



ADAPTATION TO CLIMATE VARIATION IN A COASTAL STRETCH – A CASE STUDY OF NAGAPATTINAM DISTRICT

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ABSTRACT

Intergovernmental Panel on Climate Change (IPCC) released its Fifth Assessment Report in early 2013, saying that climate change is now unequivocal. It confirms that extremes are on the rise and that the most vulnerable people, particularly in developing countries, face the brunt of impacts. This study was carried out in Nagapattinam District, Tamil Nadu, India, which is one of the coastal districts. It aims at perceiving the changes witnessed in vegetation and waterbodies due to climate variation. Landsat data were collected for nine years from 2010 to 2018. Normalized Difference Vegetation Index (NDVI) and Modified Normalized Difference Water Index (MNDWI) indices were found out for the above said years. The results of these remote sensing-based indices showed that there is a decreasing trend in vegetation and waterbodies.

The perception of people on the adaptive strategies and management practices before, during, and after disaster were collected through Questionnaire survey, Key Informant Interview and Focal Group Discussion. The performance of the Officials, as perceived by the local people were ranked using Likert's scale. The satisfaction level of the people about disaster management was represented through a spider diagram. This study gives recommendations for better adaptation and management practices. The critical evaluation of the Tamil Nadu Disaster Management Plan, 2016, was reviewed in the light of the Kerala State Disaster Management Plan, 2016, and West Bengal Disaster Management Plan, 2016. It was inferred

that there is a need to update the Tamil Nadu Disaster Management Plan, 2016, in the light of an integrated approach incorporating more sustainability options, gender inclusiveness, adaptation approaches, cross cutting policies incorporating the learnings from the traditional practices, and defining specified roles and responsibilities for related departments.

Keywords: Disaster Management, Climate variation, Remote-Sensing based indices, Coastal, IWRM approach.

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) published the Fifth Assessment Report (AR5) in September 2013, and confirmed that global warming will persist. Global climate is projected and it was found that there is a continuous change over this century and beyond. The current changes in climate are attributed to the extreme results of human activity. Due to the unprecedented and continuous changes happening, it is likely that the cyclones and other extreme weather events will become more intense, and will affect the livelihood.

Climate variation is having its impact on all the countries, but people in the poorest countries and people living near to coasts are to suffer the most. The changes in precipitation and temperature are the most visible factors in identifying climate variation. Natural hazards and climate variation present considerable challenges for poverty reduction and sustainable development because they affect a wide range of social and ecological systems (IPCC, 2001).

India is having a long and densely populated coastline of more than 7,500 kilometers, which is crucial in terms of managing the impacts of climate variation. Climate variation impacts have already posed to alter the coastal ecosystem through salinization, strong coastal storms, heavy rains, strong winds, coral bleaching, and coastal erosion.

Thomalla et. al. (2006) underlined that, in most of the developing and least developed countries of the world, the extreme events occur so frequently that they tend to overwhelm their coping capacity and hamper long-term progress because attention and resources are desperately needed for poverty reduction and economic development are diverted to disaster relief and reconstruction. Many societies today are still ill-prepared to cope with extreme events and climate threats. There is a need for proactive adaptation and disaster management to reduce the negative impacts of climate variation and disasters on ecosystems. Well-designed adaptation measures could increase the resilience of ecosystems, and also reduce the risk of climate-related disasters (Munang et. al., 2013).

Climate variation affects disaster risks in two ways: firstly, by day to day weather changes and secondly by the increase in the vulnerability of communities, affecting their livelihood, degrading the ecosystem, negatively impacting the basic services like potable water and food availability.

The livelihood of the coastal people is highly dependent on climate-sensitive sectors, but their adaptive capacity to cope with climate impacts is very low. Due to climate impacts, both the ecosystem and the socio-economic condition of vulnerable people were highly affected. This study attempts to detect the changes that happened in the land-use/land cover, to understand the perception of the people, and to critically analyze the Tamil Nadu State Disaster Management Plan, 2016. The objectives of the study were framed to link the SDGs (SDG 11- sustainable cities and communities and SDG 15- life on land), focusing on climate-related factors, critical analysis of the implementation of a disaster management plan, and adaptation strategies.

STUDY AREA

Nagapattinam, which is a coastal district that lies on the east coast of Tamil Nadu bordering the Bay of Bengal and extending up to the Palk Strait was taken up for the study. Nagapattinam lies on the shores of the Bay of Bengal between latitude $10^{\circ} 47' 26.16''$ N and longitude $79^{\circ} 50' 34.08''$ E. The coastal length of Nagapattinam district is 187.9 km and the total geographical area is around 3,536 km². Administratively this district is divided into seven Taluks, of which five coastal Taluks namely Sirkali, Tharangambadi, Nagapattinam, Kilvelur and Vedaranyam were taken up for the study. The coastal regions of the Nagapattinam district depend mainly on agriculture and fishing. No major industries are located here. The inland freshwater area spreads for about 1,000 hectares. Marine fishing is practiced in 53 coastal villages of the district. Hence, most of the population of these areas live at the mercy of nature. Generally, the socio-economic status of the people stands low when compared with many parts of Tamil Nadu, as this is prone to the vagaries of nature quite often. Cyclones and floods damage the standing crops and scratches away the livelihood of the people. In the recent past, the Nagapattinam district was affected by extreme weather events. It had faced a severe Tsunami and floods during 2004, in which many coastal people lost their lives. On the other hand during monsoon failures there exists drought in this area because this district is located at the far end of the Cauvery delta region, which in turn reduces the crop productivity and livelihood of farmers.

Two villages, Pazhayar and Allakudi were selected for the in-depth study, considering the severity and frequency of extreme weather events that happened over the past years, to understand the perception of the people about climate variation and its impacts, and to know about their awareness towards extreme events and management practices.

MATERIALS AND METHODS

The study on land-use/land cover changes were focusing on the vegetation and water bodies in Nagapattinam district using the satellite data. Satellite images from the Landsat 4-5 Thematic Mapper (TM), the Landsat 7 Enhanced Thematic Mapper Plus (ETM+), the Landsat 8 Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS) for a period of nine years from 2010 to 2018, were used for

studying the change detection. The perception of the people was captured by using tools like questionnaire surveys, key person interviews, and focus group discussions. Focus group discussions were conducted with the fishing community and the farmers. The questionnaire survey consisting of both open-ended and close-ended type questions was administered. To measure the level of satisfaction of the people from a disaster management perspective, the Likert's scale, assigning a score from 1 (strongly disagree) to 5 (strongly agree) was used. The critical analysis of the Tamil Nadu State Disaster Management Plan, 2016, was carried out in the light of the Kerala State Disaster Management plan (2016) and the West Bengal State Disaster Management plan (2016).

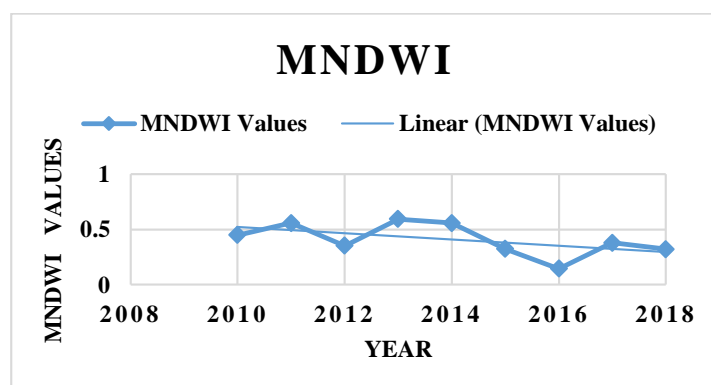
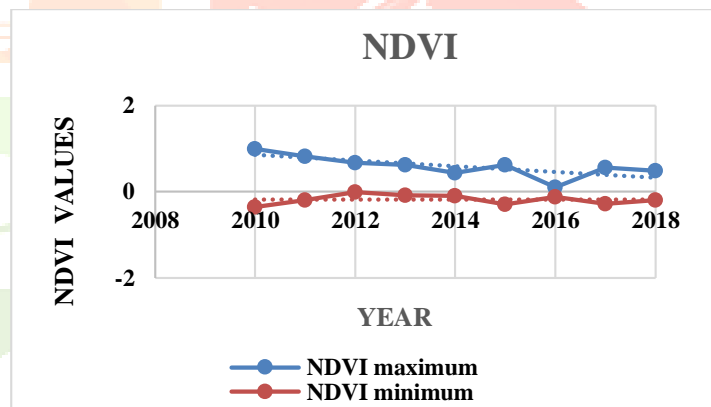
RESULTS AND DISCUSSION

DETECTING THE CHANGES IN VEGETATION AND WATERBODIES

The NDVI and MNDWI values were calculated in the ArcGIS 10.3 environment, using the Landsat images downloaded from the USGS Earth Explorer. The NDVI values show a decreasing trend in vegetation. Due to continuous variation in climate, the annual rainfall pattern got affected, which leads to loss of vegetation and waterbodies resulting in drought too. Table 1 and Figure 1 show the NDVI and MNDWI values calculated from 2010 to 2018 and the MNDWI maps created.

Table 1 NDVI AND MNDWI VALUES

S. No.	Year	NDVI	MNDWI
1	2010	0.99	0.45
2	2011	0.83	0.56
3	2012	0.89	0.35
4	2013	0.06	0.13
5	2014	0.10	0.56
6	2015	0.62	0.46
7	2016	0.59	0.59
8	2017	0.56	0.38
9	2018	0.49	0.43



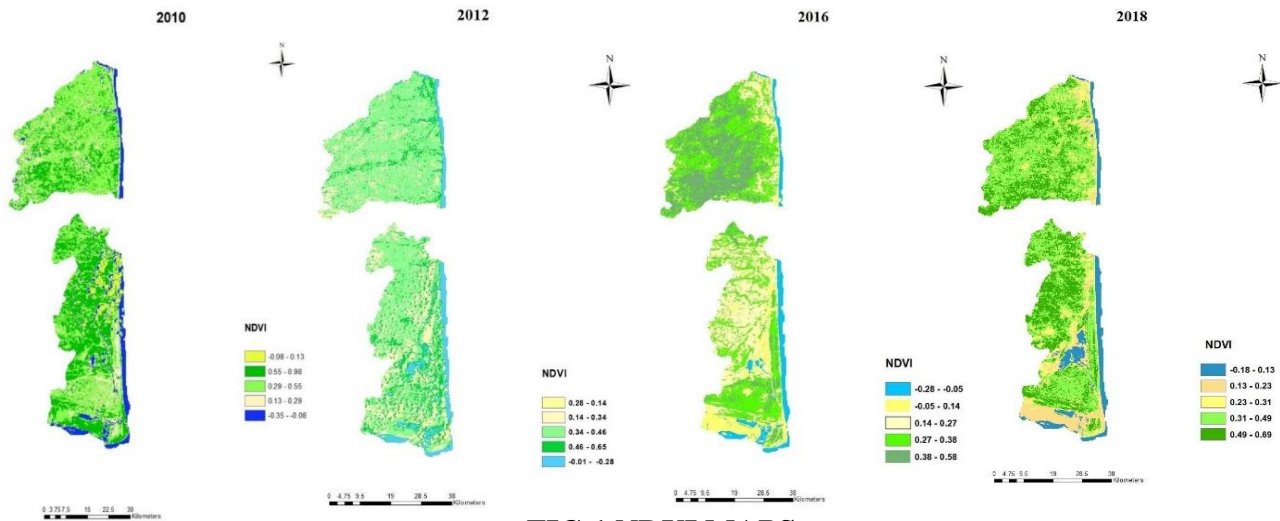


FIG 1 NDVI MAPS

Table 1 and Figure 1 show the maximum NDVI values show decreasing trend and the minimum NDVI values show an increasing trend. This shows that the vegetative cover and waterbodies are decreasing over the period in the study area. MNDWI shows there is a decrease in water body It is clear that there is a decrease in potential waterbodies in 2016, which is a drought year in Nagapattinam district, so there is a significant fall in rainfall, vegetation, and waterbodies.

Perception of the people

This study used the questionnaire survey, key person interview, and focus group discussions to gather the primary data. Data were collected in such a way to know about their perception of extreme weather events, their vulnerability state, coping mechanism, and preparedness. 30 representative samples were selected from each of the five villages, totaling 150, and focus group discussions were conducted with members belonging to the respective villages. The key person interview was conducted to get a deeper understanding. Besides, the perception of the respondents about their satisfaction, the effectiveness of management practices was measured based on a five-point Likert scale.

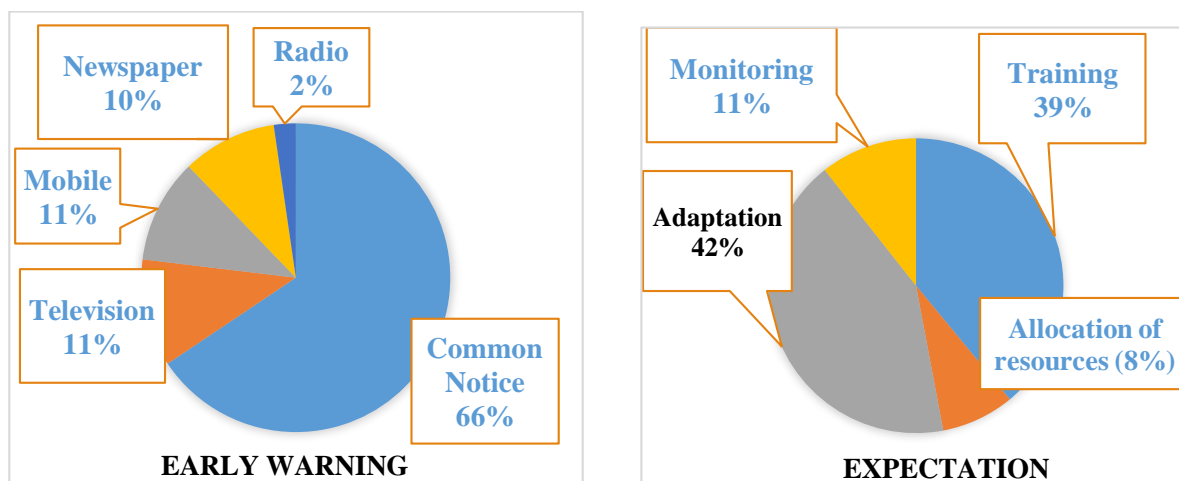


FIG 2 EARLY WARNING AND EXPECTATION

From Figure 2, it was understood that people believe that early warning reach given as common notice (66%) was much effective when compared with other modes. People in coastal areas believe that due to continuous extreme threat of weather events, they require adaptation measures (42%) for coping with these. The necessity of training came as the second major expectation (39%) from the analysis. The analysis revealed that men are trained more in number than women and they remain less-informed about rescue operations.

Pre-disaster phase

The spider diagram (Figure 3) reveals that during the pre-disaster phase, the overall performance of the NGOs and Government were high and non-structural measures such as flood insurance, evacuation of people, structural measures, and awareness creation were observed with low value.

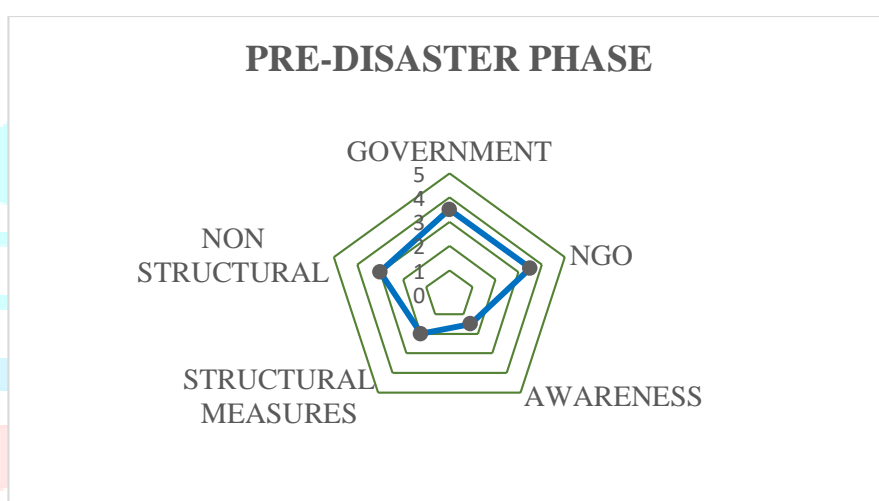


FIG. 3 PRE-DISASTER PHASE

During disaster phase

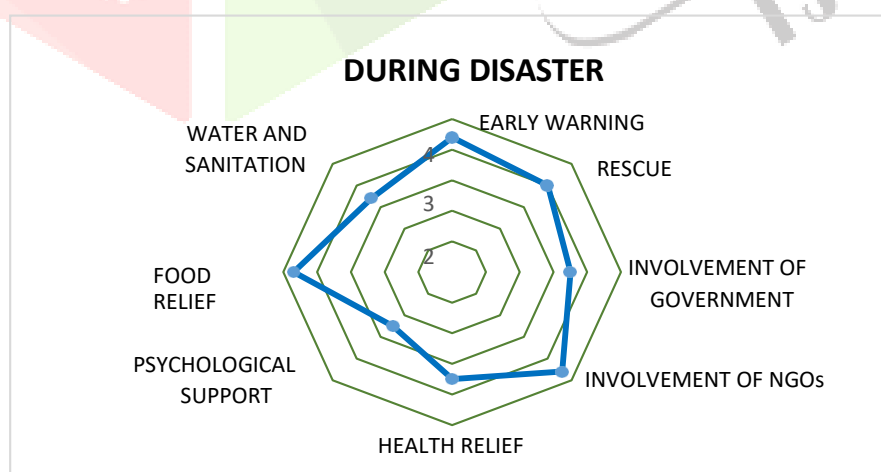


FIG. 4 DURING DISASTER PHASE

Figure 4 shows the overall performance during the disaster phase. Activities such as flood relief, involvement of Government and NGOs, early warning, and rescue operations show high values. Water and sanitation occurred with moderate value and low value was observed in lack of psychological support

provided to the victims. So there is a need for mental health training to be given at times of disaster to make people stronger and proper attention needs to be paid to maintaining the health and sanitation facilities. Figure 5, shows the overall performance during the post-disaster phase. The contribution from the NGOs is rated a little higher than the government activities and the distribution of relief materials scored low since people reported that only in extreme events do they get the relief. People also conveyed that the temporary and permanent shelters were given by both the government and NGOs.

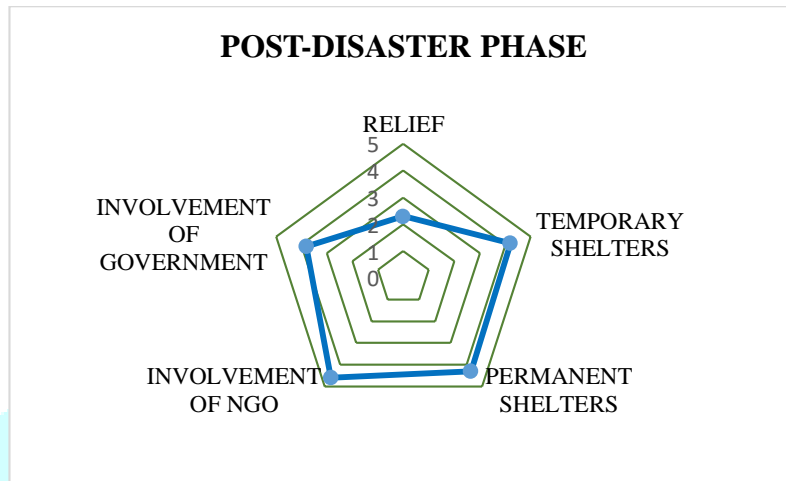


FIG. 5 POST-DISASTER PHASE

From the overall performance of three disaster phases, the Government activities are found higher during the disaster time and there is a lack of adaptation measures on preparedness and prevention. The focus is more on the mitigation perspective. It is also understood that the NGOs were much helpful during all three phases of the disaster.

Table 2 Frequency Analysis of Management Practices

S. No.	Management practices	Male (%)	Female (%)
1.	Awareness on District Emergency Centre	66.7	33.3
2.	Feeling stress during extreme events	40.0	60.0
3.	Climate variation impacts on livelihood	56.0	44.0
4.	Training on rescue measures	87.5	12.5

From the above Table 2, it is inferred that women remain extremely stressed about the situation and are less aware about the management practices. Compared to women, men are exposed to more rescue training.

Inferences form the Key Person Interview

The key person interviews were conducted with the Associate President of the fisherman community and the Head, Panchayats of IFAD (International Fund for Agricultural Development). The findings are: Due to Tsunami, in 2004, 75 members have lost their life. Some people who escaped from the Tsunami got a paralytic attack because of the trauma. Before Tsunami these people were living along

the edges of the coastal line and after the disaster, everyone got the Tsunami houses within 2008, with the help of the Government and NGOs. Totally 1,000 houses were given after the Tsunami. Subsidies were given for boat damages and prawn culture. During the Thane cyclone, 2011, Rs.30, 000/- per head was given as subsidy. During 2018, flood prawn culture was reduced drastically and caused a loss of Rs. 8 lakhs. Naturally, the Pazhayar village has mangrove forests and pine trees, which are maintained by the Forest department. In Allakudi village, the groundwater got affected due to saltwater intrusion. For the past 15 years, agriculture was greatly affected and many people were forced to sell their lands and their livelihood got greatly affected. Agriculture fields depend on water from the Mettur dam during June and July each year. The farmers seldom get any assistance from the government for agriculture. During a disaster, people who are living in nearby river areas only get relief, and others fail to get timely relief.

Inferences from the Focus Group Discussion

Focus group discussions were conducted among the members of the Pazhayar village and the Allakudi village, whose livelihood depends on fishing and agriculture respectively. The discussion aimed at analyzing the impacts of climate variation on their livelihood. The major inferences from the discussion are, in Pazhayar, the saltwater treatment plant is not functioning properly. Hence the villagers buy water for both drinking and domestic purposes, because of the high salinity level. They spend approximately Rs. 300/week to buy drinking water. More than 10,000 families depend on fishing in this village. In the Allakudi village, the people are getting municipal water twice a week. They are skeptical about the measures taken pre-during-post phases of disaster.

Critical analysis of the Disaster Management Plans

The critical analysis of the disaster management initiatives enacted in few coastal states like the Tamil Nadu State Disaster Management Plan (2016), the Kerala State Disaster Management Plan (2016) and the West Bengal Disaster Management Plan (2016), were made and presented in Table 2.

TABLE 2 CRITICAL ANALYSIS OF THE DISASTER MANAGEMENT PLANS

S. No.	Action	Tamil Nadu Disaster Management Plan, 2016	Kerala Disaster Management Plan, 2016	West Bengal Disaster Management Plan, 2016
1	Structure the plan	Based on the Disaster Management Act, 2005, the National Disaster Management Policy, 2009 and the State Disaster Management Plan, 2013	Based on the customization of the Sendai Framework (2015-2030) with the National Disaster Management Policy, 2009, the State Disaster Management Policy, 2010	Based on the paradigm shift in disaster management from a relief centric approach followed by the National Disaster Management Authority and various State Government's Disaster Management Plans and the Hyogo Framework (2005-2015)
2	vision	A holistic and multi-pronged strategy	Towards sustainable development	A holistic, proactive, multi-disaster and technology-driven strategy towards sustainable development
3	Theme	Focus on the four phases of disaster: outline vulnerability, early warning and dissemination	Based on disaster risk reduction resilience and build back strategy	Aims to improve on a continuous and sustainable basis, the infrastructure and processes for relief, rehabilitation and reconstruction and institutionalize capacity building at all levels within the State in order to mitigate the impact of disasters
4	Hazard vulnerability and risk assessment	Basic vulnerability and risk assessment report on the basis of the information already available	Assessment of hazards and vulnerabilities to major disasters in a heuristic manner	Risk analysis is based on the review of both the technical features of hazards and also the analysis of socio economic conditions
5.	Disaster risk management strategies	Inclusion of disaster risk reduction in development plans critically not only in vulnerability perspective but also from the perspective of minimizing that activity's potential contribution to the hazard	A multi-hazard susceptibility map have been prepared according to natural hazard, anthropogenic activities and incorporated into the district disaster management plans for response planning and their coping mechanism	Hazard, Risk and Vulnerability Analysis (HRVA); Multi-prong approach was taken to disseminate DRR messages to all types of stakeholder right from community level to Policy makers; Various Information Education Communication (IEC) materials have been developed and circulated for increasing awareness; Elected members of three-tier Panchayat Raj Institution and Government Officials

6	Mitigation strategies	Mitigation measures were divided into four stages based on risk assessment and vulnerability analysis: construction work research and technology transfer and capacity building; trigger mechanism concept envisaged as an “emergency quick response mechanism”, which, when activated prior to or during a disaster	Mainstreaming both climate change adaptation and disaster risk reduction; Mitigation models followed: Mazhapolima-Thrissur Model, Jalavarshini Minor check dams with local materials, Malappuram model, Water Kiosks- Kannur model, Mullaperiyar Crisis Management Plan	Short and long term mitigation measures; Long term mitigation is based on assumption of cost benefit analysis because it is essential to analyze the extent of loss- reduction
7	Adaptation strategies	Focus on pro-active mitigation and there is no adaptation for sustainability	Focus on more sustainability with respect to mitigation but need to focus on next step of adaptation	Adaptation measures were concentrated focusing on sustainable agriculture, women empowerment, and capacity building

From the above critical analysis, it was inferred that the West Bengal Disaster Management Plan, 2016, they ensure that the planning of preventive and mitigation measures a need to be taken into account both by the State administration and local authorities in an equitable manner. The local self-government institutions prove how strongly women are included in many areas and people remain central to the decision-making process for every stages of disaster management. West Bengal ensures to address the beneficiary grievances at various levels and explore more innovative ways to reduce disputes among people. The mitigation measures are incorporated with a cost-benefit analysis. The plan believes that the effectiveness and efficiency of mitigation investments are directly influenced by scientific development in hazard identification and loss of reduction measures. For building a stronger disaster response system they amalgamated three departments: Disaster Management, the Fire and Emergency Services, and the Civil Defence so that it becomes easy for them to effectively coordinate in crisis and ensure holistic disaster management. One of the drawbacks of the West Bengal plan is that the issues of climate change and its impact as a significant component have not yet been considered/ incorporated in the related sectoral policies/ plans.

In Kerala, the existing information management capacity of the Kerala State Disaster Management Authority and their District Disaster Management Authority needs to be substantially expanded and strengthened. Local self-government institutions play a key role in Kerala's developmental initiatives. The Panchayat Raj system in Kerala is very efficient and is the best example model for other states. Moreover, local self-government institutions prove how strongly women are organized in many areas. Nava Keralam project shows how the ecosystem plays an important role in sustainable development in Kerala.

The Tamil Nadu plan is focusing only on proactive mitigation measures. It is lacking in sustainability aspects. Interaction and institutional overlap of each department and more confusion in the division of roles and responsibilities among the institutions are noticed. The major advantage is that the State is focusing on climate change issues but there is a gap in the inclusion of climate change within the district disaster management plans. The disaster management plan seldom recognizes the special cases of fragile and vulnerable areas and there is a need for enhanced support and attention to be paid towards their higher vulnerability and risk levels. There is a low level of understanding of resilience and a lack of new and innovative models for financial risk management. More dedicated action needs to be focused on tackling underlying disaster risk drivers, such as the consequences of poverty and inequality, and climate variability.

From the overall critical analysis, it was inferred that the ecosystem-based approaches to disaster risk reduction and managing climate change hold much promise, and investing in healthy ecosystems provides a viable route. There needs to be a shift from relying on structural engineering solutions to increased acceptance of social engineering approaches through consensus-building with disaster-affected communities. Like West Bengal, disaster mitigation should be included in the school curriculum to train students to better equip them to deal with natural calamities and to help reduce casualties.

CONCLUSIONS

NDVI values show a decreasing trend throughout the analysis, inferring a decrease in vegetation. Due to variation in climate, the annual rainfall gets affected, which leads to loss of vegetation and waterbodies and drought in Nagapattinam district. The gendered impacts on the disaster were captured using the questionnaire, the key person interview, and the focus group discussions. It was inferred that women are highly concerned about climate variation, disaster preparedness, and adaptation measures but men are highly inclined towards the economy. From the critical analysis of the disaster management plans, it was found that Tamil Nadu wants the adaptation strategies and there is a lack of institutional mechanism and there is a need for socio-economic approaches rather than straight structural engineering solutions. Plans focussing on disaster risk reduction approaches are the need of the day.

REFERENCES

1. IPCC, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, USA.
2. Kerala State Disaster Management Plan (2016), Kerala Tamil Nadu State Disaster Management Authority, Department of Revenue and Disaster Management, Government of Kerala.
3. Munang, R., Thiaw, I., Alverson, K., Liu, J. and Han, Z., 2013. The role of ecosystem services in climate change adaptation and disaster risk reduction. *Current Opinion in Environmental Sustainability*, 5(1), pp. 47-52.
4. Tamil Nadu State Disaster Management Plan (2016), Tamil Nadu State Disaster Management Authority, Government of Tamil Nadu.
5. Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G. and Rockström, J., 2006. Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters*, 30(1), pp. 39-48.
6. West Bengal Disaster Management Plan (2015-2016), Department of Disaster Management, West Bengal.