Impact Assessment of FENGAL Cyclone in Tamil Nadu By Using ARCGIS

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Abstract - Cyclones are powerful natural disasters that frequently impact the coastal regions of Tamil Nadu, causing significant socio-economic and infrastructural damage. The 2024 Fengal Cyclone severely affected the Cuddalore and Viluppuram districts, highlighting the urgent need for advanced disaster risk assessment and management strategies. This study assesses the impact of the Fengal Cyclone in Tamil Nadu using Geographic Information System (GIS) techniques, specifically ArcGIS, to map and analyze cyclone vulnerability zones. By integrating key physical parameters such as slope, elevation, land use and land cover, drainage density, and precipitation, the research identifies and classifies flood risk zones along the coast. The resultant thematic maps provide spatial insights into cyclone risk, enabling more effective disaster preparedness, mitigation planning, and resource allocation. The findings support local authorities, urban planners, and disaster management teams in developing targeted interventions to reduce the adverse effects of future cyclonic events in the region.

Keywords - Cyclone, GIS Technique, Flood risk zone map.

1. INTRODUCTION

Cyclones are among the most devastating natural disasters affecting coastal regions worldwide, often resulting in widespread destruction and significant socio-economic impacts. Tamil Nadu, with its extensive eastern coastline along the Bay of Bengal, is particularly vulnerable to cyclonic storms, as evidenced by recurring events over the past decades. The recent Fengal Cyclone of 2024 once again highlighted the urgent need for comprehensive disaster preparedness and risk assessment strategies in the state, especially in the districts of Cuddalore and Viluppuram, which are frequently in the path of such storms. This study focuses on the impact assessment of the Fengal Cyclone in Tamil Nadu, utilizing advanced Geographic Information System (GIS) techniques, specifically ArcGIS, to map and analyze vulnerability zones. By integrating key physical parameters such as slope, elevation, land use and land cover, drainage density, and precipitation, the project aims to provide a spatial understanding of cyclone risk. The resulting maps and analyses not only identify high-risk zones but also serve as valuable tools for disaster management authorities, urban planners, and policymakers. Ultimately, this research supports the development of more effective mitigation and adaptation strategies to reduce the adverse effects of future cyclonic events in the region

2. OBJECTIVES OF STUDY

- To map the vulnerability regions of Fengal Cyclone in Viluppuram and Cuddalore districts using GIS techniques (ArcGIS).
- To create detailed thematic maps depicting the direction of the cyclone, wind intensity, land use and land cover, rainfall distribution, flood hazard zones, slope, and elevation.
- To integrate multiple physical parameters—such as slope, elevation, land use/land cover, drainage density, and precipitation—using GIS for comprehensive cyclone risk assessment.
- To identify and classify flood risk zones along the coast, aiding in disaster preparedness and mitigation planning.
- To provide actionable insights and spatial data to support local authorities, urban planners, and disaster management teams in minimizing the adverse impacts of cyclones.

3. LITERATURE REVIEW

- From storm to safety: public health success measures in managing cyclone fengal: Subhashini K J, Priyadharshani.A, Avudai Selvi R, Ramya R, Mohammed al Ossama, Bhuvana K,Ganapathy M, Senthil Kumar , Sampath P, Selvavinayagam T S, 2024.
  Tamil Nadu's public health response to Cyclone Fengal was well-coordinated and data-driven, with strong disease surveillance and community education. While effective overall, early network issues showed a need for better infrastructure. The model's wider use in disaster-prone areas should be evaluated.

- Cyclone vulnerability assessment of the western coast of Bangladesh: Muhammad Al-Amin Hoque,

Biswajeet Pradhan, Naser Ahmed, Bayes Ahmed & Abdullah M. Alamri, 2022.
The study uses Fuzzy Analytical Hierarchy Process (FAHP) and geospatial methods to map cyclone vulnerability in western coastal Bangladesh. It finds that southern and south-eastern areas are most vulnerable due to low elevation, proximity to the sea, frequent past cyclones, risky land use, and weak socio-economic conditions.

- Vulnerability analysis of cyclone hazards and the changing Dimensions of disaster risk management in odisha along the east Coast of india: Jitendra Kumar Behera and Gopal Krishna Panda, 2022.
The study finds that Odisha is increasingly vulnerable to severe cyclones from the Bay of Bengal, but improved crisis management and community-based preparedness have successfully reduced disaster risk.
- Assessment of potentially vulnerable zones usinggeospatial approach along the coast of Cuddaloredistrict, East coast of India: K. S. S. Parthasarathy, Subbarayan Saravanan, Paresh Chandra Deka &Abijith Devanantham, 2020.
The study used various coastal and environmental data layers to assess vulnerability, finding that 15% of the coast is very highly vulnerable and 10.2% highly vulnerable. Factors like geomorphology, bathymetry, slope, beach width, and shoreline significantly influence coastal vulnerabilityReliability-Based Structural Design, Bilal M. Ayyub and Ibrahim A. Assakkaf, 2004.
- Effect of indian ocean cyclone on coastal region using remote sensing and gis: Kushboo Kumari and Asmita A. DEO, 2020.
The study uses remote sensing and GIS to assess land use and vegetation changes caused by four cyclones in different coastal regions. By comparing pre- and post-cyclone images, it monitors how cyclones impact land cover and vegetation, aiding in change detection and trend analysis.

4. CYCLONES

A cyclone is a large-scale rotating air mass that forms around a low-pressure center, moving counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. Cyclones are categorized into extratropical, tropical, mesocyclones, subtropical, and polar types based on their origin and characteristics.

Fig 1. Cyclone

A. Characteristics of a cyclone

[1] Cyclones are low-pressure systems rotating due to the Coriolis effect, with counterclockwise rotation in the Northern Hemisphere and clockwise in the Southern Hemisphere.

[2] Strong pressure gradients within cyclones cause high wind speeds, often exceeding 252 km/h in extreme cases. The maximum winds occur around the eyewall, and the center features a calm region known as the eye.

[3] Cyclones bring primary hazards like storm surges, which cause abnormal sea-level rise, and heavy rainfall leading to inland flooding and landslides. These conditions amplify structural damage and environmental impact.

B. Classification of cyclonic disturbances

Tamil Nadu is divided into different cyclone risk zones based on wind speeds and storm surge vulnerability. These zones align with IS 875 (Part 3): 2015 – Indian Standard Code for Wind Loads and NDMA Cyclone Risk Mitigation Guidelines.

TABLE I Classification of cyclonic disturbances

SI No	Types of disturbance	Associated maximum sustained wind (1 knot - 1.85 kmph)
1	Low Pressure Area	Not exceeding 17knots (<31kmph)
2	Depression	17 to 27 knots (31-49 kmph)
3	Deep Depression	28 to33 Knots (50-61 kmph)
4	Cyclonic Storm	34 to 47 Knots (62-88 kmph)
5	Severe Cyclonic Storm	48 to 63 Knots (89-117 kmph)
6	Very Severe Cyclonic Storm	64 to90 Knots (118-167 kmph)
7	Extremely Severe Cyclonic Storm	91 to119 Knots (168-221 kmph)
8	Super Cyclonic Storm	120 Knots and above (≥222 kmph)

C. Cyclone zones in Tamilnadu

Tamil Nadu is divided into different cyclone risk zones based on wind speeds and storm surge vulnerability. These zones align with IS 875 (Part 3): 2015 – Indian Standard Code for Wind Loads and NDMA Cyclone Risk Mitigation Guidelines.

TABLE II Cyclone zones in Tamilnadu

Zone	Wind Speed (km/h)	Districts Affected
High-Risk Zone	>160 km/h	Chennai, Cuddalore, Nagapattinam, Thoothukudi, Ramanathapuram

Moderate-Risk Zone	120 - 159 km/h	Thanjavur, Pudukkottai, Kanyakumari, Karaikal, Thiruvarur
Low-Risk Zone	80 - 119 km/h	Madurai, Sivagangai, Tirunelveli, Virudhunagar

Fig 3 Cyclone zoning map of Tamilnadu

E. List of cyclones affected in Tamilnadu

The coastal regions of Tamil Nadu and Andhra Pradesh have faced frequent cyclonic events, with severe impacts recorded in multiple years. Major cyclones like Ockhi (2017), Gaja (2018), and Nisha (2008) caused significant casualties and property damage. The highest wind speed was recorded during Ockhi at 185 km/h, resulting in over 200 deaths. Cyclones often bring intense rainfall, such as Nisha's 660 mm in 24 hours and Michaung's heaviest in 47 years.

TABLE III List of cyclones affected in Tamilnadu

Cyclone Name	Speed (kmph)	Location	Impact Summary
Fengal (2024)	90	Tamilnadu, Sri Lanka, Andra Pradesh.	Heaviest rainfall; 37 deaths
Michaung (2023)	110	Tamil Nadu, Andhra Pradesh	Heaviest rainfall in 47 years; 17+ deaths
Mandus (2022)	95	Tamil Nadu Coast	4 deaths reported
Nivar (2020)	125	Between Pondicherry & Chennai	Heavy rainfall
Gaja (2018)	130	Tamil Nadu Coast	40+ deaths; 2.5 lakh displaced; livelihood loss
Ockhi (2017)	185	Kanyakumari, Lakshadweep	218 deaths; 600+ missing; widespread destruction
Vardah (2016)	155	Near Chennai	Severe damage; 15+ deaths; ₹1000 crore loss
Thane (2011)	135	Between Puducherry & Cuddalore	45+ deaths; major crop & property damage
Jal (2010)	110	Near Chennai	50+ deaths; 300,000 ha crops lost
Nisha (2008)	100	Tamil Nadu Coast	189 deaths; 660 mm rain in 24 hrs; 1.5 lakh houses damaged

6. STUDY LOCATIONS

A. Viluppuram District

Fig 4. Viluppuram map created in ARCGIS

Viluppuram district is the largest district in Tamil Nadu, India, formed on 30th September 1993 by bifurcating the South Arcot district. It is located between latitudes 11°38′25″N and 12°20′44″N and longitudes 78°15′00″E and 79°42′55″E, covering an area of about 3,725.54 square kilometers. The district lies along National Highway 45, connecting Tiruchirapalli and Chennai, and is well connected by rail and road, serving as a major junction. Geographically, Viluppuram is bordered by Cuddalore district to the east and south, Kallakurichi district to the west, and Thiruvannamalai and Kanchipuram districts to the north. It also has a coastline along the Bay of Bengal in the east, extending about 32 km in the Marakkanam and Vanur blocks. The terrain mainly consists of plains used for agriculture, with notable hills such as the Gingee and Kalrayan hills. The district headquarters is the town of Viluppuram, located on the banks of the Thenpennai River, about 160 km south of Chennai and 35 km northwest of Cuddalore. Viluppuram town is a special grade municipality and a major railway junction. Administratively, Viluppuram district comprises 2 revenue divisions, 9 taluks, 932 revenue villages, 2 municipalities, and 8 town panchayats. The district has a rich cultural heritage with many ancient temples, mosques, and churches.

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B. Cuddalore

Fig 5. Cuddalore map created in ARCGIS

Cuddalore is a coastal district in the northeastern part of Tamil Nadu, India, with the Bay of Bengal to its east. The district headquarters is Cuddalore town, located at the confluence of the Gedilam and Pennaiyar rivers, about 200 km south of Chennai and 22 km from Puducherry. The district spans approximately 3,678–3,703 square kilometers and features a 68 km coastline stretching from Puducherry in the north to the mouth of the Coleroon River in the south. The region is characterized by coastal plains, sandy beaches in the north, and mangrove swamps in the south. Cuddalore is historically significant, having been ruled by various dynasties such as the Cholas, Pallavas, Pandyas, and later by the Dutch, French, and British. It was notably the site of the 1783 Siege of Cuddalore during the Seven Years' War. Economically, Cuddalore is known for agriculture (especially cashew and jackfruit), fishing, and industries including chemicals and energy. The district is also home to a large fisher population and has small lignite deposits supporting local industries. Cuddalore is considered multi-hazard prone due to its long coastline, making it vulnerable to cyclones, floods, and events like the 2004 tsunami. The city is administered as a municipal corporation and is an important industrial and educational hub in the region.

7. FIELD SURVEY – DATA COLLECTIONS

A. GENERAL DETAILS – TINDIVANAM

SI. NO	Category	Details
General Information		
1	Location	Tindivanam, Viluppuram district, Tamilnadu.
2	Cyclone, Flood & Storm Surge Prone	Yes
3	Population	72796 people (17088 houses)
4	Cyclone Shelter	Yes, 1 km away (Capacity: 1000 - 1500 people)
5	Storm Water Drainage	Present but poorly maintained

1. STRUCTURAL ASSESSMENT

TINDIVANAM SURVEY NO: A1

TINDIVANAM		 
1	Type	Non-Engineered
2	Size	8m ×6.5 m
3	Roof	Thatched Roof with Wooden Support
4	Walls	Brick wall
5	Foundation	Stone or Mud Foundation (Shallow)
6	Plinth	0.30m above grounf
7	Estimated Age	10 years
8	Estimated Cost	₹80,000
Structural Damage Summary		

1	Roof	Major Damage
2	Front & Side Walls	Major Damage
3	Foundation	Weak
4	Columns	None
5	Doors, Windows & Ventilators	Minor Damage
6	Cracks in Walls	Minor
7	Erosion Due to Flooding	Significant Erosion Around Foundation

Issues & Recommendations

The building has major wall damage, weak shallow foundation with erosion, and lacks supporting columns. Minor roof and wall cracks are present. Stability can be improved by strengthening walls with cement plaster and bracing, reinforcing foundation with stone/concrete, upgrading drainage, raising the plinth, and adding vertical supports for flood resistance.

2. TINDIVANAM SURVEY NO: B1

TINDIVANAM		
1	Type	Semi-Engineered
2	Size	10m × 6m
3	Roof	Asbestos sheet
4	Walls	Brick Masonry
5	Foundation	Random Rubble Masonry
6	Plinth	0.50m above ground
7	Estimated Age	20 years
8	Estimated Cost	₹1,00,000
Structural Damage Summary		
1	Roof	ModerateS Damage
2	Front & Side Walls	Moderate Damage
3	Foundation	Minor Damage
4	Columns	None
5	Doors, Windows & Ventilators	None
6	Cracks in Walls	Minor Damage
7	Erosion Due to Flooding	Significant Erosion Around Foundation

Issues & Recommendations

The building requires timely repairs to ensure long-term stability. Walls should be strengthened with cement reinforcement and bracing, broken roof tiles replaced, and a water-resistant coating applied. Foundation settlement needs monitoring and reinforcement, while drainage channels should be improved to prevent water pooling. The retrofitting priority is medium.

3. TINDIVANAM SURVEY NO: C1

TINDIVANAM		
1	Type	Engineered
2	Size	10m × 8m

3	Roof	RCC Slab with Proper Waterproofing
4	Walls	Reinforced Brick Masonry with Cement Plaster
5	Foundation	Reinforced Concrete Footing
6	Plinth	0.80m above ground
7	Estimated Age	18 years
8	Estimated Cost	₹3,00,000
Structural Damage Summary		
1	Roof	No Damage
2	Front & Side Walls	No Major Cracks
3	Foundation	Stable
4	Columns	Stable
5	Doors, Windows & Ventilators	No Damage
6	Cracks in Walls	Very Minor
7	Erosion Due to Flooding	Major Damage
Issues & Recommendations Regular inspection and maintenance are recommended. Continue annual roof waterproofing checks and monitor the foundation for settlement. Keep storm drainage clear to prevent blockages. Overall, the building is well-built and needs only routine upkeep.		

B. GENERAL DETAIL – DEVANAM PATTINAM

SI. NO	**Category**	**Details**
General Information		
1	Location	Devanampattinam, cuddalore district, Tamilnadu.
2	Cyclone, Flood & Storm Surge Prone	Yes
3	Population	6737 people (2245 houses)
4	Cyclone Shelter	Yes, 1 km away (Capacity: 250 – 500people)
5	Storm Water Drainage	Present but poorly maintained

1. STRUCTURAL ASSESSMENT – DEVANAMPATTINAM

DEVANAMPATTINAM SURVEY NO: A1

DEVANAMPATTINAM		
1	Type	Non-Engineered
2	Size	12m × 5m
3	Roof	Thatched Roof
4	Walls	Mud Wall
5	Foundation	None
6	Plinth	None
7	Estimated Age	5 years
8	Estimated Cost	₹50,000
Structural Damage Summary		
1	Roof	Major Damage
2	Front & Side Walls	Major Damage

3	Foundation	None
4	Columns	None
5	Doors, Windows & Ventilators	None
6	Cracks in Walls	None
7	Erosion Due to Flooding	None

Issues & Recommendations

The building has major wall damage, weak shallow foundation with erosion, and lacks supporting columns. Minor roof and wall cracks are present. Stability can be improved by strengthening walls with cement plaster and bracing, reinforcing foundation with stone/concrete, upgrading drainage, raising the plinth, and adding vertical supports for flood resistance.

2. DEVANAMPATTINAM SURVEY NO: B1

DEVANAMPATTINAM		
1	Type	Semi-Engineered
2	Size	8m × 5.3m
3	Roof	Asbestos sheet
4	Walls	Brick Masonry
5	Foundation	Random Rubble Masonry
6	Plinth	0.50m above ground

7	Estimated Age	15 years
8	Estimated Cost	₹1,20,000
Structural Damage Summary		
1	Roof	Moderate Damage
2	Front & Side Walls	Moderate Damage
3	Foundation	No damage
4	Columns	No damage
5	Doors, Windows & Ventilators	No Damage
6	Cracks in Walls	Minor—Hairline Cracks
7	Erosion Due to Flooding	Some Soil Erosion

Issues &Recommendations

The building requires timely repairs to ensure long-term stability. Walls should be strengthened with cement reinforcement and bracing, broken roof tiles replaced, and a water-resistant coating applied. Foundation settlement needs monitoring and reinforcement, while drainage channels should be improved to prevent water pooling. The retrofitting priority is medium.

3. DEVANAMPATTINAM SURVEY NO: C1

DEVANAMPATTINAM	

1	Type	Engineered
2	Size	8m × 5.5m
3	Roof	RCC Slab
4	Walls	Reinforced Brick Masonry with Cement Plaster
5	Foundation	Reinforced Concrete Footing
6	Plinth	0.80m above ground
7	Estimated Age	12 years
8	Estimated Cost	₹12,00,000
Structural Damage Summary		
1	Roof	No Damage
2	Front & Side Walls	No Major Cracks
3	Foundation	Stable
4	Columns	Stable
5	Doors, Windows & Ventilators	No Damage
6	Cracks in Walls	Very Minor
7	Erosion Due to Flooding	No Significant Erosion Observed
Issues & Recommendations Regular inspection and maintenance are recommended. Continue annual roof waterproofing checks and monitor the foundation for settlement. Keep storm drainage clear to prevent blockages. Overall, the building is well-built and needs only routine upkeep.		

8. MAP CREATION BY USING ARCGIS

A.Land use and Land cover map

a. Viluppuram district

The land use and land cover (LULC) of Villupuram district is predominantly agricultural, with vast areas under both irrigated and rainfed cultivation. Major crops include paddy, sugarcane, groundnut, and pulses, which vary seasonally. Built-up areas are expanding, especially around Villupuram town and along major transport routes, due to increasing population and infrastructure development. The district also contains forested regions, particularly in the Kalrayan Hills, which contribute to biodiversity and act as important ecological zones. Barren lands and wastelands are scattered across the district, mainly in dry or rocky regions unsuitable for farming. Water bodies such as rivers (notably the Pennaiyar and Gingee), irrigation tanks, and ponds play a vital role in agriculture and local livelihoods. Additionally, seasonal wetlands are present in low-lying areas, supporting both agriculture and ecological balance.

Fig 6. Land use Land cover map for Viluppuram district

B. Cuddalore district

Cuddalore District's land use is shaped by its coastal setting, agriculture, urban growth, and natural ecosystems. Agriculture remains dominant, with about 313,000 hectares under crops like rice, groundnut, sugarcane, and pulses, aided by major rivers for irrigation. Urban areas have grown rapidly, expanding from 1.72% in 1993 to over 7.4% in 2023 due to population and infrastructure growth. The district contains important ecological zones, such as the 1,400-hectare Pichavaram mangroves, and moderate forest cover. Wetlands and water bodies have sharply declined, dropping from 3.89% to 0.9% of the area over three decades. Land use change analysis shows a decrease in agriculture and grasslands, with increases in barren land and mining, highlighting a shift towards urbanization and industrialization and raising new environmental challenges for sustainable management.

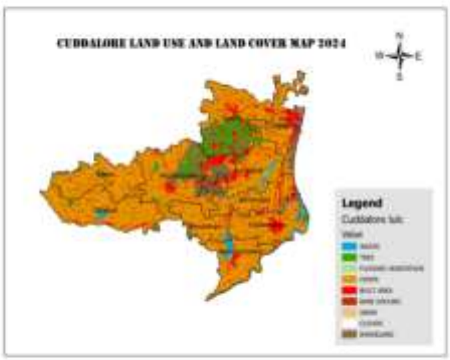

Fig 7. Land use and Land cover map for cuddalore

B. Rainfall map During Fengal Cyclone

a. Viluppuram district

This rainfall map of Villupuram, using IMD data, visually displays rainfall intensity with shades of blue: darker blues indicate higher rainfall (390.127–511.859 units), while lighter blues show lower amounts (2.021–43.388 units). Labeled locations help identify which areas received more or less rain, providing a clear overview of rainfall distribution across the district.

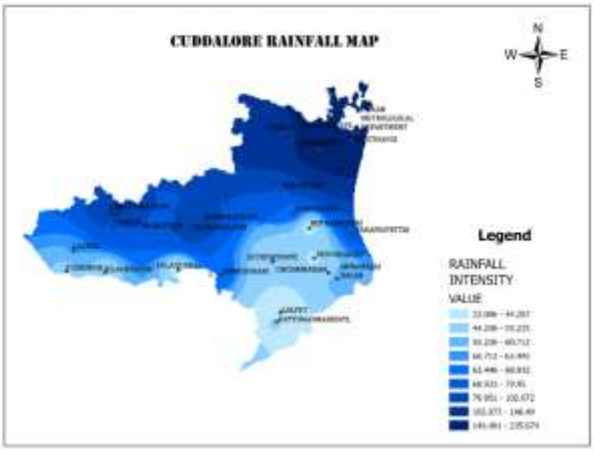

Fig 8. Rainfall map For Viluppuram during Fengal cyclone

FID	AREA	LONG	LAT	RANIFALL
0	MAILAM	79.62189	12.12241	512
1	KEDAR	79.40427	12.00835	419
2	SOORAPATTU	79.4324	12.0066	383
3	VILLUPURAM	79.49741	11.9459	348
4	MUNDIYAMPAKKAM	79.5158	11.9976	322
5	KOLIYANUR	79.5477	11.9265	320
6	MUGAIYUR	79.3043	11.9778	302
7	VALAVNUR	79.5792	11.92	298
8	NEEMOOR	79.49741	11.94596	295
9	KANJANUR	79.4507	12.0622	285
10	MANAMPOONDI	79.2055	11.9775	285
11	ANANDHAPURAM	79.3829	12.1218	175
12	SEMMEDU	79.2874	12.2533	113
13	ARASOOR	79.4274	11.828	75
14	THIRUVENNAINALLUR	79.3663	11.862	73
15	AVALURPETTAI	79.2435	12.3405	68
16	GINGEE	79.416	12.2529	41
17	VALATHY	79.3775	12.3471	40
18	VALLAM	79.5182	12.2453	18
19	THINDIVANAM	79.6498	12.22749	13
20	VANUR	79.7328	12.0215	10
21	MARAKANNAM	79.9249	12.1899	2

Fig 9. Rainfall level in mm during fengal cyclone

b. Cuddalore district

This map illustrates the spatial pattern of rainfall intensity across the Cuddalore region during Cyclone Fengal. The different shades of blue clearly indicate the areas that experienced varying amounts of rainfall associated with the cyclone.

- Darker blue areas: These zones received the heaviest rainfall, with values ranging from 146.491 to 235.674 units (in millimetre's). These areas would have been most impacted by intense downpours, potentially leading to flooding and other water-related issues.
- Lighter blue areas: These regions experienced progressively lower amounts of rainfall, ranging from 102.073 down to 22.086 units. While still significant, the impact of rainfall might have been less severe in these areas compared to the darker blue zones.

The labeled locations provide geographical context, allowing us to see which specific towns and areas within Cuddalore received particular amounts of rainfall during the cyclone. For instance, areas with labels falling within the darker blue patches experienced the brunt of the rainfall. The data was obtained from IMD (Indian meteorological department).

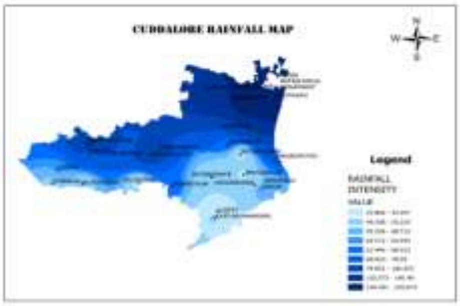

Fig 10. Rainfall map For Cuddalore during Fengal cyclone

FID	AREA	LONG	LAT	RAINFALL
0	INDIAN METROLOGICAL DEPARTMENT	79.77	11.77	236
1	COLLECTORATE	79.7566	11.7734	213
2	VANAMADEVI	79.6664	11.7283	185
3	KUDITHANGI	79.75	11.75	175
4	PANRUTI	79.5629	11.7666	140
5	KATTUMAIYILUR	79.1232	11.5668	110
6	VRIDHACHALAM	79.3266	11.5161	87
7	KUPPANATHAM	79.3604	11.5405	86
8	Me.MATHUR	79.28015	11.5168	80
9	VADAKUTHU	79.5632	11.6224	79
10	VEPPUR	79.1219	11.5266	75
11	PARANGIPETTAI	79.7568	11.5084	71
12	SRIMUSHNAM	79.4061	11.4017	68
13	KURINJIPADI	79.5973	11.5622	65
14	LAKKUR	79.0144	11.4666	61
15	ANNAMALAI NAGAR	79.7147	11.3921	60
16	CHIDAMBARAM	79.6912	11.407	52
17	TOZHUDUR	78.995	11.4117	51
18	KATTUMANNARKOVIL	79.5519	11.28	48
19	SETHIYATHOPE	79.5425	11.4369	45
20	KILACHERUVAI	79.0977	11.4082	45
21	BHUVANAGIRI	79.653	11.4459	41
22	KOTHAVACHERI	79.6406	11.5238	40
23	PELANDURAI	79.2917	11.415	39
24	LALPET	79.5629	11.3044	22

Fig 11. Rainfall level in mm during fengal cyclone

C. Elevation map

Elevation refers to the height of an object on the earth's surface from Mean Sea Level (MSL). From the past cyclone data analysis over the area, it was found that mountain/hills are working like as a barrier for cyclone wind, they protect all the areas/land that is behind of them from the effect of cyclone wind. The elevation dataset was obtained from shuttle radar topography mission (SRTM GL3) global 90mm. In the present study, elevation was considered as an important parameter for mapping of cyclone vulnerability wherein the elevation dataset of the study area has been divided into five cyclones vulnerable zone based on the height of the land. Fig 5. depicts the elevation map of the region

Table VI Elevation range

TERM	APPROXIMATE ELEVATION RANGE	DESCRIPTION
Lowland	0 – 200 meters (0 – 650 ft)	Flat areas near sea level; plains, coasts
Upland	200 – 500 meters (650 – 1,640 ft)	Gently rising hills and plateaus
Highland	500 – 1,500 meters (1,640 – 4,900 ft)	Hilly or mountainous terrain
Mountainous	1,500 – 3,000 meters (4,900 – 9,800 ft)	Steeper mountains, alpine regions
High Mountain / Alpine Zone	3,000+ meters (9,800+ ft)	Very high elevations; snow-capped peaks

a. *Viluppuram district*

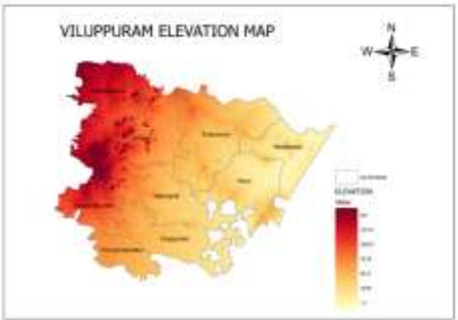

Fig 12. Elevation map for Viluppuram district

b. *Cuddalore district*

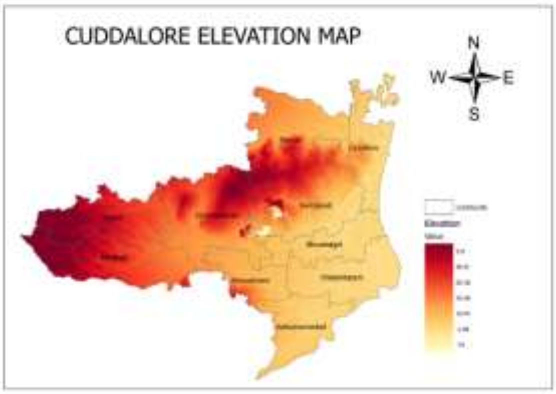

Fig 13. Elevation map for Cuddalore district

D. Slope map

The slope of a line is the measure of the steepness and the direction of the line. Finding the slope of lines in a coordinate plane can help in predicting whether the lines are parallel, perpendicular, or none without actually using a compass. The slope of any line can be calculated using any two distinct points lying on the line. The slope of a line formula calculates the ratio of the "vertical change" to the "horizontal change" between two distinct points on a line. The slope data was obtained from shuttle radar topography mission (SRTM GL3) global 90mm.

Table VII Slope range

Slope (%)	Slope (°)	Description
0–2%	0–1.1°	Flat or nearly flat
2–5%	1.1–2.9°	Gentle slope
5–15%	2.9–8.5°	Moderate slope
15–30%	8.5–16.7°	Steep slope
30–45%	16.7–24.2°	Very steep
45%+	24.2°+	Extremely steep

a. Viluppuram district

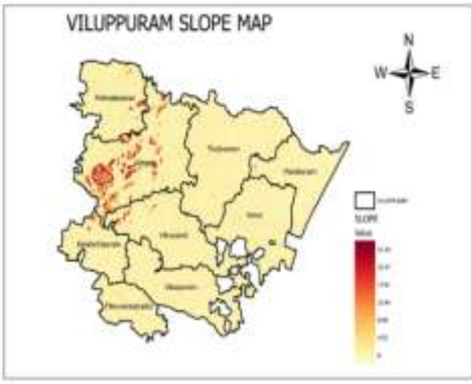

Fig 14. Elevation map for Viluppuram district

b. Cuddalore district

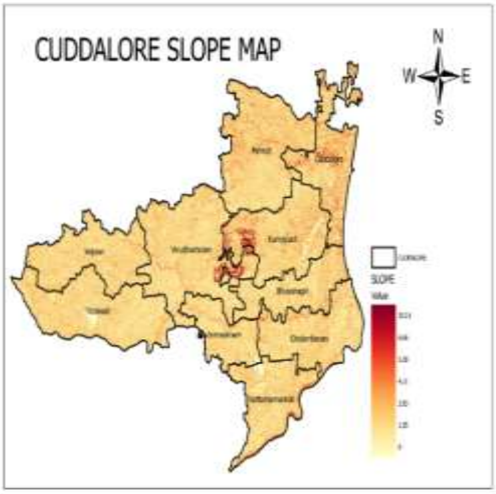

Fig 15. Elevation map for Cuddalore district

E. Wind map

a. Viluppuram district.

A wind speed distribution map was developed for Viluppuram district to assess the storm's impact. This map utilized a color-coded scheme: dark green indicated areas experiencing wind speeds up to 45 miles per hour (approximately 72 km/h), light green represented zones with wind speeds ranging from 35 to 40 mph (56–64 km/h), and yellow denoted regions with wind speeds between 20 to 25 mph (32–40 km/h). The analysis revealed that the northern and coastal regions of Viluppuram were subjected to higher wind intensities, correlating with the cyclone's trajectory and the India Meteorological Department's reports of gale winds reaching 70–80 km/h, gusting up to 90 km/h in the area.

Fig 16. Wind density map for Viluppuram district

c. Cuddalore district

A wind speed distribution map was developed for Cuddalore district to assess the storm's impact. This map utilized a color-coded scheme: dark green indicated areas experiencing wind speeds up to 45 miles per hour (approximately 72 km/h), light green represented zones with wind speeds ranging from 35 to 40 mph (56–64 km/h), and yellow denoted regions with wind speeds between 20 to 25 mph (32–40 km/h). The analysis revealed that the coastal and central regions of Cuddalore were subjected to higher wind intensities, correlating with the cyclone's trajectory and the India Meteorological Department's reports of gale winds reaching 75–85 km/h, gusting up to 95 km/h in the area.

Fig 17. Wind density map for Cuddalore district

F. Stream order map

Stream order is a system for classifying streams by size and branching complexity, with higher-order streams formed as smaller ones merge. Stream order maps are crucial for flood risk assessment, as higher-order streams have larger catchments and greater flood potential. These maps help identify flood-prone areas and guide flood management and planning without complex modeling. Here is the stream order maps for Viluppuram and Cuddalore, useful for identifying areas at risk of flooding.

a. Viluppuram district

Fig 18. Stream order map for Viluppuram district

b. Cuddalore district

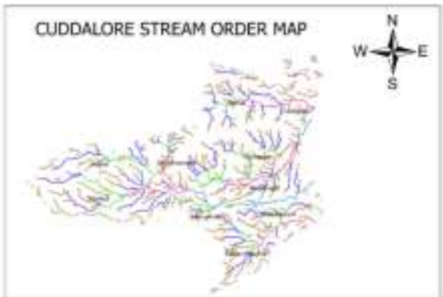

Fig 19. Stream order map for Cuddalore district

G. Drainage Density map

A drainage density map is a spatial representation that illustrates the total length of all streams and rivers within a drainage basin divided by the basin's total area. Mathematically, it's expressed as:

Drainage Density (Dd) = Total Length of Streams (L) / Basin Area (A)

a. Viluppuram district

The Viluppuram Drainage Density Map provides a spatial representation of drainage density across the district, which is a critical factor in flood risk assessment. Drainage density, defined as the total length of streams per unit area, influences the area's hydrological response to rainfall. High drainage density areas, shown in red and orange shades on the map, typically indicate regions with faster runoff and potentially higher flood susceptibility due to reduced infiltration and rapid water accumulation. Conversely, areas with low drainage density, represented in green shades, are less prone to flooding. This map serves as a foundational layer in identifying zones at greater risk of flooding and aids in planning effective water management and disaster mitigation strategies in Viluppuram.

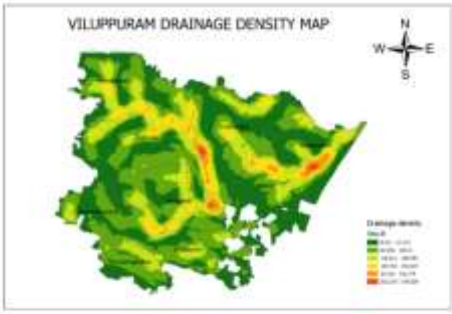

Fig 19. Drainage density map for viluppuram district

b. Cuddalore district

The Cuddalore Drainage Density Map illustrates the spatial variation in drainage density across the district, which is a vital parameter in understanding and evaluating flood risk. Areas with higher drainage density, shown in red and orange hues, are more prone to rapid surface runoff due to the presence of a dense network of streams and rivers. These zones are more susceptible to flooding, especially during intense rainfall events. On the other hand, regions represented in green tones have lower drainage density and are typically less vulnerable to flood hazards. By analyzing this map, critical flood-prone areas in Cuddalore can be identified, enabling better planning and implementation of flood mitigation and land-use management strategies.

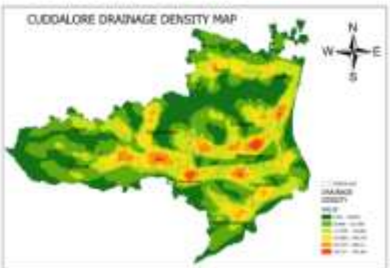

Fig 20. Drainage density map for Cuddalore district

H. Flood risk assessment and mapping

A comprehensive flood risk assessment was conducted for the districts of Viluppuram and Cuddalore in Tamil Nadu, utilizing a multi-criteria geospatial approach. Key parameters integrated into the analysis included land use and land cover (LULC), drainage density, slope, elevation, and precipitation. Each of these factors plays a significant role in influencing flood susceptibility.LULC analysis revealed that urbanized areas, characterized by impervious surfaces, tend to have higher runoff rates, thereby increasing flood risk. Conversely, regions with dense vegetation or forest cover can mitigate flooding by enhancing infiltration and reducing surface runoff.

Drainage density, calculated as the total length of streams per unit area, was found to be a critical factor; areas with higher drainage density facilitate quicker water movement, which can lead to rapid flooding during heavy rainfall events.

Topographical features, such as slope and elevation, were also significant. Steeper slopes contribute to faster runoff, reducing the time for water to infiltrate the soil, while low-lying areas are more prone to water accumulation. Precipitation data, particularly monthly rainfall patterns, provided insights into temporal variations in flood risk, highlighting periods when the districts are more vulnerable to flooding.

By integrating these parameters using Geographic Information System (GIS) tools, flood-prone zones were delineated, categorizing areas into varying risk levels. This assessment serves as a valuable resource for urban planners, disaster management authorities, and policymakers, facilitating informed decision-making for flood mitigation strategies and sustainable land use planning in Viluppuram and Cuddalore.

a. Viluppuram district

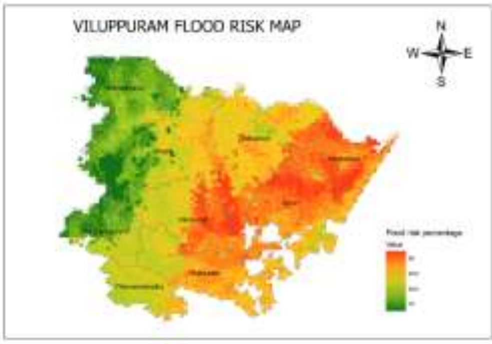

Fig 21. Flood risk assessment and mapp for Viluppuram district

b. Cuddalore district

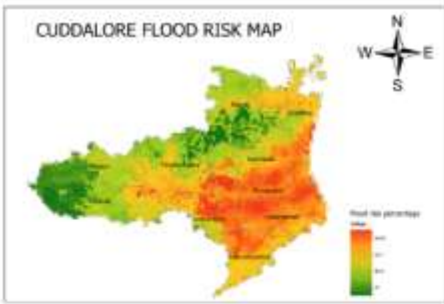

Fig 22. Flood risk assessment and map for Cuddalore district

9. IMPACT OF FENGAL CYCLONE

A. Impact of fengal cyclone on public health:

The Fengal Cyclone (November 2024) had several impacts on public health in affected areas like Viluppuram and cuddalore regions.

B. Flooding and waterborne diseases:

Heavy rainfall and flooding caused contamination of drinking water sources. This increased the risk of waterborne diseases like diarrhea, cholera, and dysentery, especially in flood-affected areas.

C. Increased risk of vector-borne diseases:

The stagnant water left behind by the cyclone's rainfall provided breeding grounds for mosquitoes, leading to a higher risk of diseases like malaria, dengue, and chikungunya

D. Injuries and accidents:

Strong winds and fallen trees caused injuries to people. The destruction of infrastructure, including roads and buildings, increased the risk of accidents and made emergency medical services harder to access.

E. Mental health issues:

The trauma caused by the cyclone's destruction, loss of homes, livelihoods, and the psychological strain of recovery, led to an increase in stress, anxiety, and depression among the affected population.

F. Disruption to healthcare services:

Flooding and damage to roads disrupted the movement of healthcare workers, medicines, and medical supplies, hampering efforts to treat patients and control diseases.

G. Malnutrition

The cyclone damaged crops and food supplies, leading to food shortages. This posed a risk of malnutrition, especially among vulnerable groups such as children, the elderly, and those with pre-existing health conditions.

H. Public health interventions:

Several Public Health Interventions were implemented to address impending potential outbreaks following a disaster, including:

- Proactive Preparedness ahead of Cyclone Fengal
- Timely communication and response to Cyclone Fengal alert
- Establishment of State-level advisory and monitoring Team
- Establishment of District control room at the district level
- Reactivation of the dedicated Helpline for emergency support
- Risk assessment and stratification of affected blocks in the flood affected districts
- Deployment of Task-Specific Teams for Post-Flood Public Health Management
- Disease surveillance and outbreak prevention

1.proactive preparedness ahead of cyclone fengal

With the onset of the Northeast monsoon, a comprehensive "Assessment of Health Facilities" was carried out across 14 coastal districts to strengthen emergency preparedness and disaster response mechanisms. This included evaluating the capacity and readiness of existing healthcare infrastructure to manage potential crises, such as floods and disease outbreaks. Alternate health facilities were identified and strategically mapped to provide seamless healthcare services in areas where Primary Health Centres (PHCs) were likely to be affected by flooding.

2. Timely communication and response to cyclone fengal alert

Once the weather alert for Cyclone Fengal was issued by the Regional Meteorological Centre, India Meteorological Department (IMD), Chennai the information was promptly communicated from the State Headquarters to the Districts. Immediate action was taken to notify and alert the concerned districts, ensuring all relevant authorities, including the State and District Disaster Management Authorities, State Disaster Response Force, Police and Fire Departments, Municipal Administration, and the Rural and Panchayat Raj Department, were kept informed and mobilized without delay. This swift communication enabled the districts to initiate appropriate preparedness measures, including monitoring, evacuations, and deployment of resources, to mitigate the impact of the cyclone and safeguard public safety.

3. Establishment of state-level advisory and monitoring team

A State-Level Advisory and Monitoring Team was set up to manage health challenges after Cyclone Fengal. Led by senior public health officials, the team coordinated with district health officers to oversee medical camps, disease surveillance, water chlorination, vector control, and medical supplies. Daily review meetings ensured timely responses and addressed district-specific needs. The team also secured additional funds from state disaster management authorities to support their efforts.

4. Establishment of district control room at the district level

The district administration set up a District Control Room led by the District Collector, bringing together departments like Revenue, Health, Police, Electricity, and Water Boards to coordinate flood rescue and recovery with the State Disaster Response Force. Public health teams quickly launched epidemic prevention measures, activated emergency operation centres and helplines, and monitored disease incidence in flood-affected areas. Field activities included data collection from mobile medical units, static camps, and the IHIP platform to guide response efforts.

5. Reactivation of the dedicated helpline for emergency support

A District Public Health Control Room was set up in all flood-affected districts within the District Collectors' Office, comprising officials from key departments, including Health, Municipalities/Corporations, Electricity, Fire and Safety, Police, Public Works, and Highways. The existing Disaster helpline (1077) was reactivated, with extensive publicity through media channels to ensure prompt assistance. Managed by the District Disaster Team, the helpline received calls from the public, and the relevant officials were promptly notified to take appropriate action. Additionally, the team gathered information on critical needs such as electricity restoration, waterlogging issues, and food distribution.

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6. Risk assessment and stratification of affected blocks in the flood affected districts

Following an assessment of the damage by the Revenue Department, Mobile Medical Teams were strategically deployed to areas with the most severe impact for disease surveillance. Among the 14 affected districts, Tiruvannamalai (including Cheyyar), Villupuram, Krishnagiri, and Cuddalore were particularly hard-hit. Within these four districts, 14 blocks were identified as the most severely impacted. The teams monitored the number of illnesses reported at the Medical camps, and based on this data, the affected areas were categorized by their risk of disease outbreaks. These high-risk blocks were placed under continuous surveillance to monitor for any potential outbreaks.

7. Deployment of task-specific teams for post-flood public health management

Additional and Joint Directors of Public Health were appointed to oversee district health activities after Cyclone Fengal, supervising medical camps, vector control, and chlorination. District Health Officers managed field operations and quickly organized logistics within 1-2 days. Daily virtual meetings with block teams guided post-flood disease control, using data analysis to plan targeted medical camps. Block teams helped prioritize high-risk areas and plan outbreak prevention. Field teams ensured chemoprophylaxis and NCD drug distribution in affected regions. Task-specific teams for flood response, vector control, and water analysis were formed, enabling prompt epidemic prevention and disease control based on field reports.

8. Flood response medical teams:

To combat disease during the North East monsoon, Tamil Nadu launched 1,000 special medical camps from October 2024, serving over 42 lakh people by December. In flood-affected districts, 7,870 camps treated thousands of fevers, ARI, and ADD cases. Medical teams provided treatment, preventive medicines, and care for vulnerable groups. Mosquito control measures included larvicide, fogging, and use of oil and bleaching powder balls to prevent outbreaks of diseases like dengue and leptospirosis.

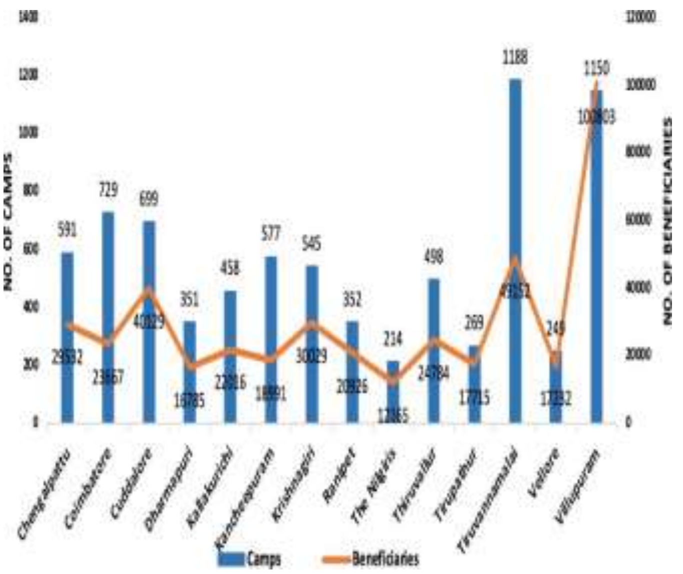

Fig 23 Distribution of Medical Camps and Beneficiaries in the fourteen Cyclone Fengal-affected Districts of Tamil Nadu between December 1 and 13, 2024

10. CONCLUSIONS

- Cyclones pose significant hazards to Tamil Nadu, especially its coastal districts, causing high winds, storm surges, and heavy rainfall that lead to casualties, property loss, and environmental damage.
- Cyclone risk varies across Tamil Nadu, with districts like Chennai, Cuddalore, Nagapattinam, Thoothukudi, and Ramanathapuram classified as high-risk zones due to their exposure to wind speeds exceeding 160 km/h and storm surge.
- Structural assessments in cyclone-prone areas reveal that non-engineered buildings with mud walls and thatched roofs suffer major damage during cyclones, while engineered structures with reinforced concrete and proper drainage systems show minimal damage and better resilience.
- Land use in both Viluppuram and Cuddalore districts is dominated by agriculture, but rapid urbanization and declining wetlands in Cuddalore are increasing environmental challenges and vulnerability to cyclonic impacts.
- Recent cyclones such as Ockhi (2017), Gaja (2018), and Fengal (2024) have demonstrated the recurring and severe nature of cyclonic events in this region, underlining the need for improved infrastructure, regular maintenance, and disaster preparedness to reduce future risks.

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