



## Very severe cyclonic storm “Gaja” and its impact off the Tamil Nadu coastline

S S Salim\* & Monolisha S

Fishery Resource Assessment, Economics and Extension Division, ICAR-Central Marine Fisheries Research Institute,  
Kochi – 682 018, India

\*[E-mail: shyam.icar@gmail.com]

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This paper presents an overview of the Gaja – a very severe cyclonic storm that battered thousands of lives in Cauvery delta regions of Tamil Nadu. The cyclone originated from the Gulf of Thailand on 5<sup>th</sup> November 2018 and gradually turned into a very severe cyclonic storm that made a landfall at Tamil Nadu coast on 15<sup>th</sup> November 2018. Nagapattinam was one of the most affected coastal districts, which endured extensive damage due to coastal flood and wind-rose to about 120 kmph. The current study was focused on the impact assessments of the co-operative society members. The statistical chi-square distribution was calculated to substantiate the significant relationships between the physical attributes, socio-economic conditions and level of vulnerability to the coastal communities affected by the cyclone. The major findings of the study reveals that the human vulnerability is highly significant to the physical attributes and socio-economic factors such as mean sea level, distance of house-holds from the shore-line, house type, income and education. The study suggests that the policy managers should proactively consider all the identified variables homogeneously to proficiently improvise the disaster management, preparedness; adaptation and mitigation measures to efficiently conserve the resources from vulnerable hazards.

[**Keywords:** Disaster, Gaja, Impact, Management, Socio-economics]

### Introduction

Tropical cyclones are an intense low-pressure weather system that affects the tropical oceans. Northern Indian Ocean Basin is extremely cyclone prone and it is associated with natural hazards such as storm surge, flood, heavy rains and landslide. The tropical cyclones across the Northern Indian Ocean basin frequently affects the Bay of Bengal region (East coast) and the Arabian Sea (West coast) in comparison to about 7 % of the globally affected cyclones<sup>1</sup>. The impact of tropical cyclones in the east coast of India and Bangladesh is relatively more devastating when compared to the other tropical regions. Since 1910, India has experienced more than 161 tropical cyclones and convective storms resulting in over 163767 deaths and inestimable economic damage of about 223 million US\$ (EM-DAT Database, see [https://www/emdata.be/](https://www.emdata.be/)).

In the year 2018, east coast of India experienced 4 major cyclonic storms and the fifth was the very severe cyclonic storm, named as GAJA by the Indian Meteorological Department. The wreck started as a low-pressure system over the Gulf of Thailand and crossed through Southern Thailand and the Malay Peninsula during 5<sup>th</sup> – 8<sup>th</sup> November 2018. On the

subsequent days, the pressure system crossed the Andaman Sea and further intensified as a depression over the Bay of Bengal on November 10. It was first designated by the IMD as BOB 09. On November 11, the deep depression upheld as a cyclonic storm termed GAJA. It further travelled west-south-westward with a wind speed of about 120 kmph and made a landfall near Nagapattinam district off Tamil Nadu on November 16. It further sheared through different regions of Cauvery delta regions of Tanjore, Tiruvarur, Pudhukottai and Nagapattinam of Tamil Nadu and Kariakal of Puducherry on the same day and continued moving westward. The storm remnants finally dissipated near Socotra Island off the Arabian Sea on 21<sup>st</sup> November.

From the Gaja affected regions, we have selected the coastal regions of Nagapattinam, Southeast coast of Tamil Nadu for this study. These regions are highly affected by the cyclonic winds, coastal flooding and downpour during 15<sup>th</sup> to 17<sup>th</sup> November 2018. The current study focuses on analysing the impact on physical, socio-economic and other related factors of human vulnerability to Gaja cyclone at household level in the six coastal villages of Nagapattinam coast.

## Materials and Methods

### Study area

The present study was conducted in six cyclone prone villages of the Nagapattinam district, Tamil Nadu. The cyclone swirled the agronomic productive regions of Tamil Nadu and battered the areas to an implausible state. Nagapattinam is one of the coastal districts among the extremely affected regions which faced the eye of the cyclonic storm Gaja that made landfall at the Vedaranyam village of the district. The villages for the study were selected using the following criteria: a) the extent of damage, i.e., loss of lives and fishing assets; b) diversity of fishing practices and gear, safety equipment, etc., so as to have an overall picture of each group's specific vulnerabilities and emergency strategies. The broad-spectrum information on the above criteria was discussed with the regional non-government organisation - Sneha Foundation, functioning at Nagapattinam, Tamil Nadu. Six coastal villages such as Seruthur, Kameswaram, Therku Vizhunthamavadi, Vellapallam, Vanavanmahadevi, Pushpavanam from the Velankanni to Vedaranyam coastal belt were selected for the study. These villages were situated on the coastal stretch of the Nagapattinam district extending from Nagapattinam fishing Harbour to Vedaranyam. The coastline serves as an important source of livelihood for the villagers and fishing is the main occupation of these communities. The study area is presented in the Figure 1.

### Methodology

The primary data was collected through household questionnaire survey, interview with key-informants and field observations in the month of March 2019. A total of 60 affected households were selected for the study through random sampling procedure and the samples were equally proportionate in all the selected villages. The male respondent/ the family head were interviewed using structured questionnaire to analyse the impacts of the cyclone in the villages. Information on socio-economic factors, losses incurred, experience and impacts from previous cyclone or a natural hazard was collected from the local government officials, fishermen co-operative society representatives, social workers and non-government organisations. The information on these factors leads to an inclusive attempt examining the relationship with the losses confronted by the households during the cyclone. In addition, the assessment of impacts caused by cyclone Gaja was studied using multiple factors such as loss of

lives, injuries caused, property loss, occupational loss and amenities loss. The assessment will exemplify and recommend the future requisites for better disaster preparedness and mitigation measures to reduce complex vulnerabilities. Secondary literature collations were made to append the quantitative household datasets. Statistical measures were executed using the statistical software R. The study template was based on the Nazir Hossain, 2015<sup>(ref. 2)</sup>.

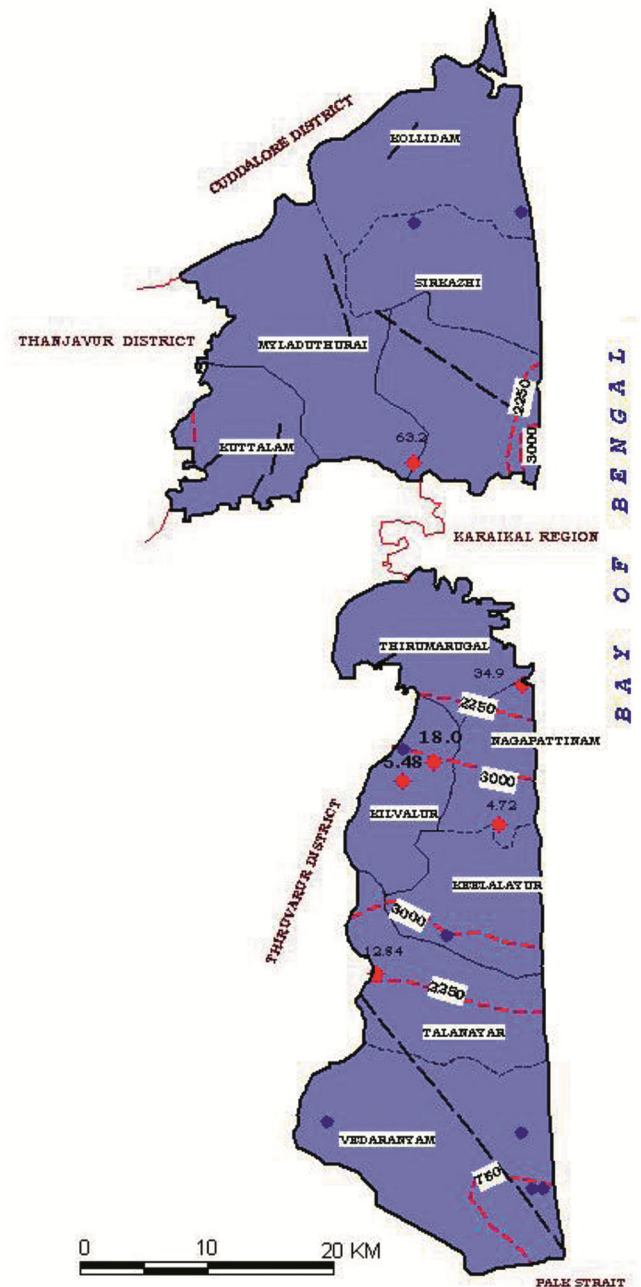


Fig. 1 — Study area – Nagapattinam coast. Source: Central ground water board, Tamil Nadu

**Results and Discussion**

The present study assessed and analysed the impacts of Gaja cyclone on the basis of physical and socio-economic factors. The estimations on total losses and gains acquired from adoption of the scientific weather forecasts were also carried out. Moreover, recommendations on efficient disaster management, preparedness and mitigation measures were also discussed in the study.

**Impact assessment based on the socioeconomic factors**

The study assessed the diverse attributes that affected the socio-economic factors and the livelihood conditions of the coastal villages during cyclone. Some of the attributes studied are the total population and households vulnerable to the cyclone, housing conditions and income, literacy rate and the level of insecurity towards the cyclone.

**Population**

Among the total fishing population of 13,770 individuals from all the surveyed villages, 33 % of the fishing population was from Seruthur followed by Therku Vizhunthamavadi (17 %) and Vellapallam (16 %). The human population vulnerable to the damages were estimated as the proportion of total population to the affected individuals. The vulnerable population range was higher with 83 % in Pushpavanam, 25 % in Therku Vizhunthamavadi and 20 % in two coastal villages such as Vellapallam and Vanavanmahadevi. Figure 2(a) and (b), represents the

percentage variability of total population and the affected individuals.

**Housing and income**

From the study locations, 38 % of the population earns Rs. 5000 to 10000 representing the lower middle income, 25 % earns low income below Rs. 5000, 20 % are upper middle income (Rs. 10000 to Rs. 20000) and 10 % earns above high income (Rs. 20000 to Rs. 35000). The types of houses and the construction materials of the houses tend to be an important attribute contributing to the vulnerable impacts of cyclone and storm surges. The housing conditions in the village were also studied and found that 37 % are the huts thatched from natural materials such as bamboo, cole-straw, coconut/palm leaves, 33 % are the Kutcha houses made of bricks and brick-sheets, 17 % are semi-pucca houses (brick walls and iron sheets) and 13 % are the pucca houses. It is noted that 67 % of the households of low income (below Rs. 5000) lives in thatched huts, 52 and 30 % of the households earning low middle income groups survives in kutcha and thatched houses, respectively. The households with high income eke out a living in the pucca (30 %) and semi-pucca houses (40 %). The significant relationships between the household and income ranges were statistically represented in Table 1. The chi-square distribution states higher significance level towards the type of houses and income range. It is evidential that the most vulnerable

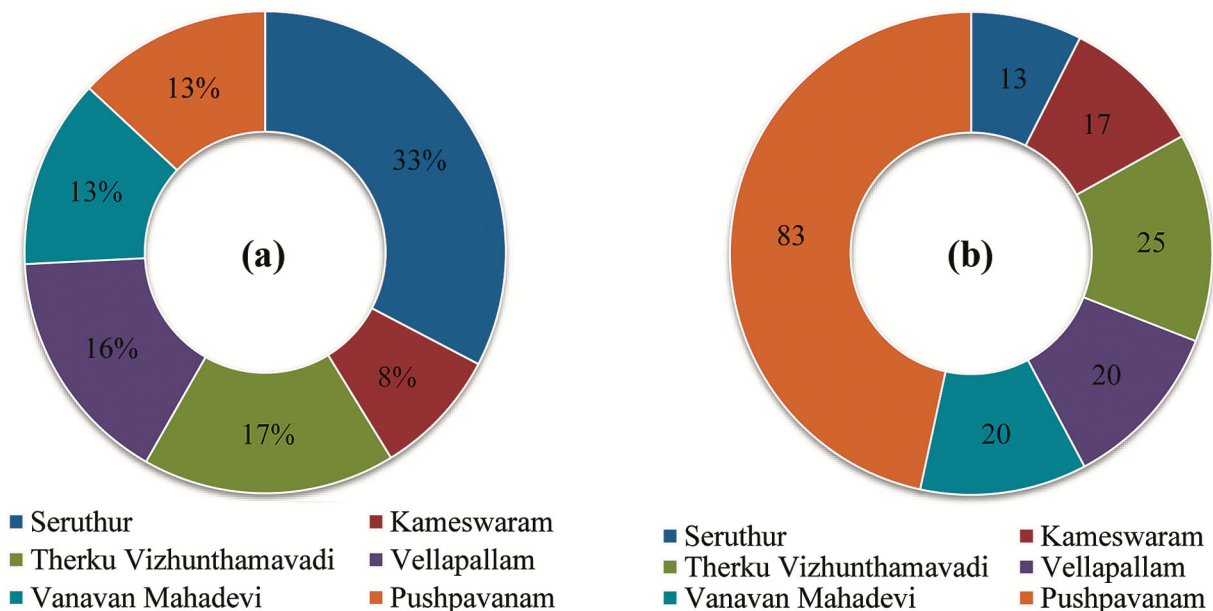


Fig. 2 — a) Percentage variability of total fishing population; and b) affected individuals

Table 1 — Housing and income

	Low income	Low middle	Upper middle	High income	Total	Percentage
Thatched huts	10	12			22	37
Kutcha houses	5	7	5	3	20	33
Pucca houses		1	4	3	8	13
Semi-pucca		3	3	4	10	17
Total	15	23	12	10	60	100

X-squared = 29.1221, df = 9, p-value = 0.000618

population belongs to the low income group and thatched houses. The group with high income lives in decent housing condition with relatively less household damage.

#### *Literacy and extent of damages*

It is necessitous to understand the educational status of the region to comprehend the level of awareness and adoption on disaster forecast, warning and preparedness to the disasters. The present study reveals that large numbers of people (55 %) from the total respondents are from primary level of education in the study villages. About 35 % of the respondents have reached to the level of higher secondary and 10 % of respondents had their education to the graduate level. To substantiate the association with the literacy rate and the awareness towards disasters and extent of damages, the significant relationship with the households, losses incurred and the literacy rate were also studied. The educational status of the respondents were categorised into two: low literacy rate (Primary) and high literacy rate (Higher secondary and above higher secondary).

The analysis on these attributes unveils that there is significant contribution towards increased vulnerability in the households with respondents of low literacy rate. The cyclone induced occupational losses were higher with 61 % of households with low literacy rates whereas occupational losses in households with high literacy rate were low (41 %). This condensed extent of damage may be due to their optional source of livelihood such as fish marketing, processing, agriculture and cattle farming. Amidst this, the respondents also articulated the loss of cattle's from agronomic villages such as Kameswaram and Therku Vizhunthamavadi.

In addition, all the six coastal villages were affected by silt and mud deposition during the cyclonic period which seriously impaired their crafts

Table 2 — Relationship between the literacy rate and losses incurred

	Low literacy rate	High literacy rate
Property loss	HH	HH
About Rs. 1 lakh	22	6
About Rs. 50000	7	4
About Rs. 20000	4	17
X-squared = 17.5845, df = 2, p-value = 0.0001519		
Occupational loss	HH	HH
About Rs. 15000	20	11
Less than Rs. 10000	13	6
About Rs. 5000	0	10
X-squared = 14.7392, df = 2, p-value = 0.0006301		
Losses of earning post cyclone	HH	HH
Yes	28	15
No	5	12
X-squared = 4.9156, df = 1, p-value = 0.02661		

and gears. The silt and mud flooded the near-shore fish-landing areas, auction-centres and the households to about 15 – 20 feet height. The panic emerges out of devastations, unfavourable climatic conditions and loss of crafts and gears making them being inactive from fishing on the dole until March 2019. The loss of earning post cyclone until March 2019 was reported from 85 % of the respondents. Besides this, no human life loss was reported from the villages whereas the households and property losses were the notable damages encountered during the hazard. Table 2 represents the associations between the households, respondents' literacy rate and damages experienced during the cyclone.

Investigations on using diverse alternatives of socioeconomic attributes states that low income and low literacy rates are inherently prone to the increased vulnerability towards cyclone and storm surges. The results also commend that it is compulsory to exterminate the low literacy level to lessen the extent of damages and to be vigilant from vulnerable natural hazards.

#### **Impact assessment based on the physical factors**

##### *Location and elevation of houses near coast*

The households of all the six villages were situated nearer to the coastline. This ascertains the geomorphological exposure of houses in the villages to natural hazards. The villages are scattered across the shoreline as a rectilinear stretch inhabiting to about 15 – 20 feet mean sea level. During the survey,

the collectively enunciated peril among the fishers was the flooding experienced on 15<sup>th</sup> November 2018. The fishers' picturized the nightmare as sea-level entering inside the villages were similar to the tsunami event 2004 and the water-level persisted to the height more than 20 feet engulfing all the shoreline constructions until the dawn of 16<sup>th</sup> November 2018. This menace experience authenticates the future likelihoods of elevated mean sea level in these regions. Moreover, there are chances of storm surge and coastal flooding overtopping the constructions even during the upcoming disasters. The mental perception of the households corroborates their constant state of distress towards exposure to storm surges and cyclone in the region.

#### *Condition of roads and transportation*

The poor connectivity to roads and transportation to other regions for emergency provisions were a major disadvantage. The roads in the villages were not favourable to carry out evacuation, rescue or food distribution to the affected villages. It was not accessible for any organisations to reach these villages for rescue operations during disaster or post disaster to about 4 – 5 days. The roads and pathways are narrow and lashed continuously by uprooted trees and electric lines. These conditions were miserable and ended up the disaster response forces to undoubtedly exaggerate the extent of damage in higher range. There were no any embankments built across the shoreline/ in the villages to reduce the flooding impacts out of storm surge/ coastal flooding. Due to failures in accessibility to the villages, lack in stock of food materials were reported. The food provided in camps is not wholesome nutritious and the condition retained for about 4 to 5 days.

#### *Cyclone shelters*

The government of Tamil Nadu opened more than 500 relief camps across the delta regions of the state. Nevertheless, the fisher folk villages were not taken into account and the camps were not functional during the cyclone. In the advent of the disaster, local community leaders made arrangements in their village cyclone shelters and also settled up additional makeshift shelters to be safe and protected from further risks. Some families migrated to the nearby towns or other non-affected districts. All the coastal villages surveyed had their own cyclone shelters (Fig. 3) excluding the village-Vanavan Mahadevi. But in the verge of exposure to the cyclone Gaja,

the village heads transformed their Fishermen Co-operative Society buildings into a relief camp. The cyclone shelters were constructed in all the coastal villages across the Nagapattinam coastal stretch post tsunami. These buildings are utilised as a public facility centre during the advent natural hazards. The distance of these cyclone shelters were accessible and situated within 2 – 5 km distances inside the village. All the villages excluding Seruthur were away from all the accessible highways and transportations. Access to these villages was the difficult mission during rapid storm or cyclonic events. The fisher folks were prepared to get relocated themselves to the relief camps and cyclone shelter a day in advance. The number of cyclone shelters and the capacity of the building must be increased to accommodate all the population. Fishers articulated about accommodating the females and males in the cyclone shelter during the cyclone due to constrictions for food and space in the building. It was whinged about being overcrowded in the cyclone shelter which was constructed nearly years back. Being overcrowded, the village Anganawadis, marriage-halls, middle-school buildings and government schools were turned into a makeshift relief camp in most of the villages. The different limitations experienced by the villagers in the relief camps were also studied during this study. The responses were ranked based on their order of preference. The rankings were then statistically calculated using Garette ranking technique. Table 3 represents the constraints experienced in the cyclone

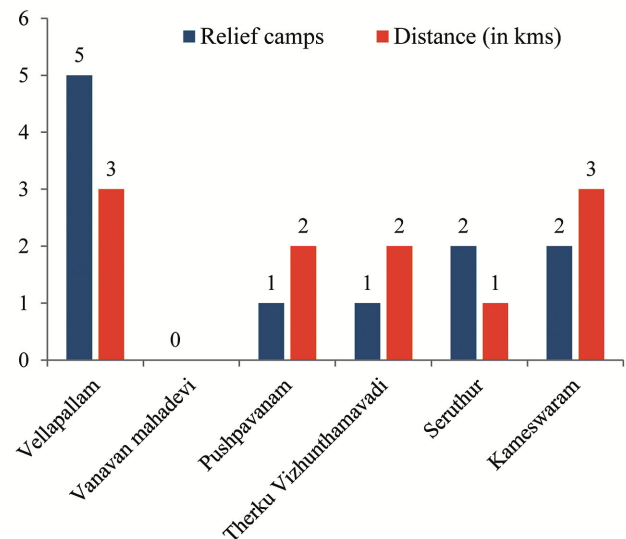


Fig. 3 — Cyclone shelters in the villages showing distance to access



Table 3 — Limitation experienced in the cyclone shelters

Limitations	Ranks	Scores
Insufficient food	II	69
Lack of cleanliness	V	58
Faced discrimination	VIII	44
Lack of proper sanitation	III	67
Overcrowded	I	70
Internal conflicts	VII	50
Political issues	IX	40
Unavailability of medicines	VI	54
Shortage of medical support	IV	67
Any others	X	36

shelter. Over-crowd, insufficient food and lack of proper sanitation are alleged to be the major constraints encountered in the cyclone shelters of the villages. Coastal floods contaminated and damaged the water bodies or sources in the villages. The major water source in the villages is bore well and groundwater facilities. Access to drinking waters and scarcity for water is still a prevailing condition in these areas. There were no toilet facilities in the cyclone shelters, which was a state of insecurity to the women and children accommodated in the shelters. This also led to poor sanitation as the communities' practised open defecation.

#### Extent of damages in the villages

The cyclone battered more than 250,000 people in delta districts of Tamil Nadu claiming loss of 63 individuals. Inter-governmental agency of the state reported 63 human deaths, 307,819 individuals evacuated, 12,298 cattle death, more than one lakh trees uprooted, 3 lakh coconut trees were fallen, agriculture farms of about 32,000 hectares demolished, 1500 fishing boats completely damaged and 2625 partially damaged boats<sup>3</sup>. The fisher folks of the village lost their boats, gears and nets. Fishing boats were fully or partially damaged. The damages totally destructed the livelihood to the expiration. Respondents added that the damages were similar to the disaster caused during the Indian Ocean Tsunami event in the year 2004. The present study states that among the sixty households surveyed, respondents with sectors highly vulnerable to damage are fisheries (36 %) followed by household goods damage (34 %) and loss of houses (27 %) and livestock (3 %). There were no any reports of human loss or accidental injuries reported. So, the percentage variability constitutes the vulnerable sector beyond the human loss. Photographs documenting the damages were portrayed in Figure 4.



Fig. 4 — Extent of damages documented off the Nagapattinam coast, Tamil Nadu

#### Disaster preparedness, adaptation and management approaches delivered

In aim of reducing the risk and vulnerability during the natural disasters, several national and international hierarchical consortiums were initiated in all the states of India. It is a multi-level synergy including state, centre and district level response force which will be involved in preparedness, adaptation and mitigation activities across the different regions. This section will deliberate the different measures such as adoption level of weather and climate forecast, income, savings and household coping strategies, emergency relief support and disaster management capacity building training programmes that has been significantly active in the region during the Gaja cyclone.

#### Awareness and knowledge on scientific weather and climate forecast

Most of the respondents are aware of the scientific weather forecast provided by Indian Meteorological Department (IMD) and Earth System Science Organisation-Indian National Centre for Ocean Information Services (INCOIS). These organisations work under the Ministry of Earth Science, Government of India as the official bodies of weather and climate related predictions, monitoring, warning and forecast. Since 2005, the organisations developed early warning systems to prevent huge loss out of disasters in the country. In the recent years, these forecast predictions were disseminated directly to the

human population through modes such as television, radio, newspapers and more improvised modes such as audio-advisory calls, helpline services, mobile app and electronic display boards in the fishing harbours. Different sources of information are Department of fisheries, Non-government organisation and local fishermen co-operative societies. From the total respondents, diverse source of information and periodicity of received and used information were counted (Figs. 5 & 6).

Figure 6 elucidates the periodicity of warnings and forecast on Gaja cyclone and it implies that the frequency range was higher in all the months. However, the usage frequency stands with the range of 10 – 25 respondents among the respondents surveyed. In proliferating the same with the population range, the frequency of usage among the communities are slightly on the lower side. This may be due to low literacy rate (explained in the previous

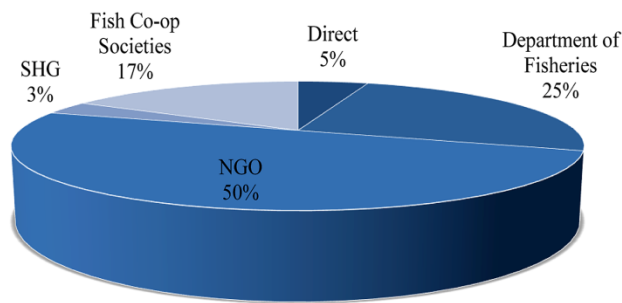


Fig. 5 — Percentage variations in respondents using different source of forecast

section) or could be lack of awareness on scientific predictions and forecasts. The opinions on the scientific forecast were categorised based on different factors such as information deficiency, delay in receipt, language not amenable, complexity to understand and inaccuracy. The most opined factor was delay in receipt and information deficiency. Moreover, the fisher folk communities also demand for advancements and now-cast weather warnings and 10-day advanced predictions considering both the spatial and temporal scale. Some respondents also expressed their indigenous climate indicators before the onset of cyclone. “Ciphers of wind-rose and varied fish species aggregations provided specific cues for changing climate conditions” revealed the respondents of the Pushpavanam village.

*Income, savings and household coping strategies*

The fisher folks of the village with less income do not have any option of saving money for future purposes. However, the high-income groups also had family conditions to save money. The high-income groups stocked food items and rations before the cyclone and they also extended help for other affected communities in the surrounding villages. The optimal source of credit for food and shelter was provided by the government sector and non-government organisations such as SNEHA, OMCAR foundation and M S Swami Nathan Research foundation (MSSRF). Otherwise, the affected communities borrow loans for excessive interest rate from micro-credits from the government/non-government

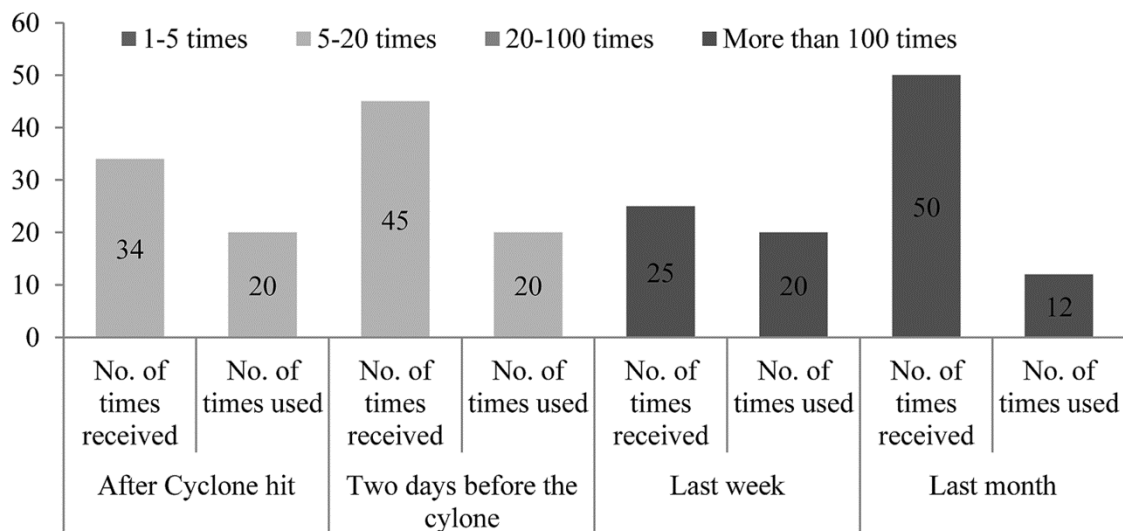


Fig. 6 — Periodicity and usage frequency of the weather forecast

Table 4 — Relief measures provided by the state government after Gaja cyclone

Coastal villages surveyed	Relief amount received (in Rs.)	House construction (in Rs.)	Livestock (in Rs.)
Vellapallam	150,000	10,000	NP
Vanavanmahadevi	150,000	5,000	NP
Pushpavanam	150,000	5,000	NP
Therku Vizhunthamavadi	150,000	NP	NP
Seruthur	NP	5,000	NP
Kameswaram	15,000	NP	4,000

\*NP - Not provided on account of minimal damage/ loss

consortiums. Apart from this, mitigation measures such as repairing the dwellings, boats and gears takes enormous time leading to occupational loss and migration to different employment to survive their basic necessities.

#### *Disaster response and relief measures*

The state disaster relief support of INR 1000 crores was allocated by the Chief Minister of Tamil Nadu for compensation to the affected families and communities who suffered serious injuries. Relief assistance for each coconut tree of Rs. 600 and Rs. 1 – 2 lakh was announced to be given. The damaged catamarans were given Rs. 42,000 and partially damaged catamarans with nets were specified Rs. 20,000, FRPs and nets fully damaged (Rs. 85,000) and partially damaged FRPs were set Rs. 30,000; fully damaged mechanised boats were given Rs. 5 lakhs and partially damaged mechanised boats (Rs. 3 lakhs each), for nets (Rs.10,000) and for repairing engines (Rs. 5000) were provided. During the study, the relief measures for livelihood assistance, fishing assets, house construction and agriculture and live-stock was received<sup>3</sup>. The complete amount received from the government as relief support for each village is provided in the Table 4.

In addition, the government also promised to support in construction of 100,000 concrete houses in the Nagapattinam district. The fisher folk's satisfactory level with the received relief assistance was very low and they stated that the losses incurred will not be contented with the relief measures so far provided.

#### *Disaster preparedness awareness and capacity building programmes*

There were no any disaster preparedness awareness programmes conducted in these villages so far. However, some capacity building programmes on utilising safety equipment such as personal floating device, GPS and Walkie-talkie were organised through the department of fisheries. The fisher folks of the villages were also involved in access to weather

forecast warning through mobile phones, mobile-apps and electronic display boards by MSSRF. Likewise, disaster preparedness, mitigation and adaptation level trainings should be administered through the local self-governing bodies to avoid severe vulnerability out of future disasters. Additionally, gadgets such as very high frequency radio, satellite phones and Distress Alert transmitters are to be provided under subsidy to impart safety at sea. Disaster preparedness measures, long-term rehabilitation policies, advancements in innovative technologies, modified adaptation and mitigation plans and policies can condense the extent of damages and fatalities crossways both on the household and community perspective.

#### **Conclusion**

In the present study the micro-level analysis on the impact of Gaja cyclone in the Nagapattinam district of Tamil Nadu coast was assessed. The assessment on different factors summarises that the socio-economic conditions and physical attributes of the village amplified the vulnerability of cyclone in the household level. Besides the socio-economic condition such as literacy rate and income range are identified to be the significant factors contributing to the awareness, preparedness actions and extent of damage during the cyclone. The physical attributes such as geomorphological conditions of the houses, type of houses and distance of house from the sea-shore are not to be the severe susceptible conditions for exposure and external shock to the cyclones/storm-surges. Therefore, the study recommends that the disaster preparedness plans, policies and recommendations from government and non-government agencies should pay attention to these diverse attributes for effective conservation and sustainable management. The major implications and recommendations to reduce the coastal vulnerability from cyclone and storm surges are timeliness in dissemination and rescue/relief operations during distress; cyclone preparedness at sea; reliable data on fishing operations; disaster management training and co-ordinations between agencies; integrated national



and local self-governing bodies in disaster planning; community-based disaster management approach; assessments on ecosystem revitalisation and environmental effects; women and children rehabilitation for the highly affected families; and increased rehabilitation and relief assistance measures.

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