

Geo-Computational Intelligence for Predictive Cyclone Impact and Multi- Tiered Risk Stratification in Chennai, Tamil Nadu Leveraging AI-Enabled Framework

A. Pon Priya¹,

¹Department of Environmental Engineering, Government College of Technology, Coimbatore
Thadagam Road, Coimbatore, Tamil Nadu - 641 013, India, ponpriya100@gmail.com

Dr.M. Kumar²

²Department of Civil Engineering, Government College of Technology, Coimbatore
Thadagam Road, Coimbatore, Tamil Nadu - 641 013, India, kumargeo_77@gct.ac.in

ABSTRACT

Cyclones are a recurring natural hazard in India, often resulting in significant loss of life and property. Chennai, a coastal city in Tamil Nadu, India, is particularly at risk to cyclone damage because of many factors, like high population density, encroachment in coastal areas and water bodies, and its proximity to the Bay of Bengal. Therefore, the study focuses to predict the Cyclone Damage by combining remote sensing, GIS, and machine learning techniques. Ten spatial criteria were selected; they are processed into thematic layers. Hexagonal Tessellation is used to create a Random Points for training the machine learning model—the random forest classifier. Random points were generated within these hexagonal grids to collect sample data for model training. Each point was assigned values from thematic layers. The Random Forest Classifier was trained using these points to learn relationships between input factors and damage levels. The model categorized the area into low, moderate, and high damage zones based on combined factor influence. The findings shows that 26% of the total area comes under highly damageable zone, 66% under moderate damageable zone and 8% under low damageable zone.

Keywords: Artificial Intelligence, Chennai Cyclone, Cyclone Damage, Disaster Risk Reduction, Machine Learning Model, Training and Validation.

I. INTRODUCTION

Cyclones are triggered by atmospheric instabilities around a low-pressure area. Cyclones are typically accompanied by extreme storms and worst weather condition. The air circulates inner in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere [1] Cyclones are categorized by their disastrous potential to harm the constructions such as Residential Buildings, Hospitals, Storage Facilities, Roads and Railways, Agri crops, Vegetation, due to extreme wind speed. Heavy rainfall leads to inundating. Storm surge overwhelms the low-lying zones in coastal side area which results in loss of lives and properties, including beach erosion, loss of vegetation and reducing the quality of soil conditions. Even though it is impossible to completely dodge the effects formed by natural disasters, but it can be reduced by undertaking some long time or short time Structural and Non-structural mitigation measures such as developing early warning system provision, restrict the construction in prone zones, waterbodies, providing better evacuation and safe shelter locations to the people those who are in predicted damageable areas.

1.1 TROPICAL CYCLONE

- Tropical cyclones, are main natural instabilities affecting natural life, property and the environment in coastal areas [2] .
- They form above warm ocean waters adjoining the equator, where the sea surface temperature is at least 26.5 °C [3].
- Cyclones in the North Atlantic and Northwestern Pacific are classified on the Saffir-Simpson

Hurricane Wind Scale, ranging from Category 1 to Category 5, which evaluates the potential damage of the cyclone [4].

- The impacts of tropical cyclones can be decreased by using suitable management methods. An active cyclone disaster management plan is planned into four phases response, recovery, prevention/reduction and preparedness [2].
- The Saffir-Simpson Hurricane Scale is shown in Table 1.1

TABLE 1.1 SAFFIR-SIMPSON HURRICANE SCALE

Category	Sustained Windspeed in mph	Damage
1	74-05 (64-82kt)	Minimal
2	96-110 (83-95kt)	Moderate
3	111-130 (96-113kt)	Extensive
4	131-155 (114-135kt)	Extreme
5	156 or above (135 kt or more)	Catastrophic

Source: National Oceanic and Atmospheric Administration (NOAA) [5]

The classification of cyclone based on wind speed over the North Indian Ocean is shown in Table 1.2

TABLE 1.2 THE CLASSIFICATION OF CYCLONE BASED ON WIND SPEED

Type	Windspeed in kmph	Windspeed in Knots
Low Pressure area	Less than 31	Less than 17
Depression	31-49	17-27
Deep Depression	50-61	28-33
Cyclonic Storm	62-88	34-47
Severe Cyclonic Storm	89-118	48-63
Very Severe Cyclonic Storm	119-221	64-119
Super Cyclone	222 or more	120 or more

Source: Cyclone Warning in India – Standard Operation Procedure (SOP)- Indian Meteorological Department (IMD) [6]

1.2 HISTORICAL CYCLONE EVENTS

Reviewing **historical cyclone events** provides details about their frequency, intensity, and changing patterns over time. It helps scientists, meteorologists understand how climate variability, influences cyclone's behavior. Historical data also play an important role in **improving forecasting, early warning systems, enhancing disaster preparedness, and mitigation strategies**. The Table 1.3 shows the Historical cyclone events in study area.

TABLE 1.3 THE CLASSIFICATION OF CYCLONE BASED ON WIND SPEED

Year	Cyclone Name	Windspeed in Kmph	Cyclone Type
2011	Thane	145	Very severe cyclonic storm
2012	Nilam	85	Cyclonic storm
2016	Vardah	130	Very Severe cyclonic storm
2020	Nivar	120	Very severe cyclonic storm
2022	Mandous	95	Severe cyclonic storm
2023	Michaung	100	Severe cyclonic storm

1.3 CYCLONE IMPACT REDUCTION & MITIGATION MEASURES

According to the National Disaster Management Authority (NDMA) guidelines [4], cyclone risk reduction must change beyond post-disaster relief towards a

mitigation-based and preparedness-based approach.

It involves combining structural and non-structural measures. According to NDMA guidelines, Mitigation Measures were classified into Short-term strategies and Long-term strategies.

1.3.1 SHORT-TERM STRATEGIES

- Identify the vulnerable infrastructure and Population using High risk zones map.
- Use AI model to propose the Safe Evacuation maps and Safe shelter locations.
- Instant protective measures such as safeguarding buildings, cleaning DRAINAGE, relocating livestock and equipment in mapped vulnerable zones.
- Spatial Outputs are used for Emergency Response Planning like supporting relief centres, allotting resource, medical attentiveness.

1.3.2 LONG-TERM STRATEGIES

- Prevent construction in restriction zones like in waterbodies, coastal area which are falls under High-risk zones.
- Managing the coastal zone by protecting and improving the Mangroves, wind break plantations such as Casuarina, Palmyra palm, Eucalyptus etc.
- Build the public usage infrastructures like Roads, Bridges, House, Drainage, Hospitals, Community Halls, Shelter sites, multi-purpose hall in low-risk zones.
- Build the AI risk models for cyclone impact prediction and to alert the localities.

1.4 AIM

The research aims to predict cyclone-induced damages efficiently by integrating the advancements in Geospatial technologies and Artificial Intelligence to quantify the risk stratification of cyclone damage for Chennai District, Tamil Nadu.

1.5 NEED OF THE STUDY

- To assess the Environmental Impact like Urban area flooding, Coastal erosion, Water treatment and drainage infrastructure damage.

- To design the sustainable urban planning by identifying the high-risk zones to prevent construction in restriction(vulnerable) area and to ensure harmless urban growth associated with environmental sustainability.
- To enhance Disaster risk reduction and preparedness by predicting areas that falls under risk zones before cyclone landfall and it will enable the hands-on planning mitigation strategies like stormwater management, clearance drainage, flood barriers etc.

1.6 OBJECTIVE OF THE STUDY

- To define and delineate the study area – Chennai city.
- To collect geospatial datasets, including cyclone track, rainfall, wind speed, population, pre- and post-cyclone satellite images, and stream network.
- To prepare thematic layers such as rainfall, wind speed, population and household density, stream and cyclone track range, and land use land cover change.
- To train a machine learning model -Random Trees Classifier using random sample points with different variables and damage status.
- To produce a spatial damage risk prediction map classifying areas into high, moderate, and low risk zones.

II.LITERATURE REVIEW

M. Thenmozhi et al., have conducted research on “Assessment of cyclone risk and case study of Gaja cyclone using GIS techniques and machine learning algorithms in coastal zone of Tamil Nadu, India” 2024: This study evaluated cyclone risk and the impact of Cyclone Gaja, by weighting key factors like elevation, slope, distance to coast, cyclone tracks, LULC, population density, cyclone shelter proximity, household density, healthcare access, NDVI, and awareness levels. Areas such as Daddavari, Vedharanyam, and Velankanni face high risk, while Nagore and Nagapattinam are low-risk zones. They used ML Model to generate pre- and post-cyclone LULC maps, representing main changes: farm land, barren land, built-up are decreased and water bodies are increased. [7].

Sultan AL Shafian et al., have researched on **“Integrating Machine Learning and Remote Sensing in Disaster Management: A Decadal Review of Post-Disaster Building Damage Assessment” 2024**: This paper presents a bibliometric review of methodologies for post-disaster building damage valuation, focusing on advanced data acquisition technologies and computer-based techniques. These findings show important progress in data collection and analysis, with machine learning and remote sensing playing a vital role in improving damage assessments [8].

Showmitra Kumar Sarkar et al., studied **“Cyclone vulnerability assessment in the coastal districts of Bangladesh:” 2024**: This study developed a cyclone vulnerability map using Principal Component Analysis (PCA), focusing on three key dimensions: exposure, sensitivity, and adaptive capacity. Eighteen factors were analyzed, with sensitivity and adaptive capacity explaining high chances of data variation. Sensitivity was generally excessive, especially in Noakhali, Lakshmipur, and Chandpur, highlighting these regions vulnerability to cyclones [9].

Subbarayan Saravanan et al., done research on **“Multi-Criterion Analysis of Cyclone Risk along the Coast of Tamil Nadu, India—A Geospatial Approach” 2023**: This study includes the creation of a cyclone risk map by using four different components: hazards, exposure, vulnerability, and mitigation. They used an Analytical Hierarchical Process (AHP) technique to calculate a united risk index considering 16 spatial variables. The resulting risk assessment shows the cyclone risk is higher in zones 1 and 2 in the study area and emphasizes the variations in mitigation impact on cyclone risk in zones 4 and 5. The final ending risk maps explains that low-lying areas near the coast, comprising about 3%, are recognized as taking the adaptive facility for disaster mitigation [10].

Hamid Varikkodan et al., conducted a study on **“Tropical cyclone risk assessment of Port Blair, Andaman Islands, India by using numerical modelling and geospatial techniques” 2023**: This study developed a comprehensive cyclone risk map using numerical modelling and GIS technology. They consider 13 criteria under vulnerability, hazard, and mitigation were weighted using the Analytical Hierarchy Process

(AHP) and combined into an overall risk map. Ending results show that 13% of the area falls in the very low-risk zone, 21% in low-risk, 22% in medium-risk, 34% in high-risk, and 10% in extremely high-risk zones. Their study highlights the significant cyclone risk due to the region’s location near cyclogenesis areas in the Bay of Bengal and provides a foundation for informed disaster risk reduction strategies by local authorities [11].

Chaoyong Tu et al., carried out study on **“Tropical Cyclone Damage Assessment using a Projection Pursuit Dynamic Cluster Model” 2022**: This study used data from Sixty-two tropical cyclones that crossed in Guangdong Province, China, between 2000 and 2019 to assess cyclone damage risk. Six indices were considered: least central pressure, extreme wind speed, extreme rainstorm ratio, cumulative surface rainfall, cyclone track length, and lifetime. Their Results show that the PPDC model accurately reflects cyclone damage intensity and offers a scientific, objective method to support disaster prevention and mitigation strategies [12].

Muhammad Al-Amin Hoque et al., conducted a study on **“Tropical cyclone risk assessment using geospatial techniques for the eastern coastal region of Bangladesh” 2019**: This study developed a tropical cyclone risk map using geospatial methods. They consider fourteen spatial criteria under vulnerability, hazard, and mitigation were weighted using the AHP and combined through a weighted overlay method [13].

Hal F. Needham et al., studied about **“A review of tropical cyclone-generated storm surges: Global data sources, observations, and impacts”**: This study provides the detailed global evaluation of Tropical cyclone – storm surge data bases. This study provides info about Tropical Cyclones and its impacts on people and property. The Bay of Bengal detects the most calamitous surge impacts, as 59% of global tropical cyclones that have killed at least 5000 people occurred in this basin. The six deadliest cyclones in this region have each killed at least 140,000 people, and two events have killed 300,000 [14].

Akhila G Nair et al., conducted a study on **“A Study on Various Tropical Cyclone Hits in India – Through Gis Approach” 2018**: In this paper, they studied about various tropical cyclone. And the effects of TC are Storm

surges, flood, high winds, inundation and erosion etc. Here Remote Sensing and GIS play an important factor in speedy warning, real time monitoring and damage assessment [15].

Ubaydur Rahaman et al., conducted research on “Cyclonic track analysis using GIS over the Bay of Bengal” 2012: This paperwork noted the occurrence, past records, and severe cyclonic track of cyclones over the Bay of Bengal for the last 100 years. Their unique combination of a large tide, a funneling coastal configuration, low flat terrain and frequent severe tropical storms occasionally produce storm surges that have killed thousands of people. GIS method has been used to find out the formation area and tracks of Tropical Cyclones over the Bay of Bengal [16].

III. STUDY AREA AND ITS DESCRIPTION

3.1. STUDY AREA

- The selected study region is Chennai, Tamil Nadu with 16 administrative taluks, shown in Fig 3.1 also known as Madras is the capital city of the Tamil Nadu [17].
- Chennai is situated on South-east coast of India in the North-Eastern part of Tamil Nadu. Chennai is located at flat coastal plain with average elevation of 6.7m [18]. Usual gales in Chennai region are south-west among April and October and north-east during the balance of the year.
- Cyclones and depressions are common natural disturbances during this season in Chennai region. Flooding occur in low-lying areas during this season like significant flooding in 2015 and 2023. Chennai had high number of lakes extent across the city, but high city growth has led to the reduction of water bodies and marshlands [18]. So it represents increase in impervious surface will lead to flooding, inundation problems.
- Chennai city is spread over an area of 426 sq.km, divided into North Chennai, South Chennai and Central Chennai. According to 2011 census, Chennai had a population of 6.7 million.

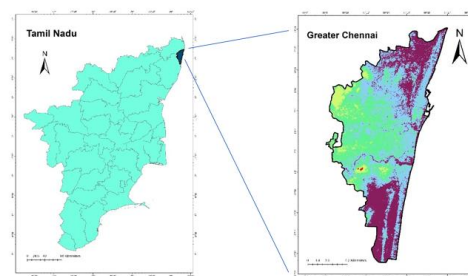


Figure 3.1 Study Area : Chennai District

3.2 ADMINISTRATION BOUNDARIES

The entire study area is classified into three administrative divisions, namely North Chennai, South and Central Chennai with 16 taluks is mentioned in the Table 3.1.

TABLE 3.1 ADMINISTRATIVE DIVISIONS OF CHENNAI

S.No.	Taluk	Area(sq.km)
1	Alandur	25.96 sq.km
2	Ambattur	37.56 sq.km
3	Aminjikarai	15.99 sq.km
4	Ayanavaram	15.31 sq.km
5	Egmore	17.41 sq.km
6	Guindy	20.90 sq.km
7	Madhavaram	35.62 sq.km
8	Maduravoyal	22.65 sq.km
9	Mambalam	14.85 sq.km
10	Mylapore	22.31 sq.km
11	Perambur	17.88 sq.km
12	Purasaivakam	16.79 sq.km
13	Shollinganallur	75.88 sq.km
14	Thiruvottiyur	62.44 sq.km
15	Tondairpet	13.67 sq.km
16	Velalcheri	19.59 sq.km

IV. DATA AND SOFTWARE USED

4.1 GENERAL

This chapter deals with the materials, methodology and software that have been used in this study.

4.2 DATA USED

The data used for predicting cyclone impact are shown in Table 4.1

TABLE 4.1 DATA USED

S.No.	Data	Source
1	SRTM (Shuttle Radar Topography Mission)	United States Geological Survey
2	LANDSAT 8, 9 OLI/TIRS	United States Geological Survey
3	Cyclone Wind intensity	NASA Power - Data Access viewer, Cyclone Event Report - IMD
4	Rainfall	TNSMART, NASA Power - Data Access viewer
5	Population Data	GeoIQ
6	Household Data	Open Street Map (Extract bbike)
7	Public Buildings	Diva GIS
8	Stream Data	Diva GIS
9	Cyclonic Track	NOAA - IBTrACS

4.3 DATA DESCRIPTION

4.3.1 SRTM DIGITAL ELEVATION MODEL

- **Shuttle Radar Topography Mission (SRTM)** were used to derive Digital Elevation Data (DEM) with high resolution of 3 arc- seconds. It is shown in Fig 4.1
- It is acquired from USGS (**United States Geological Survey**) Website [19].
- It provides information about land's surface without any physical features like settlements, plants, trees, or other things in Earth.
- It shows the land's surface with elevation like mountain or valley.
- It helps to identify the area with low and high elevation in land's surface.

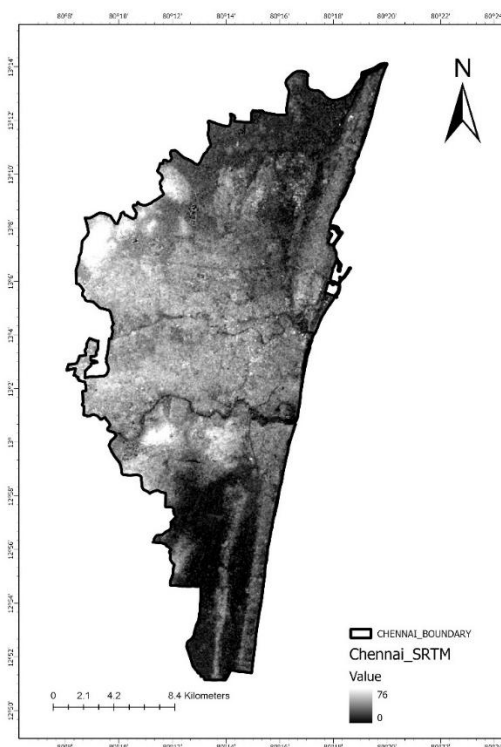


Figure 4.1 SRTM DEM for Study Area

4.3.2 LANDSAT 9 OLI/TIRS

- Landsat 9 OLI/TIRS is acquired from United States Geological Survey (USGS) which is used for classification of Land Use and Land Cover for study area. Landsat 9 OLI/TIRS which carries two instruments: OLI (Operational Land Imager) and TIRS (Thermal Infrared Sensors).
- For LULC, Band combination 4,3,2 is used for classification, it's a Natural Color Composite. This band combination is better for LULC classification, specifically for analyzing Settlements, Roads, and water bodies, vegetation based on their natural appearance.
- OLI provides nine spectral bands and TIRS provides two spectral bands. They are shown in Table 4.2 and Image is shown in Fig 4.2

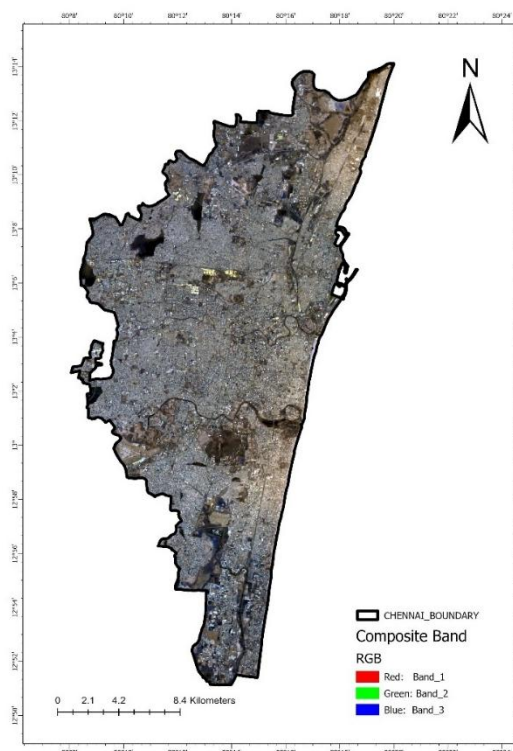


Figure 4.2 Landsat Band Combination for Study Area

TABLE 4.2 PRODUCT SPECIFICATIONS OF LANDSAT 9 OLI/TIRS

Band	Description	Wavelength(μm)
1	Visible Coastal Aerosol	0.43 - 0.45 μm
2	Visible Blue	0.450 - 0.51 μm
3	Visible Green	0.53 - 0.59 μm
4	Red	0.64 - 0.67 μm
5	Near-Infrared	0.85 - 0.88 μm
6	SWIR1	1.57 - 1.65 μm
7	SWIR2	2.11 - 2.29 μm
8	Panchromatic (PAN)	0.50 - 0.68 μm
9	Cirrus	1.36 - 1.38 μm
10	TIRS 1	10.6 - 11.19 μm

11	TIRS 2	11.5 - 12.51 μm
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Source: USGS Landsat – 9 Mission [20]

4.3.3 CYCLONE WIND INTENSITY

- The wind speed data was acquired from NASA Power - Data Access viewer and Cyclone Event Report – IMD.
- Here in this study, selected two historical cyclones: Thane (2011) and Michaung (2023).
- Both cyclone wind intensity data acquired from NASA Power – Data Access viewer and Cyclone Event Report. Training model with two historical cyclone windspeed helps to identify the high-risk areas that is repeatedly affected by extreme wind speeds.
- Fig 4.3 shows Wind Speed of Cyclone Thane acquired from IMD report and Fig 4.4 shows Wind Speed Intensity of Cyclone Thane.

Table 1. Best track positions and other parameters of very severe Cyclonic storm THANE over the Bay of Bengal during 25-31 December, 2011.

Date	Time (UTC)	Centre lat./long. E	C.I. NO.	Estimated Central Pressure (hPa)	Estimated Maximum Sustained Surface Wind(Kt)	Estimated Pressure drop at the Centre(hPa)	Grade
25.12.2011	1200	8.5/88.5	1.5	1000	25	3	D
	1800	9.0/88.0	1.5	1000	25	3	D
26.12.2011	0000	9.5/87.5	2.0	998	30	4	DD
	0600	10.0/87.5	2.0	998	30	4	DD
	1200	10.5/87.5	2.0	998	30	5	DD
	1800	11.0/87.5	2.5	996	35	7	CS
27.12.2011	0000	11.5/87.5	2.5	994	40	8	CS
	0600	12.0/87.0	2.5	994	40	8	CS
	1200	12.5/86.5	2.5	992	40	10	CS
	1800	12.5/86.0	3.0	990	45	12	CS
28.12.2011	0000	12.5/85.5	3.0	990	45	12	CS
	0600	12.5/85.0	3.0	988	49	14	CS
	0900	12.5/85.0	3.5	986	55	16	SCS
	1200	12.5/84.5	4.0	982	65	20	VSCS
	1500	12.5/84.0	4.0	980	65	22	VSCS
	1800	12.5/84.0	4.0	978	65	24	VSCS
	2100	12.5/83.5	4.0	976	65	26	VSCS
29.12.2011	0000	12.3/83.0	4.0	974	70	28	VSCS
	0600	12.0/82.0	4.5	972	75	30	VSCS
	0900	12.0/81.7	4.5	972	75	30	VSCS
	1200	12.0/81.3	4.5	972	75	30	VSCS
	1800	12.0/80.6	4.5	972	75	30	VSCS
30.12.2011	0000	11.8/79.9	4.5	972	75	30	VSCS
	0300	11.8/79.5	—	986	55	16	SCS
	0600	11.8/79.0	—	998	30	5	DD
	1200	11.8/78.2	—	1000	25	3	D
31.12.2011	0000	The system weakened into a well marked low pressure area over north Kerala and neighbourhood.					

D

DD

CS

SCS

VSCS

: Depression

: Deep Depression

: Cyclonic Storm

: Severe Cyclonic Storm

: Very Severe Cyclonic Storm

D : Depression
DD : Deep Depression
CS : Cyclonic Storm
SCS : Severe Cyclonic Storm
VSCS : Very Severe Cyclonic Storm

Figure 4.3 Wind Speed of Cyclone Thane acquired from IMD report

Latitude	Longitude	Windspeed (km/hr)
12.3	83	129.64
12	82	138.9
12	81.7	138.9
12	81.3	138.9
12	80.6	138.9
12.98	80.22	37.008
13.1347	80.2868	36
13.16	80.3	37.008
12.9	80.23	37.008
13.11	80.25	37.008
13.11	80.25	37.008
13.06	80.23	37.008
13.04	80.23	37.008
13.06	80.16	36.59
13.04	80.023	36
13.06	80.16	37.008
13.02	80.26	37.008
13.01	80.22	37.005

Figure 4.4 Wind Speed Intensity of Cyclone Thane

- The Michaung cyclone wind intensity, which is acquired from NASA Power – Data Access viewer (Overall wind speed along cyclone track) as NC file format.

4.3.4 RAINFALL

- Rainfall data was collected from Power Data Access Viewer provided by NASA and TNSMART (Tamil Nadu System for Multi-hazard potential impact Assessment and emergency Response Tracking).
- Here two historical drastic rainfall events are selected: 2015 Rainfall and Rainfall Induced Michaung Cyclone. Training AI model with two historical rainfall events is better than training with one model: it will achieve accuracy, and easy to compare and validate the result.
- Fig 4.5 shows the 2015 Rainfall data and Fig 4.6 shows that the Cyclone Michaung induced Rainfall data, both was collected from TNSMART.

Raingauge stations as on 2015-12-02						
SLNo	Name of the station	District/Taluk/Revenue Village	Started on	Latitude	Longitude	Status of station
18	Ambathur	Chennai Ambathur Ambathur	2019-10-25	13.1095	80.149	Working
19	Ayanavaram taluk office	Chennai Ayanavaram Ayanavaram (Part 1)	2019-10-25	13.0883	80.2318	Working
20	Chennai mayambakkam	Chennai Egmore Nungambakkam	2019-10-25	13.0667	80.25	Working
21	Anna university	Chennai Grundy Kottur	2019-10-25	13.0092	80.2342	Working
22	Govt sec school MGR Naras	Chennai Mambalam Saligramam	2019-10-25	13.0331	80.2027	Working
23	DIGP Office	Chennai Mylapore Mylapore (Part 1)	2019-10-25	13.05	80.2333	Working
24	Perambur Corporation park	Chennai Perambur Perambur (Part 3)	2019-10-25	13.0965	80.2922	Working
25	Chennai collectorate building	Chennai Paravakkam V.O.C Nagar	2019-10-25	13.1282	80.2916	Working
26	Sholinganallur	Chennai Sholinganallur CHOZHINGANALLUR-2	2019-10-25	12.8773	80.2277	Working
27	CD Hospital Tondiarpet	Chennai Tondiarpet Tondiarpet (Part 2)	2019-10-25	13.1093	80.2427	Working

Figure 4.5 Rainfall Data (02-12-2015): TNSMART

Raingauge stations as on 2023-12-03						
SLNo	Name of the station	District/Taluk/Revenue Village	Started on	Latitude	Longitude	Status of station
17	Alandur	Chennai Alandur MEENAMBARKAM	2019-10-25	12.9975	80.2006	Working
18	Ambathur	Chennai Ambathur Ambathur	2019-10-25	13.1095	80.149	Working
19	Ayanavaram taluk office	Chennai Ayanavaram Ayanavaram (Part 1)	2019-10-25	13.0883	80.2318	Working
20	Chennai mayambakkam	Chennai Egmore Nungambakkam	2019-10-25	13.0667	80.25	Working
21	Anna university	Chennai Grundy Kottur	2019-10-25	13.0092	80.2342	Working
22	Govt sec school MGR Naras	Chennai Mambalam Saligramam	2019-10-25	13.0331	80.2027	Working
23	DIGP Office	Chennai Mylapore Mylapore (Part 1)	2019-10-25	13.05	80.2333	Working
24	Perambur Corporation park	Chennai Perambur Perambur (Part 3)	2019-10-25	13.0965	80.2922	Working
25	Chennai collectorate building	Chennai Paravakkam V.O.C Nagar	2019-10-25	13.1282	80.2916	Working
26	Sholinganallur	Chennai Sholinganallur CHOZHINGANALLUR-2	2019-10-25	12.8773	80.2277	Working
27	CD Hospital Tondiarpet	Chennai Tondiarpet Tondiarpet (Part 2)	2019-10-25	13.1093	80.2427	Working

Figure 4.6 Rainfall Data (03-12-2023): TNSMART

4.3.5 POPULATION DATA

- Population data was collected from GeoIQ.
- It is an online platform that is developed by ESRI, a provider of GIS software and solutions. GeoIQ collects data from over 650 trusted government and public sources, including national surveys, ministry reports, open data platforms, public listings, satellite imagery, and mobility data. The data is refreshed at varying intervals-daily, weekly, or biweekly, depending on the source.
- The population data are shown in Fig 4.7

POPULATION DATA(sq.km)

Field: Add Calculate Selection: Select By Attributes

FID	Shape *	TEHSIL	Shape_Area	Population	
1	0	Polygon	ALANDUR	25.966713	10094
2	1	Polygon	AMBATTUR	37.569747	5949
3	2	Polygon	AMINJIKARAI	15.999615	36100
4	3	Polygon	AYANAVARAM	15.317292	16612
5	4	Polygon	EGMORE	17.478696	30493
6	5	Polygon	GUINDY	20.902343	1151
7	6	Polygon	MADHAVARAM	35.621887	5330
8	7	Polygon	MADURAVOYAL	22.651595	11077
9	8	Polygon	MAMBALAM	14.858091	37518
10	9	Polygon	MYLAPORE	22.317061	28493
11	10	Polygon	PERAMBUR	17.85926	22468
12	11	Polygon	PURASAIKAM	16.796984	35583
13	12	Polygon	SHOLLINGANALLUR	75.587864	8055
14	13	Polygon	TIRUVOTTIYUR	62.344417	9439
15	14	Polygon	TONDIARPET	13.679304	18422
16	15	Polygon	VELACHERI	19.598952	21113

Figure 4.7 Population density(sq.km)

4.3.6 HOUSEHOLD DATA

- The Household data was obtained from BBBike extracts Open Street Map.
- This platform provides global data in a unified scheme.
- It allows to extract study area from Planet OSM in many formats, here downloaded as .shp (shapefile) format.
- Household data was shown in Fig 4.8.

HOUSEHOLD DENSITY(sq.km) X					
Field:		Add	Calculate	Selection: Select By Attributes	
	FID	Shape *	TEHSIL	Shape_Area	Household
1	0	Polygon	ALANDUR	25.966713	746
2	1	Polygon	AMBATTUR	37.569747	829
3	2	Polygon	AMINJIKARAI	15.999615	1192
4	3	Polygon	AYANAVARAM	15.317292	1137
5	4	Polygon	EGMORE	17.478696	1029
6	5	Polygon	GUINDY	20.902343	588
7	6	Polygon	MADHAVARAM	35.621887	534
8	7	Polygon	MADURAVOYAL	22.651595	1096
9	8	Polygon	MAMBALAM	14.858091	1796
10	9	Polygon	MYLAPORE	22.317061	718
11	10	Polygon	PERAMBUR	17.85926	822
12	11	Polygon	PURASAIKAM	16.796984	1274
13	12	Polygon	SHOLLINGANALLUR	75.587864	499
14	13	Polygon	TIRUVOTTIYUR	62.344417	55
15	14	Polygon	TONDIARPET	13.679304	89
16	15	Polygon	VELACHERI	19.598952	1000

Figure 4.8 Household Density(sq.km)

4.3.7 PUBLIC BUILDINGS

- The public buildings data was obtained from Diva GIS, to find the safe shelter locations.
- Safe shelter location must locate in Low-risk area.
- Public buildings are downloaded as point data with its spatial attributes.
- The shelter locations for entire study area are shown in Fig 4.9

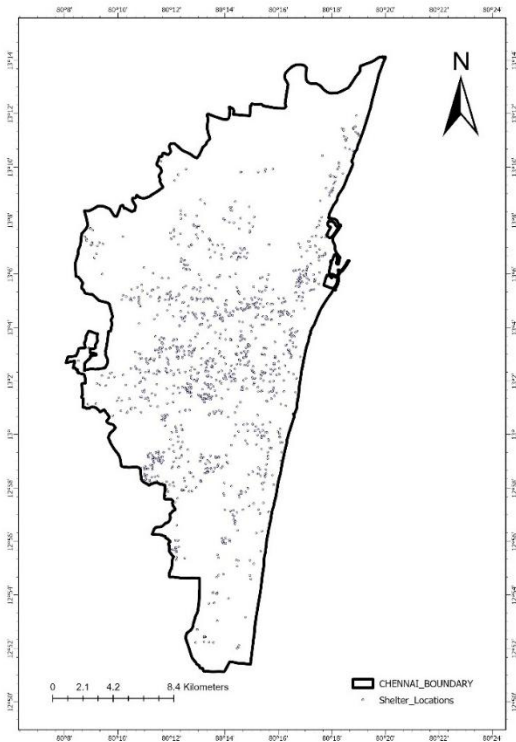


Figure 4.9 Public Building (Shelter Locations)

4.3.8 STREAM

- The stream data , Fig 4.10 was obtained from BBBike extracts Open Street Map, to find the distance from the stream.
- It provides global data in a unified scheme.
- It allows to study about destruction environments by Cyclone event to neighbourhoods.
- Stream data provides range of stream flow generated due to cyclone induced rainfall which directly leading to flooding, erosion.

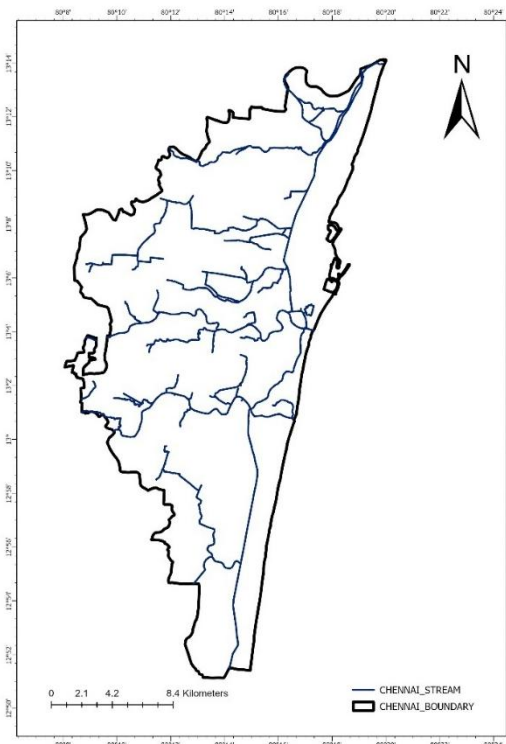


Figure 4.10 Stream Network in Chennai

4.3.9 CYCLONE TRACK

- The historical cyclone track and its details are acquired from International Best Track Archive for Climate Stewardship (IBTrACS) provided by National Oceanic and Atmospheric Administration (NOAA).
- IBTrACS is the global collection of cyclone data. The data from 1980 to present, cyclone data are available.
- Cyclone tracks are used to understand the spatial pattern of impacts and extent of damage by cyclone. The historical cyclones in Chennai district, Tamil Nadu is shown in Fig 4.11.

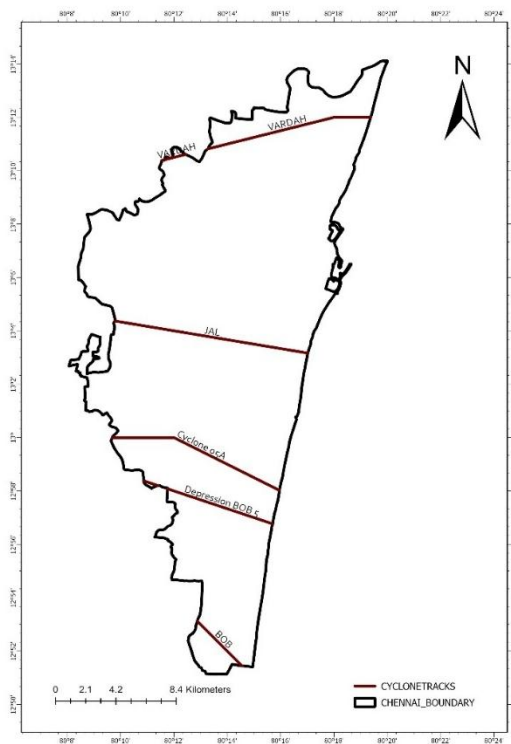


Figure 4.11 Tropical Cyclone Pathways near Chennai, Tamil Nadu Coast (IBTrACS, NOAA)

- The historical cyclones that crossed the path in Chennai district: Jal Cyclone (2010), Vardah (2016), Cyclone 05A (1996), Depression BOB (1994), Depression BOB 5 (2021).

4.3.10 CHANGE DETECTION

- Flood change detection was done using Landsat 8 Imagery for two selected flood events: Chennai 2015 Flood and Cyclone Michaung 2023 Flood. It is analyzed to validate the final model of cyclone damage prediction. Pre- and post-flood maps were processed to extract water region using NDWI (Normalized Difference Water Index) technique.

4.4 SOFTWARE USED

- ArcGIS Pro** is used for classification of given data, allows user to explore, collect, store, analyze the data.
- It is a desktop licensed software, advanced version of basic ArcMap. It is used to analyze and correlate the spatial information with its

attributes and to identify the relationship between them.

- Helps to prepare thematic layers, perform machine learning model.
- **QGIS** have same application as ArcGIS, but difference is QGIS handles lots of data, helps to predict feature classification with historical information. And QGIS is rich in many plugins, easy to work with many platforms in single software.

V.METHODOLOGY

This chapter focuses the methodology adopted for Predicting Cyclone Impact Using AI techniques. Methodology is framed to attain spatial prediction by using high resolution Satellite Images, Landsat 9 OLI/TIRS and SRTM DEM.

The flowchart of methodology is shown in Fig 5.1

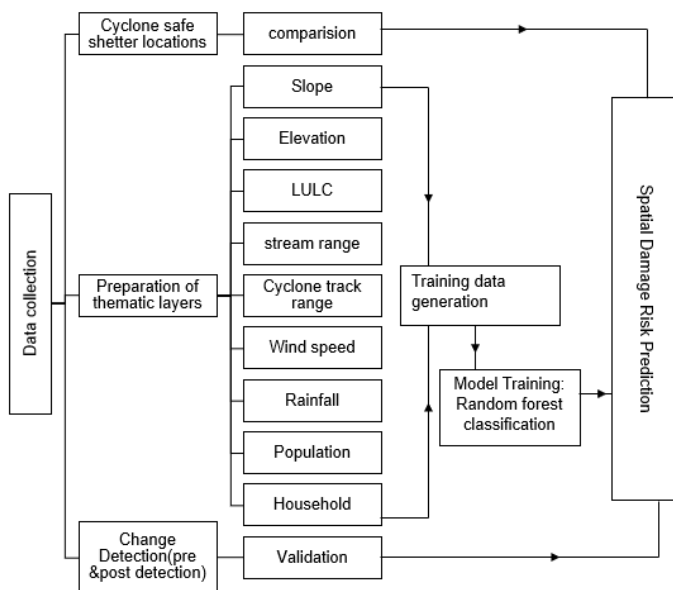


Figure 5.1 Flow chart of Methodology

5.1 DATA COLLECTION

- In this phase of study, various different datasets are collected for analyzing and predicting cyclone induced impact in study area.
- Multi-temporal satellite data (Change detection - flooded area: Cyclone Michaung and 2015 Flood), Meteorological data (Rainfall, Windspeed) and ancillary datasets were collected from Recognized web sources.

5.2 TRAINING DATASET GENERATION

- Training datasets were generated to develop and validate the AI Model for Cyclone Damage Prediction.
- The training samples are represent spatial locations within study area. It extracted the multiple values from different variables like slope, elevation, lulc, cyclone track range, stream range, change detection, rainfall and wind speed. And it acts as a dataset for training the model with extracted values.
- This training random sample points are generated using Tessellation Method. This method ensures uniform and unbiased sampling over the entire region.
- The entire region is divided into grid cells using the Fishnet Tool in ArcGIS Pro. Afterwards, this method provides uniform sized polygons and in ArcGIS Pro by using Random Points Generation tool, random sampling points were generated. The distance was limited based on the spatial resolution of the input layer and spatial extent of the study area. The random points shown in Fig 5.2

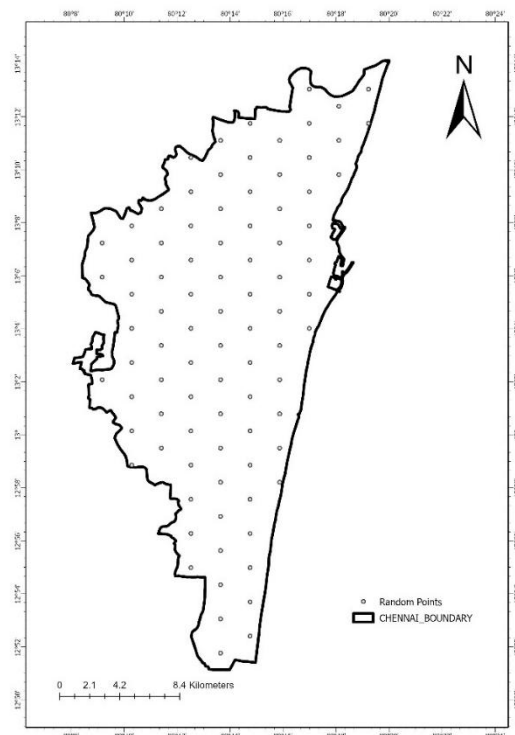


Figure 5.2 Training Points

5.3 MODEL TRAINING – RANDOM FOREST CLASSIFIER MODEL

- In order to predict cyclone-induced impact across the study area, a Random Forest (RF) classifier was selected because of its strong predicting performance in spatial modelling. Random forest (RF) is a machine learning algorithm which can help researchers' prediction or classify data and information [21]
- Preparation of training dataset for prediction includes important three steps:
 - Extract Multi values to Points (Training Points)
 - Assigning Score to each and every training point
 - Average score classified into categorical damage levels

Extract Multi values to Points

- Initially, Extracting the values from multiple variables , Fig 5.3 (slope, elevation, lulc, cyclone track range, stream range, change detection, rainfall and wind speed) through Extract Multi values to Points tool in ArcGIS Pro.

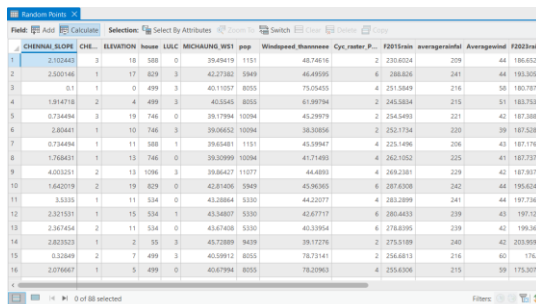


Figure5.3 Extraction of values from Multiple layers

Assigning Score to each and every training point

- For each training point, the extracted variable values were evaluated to find their comparative contribution to cyclone damage.
- Based on the standard norms, score range from 1 to 3 was given to each parameter
- 1 – Low contribution
- 2 – Moderate contribution
- 3 – High contribution

Average score classified into categorical damage levels

- After evaluating individual scores range from 1-3 for all variables, the average score was calculated to denote total cyclone damage potential at that location.
- Average score shows the mean value of all variable scores (slope, elevation, lulc, cyclone track range, stream range, change detection, rainfall and wind speed).
- This average scoring method shows in Fig5.4, helps to standardize the multiple variables into single combined impact of all variables.

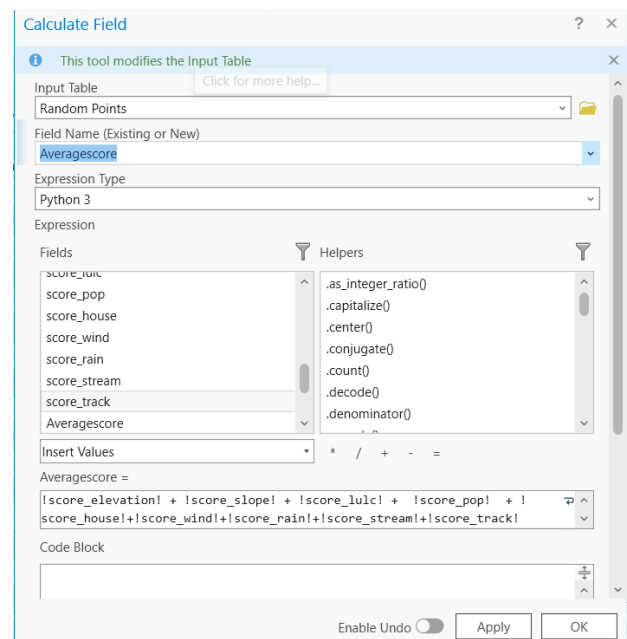


Figure5.4 Calculation of Average Score

- The computed average score is formatted into class values as 1,2,3 to make the data ready for model to predict and it is saved as new attribute field in dataset and used to predict cyclone damage classification. The class values is shown in Fig 5.5, for each training point classified into three damage category levels: They are
- 1 – Low Damage
- 2 – Moderate Damage
- 3 – High Damage

Random Forest													
Field		Add	Calculate	Selection	Select By Attributes	Zoom In	Switch	Clear	Delete	Copy			
	CHURNAL SLOPE	score_elevation	score_slope	score_hls	score_pop	score_house	score_wind	score_rain	score_stream	score_truck	Averagescore	Classvalue	Classname
1	1.038675	3	3	2	1	1	3	1	3	3	20	2	Moderate Damage
2	0.33849	3	3	1	1	1	3	1	3	3	19	2	Moderate Damage
3	1.99734	3	3	3	1	1	3	1	3	3	21	3	High Damage
4	1.674519	3	3	3	1	1	3	2	3	2	21	3	High Damage
5	2.076667	3	3	2	1	1	3	1	3	2	19	2	Moderate Damage
6	2.103443	3	3	3	1	1	3	2	3	2	21	3	High Damage
7	0.1	3	3	1	1	1	3	1	3	2	18	1	Low Damage
8	0.33849	3	3	3	1	1	3	1	3	2	20	2	Moderate Damage
9	2.367454	3	3	3	1	1	3	2	3	2	21	3	High Damage
10	0.734894	3	3	2	1	1	2	1	3	3	19	2	Moderate Damage
11	0.734894	3	3	2	1	1	3	1	3	3	20	2	Moderate Damage
12	0.929039	3	3	3	1	1	2	1	3	3	20	2	Moderate Damage
13	0.656959	3	3	2	1	1	2	1	3	3	19	2	Moderate Damage
14	0.33849	3	3	3	1	1	2	1	3	3	20	2	Moderate Damage
15	1.914718	3	3	1	1	1	2	1	3	3	18	1	Low Damage
16	0.734894	2	3	2	1	2	1	2	2	3	18	1	Low Damage

Figure5.5 Cyclone harm level in Class name

5.3.1 RANDOM FOREST (RF) CLASSIFIER

The Random Forest Classifier (RF) is a machine learning algorithm joins multiple decision trees to make accurate and predictions.

It works by following steps:

- Creating multiple trees using training points subsets of data.
- Each tree gives a “vote” for a class (e.g., Low Damage, Moderate Damage, High damage).
- The final class is elected based on majority voting.

RF Model Construction

Assumed a characterized dataset (E) for training $E = (X, Y)$ in which $x_i \in X$

($i=1,2, \dots, N$, where N is the number of training samples) is a data sample and

$Y_i \in Y$ is its class label, the Random Forest Classifier model aims at forming a model, which has ability of separating the input space into different separate regions. Each of the regions is characterized by one class label [22].

- To attain this phase, model constructs k distinct decision trees, each using:
- A bootstrap (new) sample of the training data means sampling with replacement
- Random set of predictor variables represented by random vector θ .
- This randomization ensures diversity among different trees, which improves generalization.
- Each Decision tree $r_{k(X, \theta)} = Y$
- where r_k denotes classification of function of k^{th} decision tree.

Decision Tree Separating and Node Selection

- During training, each decision tree separates the data repeatedly to maximize class clarity.
- At each node, the most suitable separation is determined using the **Gini impurity index (G)**, which measures how varied the classes are inside that node.

$$G_k = 1 - \sum_{i=1}^{n_k} p_{ki}^2$$

where,

n_k represents total number of classes in node k and p_{ki} represents ratio of samples belong to class i in node k .

- The node that reduces the non-clarity after separation is selected as ideal. The **product (P)** of the Gini impurity values before and after separation is used to determine the best section:

$$P = G_1 * G_2$$

- This process continues until all nodes are sufficiently pure or a desired criterion is reached, resulting in fully fully-fledged decision trees.

Ensemble Voting & Final Classification

- When all k decision trees are trained, the Random Forest Classifier gathers their outputs through majority voting.
- When a new input sample x is presented, each tree independently predicts a class label.
- The final predicted class y is decided as the one getting the most votes among all trees

$$y = H(x) = \argmax \{ \sum I(h_k(x, \theta_k) = z) \}$$

where $I(t)$ denote indicator function as follows:

$$I(t) = \begin{cases} 1, & t \text{ is true} \\ 0, & t \text{ is false} \end{cases}$$

VI. RESULTS AND DISCUSSION

6.1 GENERAL

This section deals with discussion on cyclone damage prediction for Chennai, Tamil Nadu.

6.2 STUDY AREA EXTRACTION

The study area was extracted from Survey of India in shape file format is shown in Fig 6.1

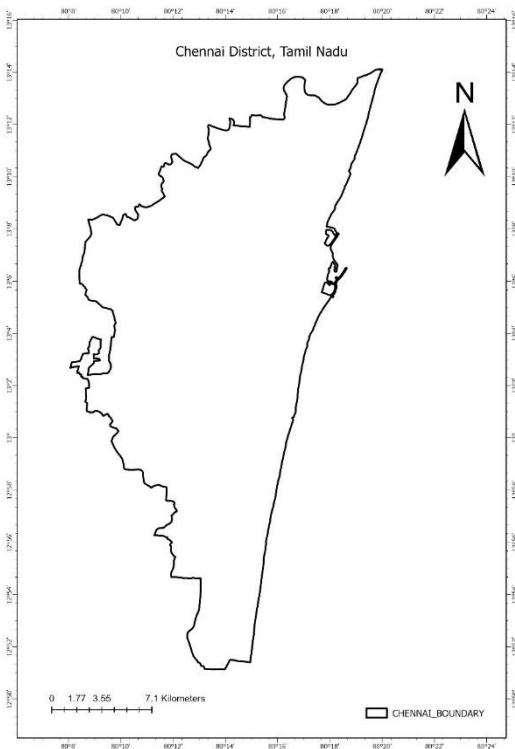


Figure 6.1 Study area: Chennai, Tamil Nadu

6.3 ELEVATION

- A DEM is a 3-Dimensional representation of land surface, show the ground surface varies in horizontal direction.
- In Cyclone Damage prediction, elevation helps to determine which areas are falls under Low elevation or High elevation.
- Areas in low elevation are risky or prone to damage induced by cyclone. Although city is located on flat coastal plain with average elevation is 7m. Digital Elevation Model is shown in Fig 6.2.

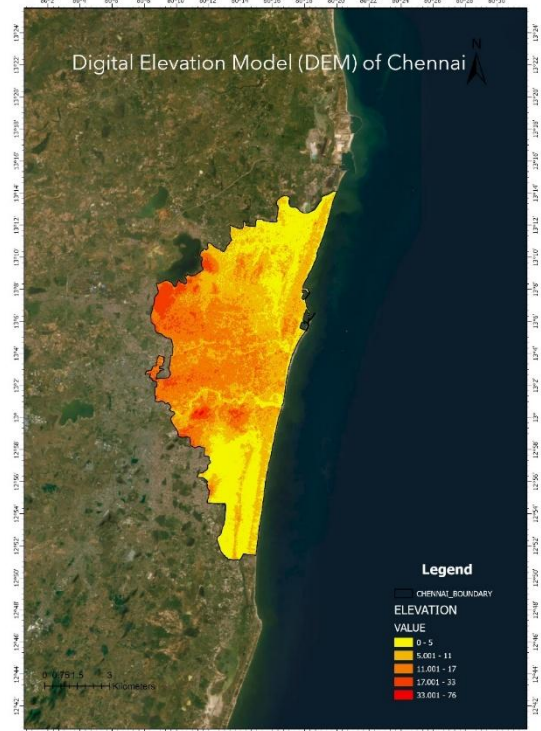


Figure 6.2 Elevation Map

6.4 TOPOGRAPHIC SLOPE

- Slope represents the steepness of the land surface.
- It is calculated from land surface from a raster, which contains elevation values for each and every cell.
- It is important factor to asses or predict the damage caused by cyclone.
- Gentle and flat slope areas are prone to inundation problems from storm surges near coastal or water bodies, at a same time steeper slopes are also prone to erosion like coastal erosion.
- Chennai faced many coastal erosions due to storm surges, high tide and changes in climate change leads to increase in sea level. Slope of study area is shown in Fig 6.3.

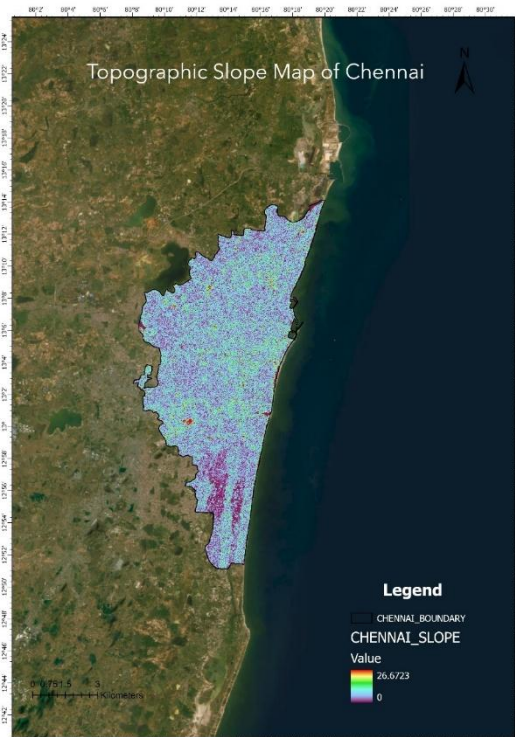


Figure 6.3 Slope Map

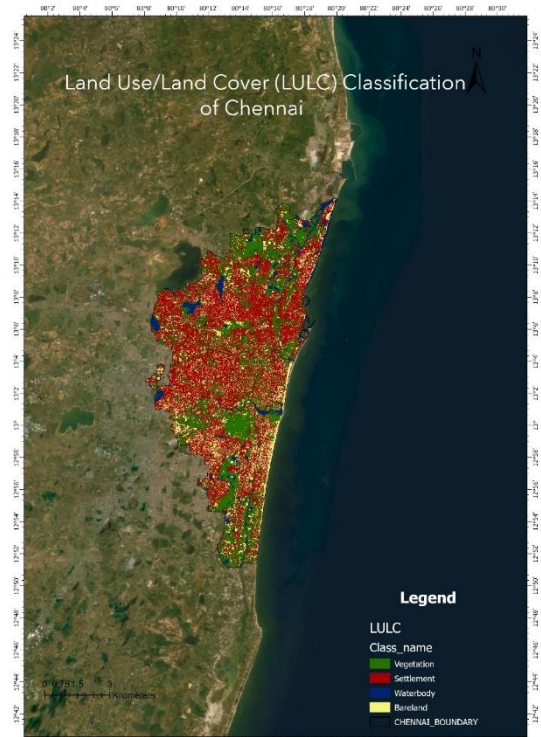


Figure 6.4 Land Use/Land Cover Classification Map

6.5 LAND USE LAND COVER CLASSIFICATION

- Land Use Land cover map shows how land is occupied. It helps to understand how the land surface characteristics influence the potential of damage caused by cyclone.
- Initially, Chennai has a lot of waterbodies, but now by the time waterbodies are encroached and changed into impervious surface. By this means, water doesn't have a way to go so it leads to flooding the area.
- And LULC helps to find vegetation coverage across study area, sometimes vegetation like wind break trees are prevent the extreme violent wind. In this study, study area is break into Settlements, Vegetation, Bare land, Waterbody. Settlements and Near waterbody zones are highly vulnerable to damage induced by cyclone. LULC of study area is shown in Fig 6.4

6.6 CYCLONE TRACJECTORY

- Cyclone track map shows the movement trajectory and wind intensity of cyclone over Chennai.
- Cyclone track map across Chennai is shown in Fig 6.5. Zones near to the cyclone track path are more dangerous and have a high damage to life and property.
- When the distance from cyclone track is reduced, the damage and impact will be reduced or minimal.
- Areas that are near to the track are more vulnerable to cyclone impact.

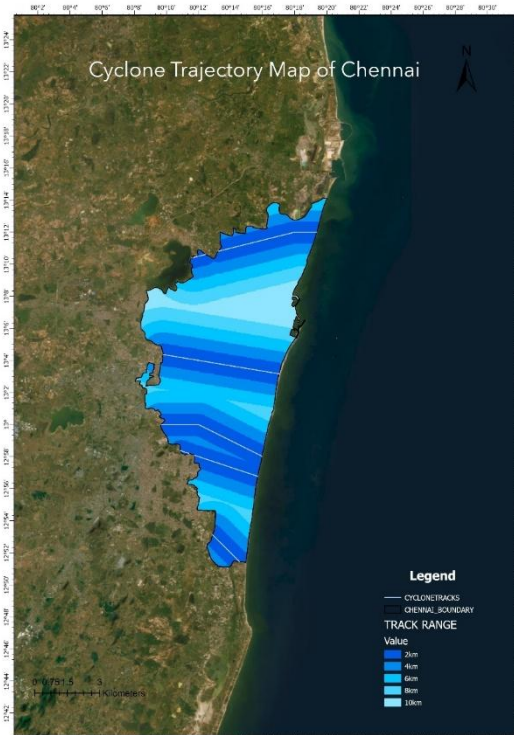


Figure 6.5 Cyclone Trajectory Map

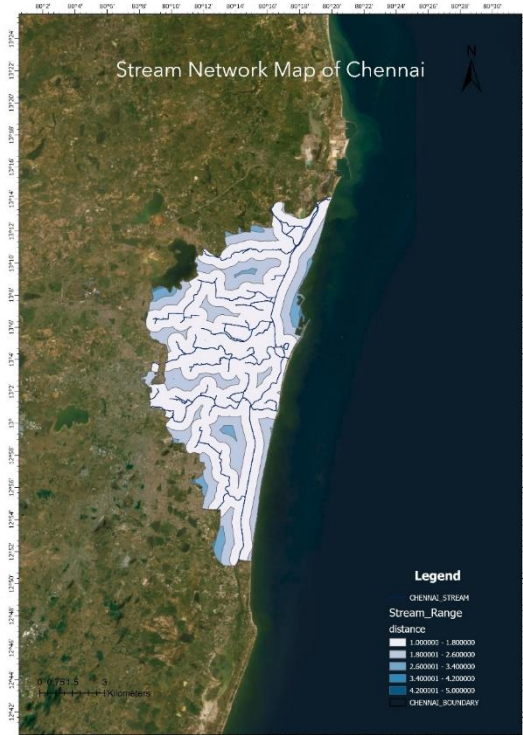


Figure 6.6 Stream Range Map

6.7 STREAM RANGE

- Stream Network Map of Chennai shows the natural and artificial drainage pathways that can carry runoff water across the city toward the coast. Streams are: Adyar River, Cooum River, Kosasthalaiyar River, Buckingham canal.
- During the cyclone event, heavy extreme rainfall leads to flooding along the river channels, extending the stream range and increasing the flood-zone areas.
- The buffer around stream network depicts the potential flood spread zone due to cyclone induced rainfall. Stream range is shown in Fig 6.6.

6.8 WIND SPEED

- Wind speed is main parameter influencing the range of damage induced by cyclone. It determines scale of structural damage, vegetation loss, failure of powerline and destruction of property across affected regions.
- In cyclone damage prediction, wind speed is a predictor for identifying damage prone zones and assessing the harm severity of cyclones on people, settlements & environments.
- For clarity and accuracy of prediction, in this study two historical cyclone events data are collected and analyzed. They are: Cyclone Thane (2011) Wind speed is shown in Fig 6.7, Cyclone Michaung (2023) Wind speed is shown in Fig 6.8.
- Cyclone Thane wind speed breakthrough 64 – 80 Km/hr at its peak in Chennai region. Cyclone Michaung peak its wind speed 110km/hr when its crossed near Chennai coastal area.
- By understanding the wind speed patterns allow for accurate identification of high-risk zones and assess the potential damage.

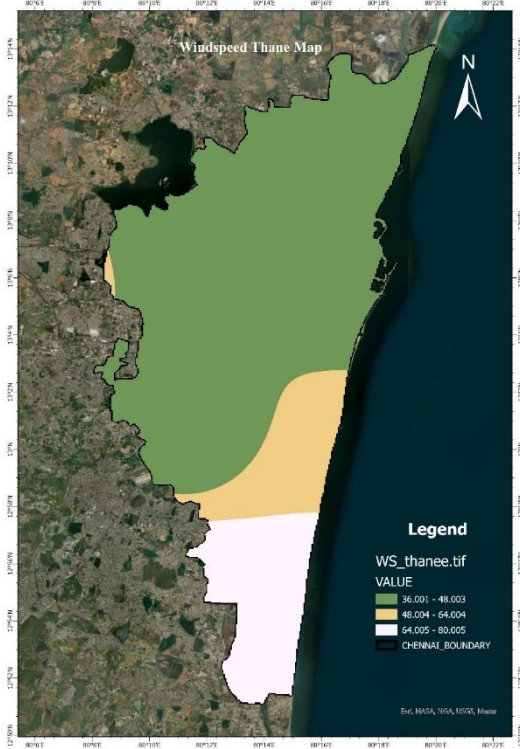


Figure 6.7 Cyclone Thane Wind Speed Map

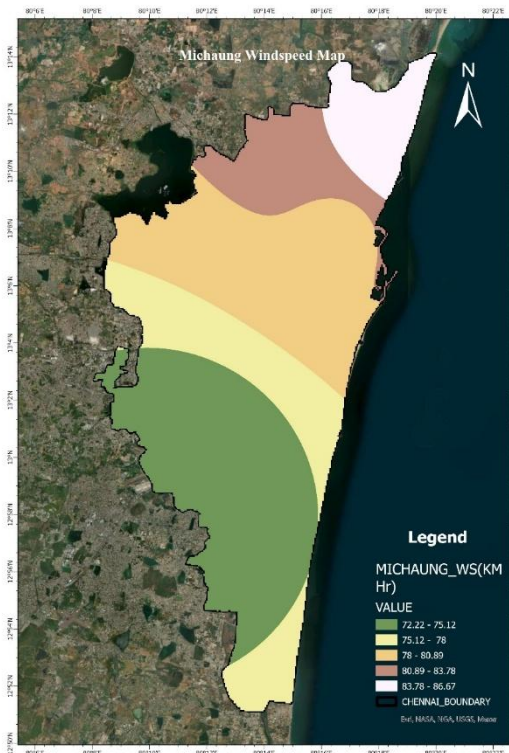


Figure 6.8 Cyclone Michaung Wind Speed Map

6.9 RAINFALL

- Rainfall is the critical meteorological parameter that contribute to cyclone induced damage.
- During cyclone event, there will be heavy and extreme rainfall. It paves the way for flooding, inundation, waterlogging, Coastal erosion, settlement collapse, these problems will arise specially in low lying areas. And damage will be high if its urban area.
- In this study, two historical rainfall events are integrated they are: 2015 Chennai Floods and 2023 Cyclone Michaung. Integrating two rainfall events enhance the model accuracy and prediction result. It helps to assess how variations in rain influence flood depth and its extent.
- During 2015 Chennai Flood, recorded Rainfall is above 220 mm/day and in some regions like Mylapore, Ambattur, Egmore rainfall reading crosses over 270 mm/day. It leads to extreme flooding and inundation, casualties, infrastructure damage. 2015 Flood – rainfall map distribution is shown in Fig 6.9
- During Michaung Cyclone, recorded Rainfall is above 180 mm/day and in regions like northern coast received a rainfall above 240 mm/day, leads to heavy and severe flooding. Michaung Rainfall map distribution is shown in Fig 6.10



Figure 6.9 Chennai – 2015 Rainfall Map

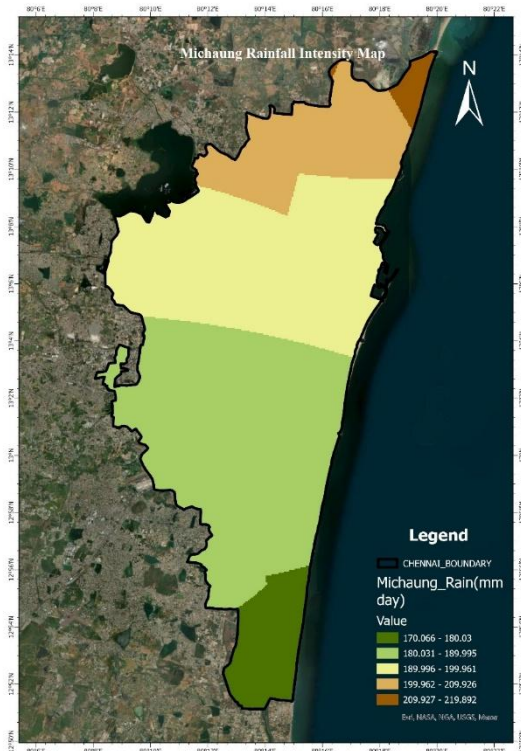


Figure 6.10 Cyclone Michaung Rainfall Map

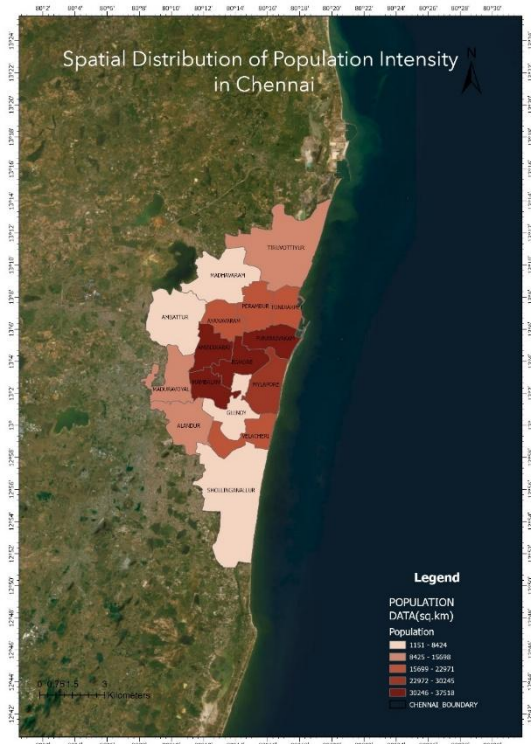


Figure 6.11 Spatial Distribution of Population Intensity Map

6.10 SPATIAL DISTRIBUTION OF POPULATION INTENSITY

- Population density is an important social-economic factor in damage prediction. It determines the level of people exposure and vulnerability to cyclone damage.
- High Population density areas, especially in coastal and urban regions are likely to experience heavy losses due to high concentrated settlements and infrastructures.
- Area with high population density is considered to be at high risk due to larger number of people and property to be exposed. Population density is shown in Fig 6.11

6.11 SPATIAL DISTRIBUTION OF HOUSEHOLD DENSITY MAP

- Household density refers to number of houses per square kilometer or square mile.
- It is used to evaluation of the number of individuals and households are affected by cyclone hazards like, inundation problems, storm surges, extreme rainfall and strong winds.
- Areas with high household density are exceedingly vulnerable to cyclone hazards due to the concentration of people and property. Household density distribution is shown in Fig 6.12

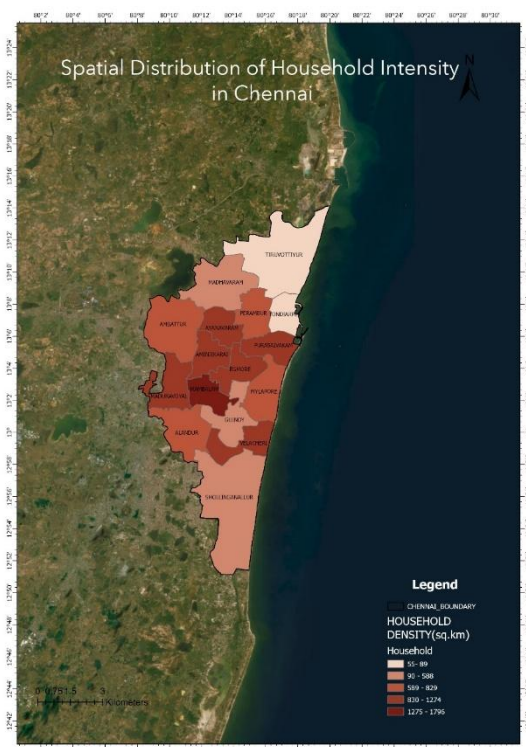


Figure 6.12 Spatial Distribution of Household Intensity Map

6.12 CYCLONE DAMAGE PREDICTION MAP

- Predicting damage caused by cyclone was carried out using Geo computational AI techniques.
- It will be useful for rescue and prior planning for mitigation, helps to take precautionary measures like, shelter locations zoning and policy, resource allocation.
- Result shows **High damage zones are found along the Eastern Coastal belt, specifically north-east and central coastal Chennai regions.**
- **Moderate damage zones** are found in interior Chennai and urban zones away from coast regions like **Porur, Tambaram and Ambattur.**
- **Low damage zones** are found in western and southern fringes, 15 to 17 km away from the land, regions like **Sriperumbudur, Vandalur, Guduvanchery parts of south-west Chennai at higher elevations.** Cyclone Damage Predication is shown in Fig 6.13

Zones that are lied in **Low Damageable category** are:

- **Guindy, Saidapet, Alandur, Kolapakkam, Moulivakkam, Adambakkam, Ambattur, Madhavaram, Kodungaiyur**
- Found in western and southern fringes, include areas where wind and rainfall intensity are lower

Zones that are lied in **Moderate Damage category** are:

- **Tondairpet, Purasawalkam, Egmore, Velachery, Sholinganallur, Western Part of Alandur, Mambalam, Northern Part of Ambattur, Parts of Madhavaram.**
- Covers interior part of Chennai and suburban zones away from the coast.
- Experienced moderate flooding and infrastructure stress.

Zones that are lied in **High Damageable Category** are:

- **Ennore, Thiruvottiyur, Adyar Mouth and**
- **Parts of Coastal Kanchipuram.**
- Represents urbanization and low-lying coastal zones, intensely impacted by storm surge and flooding.

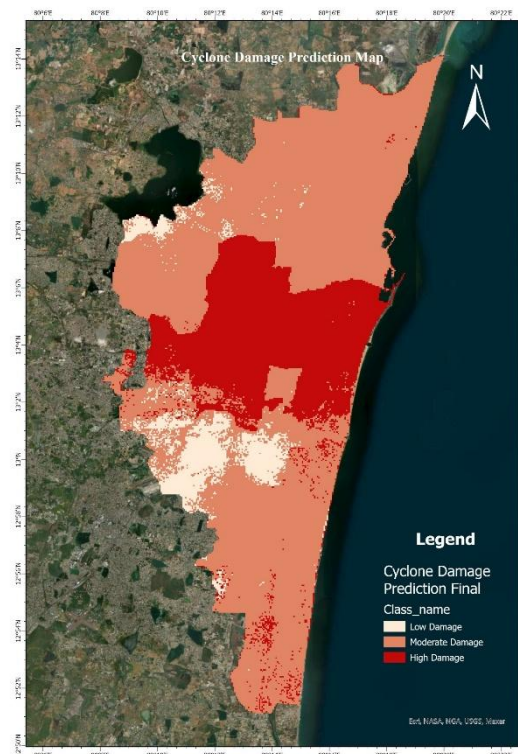


Figure 6.13 Cyclone Damage Prediction Map

6.13 SAFE SHELTER LOCATIONS MAP

- Safe Shelters are identified in 128 centres with minimal risk like Minimal wind, rainfall and flood.
- These shelters serve as evacuation and relief centres, providing safe and accessible locations outside the cyclone's core path. Initially over the entire study area there is 1000+ public buildings are identified.
- They are like Schools, Colleges, Universities, Hospitals, Clinics, Community Halls, Religious places etc.
- These shelters are identified based on predicted cyclone damage map.
- Shelters are shown in Fig 5.14

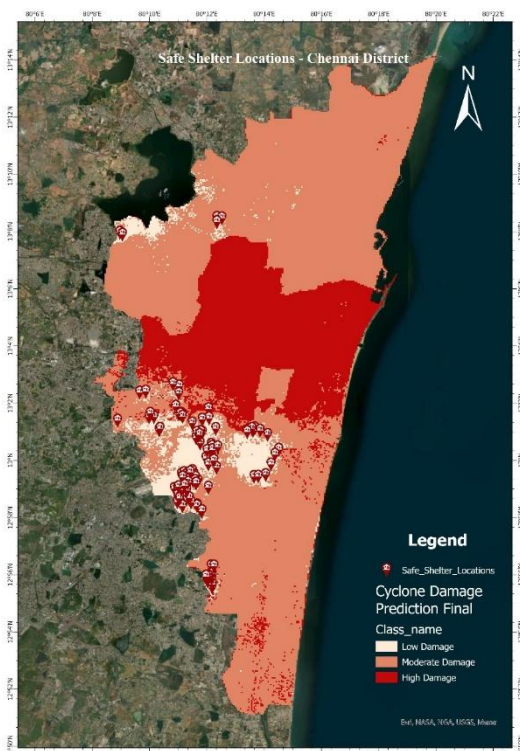


Figure 6.14 Safe Shelter Locations Map

Some of the attributes of these shelters are given in Fig 6.15:

Safe_Shelter_Locations					
Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear					
OBJECTID_1	Shape	OBJECTID	osm_id	name	type
1 63	Point	9000	156377975	வழக்கு தீர்க்கும்	place_of_worship
2 64	Point	9001	156377976	மாறியம்மன் கோ...	place_of_worship
3 127	Point	3639	1551525689	அண்ணா பல்கலை...	college
4 47	Point	2590	34370346	Yezhoor Amman Temple	place_of_worship
5 54	Point	4468	-1524058350	Visa Temple	place_of_worship
6 37	Point	1693	2145395505	Vembuli Amman Kovil	place_of_worship
7 3	Point	1175	953110024	Velammal School (Amb...	school
8 100	Point	2212	-922181013	Velachery SABA Hospital	hospital
9 114	Point	4813	-770093844	Vasanthi Dental Hospital	hospital
10 14	Point	213	280499221	Varasiddhi Vinayakar Te...	place_of_worship
11 55	Point	4702	-1067884404	Varasiddhi Vinayagar Te...	place_of_worship
12 79	Point	5689	901512463	Vaani pharmacy	pharmacy
13 118	Point	4866	-767391091	V Cure Hospital	hospital
14 113	Point	4778	-771232234	Uma Hospital	hospital
15 19	Point	579	330774689	Temple	place_of_worship
16 22	Point	776	369642135	Temple	place_of_worship
17 30	Point	1368	1329321953	Temple	place_of_worship
18 81	Point	5849	1315231622	Sunshine Pharmacy	pharmacy
19 25	Point	1159	934865005	Sumooga Vinayagar Te...	place_of_worship
20 83	Point	8762	-313551187	Star Pharmacy Adamba...	pharmacy
21 10	Point	2531	20355895	St.Johns MHSS	school
22 93	Point	768	367795605	St. Thomas Hospital	hospital
23 9	Point	2077	-1145703275	St. Christopher Nursery...	school

Figure 6.15 Safe Shelter Locations - Attributes

6.14 VALIDATION OF CYCLONE DAMAGE PREDICTION

For the validation of predicted model, it is compared with two figures that are shown in Fig 6.16, that shows the flooded area change detection maps for two historical flood event data 2015 Chennai Flood and 2023 Michaung Cyclone. By using Landsat 8 satellite data, these two maps are generated. Change detection maps checks that the high damageable zones that is predicted by RF model is make even nearly with the observed flood regions. The recurrence of flooding in these similar geographic regions during both rainfall events defines the model's accuracy and predictive ability.

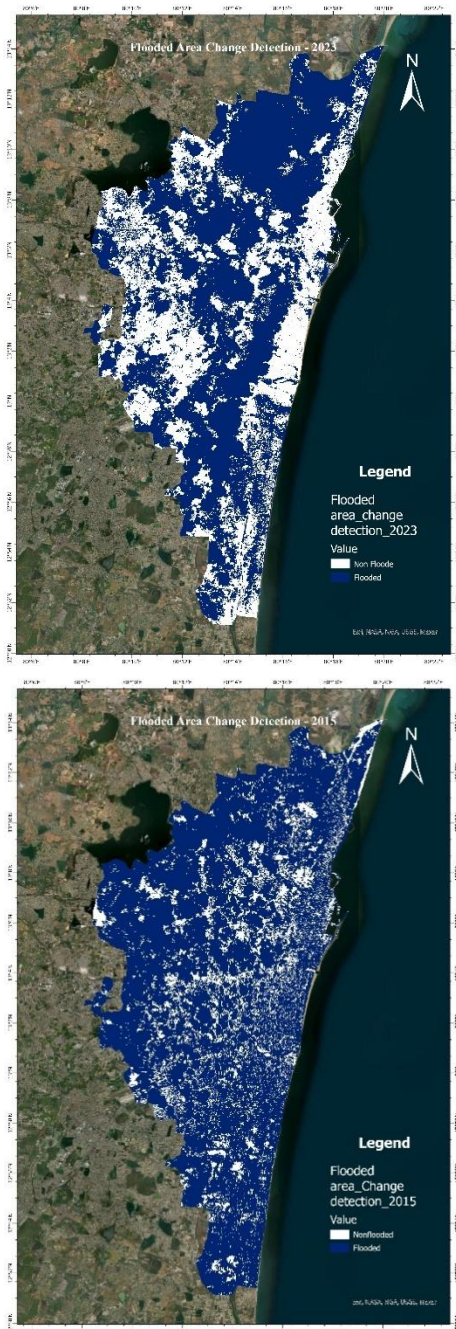


Figure 6.16 Flooded Area Change Detection: Chennai
2015 Flood – Cyclone Michaung Flood

VII. CONCLUSION

- The study has predicted the Cyclone Damage Prediction in Chennai, Tamil Nadu using Artificial Intelligence Techniques with the help of Geospatial Software.
- A thematic layer was created for all parameter like Slope, Elevation, LULC, Cyclone Track, Stream Range, Rainfall, Wind Speed, Population and Household intensity and then random training points were generated.
- By using random points trained the Random Forest Classifier Model to predict the cyclone damage by looking many decision trees. In the end, it chooses one single decision and results are shown as spatially distributed. And entire study area is categorized into three damage categories: Low, Moderate, High
- Results shows that **112 sq.km areas are falls under High Damageable zones, 289 sq.km areas are falls under Moderate Damageable zones and 33 sq.km areas are falls under Low Damageable zones.**
- **The high damage zones** are Ennore, Thiruvottiyur, Adyar Mouth and parts of coastal Kanchipuram.
- **The moderate damage zones** are Tondairpet, Purasawalkam, Egmore, Velachery, Sholinganallur, Western Part of Alandur, Mambalam, Northern Part of Ambattur, Parts of Madhavaram.
- **The low damage zones** are Guindy, Saidapet, Alandur, Kolapakkam, Moulivakkam, Adambakkam, Ambattur, Madhavaram, Kodungaiyur.
- And the study was evaluated by comparing the model spatial output with Flooded area change detection for Chennai 2015 Flood and Cyclone Michaung Flood.
- It shows similar results in observing both of them. It represents the model's accuracy is validated and it has a predictive ability. And for one of the short mitigation measure, safe shelter locations are identified according to the prediction model. Over 1000+ shelter points, this prediction model selects 128 shelter locations.

Based on findings, it is suggested that

- Flood management systems must be ensured through improved drainage conditions and waterbodies restoration.
- If the same geographical region is flooded means, then it represents the exposure to the hazard is persistently.
- It shows local systems like drainage patterns; retention areas are inadequate.
- Regulate the land use zoning according to Government Norms and must consider the Environmental Conditions.
- The strength and number of occurrence of cyclones are increasing means; it will lead to increase in MSL rise.

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