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STRATEGIES FOR PLANNING OF FLOOD RESILIENT CITY, KOZHIKODE

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Abstract- Cities need to adopt design strategies that allow them to increase their abilities to better respond to the stresses they will face in climatic changes and natural disasters. This paper helps to develop strategies for planning of *flood resilient city*, Kozhikode and assessing growth dynamics of urbanization and its vulnerability against flood. The incidences of urban flood hazards, causes and impacts were examined; The role of urbanization as large creator of flood risk for much of the urban population was analysed. The findings can be used to determine thestrategies for the planning of flood resilient city.

Key words: *flood resilient city, vulnerability against flood*, *urban flood hazards*

1. INTRODUCTION

In ecology, resilience has been described as the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state. Thus, a flood resilient city is considered to be one that can more effectively withstand external shocks and rebuild itself after experiencing those shocks.

Over the coming decades, the need to build capacity for greater resilience will require our cities to develop strategies for coping with the future shocks and stresses to our urban infrastructure systems associated with climate change and urbanisation. Effective urban planning strategies and building design could play an important role in facilitating the development of a greater capacity for future flood resilient city.

Disaster management and planning of flood Resilient cities need to adopt urban planning and building design strategies that allow them to increase their abilities to better respond and adapt to the economic, social, and physical stresses they will face as they confront the challenges of climate change and natural disasters.

In light of the recent natural calamities, the city is in dare need for a sustainable resilient city. It is high time to suggest a planning strategy for a flood resilient Calicut city.

2. OBJECTIVES AND SCOPE

1. To assess the impact of climate change on the built environment.
2. To propose strategies for planning of flood resilient city, Kozhikode.

Flood Resilient cities need to adopt urban planning and building design strategies that allow them to increase their abilities to better respond and adapt to: economic, social, and physical stresses they will face as they confront the challenges of climate change and natural disasters. This study is useful for all the line departments, Calicut Corporation, developers, business groups for implementing the projects in a resilient manner and the public is benefited by their safety and well-being.

3. METHODOLOGY

This study is mainly depend on secondary data sources and supported by primary data, collected through opinion survey and stake holder meetings. Secondary data collected from various departments includes census data for last 6 decades, soft copies of (pdf format) existing land use, Proposed Land use map & transportation network of Master plan for Calicut Urban Area- 2035 from Regional Town Planning Office, Kozhikode. All these maps were then converted into Geo data base with WGS 1 1984 as the coordinate system using online conversion methods. Feature classes and shape files viz district boundary Taluk Boundary, Ward Boundary, Planning Unit boundary, survey boundary, existing landuse-2012 and 1981, existing roads, railways, drainage, proposed land use, proposed transportation network, junctions, flood World Geodetic System : A coordinate system developed by US and internationally accepted. Plains, rehabilitation centres during the 2-18 flood, on road parking and pay and park locations were used for this thesis. High resolution Google earth satellite images were downloaded to digitise foot-prints of buildings and studying the temporal variation of the built environment. Comprehensive mobility plan Calicut city - 2015, district urbanisation report- Kozhikode, District disaster management plan, Rebuild Malabar -2018, Kerala Floods of August 2018-Study Report-CWC2 in Kozhikode district were among the major secondary data collected.

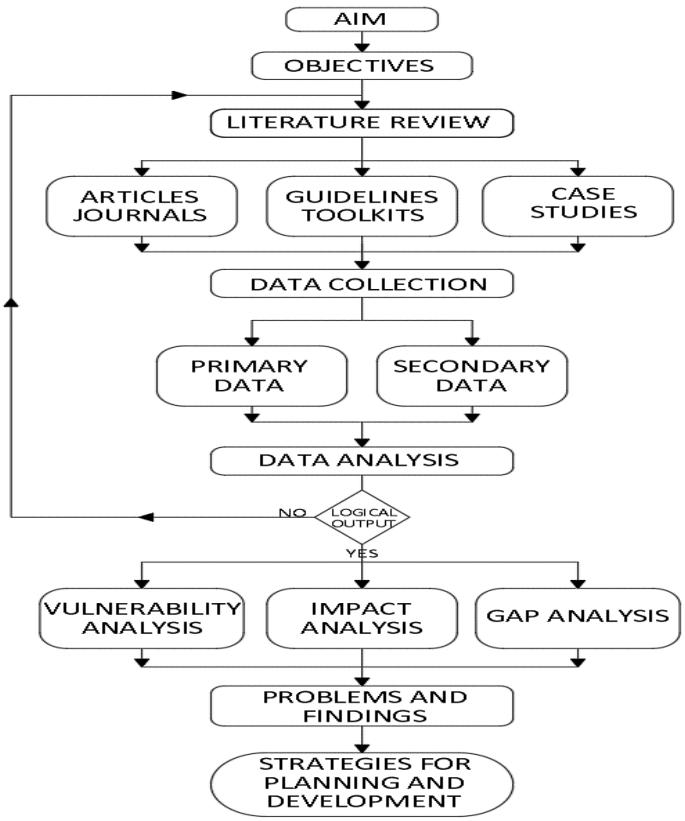

Fig-1: Methodology

4. QUESTIONNAIRE

Extensive online questionnaire survey were conducted to know the people's aspirations and their suggestions. Separate format was prepared for conducting opinion survey from the common publics and technocrats. Online Google sheets were prepared and forwarded its link to all my contacts by email as well as to whatsapp group of residential associations. Request to public were incorporated in the questionnaire for forwarding the link to their contacts who have any relation to Calicut city, so the questionnaire spread within few days to large number of people. A modified questionnaire was used to get opinion of stakeholders by personal interview.

5. STRATEGIES FOR PLANNING AND DEVELOPMENT

Based on the output obtained from various analysis, issues and problems with Strength, weakness and threat (SWOT) analysis is identified, finding of inadequacy of infrastructure by Gap analysis, Correlation of output with Service level benchmarks (SLB) and planning standards were established. Based on these findings concept for the development of resilient city was formed and detailed strategies were prepared for Planning and Development of Calicut as a Resilient City.

6. IMPACT OF CLIMATE CHANGE ON BUILT ENVIRONMENT

A. Flood plains

As per the prediction and forecast of the Indian Meteorological Department(IMD) it is sated that the Hazards would have repeat cycle of occurrence Higher the magnitude of hazard on increased repeat cycle Flood occurs every year in Calicut city and it affects 5.13 SqKm of area. The probable repeat cycle of flood after 5 year shows the impact over 13.55 Sq Km The Probable Flood occurrence on every 10 year repeat cycle affects an area on 31.13 Sq Km of Calicut City The extreme flood happens twice in a century it happened during 1924 and during 2018. These floods are classified as extreme flood, that can happen in Calicut city for the disaster management purpose. An area of 49.73 SqKm (27.89 %) of Calicut city was affected during the last flood.

B. Depth of Inundation

The depth of inundation varies from 1 to 10 foot During the last flood 2018, it is determined that 2.8% of the city is inundated at a height between 6 to 10 feet 13.5% of the area inundated at a height of 4 - 6 ft, 17.5 % of land inundated at a height of 2 to 4 feet, 27.9 % of land inundated at a height of 1 to 2 feet.

C. Vulnerability Analysis

Area close to coastlines and adjacent to river systems, are analysed for maximum possible inundation Finding of probable maximum inundation due to intense localized rainfall causing flash floods The magnitudes of inundation levels will be simulated on – GIS based inundation model, Drainage capacities in the analysis in order to estimate depth, Duration and extent of inundation by using integrated city specific framework Due to high intensity of rainfall, the major hydrological problem faced by the cities are: Increase in the volume of direct runoff, Decrease in the volume of base flow, Decrease in runoff time, Larger flow rates and Expanded areas of inundation. Urban Floods – Calicut city : One day rain exceeds 100mm – Flooding of low lying areas, 150 mm – 20% resi areas - % 30 roads in core area 200mm – most areas under water.

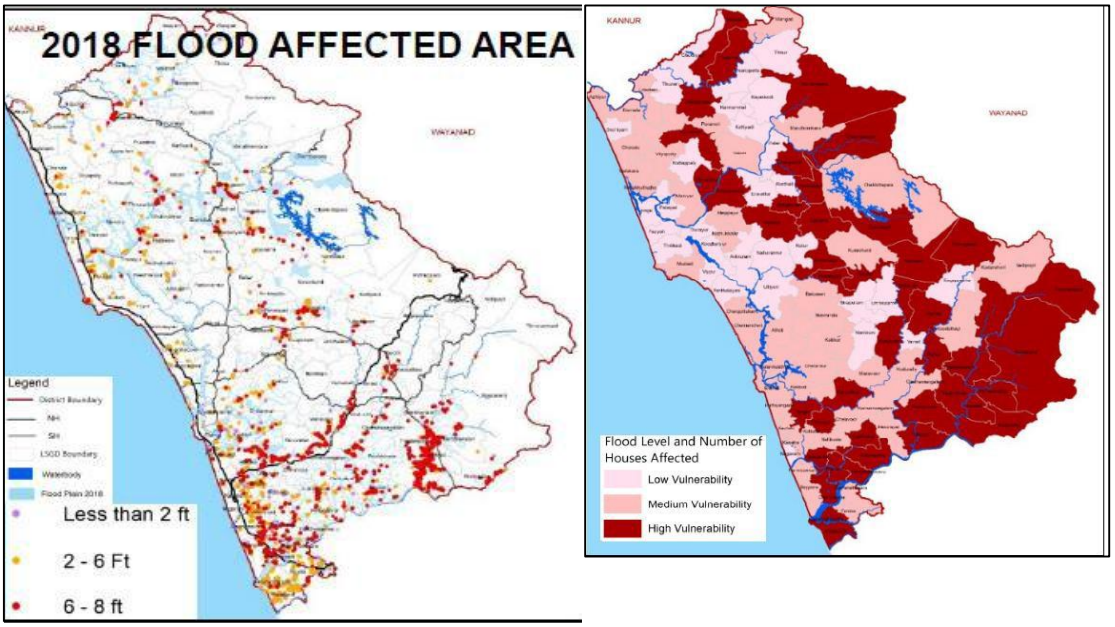

Fig 2- Flood affected area Source: Rebuild Malabar and flood vulnerability kozhikkode district

D. Land use distribution in flood plains

Table 1

Area within flood plains

Land use	Area in Hectars
Residential use	1818
Commercial use	49
Industrial use	40
Public& Semi Public Use	41
Coconut Field	554
Paddy Field	251
Total	2753

Table 2

Flood damages in Calicut city

FLOOD 2018 - DAMAGES OF HOUSE HOLD ASSETS													
	Total House hold (Nos)	Total House hold affected	Damaged - kutcha					House damaged - pucca					Total Loss
			Fully (Nos)	Damage(in Rs)	Partially (Nos)	Damage(in Rs)	Loss of House Hold Articles	Fully (Nos)	Damage(in Rs)	Partially (Nos)	Damage(in Rs)	Loss of House Hold Articles (in Rs.)	
2	3	4	5	6	7	8	9	10	11	12	13	14	15
Kozhikode Municipal Corporation	172325	8147	5	150000	21	151500	500000	23	4235700	546	9219200	5,95,00,000	7,37,56,400
Olavanna GP	17620	254	1	500000	5	36100	125000	2	1000000	25	125000	52600	18,38,700
Feroke CMC	12652	356	2	600000	12	86600	150000	4	2000000	4	20000	25300	28,81,900
Ramanattukara CMC	9230	286	1	300000	6	43300	53600	6	3000000	6	30000	46000	34,72,900
Kadalundi GP	9823	1253	10	2500000	324	2337400	523000	13	6500000	46	230000	156000	1,22,46,400
													9,41,96,300

source : Rebuild Malabar Report. RTPO Calicut

D. Opinion survey

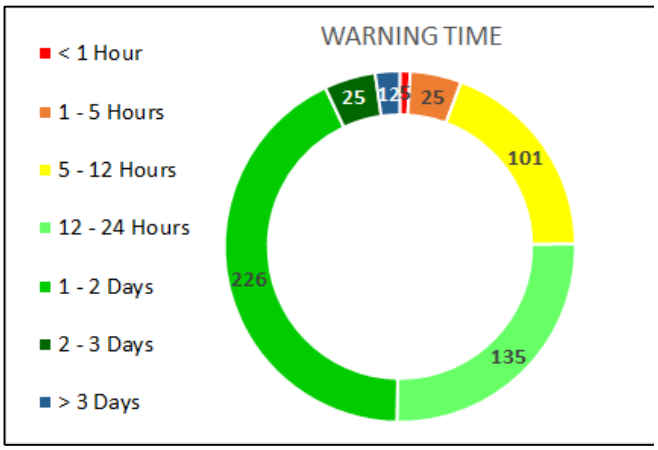

Fig 3- Warning time

Table 3

Probability of weather forecast comes true

PROBABILITYOF IMD WEATHER FORECAST COMES TRUE					
	<10%	10-25 %	25- 50%	50- 75%	Above75%
Rain		125	318	74	12
Temperature			248	268	13
Wind		142	156	172	59
Cyclone			221	286	22
Coastal Errossion		117	356	52	4

Tsunami			357	127	45
Earthquake		251	125	143	10
	0	635	1781	1122	165

7. VULNERABILITY ANALYSIS

Chaliyar or Beypore River, one of the major rivers of the State, originates from Elambileri hills. The total length of the river is 169km with a total drainage area of 2535 Sq. Km. This river is connected with Kallai by artificial Canals. The river is having a navigable length of about 70 km and motor boats can ply up to a distance of 22 km between Beypore and Vazhakkad.

Kadalundi River also known as Karimpuzha or Oravanpurampuzha, take its origin from forests of silent valley at an elevation of 1220 m above MSL. It is formed by the confluence of two main tributaries, Olipuzha and Velliyar and empties into Lakshadweep Sea at Kadalundi. The river has a total length of 130 km and drainage area of 1099 Sq. Km. and catchment area of 430 Sq. Km. The River is a part of west coast navigable system for about 23 km from Palathungal and Mannur. Kadalundi River is one of the rivers which are subjected to high flood damages.

Kallai River takes its origin from Cherukulathur village of Kozhikode Taluk at an elevation of 45 m from MSL. It is connected with Chaliyar and Korappuzha with artificial Canals. The river is tidal and has a length of 22km with drainage area of 96 km. It has a navigable length of about 10km.

Korappuzha River is formed by the confluence of Agalapuzha and Poonurpuzha and joins the Lakshadweep Sea at Elathur. It has a length of 40 kms with a drainage area of 6542 Sq. Km. Agalapuzha which is the main tributary originates from Kadiyangadumala at an elevation of 700 m above MSL. This also form an important part of West Coast Canal system. The navigable length of the river is 25 km. The other tributary Poonurpuzha, has a catchment area of 280 Sq. Km

A. Method of Vulnerable Zone Identification

List of vulnerability indicators developed by 100 Resilient cities by TARU in its report, flood disaster impact and responses in Nepal Tarai's marginalized basins Nepal, were discussed and tailored according to the district scenario to come up with a set of 12 indicators which are more relevant in the case of this disaster. The selected 10 indicators were grouped under five parameters. These components were as follows; Physical, social, economic, access to drinking water, psychological.

Table 4

Indicators of vulnerability

Parameters	Sl.no	Indicators
Physical	1	Occurrence of Flood and Landslide
	2	Severly Damaged Houses
	3	Severly damaged Plots
	4	Level of Inundation
	5	Houses near the riverr banks
	6	Density of damaged house in a cluster
Social	7	SC/ST HHs Affected
	8	Livelihood Affected
Economical	9	Livelihood Affected HHs
Access to Drinking water	10	Affected Drinking water Sources

B. Flood Vulnerability Index (FVI)

The flood vulnerability index includes damage from floods, depth of inundation and duration of inundation faced by the households. The slums, low income settlements which are located close to the river & sea shore and middle, upper SEC's (especially ground floor and first floor) residing in the periphery are more vulnerable.

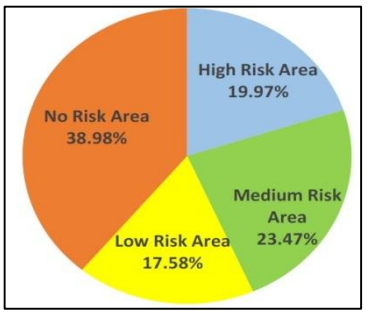

Fig 4- Flood vulnerability analysis

Table 5

Vulnerable population

Zone	Elevation	Population
High Risk Area	19.97%	72516
Medium Risk Area	23.47%	106058
Low Risk Area	29.28%	425291
No Risk Area	38.98%	203071

C. Analysis of land use in flood plain

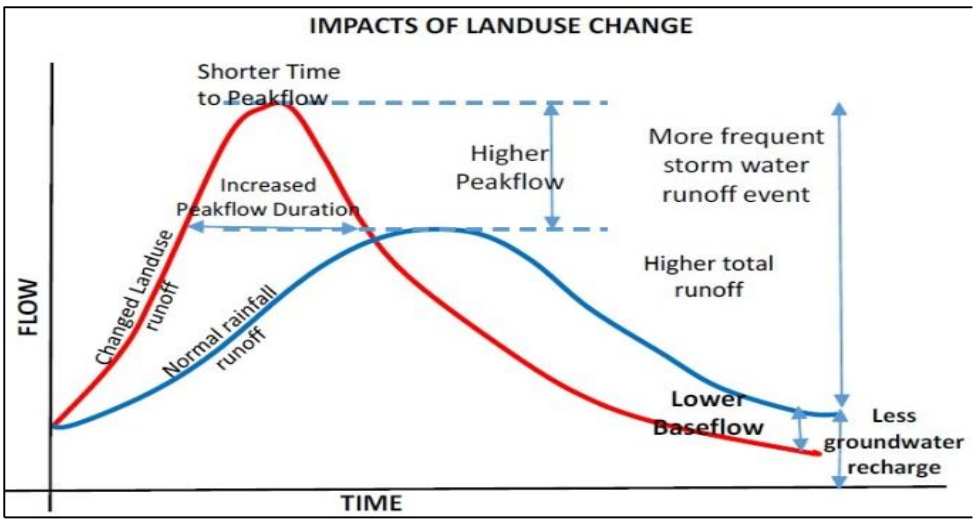

Fig 5- Impacts of land use change

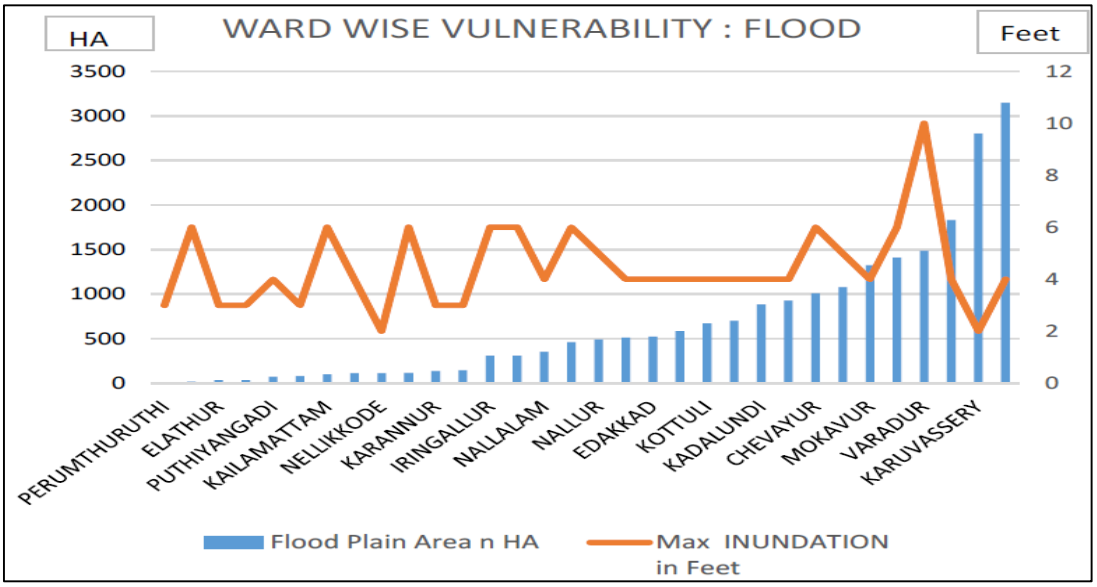

Fig 6- Ward wise flood plains and height of inundation

D. Need analysis for pre and post hazard scenarios

Table 6

Need analysis for pre and post flood scenarios

Anticipated Needs Pre- Flood		Anticipated Needs Post – Flood	
Sl. No	**Structural**	**Non – Structural**	**Rescue**
1	Clearance of water ways	Public awareness campaigns	Boats
2	Removal of encroachments	Monitoring & updating flood related parameters	Vehicles
3	Cleaning of Sewerage	Sand bags	Helicopters
4	Repairing damaged roads	Dewatering Pumps	Rescue equipments
5	Construct Water Harvesting System	Update Resource Inventories	Human resources
6	Construction of bunds, canals etc	Procurement of locally available boats	Mobile Clinics
7	Maintenance and repair of Sluice gates and spill way of reservoirs	Collect details of earth movers, cutters, JCB's and other related machineries in the District	Life saving equipments
8		Generators	
		Storage of medicine	
		Mobilize the Search & Rescue Equipment.	

The peril of hazard has to be negated with appropriate observation and focused activities, which necessitate the need of an ever vigilant forecasting system that will help in managing the disastrous effect of a hazard. The structural frame work starts with identifying, evaluating and assigning well defined roles and responsibilities of various authorities in managing disasters. Experiences with previous disasters make it clear, that authorities have to be sensitized prior and subsequent to an unturned event. Thus, coordination among stakeholders for effective management of disasters is essential and to ensure this, pre planning must be done before the onset of a disaster and specific task must be assigned to each department so as to provide training in the specific areas.

The vulnerability of the regions affected by the disaster has to be categorically delineated according to the parameters defined. In case of flood prone regions, the 100 year flood line, 25 year flood line and the 5 year flood line has to be the basic parameter for vulnerability delineation. But other parameters like height of flooding, density of the affected population.

8. PLANNING STRATEGIES

A. Capacity Building & Awareness

- The first step towards resilience should be awareness creation and education, which needs to be passed on to coming generations. Disaster history should be documented and disaster memorials shall be built to pass on information on the disaster proneness.
- Young generation shall be equipped with lifesaving skills, basic skills to identify an impending disaster, disaster history in their region etc. Such education shall be made part of the curriculum.

B. Planning Strategies

From a broader perspective, collaborative resilience and integrated approach could ensure effective transition from the crisis to the resilient community. Develop city and land use planning based on risk assessments Incorporate disaster risk reduction and climate change impacts into the urban land use plan and regulations, based on the city risk assessment. Land use planning must incorporate peripheral land around urban developments and the wider rural environment. Land use plans to prevent/control development in extreme-risk areas and to mitigate risk in existing developments; prescribe restrictions on building type, use, occupancy and density in high-risk areas. New regulations leave existing buildings vulnerable, so assess their risks and implement plans for retrofitting or alternative means to reduce risks Spread out the location of critical infrastructure, evacuation shelters, emergency services and lifelines. Identify escape routes and routes for delivery of relief supplies. Maintain an updated inventory of land use classification and vulnerability and an urban spatial and building database to monitor development in hazard-prone areas of the city. Establish a participatory mechanism to reduce risk in vulnerable settlements; take into account the population's needs and difficulties of rapidly changing existing building practices. When possible, relocate informal settlements to safer locations, while improving the quality of life, addressing livelihood needs and patterns, Promote resilient design, safer construction and strengthening of non- engineered buildings, using low-cost techniques and locally available materials. Share know-how through public campaigns and demonstrations of safer construction techniques. Build local capacities and strengthen participation in urban planning and land use Build the technical capacity and competence of local enforcement officials, builders, tradesmen and practicing professionals to promote compliance with regulations, plans and building codes and to promote/develop innovative local buildings, plans and technologies. Build local citizen awareness to monitor and report unsafe building practices and constructions to improve compliance. Create special technical task forces to conduct independent periodic inspections.

C. Safe zoning

The vulnerability mapping reveals those establishments that are critical to the disaster response, like schools, public institutions that could be used as disaster shelters. The categorization of the buildings according to the priority are :

- Priority 1: Military Buildings and administrative buildings
- Priority 2: Residences and Public Institutions
- Priority 3: Commercial Buildings

According to this priority, the buildings that are in priority 1 and within the most vulnerable zone are to be relocated, since these buildings are to be used as lifeline buildings during a disaster. Priority 2 building s will include residential buildings, which are critical in case of a disaster and would require warning to be issued prior to a calamity. The mapping and data regarding the building occupants have to be collected and accounted for use during the event of a disaster. Adequate counselling and awareness classes should be conducted through LSGs to make those inhabitants in those zones regarding the impending danger and the precautionary measures to be followed in case of a disaster.

In case of Flood, the mitigation as per Urban and Regional Development Plan Formulation and Implementation guidelines (URDPFI) are: Future Storm water drainage systems will be designed with a runoff coefficient of up to 0.95 in using Rational Method taking into account the approved Land-use Plan. Rainwater Harvesting as an integral component of the building. Encroachments on Drains and in Floodplains will be removed by providing alternative accommodation to the poor people. Low-lying areas should be reserved for parks and other low impact human activities.

D. Strengthening of Existing Institutions

Existing institutions may be vested with additional roles during the event of any disaster, and their role must be communicated to avoid any overlap of initiatives. In the times of disaster, multiple activities, including some of the complex unstructured activities demand systematic strengthening of the organisations. The experience of the recent floods alarms the need for redirection of priorities, resources and people to address the post disaster recovery and mitigation in future. GIS platform to be open source. It is observed that there is lack of information and circulation amongst the existing government bodies. This report recommends an effective central Information and communication model for optimal use of resources in the government organisations and bodies.

E. Land Use Policy

i. Land use plans and master plans should be strictly implemented considering the density of settlements and its vulnerability.
ii. Zoning strategies of the land use plans should also incorporate No development Zone (NDZ) apart from present ecologically sensitive and CRZ zones based on the degree of vulnerability.
iii. Vulnerability zoning shall be prepared for each district with plot level precision, marking highly vulnerable zones (Red), Moderate vulnerable zones (Orange) and Mild vulnerable zones (Yellow) with the help of flood plain data, flood level data, Flood duration data, flood frequency data and the loss to property and life.
iv. Clear guidelines shall be brought in separately for these zones of vulnerability for settlements, housing, land use, building typologies and structural stability
v. The concept of re densification shall be mooted for vulnerability zones 1 & 2, by encouraging community housing rather than homestead patterns by creating no building zones and transferring TDR and other benefits to the densified zones.
vi. Concept of land pooling should be encouraged to utilise the TDR of non- buildable zones and to develop more community models
vii. A land tribunal shall be formed separately to look at all complaints and concerns regarding the classifications and zoning
viii. For landslide and landslip areas, rehabilitation and relocation become a challenge which require a macro level land utilisation policy from the government.

F. Major findings

i. Vulnerable to Urban Flooding due to inadequate storm water drainage
ii. Conversion of environmentally sensitive areas
iii. Less fire and safety features provided in high rise residential flats
iv. Silting of Cannoli Canal creates major problem in draining off the storm water
v. Construction of Sewerage network paralysed
vi. Proximity of Hazardous uses to Residential apartments

9. CONCLUSIONS

From the various types of analysis performed on the demographic characteristics and infrastructure resilience characteristics along with probability analysis of occurrence of various natural and manmade hazards in the city and the location and extent of the vulnerable area, number of people affected, how these hazards affected the life and property of the people, depth of impact of hazards on infrastructure and the economic base of the city were critically analyzed.

Strategies: Resilient planning strategy to be developed based on the concept “hope for the best but plan for the worst”. “Expect maximum probable hazard and plan for developing resilience of people and infrastructure based on those hazard”, should be the strategy of any resilient city planning. Hazard is mainly controlled by the environmental setting and the risk is primarily influenced by socio-economic and demographic variables of the people. In order to reduce its vulnerability, it needs to understand the risks to which it is exposed and the potential damage such risks can cause. With this knowledge, a combination of regulations (such as land- use controls and building codes) and other risk reduction measures such as cooperation between government, NGOs, Communities, other stakeholders, the insurance industry, donors and civil society will be required to share the responsibilities when disasters strike.

Revision of Building bylaws and Master plan of Calicut urban area according to this resilience concept are some of other planning strategies for development of Calicut as a Resilient City.

REFERENCES

1. Beasley, L. (2000). 'Living First' in Downtown Vancouver, American Planning Association Zoning News, April, 1-4.
2. Basiago, A.D. (1999). Economic, social, and environmental sustainability in development theory and urban planning practice. The Environmentalist,
3. Beatley T. (2008). Green Urbanism: A Manifesto for Re-Earthing Cities. In Haas, T. (Eds) New Urbanism and Beyond – Designing Cities for the Future. New York: Rizzoli International Publications.
4. Beauregard, R. (2008) Urban Design and the Metropolis. In Haas, T. (Eds) New Urbanism and Beyond: Designing Cities for the Future New York: Rizzoli International
5. Benach, N. (2004). Chapter 8: Public spaces in Barcelona 1980-2000 in Transforming Barcelona Ed. Marshall, T. London: Routledge
6. Bertolini, L, Curtis, C. and Renne J.L. (2009). Transit Oriented Development, Making it Happen. Surry: Ashgate Publishing Limited.
7. Bohigas, O. (2004). Chapter 5: Ten points for an urban methodology in Transforming Barcelona Ed. Marshall, T. London: Routledge