density and natural-built relationships. This is the realm where major influential and effective decisions can be made; interestingly many cities have increasingly started to address issues such as urban and land use planning, flood water management, ecosystem strengthening, peri-urban agriculture and cross-platform interactions. Although it is encouraging to see urban areas address such issues of climate change sensitive urban planning and capacity building in the face of risk vulnerability, it remains to be seen whether such measures actually culminate in positive sustainable shifts in the longer time frame.

b) Institutional Coordination Mechanisms and Capacity Building Support

ACCCRN has laid emphasis on a multi-stakeholder approach in enhancing risk resilience measures and highlights that such activities, tasks and decisions should not be taken in isolation. In this regard cross-platform interactions are key; for instance, in cities plagued by poor drainage, sanitation, and poor solid waste collection, outbreak of diseases is a common feature. To address such issues, suitable coordination between different institutions is compulsory and comprehensive cooperation between public and private health supervisors, private solid waste managers, and city public works department would be beneficial, instead of a single player handling various portfolios. ACCCRN illustrates suitable evidences in this case; for example Vietnam has come up with a structural framework of urban governance wherein climate change coordination bodies are formed to enable integration of multiple departments, datasets and priority distribution to ensure effective coordination of donors and higher berths of the government. These efforts result in the generation of new incentives, sharing of critical information across various platforms, and undertaking of connected tasks. Additionally, these measures foster inter-dependencies amongst systems, institutions and sectors leading to multiple outcomes and suggestions of a problematic and threatening scenario, which can be modified to suit the needs of the region in question. Once again, we must remember that these efforts would be fruitful only upon their execution in an integrated way.

c) Drainage, Flood and Solid Waste Management [7]

Cities need to manage growing instances of flooding in high density urban areas which is a growing concern across various urban fabrics of the world. This aspect has evolved as an area of major concern and maximum efforts by the ACCCRN cities, because existent hard and soft flood mitigation measures, procedures of dealing with solid wastes and in-place response facilities in the face of severe flooding showcase a city's present flood risk and estimated damage. Any weaknesses in these elements can lead to severe devastation and lack of relief and rescue for the inhabitants. The analysis and steps taken by ACCCRN are especially important because they are context specific and aim to streamline the work progress in order to achieve precise results which pertain to the on-ground situations of the region in question. For example, it was identified that in Indonesia, flooding and drain clogging due to seasonal rainfall has increased manifolds in the past few years and this is because less than 30% of the solid waste generated is actually collected and dealt with by the bodies in-charge[10]. This holistic multi-stakeholder approach actually illustrated the relevance of the solid waste collecting system in providing flood mitigation, and such issues help in drawing the attention of potential stakeholders and city officials towards solving such problems. This enhances liveability and strengthens the overall resilience outline of the urban region.

d) The Aspect of Water and its Conservation Structure

Many Asian cities are marred by increasing fluctuations in the rainfall pattern, with more pronounces wet and dry spells which adversely affects the crop cycle, and the city's capacity to manage its water supply. Widespread construction and surface sealing activities across urban regions has reduced the water percolation into the

ground, lowering the water table and ground water storage; additionally, it is worth mentioning that an increase in the average global temperature has led to a shift in the water usage patterns ranging from domestic scenarios to industries and power plants. Several ACCCRN cities have taken some measures to increase their water management resilience, both at the private decentralized level with rain-water harvesting, as in the case of Semerang, Indonesia [11], to broader city level urban lake regeneration for emergency back-up water supply, as in the case of Indore, India. Households have also contributed significantly to the cause of water conservation, by judicious storage of high-quality clean water and effective recycling of grey water.

e) Early Warning Structure and Management in the case of Emergencies

In many cities, climate change has manifested its presence with increasing occurrences of natural disasters such as floods, cyclones, earthquakes, droughts etc. While it may be true that urban areas possess greater mitigation measures as compared to rural areas, they usually lack community support frameworks which are most crucial in the event of disasters. Additionally, in most cities critical infrastructure such as power, water, transportation and health are interconnected upon which citizens entirely depend. In the event of their failure, no back-up options are available crippling the entire movement and mitigation of the city. Therefore, it is imperative to develop social, institutional, ecological and technological capacity of cities to offer intensive early warning and post-disaster cooperation and relief and build strong urban climate change resilience, with special emphasis on coastal protection, flood early warning systems, epidemic management citizen education and improved cooperation [7]. Natural disasters lead to an immediate crippling of human and financial capabilities, and therefore, when stakeholders invest for such causes, their investment also becomes more robust with immediate visibility and a satisfaction of the conscience.

f) Robust Health Management Structure

It is encouraging to notice that many Asian cities are building their disaster resilience concerning impacts which have a slow onset, by analyzing and understanding the health challenges caused by climate change. Major areas of focus have been targeting water-borne diseases due to water logging and floods, improving the capacity of stakeholders with respect to changing climate vector-borne diseases, addressing the concerns of increased water salinity in coastal regions, and assessing the general increasing heat impacts on human health and temperament in urban regions. For example, coordination has increased between epidemiologists and climate scientists in the city of Can Tho, Vietnam [7], which has facilitated enhanced infection surveillance and management of health service providers.

g) Transport Network and Housing Resilience

Shelter leads to overall well-being and protection of inhabitants and a robust transport network enables access, connectivity and evacuation in the event of a crisis, acting as the backbone of urban fabrics. Both the elements are highly susceptible to climate change, both in the event of sudden impacts such as earthquakes, floods and cyclones, or slow-onset events such as ill equipped housing harbouring unsafe living situations which are unable to deal with extreme heat or cold over larger periods of time. Therefore, efficient siting and designing of such structures is extremely crucial for enhancing mitigation strategies and ensuring effective risk reduction in cities. For example, providing elevated roadways may be beneficial for certain regions in the sense that it would reduce direct flood damage to major transportation networks, but on the contrary, it would lead to higher chances of flooding or inundation in the nearby areas by disrupting the natural flow of water and disturbing drainage patterns. Although ACCCRN has no formal proposals as far as transport planning is concerned, it has initiated several projects dealing with housing resilience. Major efforts include increasing storm and flood resilience, design innovations to reduce heat stress and manage water scarcity, and offer financial support to households to carry out their own housing up gradation and retrofitting.

h) Preserving Ecosystem Services

Having a varied and well-functioning ecosystem ensures protection against direct and indirect vulnerabilities and risks by providing protection against floods, wind and wave movements, instability of hilly areas, and urban heat island effect. It is often the case that such natural mechanisms are more flexible and cost-effective as compared to built and artificial mechanisms for risk mitigation; it is especially beneficial for marginalized and economically weaker communities which find it difficult to prepare special infrastructure with the purpose of strengthening their resilience. However, ecosystems in urban and peri-urban areas often suffer from maladaptation and degradation because of factors such as development pressures, lack of regulations and conservation drives, and general ill-management and ignorance. ACCCRN has taken a number of initiatives in a number of Asian cities which include addressing urban agriculture, urban mangrove development, and urban river and lake rejuvenation. Urban ecosystem regeneration could be a vital tool in mobilizing community awareness and participation, and build quintessential social capital.

i) Variegation and Defence of Climate-Affected Occupations

Ensuring a stable and continuous source of income for urban poor households, which are likely to be impacted the most by climate change, is a prerequisite for enabling community and household level resilience. Sectors such as tourism, fisheries, and horticulture are directly impacted by climate change and are likely to be threatened. At the city level, natural disasters lead to physical obstructions in employment patterns such as absenteeism, and threatened economic groups. It is crucial to protect the interests and economic future of low-income households with the help of innovative financial support, insurance policies, diversification of specific professions, and provision of schemes and government funds which encourage people to start local small businesses aimed at unemployed female members of the family. Urban climate change resilience goals are different from conventional development practices and need to be addressed suitably, since increasing the income of economically weaker households is just a small cog in this large machinery. Further research, practice, and plans are essential for strengthening household level resilience.

j) Resilience Building and Awareness of Citizens

It is crucial for communities to identify and understand the shifting and uneven nature of seasonal diseases such as dengue, and to participate in effective solid waste management systems. ACCCRN cities have fortunately realized the importance of community resilience building and education and have tried to engage young people through projects. Focus has been shifted towards long-term resilience and development of new knowledge in the mainstream education framework, with the integration of disaster management and capacity building with existing subjects without the need of a new curriculum. This has enabled younger people to be more responsive, resourceful and aware, as can be seen in Da Nang, Vietnam. It cannot be denied that education and awareness amongst community members is the most cost-effective way to ensure risk resilience in the long run. However, it is challenging because such efforts are difficult to be measured quantitatively in the short run, thereby leading to lack of patience and trust.

4. Case study of Tokyo: thinking mega in the face of risk

In 2010, Tokyo consisted of 35 million inhabitants, or about 28% of the Japanese population, who lived in the Greater Tokyo Region, making it the largest urban region in the world. Interestingly, Tokyo was a mega city with more than a million residents long before industrialization happened, contrary to cities such a Beijing. In the Edo period (1600-1867), Edo (Tokyo was then called Edo) was planned according to class and rank of the inhabitants, and not according to wealth or market value. Additionally, the design primarily focused on defense against attacks, and these two principles enable us in attaining a deeper understanding about the planning history of Tokyo. Edo was characterized by divisional planning which made a clear demarcation between the Samurais who lived in the

High City and the regular population which lived in the Low City. The Low City of the common people was built on the marshy estuary of the Sumida River. Some parts of it were also built on the land reclaimed due to landfill from the Tokyo Bay and it was planned in a grid pattern of geometric blocks, as per the ancient Chinese system of measurement, interspersed by a detailed canal network [12] [13]. The Low City of Edo had an area of about 13 square kilometers in the 18th century, with a population of about 500000, which led to a population density of up to 58000 per square kilometers [14]. On the other hand, the High City of the Samurais were built on the hills and plateaus of Western Edo, near the Tokyo Castle, and evolved due to the hilly topography of the Yamanote prefecture. It is worth noting that although Samurais constituted about half the population, about two-thirds of the area of Edo was reserved for their residences, which led to low population densities in the High City to be a quarter of those in the Low City [14] [15].

The Great Earthquake of Kanto struck on September 1, 1923, crushing and incinerating about 140000 people. About 44 per cent of the urban centre of Tokyo was completely devastated, which led to the final disappearance of the built form of the feudal planned city of Edo [16]. It is common knowledge in the field of urban disaster recovery that in the event of a disaster, the main priority is to construct everything quickly in the same pattern in order to provide shelter and homes to the people who are suffering. Even if major reconstruction or change in the construction pattern is required for the area in question, mitigation and relief activities do not provide the opportunity and time for such activities and the planning process and construction is adopted from the previously same prevalent systems in the urban region. However, this was not the case in Tokyo, as after the major earthquake, a comprehensive redesign of the central area was planned and undertaken with the aim of a new hierarchy of broad boulevards, wide commercial roads and narrower streets and lanes. It is imperative to mention that this massive redesign of the city core in the face of disaster came with its own set of problems. Firstly, in order to build houses and other buildings quickly for the relief of the inhabitants, many requirements and standards for fireproofing of structures were relaxed and overlooked again and again over the next few years. This led to massive devastation of many of these buildings because of fires during the bomb raids of World War II. Secondly, the meticulously prepared plans for land development projects and construction regulations which were followed for the development of the city were destroyed in the fires which occurred after the devastating earthquake, in which the Home Ministry and the Tokyo City Hall were completely burnt up. Additionally, the time frame post the disaster, many families which were rendered homeless and could not find shelter and relief in the city moved to the urban fringe which led to a vast chunk of uncontrolled and unregulated sprawl. This is a matter of great concern even today as Japan anticipates its next great earthquake. (Historically, Japan has had a cycle of major earthquakes every 70 years). As we have already seen, Tokyo was actually planned as a military city, with the priority on defense having placed the Samurais in the High City. During this period of Edo, the government of Shogun had commanding powers in every realm including town planning and new development [17] [13]. After the devastating Great Earthquake of Kanto in 1923 and World War II, the control of planning and reconstruction again went into the hands of the central government. Since then, the government has focused on rapid growth and development, with emphasis on building of large scale infrastructure, which has contributed immensely to the overall fabric of growth. The Tokyo Bay landfills for the port and industrial complexes, expressways, bridges and airports have spearheaded Tokyo's economic and industrial growth. Throughout the last century, construction of buildings and other physical infrastructure in Tokyo has been a major industry, especially in the last few decades of low economic growth, with built regions reconstructed completely or partially. This brings us to two aspects of Tokyo's urbanization and growth. Firstly, the on-going trend to showcase a "development state" has shifted priorities towards the planning and construction of grandiose engineering projects which are heavily politicized and publicized. This has shifted the focus way from real urban priorities hindering systematic regulation and planning. Secondly, Tokyo has increasingly becoming known for suburban sprawl and substandard urban fringe development. This period of rapid urban growth has unmasked the dualistic aspect of Tokyo's urbanization – the central government is pumping incredible sums of money for the construction of large-scale infrastructure projects, whereas the suburban regions are witnessing uncontrolled and unplanned residential development with limited services such as roads, community centres and parksb [18] [19]. For this reason, although foreign visitors usually admire the mega infrastructure projects, native observers tend to notice the lack of investment in social infrastructure and prevalence of substandard living conditions. Another problem has been the failure to regulate unplanned land and housing development, which has led to haphazard development of huge areas and lack of basic infrastructure services of proper roads and sewerage.

Thus, it would not be wrong to say that Tokyo is suffering from three major issues that have a significantly spatial connotation, and which have their roots in the historic planning principles of Edo. The first issue is the continuing divide between the present day Low and High Cities, where most of the Low City lies below the mean sea level in the floodplains of the Sumida, Edogawa and Nakagawa rivers. Secondly, the continued sprawl of substandard housing in vulnerable areas of Tokyo has contributed to major risks to the city population. Thirdly, there is a huge pressure to redesign and rebuild the city core to set new international standards, a reason for which are the already mentioned new regulations which focus more on mega engineering projects while essential social infrastructure takes a back seat. In modern Tokyo, the industrial areas consist of a mélange of deeply intertwined houses, factories, warehouses, offices and retail spaces; these areas were the worst victims of pollution during the environmental crisis of the post-war period. Fortunately, the environmental laws became much stricter after 1970 and therefore, these areas could recover and have become successful examples of low-rise high-density sustainable regions.

At this juncture of the paper, it is essential to summarize the three major risks that are faced by Tokyo. The first major risk is that most of the low lying areas of Tokyo with a population of about 2.5 million lie up to 2 metros below the mean high tide level. Although these areas are protected by water gates, locks and dykes, rain water must be continuously pumped out from these areas. Therefore, these areas are constantly vulnerable to flooding in event of a failure of the emergency pumps, or if there is surge in the storm water, or if a dyke collapses. Additionally, as sea levels are rising globally and definitely, Tokyo sits at an extremely critical position because of its vast low lying areas. The second major risk that Tokyo faces is a result of the hasty rebuilding of the city after World War II, mainly because of the weak planning regulations of that time. Even today, near the Yamanote railway line, there is a huge suburban neighbourhood full of small wooden houses, narrow streets, and cobbled lanes. Although they might appear charming to live in with potted alleyways and pedestrian lanes, the fact is that in some areas the streets are not even one-car wide, and the houses are inches away from each other, which greatly increases the risk of fatality in case of fires. In the Kobe Earthquake of 1995, maximum casualties occurred because the people got trapped when the streets were blocked by the collapsed buildings and timely help and rescue could not reach the people in need. The third major vulnerability of Tokyo deals not with impending physical disasters, but with the weak and unfocused planning regulations of the city. There is a drive towards intensification and redevelopment of the Tokyo region, but overbuilding will lead to large numbers of vulnerable people in the main city core. Furthermore, these people in the inner city core will require huge investments to meet their demands of basic infrastructure. This makes it evident that the central government wants to portray Tokyo as a land development vehicle, with fewer priorities allocated to earthquake and tidal risk mitigation. Until this thought process changes, it would not be wrong to expect Tokyo to remain highly vulnerable to catastrophic events.

5. An Indian example

In 2006, 75 per cent of the city of Surat, which currently has a population of 4.48 million was inundated as a result of an emergency release from the Ukai dam on the Tapi River. The dam, which has much of its catchment in highly variable rainfall watersheds in Gujarat, Maharashtra and Madhya Pradesh, is managed primarily for irrigation and for hydropower generation. Flood control is often a secondary consideration in dam management, as reservoir managers try to maintain maximum storage to meet summer water needs for millions of farmers. Because climate change is likely to lead to more variable rainfall and more intense periods of rain, city leadership in Surat realized that the likelihood of flooding from emergency releases would only increase, and so decided to invest in developing an improved early warning system to enable citizens and city departments to take necessary preparedness measures to reduce losses of life and assets. New components of the early warning system will include increased rainfall monitoring in the upper catchment area, and improved hydrological and hydraulic models to more accurately predict the impact of increased rainfall on stream flows coming into the reservoir and the impact of dam releases on downstream communities. Additional components include the enhancement of "last mile" dissemination of emergency warnings via SMS and other mechanisms throughout the city of Surat.

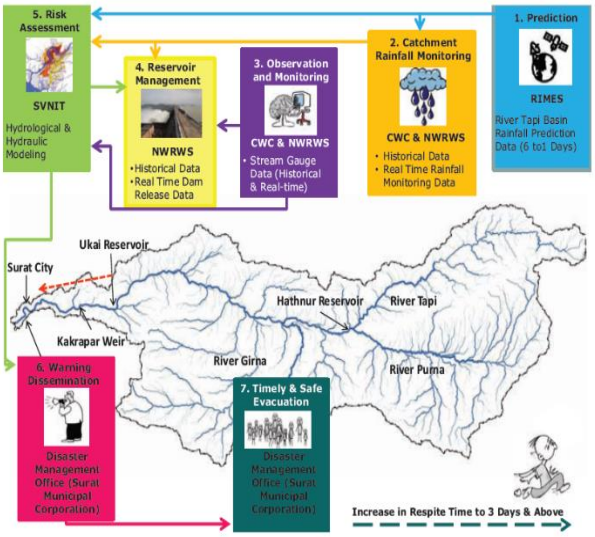

Fig. 3: Surat End-to-End Early Warning Collaboration Flow Chart.

After independence from British colonialism, the first major urban infrastructure scheme launched by the Government in India was the Subsidized Housing Scheme for Industrial Workers and Economically Weaker Sections. From 1952 up until 1980, the government played the role of a provider, focusing mainly on providing basic infrastructure services to the citizens, with little or no participatory aspect. From 1980 to 2005, the government played the role of an enabler, which illustrated that although it still focused on providing basic infrastructure in urban areas, it also brought into play a participatory approach which enabled the citizens to gain some feeling of control. After 2005, the government has adopted the role of a facilitator, which means that all the new urban development schemes in India have adopted a people-centric approach. At the same time, the issues of climate resilient and sustainable development have also taken a centre stage in these planning schemes which illustrate a bright future for a resilient development for the country.

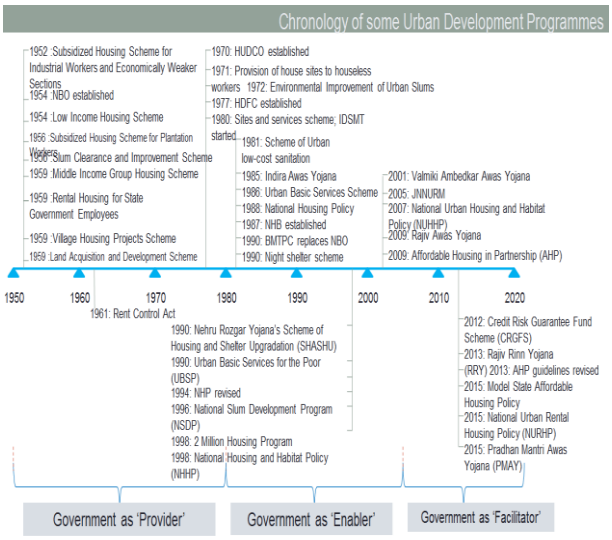

Fig. 4: Chronology of Some of the Major Urban Development Schemes in India, Highlighting the Role of the Government in Various Phases.

6. Challenges and opportunities for mainstreaming resilience into development planning processes in India

Cities at different stages of development have different challenges and difficulties. With growing urbanization, concerns of cities have moved from providing basic infrastructure and services to minimizing adverse effects of growth on existing infrastructure [20]. Post 1990s, cities in India have expanded quite rapidly in a chaotic pattern which has led to a haphazard development pattern, leading to detrimental effects on the environment and citizen which inhibits further progress [21]. Presently, only 32 per cent of the total Indian population lives in urban regions, but India still faces tremendous urban challenges. A large part of the urbanization is occurring on the fringes or outskirts of major cities, leading it to be unplanned and outside the purview of bylaws and city codes, imposing high costs on the environment. Such unprecedented growths have left municipal growths with infrastructure shortages and and service gaps, NCER 2014. Studies have also shown that environmental damage due to such uncontrolled growths have led to the reduction of India's GDP by 5.7 per cent or about YS$80 billion annually [22].

In addition to the above, climate change is increasingly emerging as one of the greatest challenges for Indian cities, which has partially been accelerated by the energy and resource-intensive growth trajectory followed in urban India. The impacts of climate change in terms of highly erratic weather patterns and extreme environmental events are expected to contribute to heavy loss of life and property. For examples, India suffered a loss of over INR 10 billion (US$ 150 million) due to the adverse winter weather in January 2013 alone [23]. Development goals of cities are also seriously undermined by climate change impacts. It has been suggested by research that there may be deeper relations between climate change vulnerability, development conflicts, and existing governance and institutional challenges [24]. Unfortunately, the resilience agenda in most of the developing countries is expected to be taken forward by regulatory channels that are already dysfunctional or are poorly implemented [25]. Resilience could best be propagated and implemented through development projects and programs and introduced as experiments and 'real time' demonstration of resilience and its benefits. Schemes such as the Smart City Mission that demonstrate participatory planning and practice innovative approaches to achieve development goals have immense potential to deliver demonstrative projects and foster resilience. The ACCCRN experience, as explained earlier in this paper, has highlighted the fact that urban resilience is a long-term iterative process that helps in identi-

fying vulnerabilities, with resilience actions and responses to vulnerabilities understood through robust risk analysis processes coupled with deeper stakeholder engagement.

In the context of smart cities, there is a potential of scaling up climate resilience. However, contrary to testing solutions through schemes such as the Smart City Mission which have immediate delivery potential, it is actually a lot more challenging to include resilience into policy planning frameworks, mostly because they are quite politically driven. These processes often have long gestation periods, whereas resilience is actually an iterative context specific process that needs constant evolution and learning to eliminate inherent development challenges and reorganize itself through the process of learning [26]. Another point to be noted is that resilience mainstreaming, however important and crucial should not overlook existing urban roadblocks and gaps in governance. Social inclusion, ecological viability, and integrating resilience aspects into development processes are among the foremost challenges of governance. But at the same time, political decisions are often made keeping in mind geographic boundaries, urban populations and development pressures [27]. Mainstreaming resilience actually requires and acceptance of the dynamics and challenges of urban development, in addition to the gaps in the system, education and systems.

In spite of all this, urban planning measures in India are still quite detached from environmental issues and issues of disaster risk reduction [28]. With the launch of the NAPCC led by then Prime Minister in 2008, state action plans on climate change have been formulated as an agenda proposed by the Government of India's Ministry of Environment and Forests (MoEF). However, the actual implementation of this agenda in urban spaces within the country is yet to be achieved.

7. Discussion and conclusion

To achieve and sustain smart growth, cities will increasingly need to invest in infrastructure that 'reduces emissions, waste production, and water use, as the way India develops, builds and renovates its cities will determine their ecological sustainability in the coming decades' [21]. Although developing and constructing green infrastructure is considered vital, reconfiguring existing infrastructure can also be a crucial step. Various cities have identified and explored the use of information and communication technology to decrease resource consumption and improve operational inadequacies of existing systems. There are numerous global examples where cities have invested in smart solutions for reducing and monitoring resource consumption such as the use of smart meters, smart grids, or other similar technology. For example, residents in Zurich are required to dispose of garbage in bags that cost around US$4.25 each. As a result, household waste generation has reduced by 40 per cent, with the average Zurich resident generating 25 per cent less waste than the average European [21]. Similarly, Singapore has resorted to technology based pricing policies such as congestion pricing, so as to effectively manage traffic problems. Additionally, cities such as Bogota and Ahmedabad have introduced special bus transit routes to enable people to move faster and also to improve local air pollution situation. Other smart solutions such as Geographic Information Systems (GIS) and hydraulic modeling for continuous water supply, real time solid waste monitoring systems, and smart street furniture and lighting are other initiatives that have the potential of improving the overall sustainability and resilience of urban and municipal service delivery [29].

However, the key link between the implementation and use of such innovative technologies and smart systems installed in the cities is smart governance. In the Indian context, smart governance would require more informed decision making and increase citizen participation. Furthermore, as municipalities remain the main centres of administration and implementation, it is important that attention to the capacity building of local bureaucracies and city officials.

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