Resilient Cities for the Future: The Case of Chennai, India.

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Abstract

Fast pace of urbanisation and population growth is an imminent global challenge. The World Urbanisation Prospects of the United Nations suggest that more than 75% of the global population will concentrate in cities by the year 2050. The pressure of this population rise on our cities and the natural systems are bound to increase in the near future. Floods, cyclones, earthquakes, wildfires and heat waves made the year 2015 a devastating one for millions around the world, with 150 major natural disasters being recorded. Asia bore the brunt of these disasters with massive earthquakes in Nepal, floods in Chennai, heat waves hitting South India and Typhoon Komen inundating the Indian subcontinent, to cite a few examples. The changes in climate and the failures of physical systems make our cities vulnerable to disasters of various kinds leading to physical collapse of the city.

This paper deals with the concept of disaster resilience in this context and how this can be applied at the city, neighbourhood as well as the individual level. The intent of the paper is to develop a framework of strategies for an emergency response programme, taking the case of the Indian city of Chennai. The initial approach surveys in detail the way the city functions with respect to the natural systems and looks into the city's growth through the ages.

The paper proposes an initial theory around the creation of an ideal emergency response model consisting of physical and technological networks that will come into play once a risk situation arises within a city. This model was first produced at a generic level where it can be applied on to any city of any context. The paper articulates the model in the city of Chennai considering its intricate labyrinth and functions.

Keywords: Resilience, Disasters, Emergency Response, physical systems, climate change

Introduction

Disasters often follow hazards and a community's lack of response to them is mainly due to the absence of accurate information available on time. The impact of the hazard on the environment is the deciding factor for the severity of the disasters that follow. Between 2000 and 2011, more than 2.7 billion people were affected and more than 1.3 trillion dollars were lost due to disasters around the world (UNISDR, 2011). The case of India is no different. Almost 85% of its land area is vulnerable to single or multiple hazards (India Disaster Knowledge Network Disaster Profile, 2015). The level of urbanization of India has increased from 27.81% in 2001 Census to 31.16% in 2011 Census (Census of India, 2001,2011). At this rate of urbanisation Indian cities are facing, people are constantly living in densely packed conditions with limited access to basic utilities in almost all the major cities. Hence, there arises a situation of unequal distribution of resources making them highly vulnerable to a disastrous outcome. Empirical findings from recent calamities such as the floods of Uttarkhand (2013), Kashmir (2014) and Chennai (2015) show that the pre-disaster mitigation measures in India have been inefficient. The key challenge here is to articulate the vulnerabilities of the place and evolve a framework of mitigation measures rooted to technology based practices, policy considerations and community interactions of that place.

The concept of resilience revolves around the capacity of individuals, communities, institutions, businesses and systems within a city to survive, adapt and grow no matter what kinds of chronic stresses and acute shocks they experience. (The Rockefeller Foundation)

A resilient city is a well-knit network of physical systems and human communities (Breen & Anderies, 2011). The built and the natural environment falls into the category of physical systems and the communities and institutions contribute to the social aspect. When a disaster strikes, the physical systems get affected first and its ability to cope and adapt is of utmost importance for the future functioning of the city, post disaster. Presently, limited scholarly attention is given to these systems while planning and designing cities.

The aim of the research is to design a framework for the development of strategies for a resilient city of Chennai. Assessment of the vulnerabilities and capacities of the city was done to formulate a response mechanism through development strategies.

The research is limited to designing the resilience framework for a specific precinct of Chepauk (name of a ward in Chennai city selected for study) through primary studies. The scope of this work is limited to a disaster management point of view and also to the physical aspects of the public realm.

Methodology

The research follows a methodology where the current status of disaster management and its shortcomings are analysed to establish that planning and design strategies need to be a part of disaster management planning for future adaptable growth of the cities. To demonstrate this, primary studies are carried out at a city and precinct level to formulate urban design guidelines.

The paper starts with an analysis of the present scenario in the field of disaster mitigation and its effectiveness globally and nationally. Further analyses of 'UNISDR – How to make cities resilient'- guidelines set by the United Nations office for disaster risk reduction is carried out and parameters derived for developing a theoretical framework. A conceptual model of emergency response derived from these data is elaborated in theory. A detailed analysis of the city and the study area is done through secondary and primary data after which structure plans and strategies are developed.

Existing Framework- Disaster Mitigation globally

The Yokohama Convention held in May 1994 underlined the need for a shift in the strategy for disaster mitigation. Disaster prevention, mitigation, preparedness and relief were four elements, which contribute to and gain from the implementation of the sustainable development policies. These elements along with environmental protection and sustainable development are closely interrelated.

The Japan emergency response management does the planning at three levels: basic disaster management plan, disaster management operation plan and the local disaster management plan. Each section has been laid out with elaborate techniques and decision making bodies for emergency response in the event of the various types of disasters the country is susceptible to. The scheme contains mainly administrative aspects and governance model at the event of a disaster strike. They take into consideration the various impact areas and addresses the needs of the evacuees and the stranded.

Another example is a design project carried out by Bjarke Ingels Group where a protective system is planned along the 10-mile stretch around the tip of the Manhattan Island, shielding buildings from floods and storm surges and providing social and environmental benefits to the community with an improved public realm. It uses hard infrastructure and soft landscaping to mitigate the hazard and also create an active public realm in the process.

It is clear from these that planning for disaster involves not only the measures taken at the time of the hazard but also the adaptation of that city or community after the risk. Further, Implementing policies from the local level gives the mitigation measures the social capital it needs.

Existing Framework- Disaster Mitigation in India and its effectiveness

According to the World Disaster Report, a total of 2,437 disasters were reported from Asia alone between 2006 and 2015. In India, 13 million people have been affected due to disasters during this period, which is roughly 11% of India’s total population of 1.21 billion persons (Census of India, 2001, 2011).

In India, the existing framework is provided by the National Disaster Management Act 2005. According to this act, a National Disaster Management Authority is established with a chairperson and other members who have the responsibility of laying down policies, plans and guidelines for ensuring timely and effective response to disasters. (The Gazette of India, 2005)

The process is carried out at the national, state, district and local levels. The document focuses mainly on assigning authorities at each level to formulate guidelines and policies for a situation, post disaster.

The absence of specific guidelines on the planning of the cities or prevention measures to be taken is seen to be a lacuna in the document. The implementation level of these policies is inefficient from various past examples of disasters in the country. For example, the floods and landslides of Uttarakand in the year 2013 saw fatalities reach 4094 persons. (India Disaster Knowledge Network Disaster Profile, 2015) The area comes under zone IV and V of the seismic zoning map of India and is known to be the most landslide prone area. (India Disaster Knowledge Network Disaster Profile, 2015) Furthermore, the encroachments of the river basins in the name of tourism infrastructure have caused more damage than the actual hazard. The domino effect of the landslides and flash floods combined with the building debris caused a tragic situation in the foothills of Kedarnath.

Taking another example of Shimla, a city designated for a population of 16,000 residents has today grown a hundred fold to become one of the ugliest urban sprawls in the Himalayas, housing 236,000 residents. (Jolly & Sehgal,2014) Shimla lies in a region of geological thrusts and faults, and studies by geoscientist V C Thakur reveals a seismic belt lying below the city. According to a report in India Today, the disaster management plan prepared for the city reveals that only 1.52 percent of the buildings are earthquake resistant constructions. With a population of over two hundred thousand and a tourist population of over nine thousand, Shimla has just 3 state run hospitals with 1,135 beds, a fire service which is 96 percent under-staffed. 72 percent of the buildings are not accessible by roads and only 0.41 percent of the total area are designated for parks and open spaces. Further, dense urbanisation of Shimla will have catastrophic effects on the city and its people. Shimla is a disaster waiting to happen.

This is the extent to which the disaster management plan is implemented in the country, due to the lack of specific planning guidelines and a serious lack in timely stringent actions. It is clear that rules for a controlled development of Indian cities are a missing piece in the development programme. More research in this field becomes mandatory as we are moving towards an unsteady future.

UNISDR- How to make cities resilient

The United Nations Office of Risk Reduction has put across 10 guidelines on making cities resilient. These guidelines are,

Table 1: Guidelines & parameters identified

Guidelines	Parameters identified
Building regulation and land use planning	Landuse Building design & Density
Infrastructure protection and up gradation	Transportation Physical Infrastructure
Environmental protection and strengthen ecosystems	Ecology (Open space, wetlands, water bodies, mangrove forests)
Protect vital facilities- health and education	Social infrastructure
Effective preparedness, early warning & response	Early warning system Emergency services- food, water, shelter, utilities

They point to all the major areas of interest out of which the substantive ones were picked out which relate mostly to physical aspects of a place. The parameters derived from them were taken into consideration primarily to form the theoretical background for the study.

Achieving Utopianism in Disaster Mitigation

An urban environment of any context that efficiently responds to a disaster situation, adapting smoothly to the change without so much as affecting the functioning of the said city is what is required for the future. From this utopian idea arose the conceptual model derived from the identified parameters. The model is based strategically on providing a faster emergency response management to the dense city areas which will be the most affected regions in the initial stages of the disaster.

In this generated model, the early warning systems installed in various parts of any city (also taking into consideration the existing vulnerability of that city) will give the necessary signals which will activate the central response team which in turn will activate the regional response teams stationed within various strategic locations inside the city. Each regional response team will be equipped with a medical team, food and water facilities and immediate rescue services. These response teams will be connected through a ring road infrastructure which will have a dedicated lane for rescue services to the inner parts of the city. These ring road systems can act as mass rapid transit systems in the city at other times or *vice versa*. The city shall be structured in such a way that there shall be a number of entry and exit gateways which are also connected to these ring road systems for rescue operations to enter and the evacuees to exit.

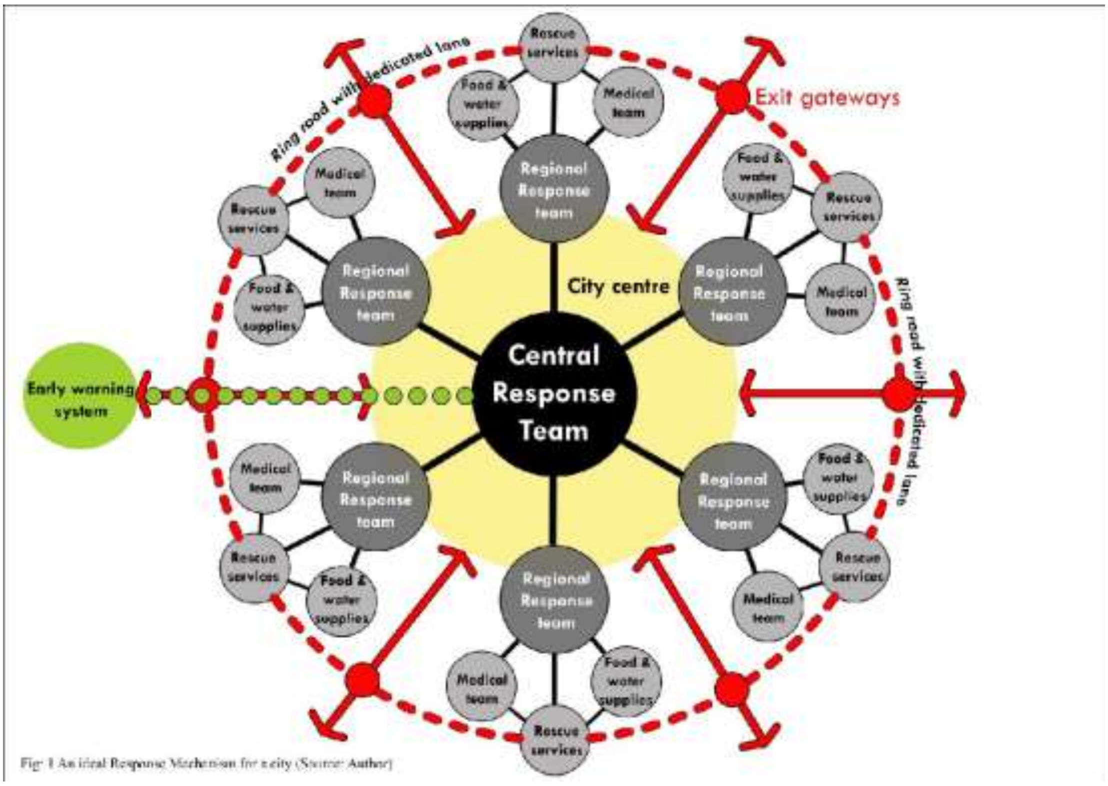

Fig. 1: An ideal Response Mechanism for a city
Source: Author

Chennai City

The capital of the state of Tamil Nadu, Chennai came into existence in 1639. As of 2011 census of India, the population of Chennai is 46, 46,730 persons and covers an area of 426 sq.km. (Census of India, 2011). The rapid uncontrolled urbanization of Chennai is causing pressure on the outdated infrastructure of the city. The major type of disasters that the city is susceptible to are cyclones (which have hit the coast 29 times in the past 50 years), tsunami in the Indian Ocean (2004), flooding due to rainfall (2015) and other such coastal disasters (Corporation of Chennai, Kyoto University, University of Madras., 2010).

Analyzing the evolution and growth of the city, it can be found that in the process of developing Chennai into a metropolitan city, many ecological aspects have been compromised paving way for a an imbalance in the natural systems existing in Chennai.

The city of Chennai grew from being a fishing village of Madrasapattinam to the present day under the British that inhabited the city for more than 300 years (Frontline, 2014). Wide roads were established, civic facilities and transportation lines were laid paving the way for development. Numerous water bodies and wetlands were covered to make way for housing the population that was soaring into the city as job opportunities increased pre and post-independence. With the infrastructure already in place, the manufacturing industries set up their plants in the city. Presently, the city is further sprawling with the population of the Chennai metropolitan region having become seven million persons according to the 2011 census of India.

Ecological downfall of Chennai

The physiography of Chennai is almost flat except for a few hills dotting the western fringes of the city (Bhatt & Mishra, 2016), facilitating movement networks and hence influencing its growth and economic activity. Two extensively polluted prominent rivers passing through the city drain into the Bay of Bengal, the Cooum River and the Adayar River.

The coastal plain stretches are divided broadly into three main geomorphological conditions namely a) Sheltered bay b) Seafront beach c) Coastal marshes. The sheltered bay consists of breakwaters and a reinforced shoreline, whereas seafront beaches and the coastal marshes (river mouths) have a low elevation and fine sediment soil condition (prone to erosion). The wetlands and lagoon which dotted the coastal areas down south have been largely filled owing to the development activities. The Buckingham Canal that was constructed by the British along with controlling storm surge has been reduced in width and suffers from high sedimentation due to dumping of solid waste. The encroachment of the rivers and wetlands was one of the major drawbacks in the ecological system that led to the 2015 floods, causing the loss of 269 lives in the city. (Narasimhan et al,2016)

The dense settlements along these coastal fringes exceed a population density of 1,40,000 persons per sq.km. (Corporation of Chennai, 2006) From detailed analysis, it was found that the unreinforced shoreline of seafront beaches and coastal marshes have severe vulnerability to storm surges, erosion and sea level rise than the reinforced shoreline of the port. This however was also reinforced through detailed area analysis of the Chepauk ward which is located along the seafront beach and has a close proximity to the Cooum river mouth.

Detailed Area Study - Chepauk

Detailed area studies are conducted on a smaller area to identify the shortcomings in terms of disaster mitigation or response and provide a strategic approach towards achieving resilience at the neighbourhood level. Resilience at this level includes physical as well as the social aspects. The selected area which is facing the beach consists of public government buildings and the internal areas house a dense residential and mixed residential settlement. The site covers an area of 1.5 sq.km. The Buckingham canal (Central) connecting the Cooum River and the Adayar creek flows through the site along with an elevated MRTS line (sub urban rail) above it. The precinct contains a very dense residential settlement with buildings up to five or six floors along roads of width two meters making it inaccessible for emergency services. In complete contrast, the public areas of the precinct are inactive in nature due to the presence of large parcels of unused land which can be converted to potential gathering or shelter spaces by making them accessible to the public. Cases of ecological ignorance are evident from the current state of the Buckingham canal which has silted and clogged due to the dumping of sewage and solid waste.

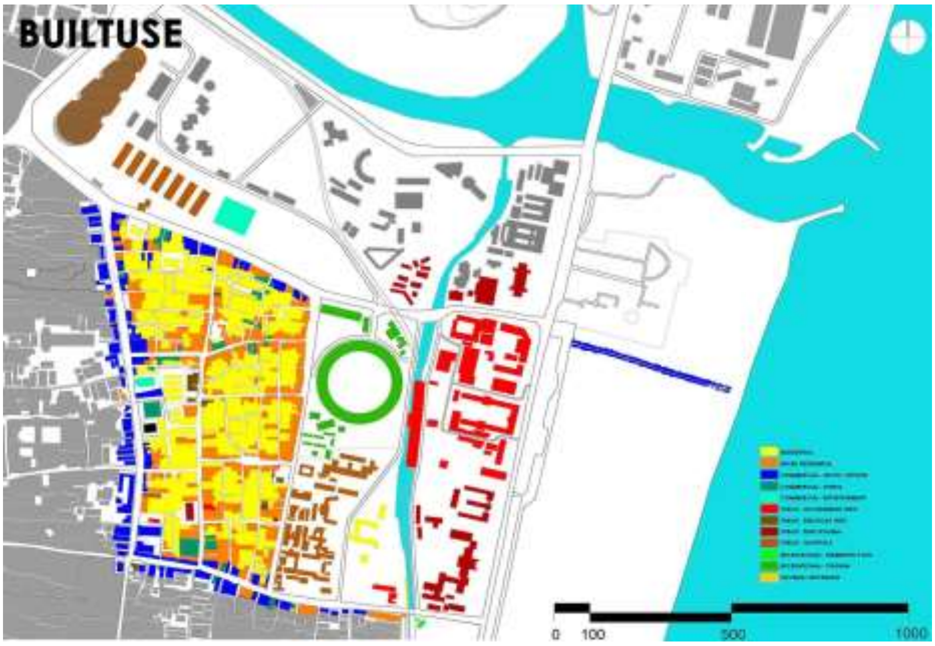

Fig. 2: Built use map of Chepauk Ward
Source: author

Issues and Potentials

The identification of the issues and potentials of the said neighbourhood will further help in devising suitable strategies for the precinct. The coast is prone to sea water intrusion, cyclones, and sea level rise as per past instances. The lack of open gathering spaces in the dense residential zone and the five to six storey buildings along narrow streets leading to *cul-de sacs* are a cause of concern in terms of disaster response. Parking of vehicles along these narrow streets further increase the vulnerability and can affect the rescue process. At the same time, it is noticed that there is an active public realm and large parcels of unused land separated by an inactive MRTS station building from this dense residential zone. This has created inactive streets and areas near this station building. It is also noticed that there is a lack of adequate connections to the MRTS station from the coastal side as well as from the residential area. The pillars of the MRTS line has decreased the width of the Buckingham Canal along with encroached informal settlements along the canal edges. The dumping of waste into this canal has resulted in silt formation which has greatly reduced its water carrying capacity.

Large parcels of public land present can be used as potential gathering spaces, emergency shelter spaces, etc. This land can be connected to the public realm through introduction of new uses. The dense residential settlements can be potentially restructured providing more open areas and reducing the density.

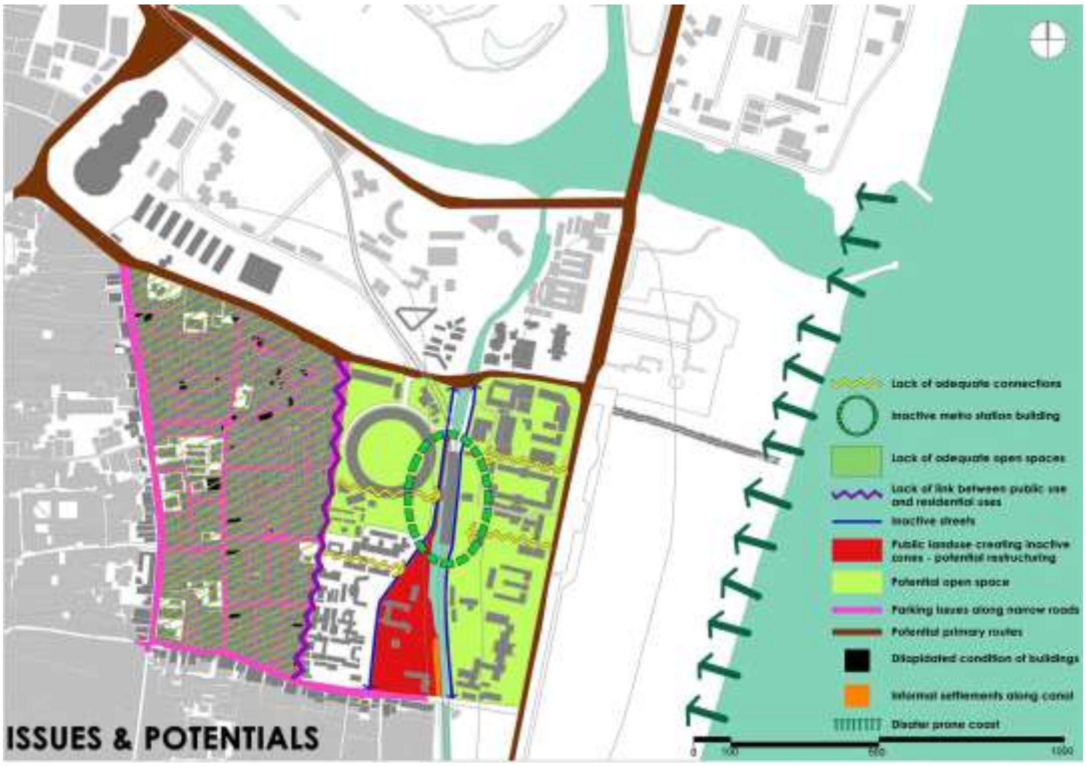

Fig. 3: Issues & Potentials of the ward
Source: author

Strategic approach to Resilience

Strategies are devised based on the primary on-site survey, taking into consideration the parameters and theory devised in the initial stages of the study. These strategies are mere indicators on the direction in which our cities need to be planned for resilience and does not provide the complete solution to avoid such situations. The strategies are formulated for both the city as well as the neighbourhood level touching upon the significant areas of interest.

Land use

City level - Parks and green infrastructure can be used to shield adjacent communities where extra water storage can be achieved in wetland zones. Revitalizing the river edges as floodable public gathering space with uses facing the river can also help control encroachments and pollution of the river. Institutional land uses along the primary roads with high speed traffic can act as emergency gathering spaces and shelters during a risk situation.

Neighbourhood level - Unused parcels of public land can be used as green infrastructure to protect the adjacent high dense residential from flooding through flood proofing the sites located along the beach side. These parcels can be used as emergency gathering spaces and shelters.

Connectivity

City level - Interconnection of roads will help relieve pressure on the major primary roads and highways in time of a risk event. Ring road system around the city with a dedicated lane for rescue services with adequate entry and exit into and from the city core can help in carrying out timely rescue operations. Providing wide pedestrian paths along all primary, secondary and tertiary roads in the city should be made mandatory. Separate lane for bicycles on major roads connecting different functions and to major bus, MRT and railway stations shall be provided.

Neighbourhood level - Interconnected network of streets with adequate width proportional to the building height should be maintained. Adequate connections to MRTS station within a radius of 1km can help activate the dead areas. Streetscape designs facilitating free flow of pedestrian with adequate street furniture and bicycle paths throughout the neighbourhood leading to MRTS Station can greatly improve the inactive zones. Raised evacuation paths and routes leading to the station and away from the vulnerable areas can be planned duly.

Ecology

City level - Green infrastructure along the major corridors should be provided with suitable native vegetation. Protection of existing mangroves plantations along the river edge should be made mandatory as they help in controlling storm surges. New mangrove plantations can be added and made a protected area. Low lying areas should be converted to constructed wetlands with water resilient native vegetation with public participation.

Neighbourhood level - Step wise / terraced transition for a better urban space. Elevating land above flood level to use as shelters or house emergency utilities or elevating the building can control loss of property. Reducing the use of impermeable surface in each plot to less than 30% of the plot area need to be practised for an efficient water conservation. Increasing the gradient to help drain storm water into the canal along with increasing the width of the Buckingham canal needs to be done, where strategic uses can be planned along its edges to avoid waste dumping.

Built up

City level - Decentralising the commercial development can encourage smart growth and hence control density. Policies should be implemented for controlling the density of new constructions in vulnerable zones. Retrofitting heritage structures to withstand the flooding events through flood proofing the building or the site can be followed. Hospitals and fire stations to be built with resilient materials and design for better protection and access during a risk situation.

Neighbourhood level - Floodable plots and inserting new buildings that act as protective levees with flood proof ground levels are measures that can be considered along with design for dynamic water forces on walls and building elements.

Infrastructure

City level - Emergency utilities should be located along the major highways and primary roads also preferably with an access to a rapid transit line. Providing adequate toilet facilities within 1 km intervals should be made mandatory for any stranded population. Coastal protection berm along the coastal edge to decrease the intensity and speed of the incoming waters can also double as a public space. Retrofitting the drainage canal for smooth flow of flood water is the current need of the hour. Making the city smart with wireless internet connectivity throughout the city will help the people to access necessary information through their smartphones.

Neighbourhood level – Decentralising the waste collection by having a neighbourhood level waste management system can reduce the pressure on the centralised waste collection units. Widening the canal for better flow of water and its surrounding areas can be developed with various uses for public accessibility. Adequate accessibility to the existing multi-specialty hospital in the neighbourhood to be maintained. Providing toilet facilities at the public areas of the neighbourhood at 1km interval for the stranded population to be made mandatory.

Emergency Response

City level – The flood waters can be delayed from entering the city by the river mouth barriers and the berm on the coastal edge. Regional response teams can be deployed through the *rapid transit systems and major highways. Hospitals can also be accessed through this dedicated lane.*

Neighbourhood level – The coastal berms can help in delaying the water from entering the neighbourhood areas. Building blocks can be arranged in a way that can change or decrease the velocity and direction of the incoming water currents.

Conclusion and Discussion

Although various guidelines are laid down by international and national agencies for the preparation of efficient disaster mitigation, specific guidelines for the planning of cities catering to this is a missing gap in the available knowledge base, especially in India. The area of study concentrated on, in this research is the emergency response of a city during the event of a disaster.

The initial attempt was to develop strategies for designing a resilient model irrespective of any context. A conceptual model was developed where the parameters were taken, not as separate entities but holistically. The detailed area studies paved way for formulating substantive strategies taking the context into consideration. This resilience model is prepared from an emergency response point of view. To elaborate, the guidelines or strategies are made for the smooth evacuation of people through hassle-free transport networks, protecting vulnerable areas in the city, providing adequate open spaces for shelters and gatherings, making available basic amenities to affected population within reachable distance, etc. by using technological tools. Although the strategies so prepared shows a suggestive utopian condition, the guidelines will determine the way in which Chennai will respond and adapt to an emergency situation.

Indian cities today are contemporary in nature with their roots in traditional and colonial elements. These cities have adapted many layers of change over the period of their existence. Presently, these changes have started to affect the cities negatively due to overexploitation. Indian cities with their current growth are vulnerable to more number of natural and man-made disasters than the present trend. Hence preparing each Indian city for a disaster is essential for its unhindered future growth. This resilience model is an important contribution towards it.

Further research can be carried out in detail for each parameter, with or without a context. This model can be applied for any city and manipulated according to the site conditions. The strategies keep evolving considering the changing trend in technology as well as the way in which each disaster happens.

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