Biological Forum – An International Journal **15(5): 1124-1130(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Flood Vulnerability and Livestock Production Risks Hazard Mapping of Flood-Prone Areas of the Cuddalore District of Tamil Nadu, India

P. Tensingh Gnanaraj[1*], P. Silambarasan[2], Thanga Thamil Vanan[3], R. Richard Churchill[4] and N. Vengadabady[5]

[1]Registrar,
Tamil Nadu Veterinary and Animal Sciences University, Chennai (Tamil Nadu), India.
[2]Assistant Professor and Head,
Veterinary University Training and Research Centre, Cuddalore (Tamil Nadu), India.
[3]Professor and Head, Dept. of Livestock Production Management,
Madras Veterinary College, Chennai (Tamil Nadu), India.
[4]Professor and Head, Department of Poultry Science,
Madras Veterinary College, Chennai (Tamil Nadu), India.
[5]Professor, Post Graduate Research Institute in Animal Sciences,
Kattupakkam, Chengalpattu (Tamil Nadu), India.

(Corresponding author: P. Tensingh Gnanaraj)*

(Received: 01 March 2023; Revised: 14 April 2023; Accepted: 18 April 2023; Published: 20 May 2023)
(Published by Research Trend)

ABSTRACT: India is one of the most disaster-prone countries in the world mainly due to its high geo-climatic conditions and its higher degree of social vulnerability. Concerning socioeconomic and environmental perspectives, flood is one of the most devastating disasters in the coastal regions of Cuddalore in recent years. The main aim of this study is to create a flood vulnerability and livestock production risks hazard map for the coastal district of Cuddalore with the integration of Geographic Information System (GIS), and the Multi-criteria Decision-Making-Analysis (MCDM). The study was carried out in the most flood-prone areas of Cuddalore. Based on the geographical data a Geographical map was prepared with the technical assistance of the Department of Earth Sciences, Annamalai University using Arc GIS software. The details included in the flood hazard map are the rivers entering the Cuddalore district, their route to the draining Bay of Bengal, their longitude latitude on touching the selected block, available lakes, their drainage pattern, and artificial drainage canals passing through the selected blocks. In addition, connecting roads were also marked. The prepared map can be used to forecast the possibility of flood occurrence and formulation of mitigation strategies in the future.

Keywords: Cuddalore, Flood, GIS, Vulnerability map.

INTRODUCTION

Disasters are not new to mankind they have been the constant and inconvenient companions of human beings since time immemorial. World Health Organization (WHO, 2002) defines a disaster as any occurrence that causes damage, ecological disruption, loss of human life, or deterioration of health and health services on a scale sufficient to warrant an extraordinary response from outside the affected communication or area (Antzoulatos *et al.*, 2022). Sen and Chander (2003) described that the states most exposed to floods surges are West Bengal, Orissa, Andhra Pradesh and Tamil Nadu along the Bay of Bengal, and Gujarat and Maharashtra along the Arabian Sea. There has been an increase in the frequency and intensity of disasters that have posed a threat not only to the people but to livestock as well. Floods can be explained as excess flows exceeding the transporting capacity of river channels, lakes, ponds, reservoirs, drainage systems, dams, and any other water bodies, whereby water inundates outside water bodies areas (Abbas *et al.*, 2017). Flooding can be caused by, for instance, heavy rain, snow melt, land subsidence, rising of groundwater, and dam failures (Membele *et al.*, 2022). Moreover, since the industrial revolution, climate change has been clearly influencing many environmental and social sectors; in particular, it has been showing a significant impact on water resources (Behera *et al.*, 2021). Flood is one of the major natural disasters that have been affecting many countries or regions in the world year after year causing great damage to the livestock sector.

Livestock disaster scenario in Tamil Nadu. Tamil Nadu is one of the most disaster-prone countries in the world mainly due to its high geo-climatic conditions and its higher degree of social vulnerability. According to National Disaster Management Authority (Bhanja *et al.*, 1999) nearly 58.6 per cent of India's land area is prone to earthquakes of moderate to very high intensity, and over 40 million hectares (12 per cent of land) is prone to floods and river erosion. About 2 per cent of its land area is landslide-prone, and 68 per cent of its cultivable area is affected by droughts. Close to 5700 km of its 7516 km coastline is cyclone prone and exposed to events like tsunamis and storm surges (Pareek and Trivedi 2011).

The Cuddalore district is categorically classified as Disaster Prone Area because of its low-lying geological position. The Cuddalore district is frequently subjected to natural disasters such as Flood, Tsunami, Drought, Cyclone, etc., and the major reasons for flooding in Cuddalore district include the rivers draining into the Bay of Bengal and are closer to each other. The terrain is flat and just 1.50 m above M.S.L; therefore, all the flood water that accumulates in this area could not easily get drained into the sea. The bed level of rivers lies minus one meter from the sea. Due to this, the backwater from the rivers during flood causes huge damage (Mohammad and Bishnoi 2021). Moreover, the district of Tamil Nadu lies in the coastal line and is one of the most backward districts recurrently hit by natural disasters every year. Out of the 13 blocks in Cuddalore district, 11 blocks are highly hit by flood, and 7 blocks are put under the most affected list. The district witnessed the loss of 54 human lives and thousands of cattle, damage to 50000 huts, and over 24000 hectares of crops were completely damaged due to the cyclone in 53 villages in the year 2015 due to flood (Nithya and Priyanka 2019).

Remote sensing and GIS-Arc SWAT tool techniques are used to assess various terrain (Aja *et al*., 2020; Saha and Agarwal 2020; Junger *et al.,* 2022). It is also a convenient method for morphometry analysis as the satellite images provide a view of a large area and are very useful in the analysis of drainage basin morphometry and will also provide a platform for the storage and management of all types of data that can be easily accessed during flood disaster.

GIS will provide complete information about the flood-prone areas which will help to reduce the vulnerability of flood disasters and develop mitigation strategies like early warning and quick response and thereby reducing the impact of possible flood events (Junger *et al*., 2022). Against this backdrop, this study was planned with the aim of developing a flood vulnerability and livestock production risks hazard map to overcome flood disasters to livestock and poultry in the Cuddalore district.

MATERIALS AND METHODS

A. Geomorphology map

Based on the geographical data a Geomorphology map was prepared as per the method described by Gesch (2009) with the technical assistance of the Department of Earth Sciences, Annamalai University using Arc GIS software. The details included in the Geomorphology map are the rivers entering the Cuddalore district, their draining route to the Bay of Bengal, their longitude latitude on touching the selected block, available lakes, their drainage pattern, and artificial drainage canals passing through the selected blocks. In addition, connecting roads were also marked.

B. Thematic map

It refers to the specific theme or subject area. Here multi-thematic studies were carried out to identify the flood-prone zone using rainfall, geomorphology, soil, slope, drainage density, and elevation. IRS P6 LISS-III satellite digital data, Landsat 8 OLI (Operational Land Imager), ASTER L1T, and LISS IV data were used for geomorphological mapping. The satellite data namely LISS III was downloaded from the NRSC website.

C. Preparation of flood hazard map

In the present study, the parameters have been selected based on different case studies for multicriteria analysis which focus to identify the flood-affected areas of the Cuddalore district using a multi-thematic approach on the GIS platform (Gesch, 2009). Geospatial data of DEM was used to model flood by combining with satellite data through GIS techniques to acquire the relationship between flood extent, elevation, and discharge with reasonable accuracy as per Sanyal and Lu (2004); Younghun *et al.* (2014). The soil distribution was derived from the spectral characteristics of remotely sensed data based on its spectra as per Boettinger *et al.* (2008); Mohamed (2017). To map the soil distribution IRS-1C, LISS III, and PAN data at 1:25,000 to 1:12,500 scales was generated through the combination of these data (Kudrat *et al.*, 2000).

The LISS IV multispectral (MX), IRS P6 LISS III satellite data, Landsat 8 OLI data, and ASTER L1T data were used for geomorphology mapping. Three season data (IRS LISS III data of January/April/November 2006, Landsat MSS data of 13.01.1977, ASTER data on 25.04.2017) were used in order to observe the contrast between the various landforms of the Cuddalore area. The satellite scenes were loaded into the system and the desired areas were extracted. The extracted digital data of the area were georeferenced using toposheets as a base map using the image-to-image registration technique. The digital data was subjected to various enhancements and filtering techniques and was studied in different band combinations, using ERDAS and ARC GIS software. The spatial resolution of ASTER L1T data (15.0m resolution) was used and Lands at 8 data was enhanced using Landsat 8 pan (15.0 m resolution) using the pan-sharpening technique for the preparation of geomorphology maps. The Landsat 8 pan-sharpened image could differentiate even settlement areas which could be recognized by their small rectangular shapes and light to bluish tone, but on LISS III image these areas show light tone. The shaded relief map and the topo sheets were useful in interpreting the alluvial plain, coastal plain, deltaic plain, flood plain, and peneplain complex. The methodology used for geomorphological mapping is based on the Manual for Geomorphological mapping on a 1:50000 scale using satellite data published jointly by GSI and ISRO (GSI and NRSC, 2012).

RESULTS AND DISCUSSION

A. Geomorphology map

The areas under study form a part of contrasting lithology varying from charnockites and migmatitic gneisses of Archaean age, older sedimentary rocks of the Cretaceous age and younger sedimentaries of Mio-Pliocene age, lateritic soil cover over Mio-Pliocene sediments in the central part, a narrow tract of coastal plains in the east fringing Bay of Bengal and alluvial plains of the Ponnaiyar and Gadilam river in the north and Vellar and Kollidam rivers in the south. The landforms identified in the area based on the study of satellite imagery (RS LISS III, LISS IV, Cartosat-2, ASTER L1T) are alluvial plain, coastal plain, deltaic plain, flood plain, and peneplain complex. The different weightages are assigned to the geomorphic units as given in Table 1. The high weightage '6' is assigned to the flood plain and water body, the alluvial plain is assigned as '3', the coastal and deltaic plain is assigned as '2', and the mine dumb area is assigned as '1'. The influence factor was given as '21'. The geomorphology of the Cuddalore district is presented in Fig. 1.

B. Thematic map

Soil: The soil of the Cuddalore district has been classified into clay, clay-loam, loamy sand, silty clay, sand, sandy clay, silty clay loam, and sandy loam (Fig. 2). The major areas are dominated by sandy loam soil followed by sandy clay loam and sandy clay. The weightage was assigned to the soils based on the impact related to the flood. The weightage 1 and 2 were assigned in the soil type and the influence factor was assigned as 12.

Average annual rainfall: The recorded rainfall values in the eastern part are from 1,619.41 to 1,855.9 mm, the middle and northwestern part shows the values as 1,289.5 and 1,401.4 mm, and the southern part recorded between 1,498 and 1,619.3 mm. The eastern side which is near to the coastal region observed higher rainfall when compared to other sides. Fig. 3 shows the spatial distribution map of the average rainfall of the study area. The weightage 2, 3, and 4 were assigned based on the values and an influence factor of 15% was assigned to the rainfall.

Drainage density: Drainage density shows lower in the border of the district, and higher in the middle part of the district with ranges between 3233 and 4785. The spatial distribution map of the drainage density is shown in Fig. 4. The weightages are assigned to the drainage density based on the impact and influence. The high weightage (6) was assigned to the density values between 1.118 and 2.52. The low weightage (2) is assigned to the values between 2.521 and 4.785, whereas the moderate weightage (4) is assigned to the value 0.01272-1.117. Overall influence factor of the drainage density ranked as 20.

Slope: The slope of the district has been classified into five types as follows 0 - 1.54, 1.55 - 3.86, 3.87 - 6.95, 6.96 - 14.4, and 14.5 - 65.6. The slope value is higher in the middle part and lower in the entire eastern, southern, northern, and western side of the study area. The figure shows (Fig. 5) the spatial distribution map of the slope of the Cuddalore district. The weightage was assigned according to the slope values and the influence factor was assigned as 10.

C. Flood –Hazard Mapping

Flood hazard mapping is an important element for finding and categorizing flood-prone areas, which would help in planning long-term mitigation strategies by the decision and policymakers. For identification of flood hazard zone in the study area GIS techniques are used for mapping the vulnerable areas. Based on the results the different vulnerable zones are identified in the study area. It ranges from low vulnerable to very highly vulnerable as shown in Fig. 6. The highly vulnerable blocks identified were Cuddalore, Puduchattiram, Parangipettai, Melbhunagiri, Keerapalayam, and Kurinjipadi. The scarcity of flood damage data and information are major obstacles faced in conducting flood damages assessment studies. Junger *et al*. (2022) described that in order to reduce flood risks, a shift from controlling rivers and hazard prevention to an integrated approach of flood risk management can be observed.

In the current study, an attempt was made to identify the vulnerable zone of flood in the Cuddalore district, which is affected regularly during rainy seasons in the state of Tamil Nadu, India. GIS techniques were used to identify the vulnerable areas based on different environmental parameters such as rainfall, slope, soil, land-use/land cover, geomorphology, and drainage density. From the obtained results it was observed that 40% of the areas are highly vulnerable, 30% of areas demarcated as moderately vulnerable, and 30% are low vulnerable areas in the study area. Silambarasan *et al*. (2022) stated that the available multipurpose evacuation shelters are located in low lying area making unfit to use for animal mobilization and hence suitable sites need to be identified in elevated locations and steps may be initiated to construct community animal shelter with the assistance of District disaster management. By considering this aspect, the government can implement rainwater harvesting systems in the nearby drought-prone districts namely Permbalur and Ariyalur. Check dams can also be constructed along the river to store rainwater and can be supplied to the nearest low- and high-elevated areas by pumping the water (Silambarasan *et al*., 2022). The created flood hazard map will aid the policy planners, stakeholders, public work department, and hydrological department of the district in the formulation of suitable development plans to reduce the severity of floods in vulnerable areas.

Borah *et al.* (2018) observed that Synthetic Aperture Radar (SAR) data is preferred for detecting inundated areas and providing reliable information during a flood event due to its capability to operate in all weather and day/night time.

From the study, it is concluded that the geographical location, heavy precipitation during monsoon, and river draining through Cuddalore district predisposes the district to the frequent occurrence of flood disasters, causing economic loss to livestock farmers in terms of loss of animals, damage to animal shed, feed and fodder with maximum loss at low lying area (Geographical area I). Since the occurrence of flood cannot be prevented, the farmers are to be motivated to adopt preventive and mitigation measures to minimize the loss due to flood. Awareness must be created among farmers regarding the flood hazard map which would render the required information to reduce flood-induced losses.

Table 1: Weightage and ranking of the different parameters of Cuddalore district.

Parameter		Values	Scale Weight	Influence (%)
Rainfall	1	1,062.1 - 1,289.4	2	15
	2	1,289.5 - 1,401.4	2	
	3	1,401.5 - 1,497.9	3	
	4	1,498 - 1,619.3	4	
	5	1,619.4 - 1,855.9	4	
Slope%	1	0 - 1.54	3	10
	2	1.55 - 3.86	3	
	3	3.87 - 6.95	2	
	4	6.96 - 14.4	1	
	5	14.5 - 65.6	1	
Drainage Density	1	0.01272 - 1.117	6	20
	2	1.118 - 1.847	6	
	3	1.848 - 2.52	4	
	4	2.521 - 3.232	2	
	5	3.233 - 4.785	2	
Soil	1	Sand	1	12
	2	Sandyloam	1	
	3	Clayloam	1	
	4	Siltclayloam	1	
	5	Sandyclayloam	1	
	6	Clay	2	
	7	Sandyclay	1	
	8	Siltyclay	2	
	9	Mining	1	
	10	Loamysand	1	
Land Use Land Cover	1	Agriculture	6	24
	2	Barren Land	3	
	3	Water	6	
	4	Buildup	6	
	5	Forest	3	
Geomorphology	1	Pediment Pediplain Complex	1	21
	2	Alluvial Plain	3	
	3	Flood Plain	6	
	4	Coastal Plain	2	
	5	Deltaic Plain	2	
	6	Water body	6	
	7	Mine and Mine Dump	1	

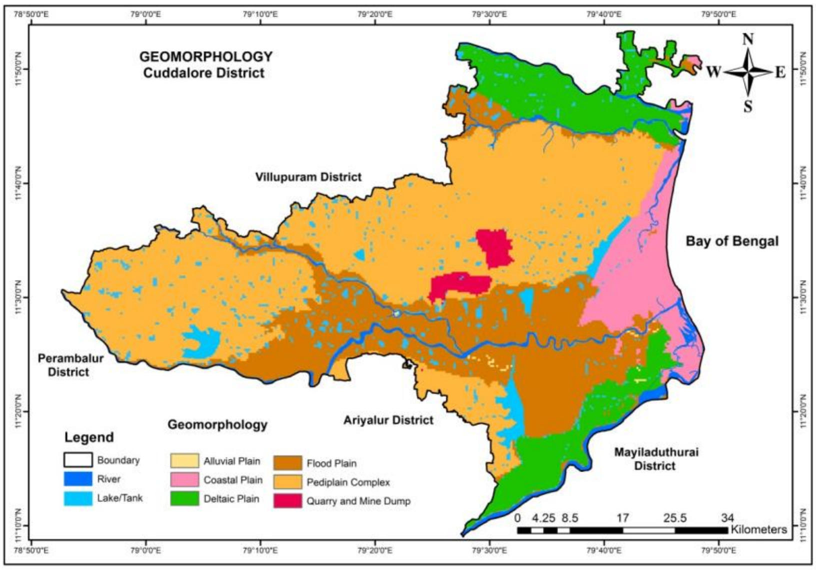

Fig. 1. Geomorphology of Cuddalore district.

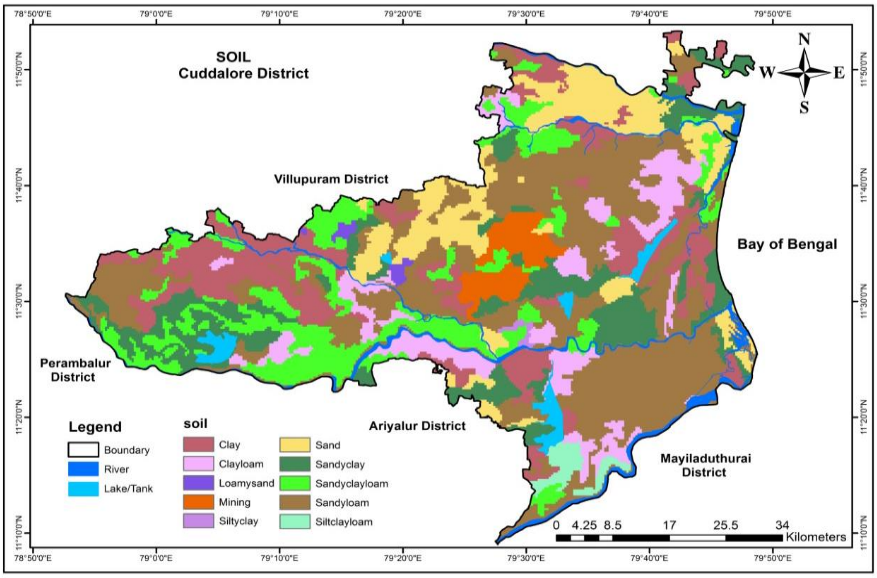

Fig. 2. Soil pattern of Cuddalore district.

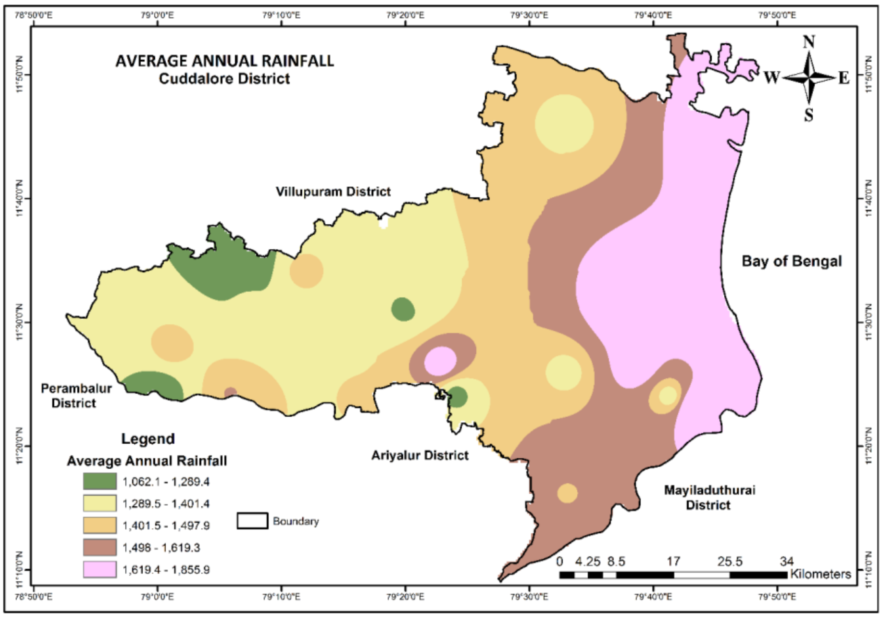

Fig. 3. Average annual rainfall.

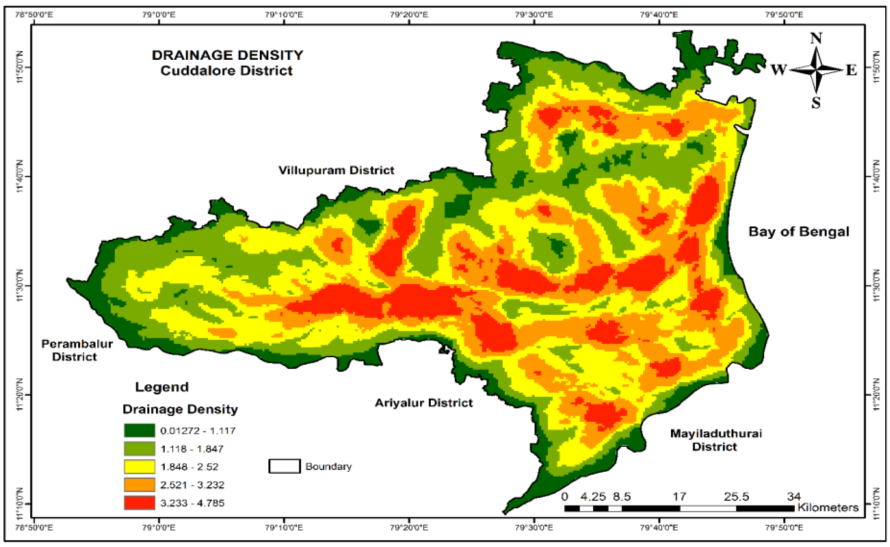

Fig. 4. Drainage density.

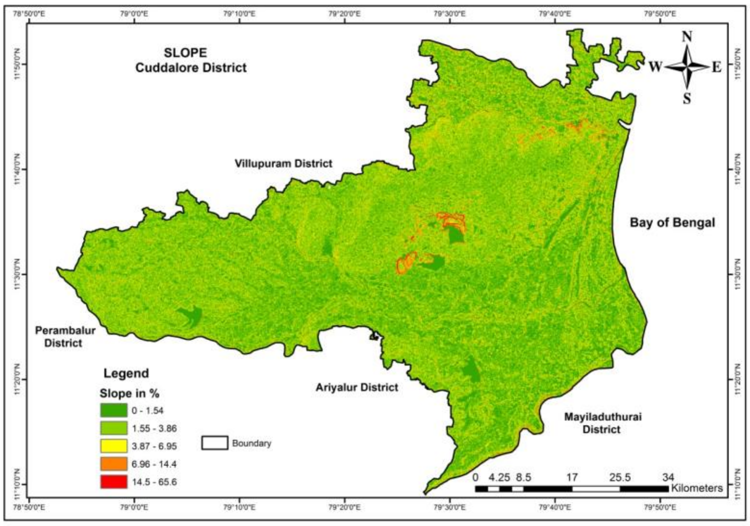

Fig. 5. Slope of Cuddalore district.

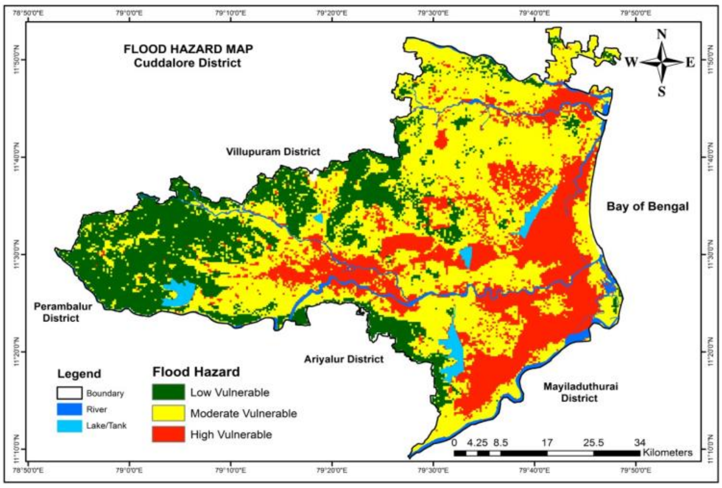

Fig. 6. Digital elevation model of Cuddalore district.

CONCLUSIONS

Currently GIS techniques are used to identify the flood-vulnerable areas in the Cudddalore district of Tamil Nadu based on the different environmental parameters such as rainfall, slope, soil, land use/land cover, geomorphology, and drainage density. From the obtained results it was observed that 40% of the areas are highly vulnerable, 30% of areas demarcated as moderately vulnerable, and 30% are low vulnerable areas in the study area. Based on this study it is put forth that the livestock in the low-lying areas suffer to the deep end because of the typographical location. To overcome this misshapen the farmers must be educated on the flood hazard map which would render the required information to prevent monitory loss.

FUTURE SCOPE

The created flood hazard map will aid the policy planners, stakeholders, public work department, and hydrological department of the district in the formulation of suitable development plans to reduce the severity of floods in vulnerable areas.

Acknowledgement. The authors would like to thank the Vice Chancellor, TANUVAS and Department of Earth Sciences, Annamalai University for providing facilities for carrying out the research.
Conflict of Interest. None.

REFERENCES

Bhanja, S. K., Mohanty, P. K., Sahoo A. and Patra R. C. (1999). Impact of supercyclone in Orissa on livestock wealth and its remedial measures: a report. Indian Veterinary Research Institute, Izatnagar, India, 25 pp

Abbas, G., Ahmad, S., Ahmad, A., Nasim, W., Fatima, Z., Hussain, S. and Hoogenboom, G. (2017). Quantification the impacts of climate change and crop management on phenology of maize-based cropping system in Punjab, Pakistan. *Agric. For. Meteorol.*, *247*, 42-55.

Aja, D., Elias, E. and Obiahu, O. H. (2020). Flood risk zone mapping using rational model in a highly weathered Nitisols of Abakaliki Local Government Area, South-eastern Nigeria. *Geology, Ecology, and Landscapes*, *4*(2), 131-139.

Antzoulatos, G., Kouloglou, I. O., Bakratsas, M., Moumtzidou, A., Gialampoukidis, I., Karakostas, A. and Kompatsiaris, I. (2022). Flood hazard and risk mapping by applying an explainable machine learning framework using satellite imagery and GIS data. *Sustainability*, *14*(6), 3251.

Behera, J., Jha, S. K., Maiti, S. and Garai, S. (2021). A Study on Housing Management Strategies Adapted by Livestock rearers in Flood-prone Districts of Odisha.

J. Community Mobilization Sustain. Dev., *16*, 223-228.

Biswas, S., Mahajan, P., Sharma, A., Singh Baghel, D. and Nmims, I. (2018). Methodologies for Flood Hazard Mapping-A Review. *NMIMS, MPSTME, SVNIT: Surat, India*.

Boettinger, J. L., Ramsey, R. D., Bodily, J. M., Cole, N. J., Kienast-Brown, S., Nield, S. J., Saunders, A. M. and Stum, A. K. (2008). Landsat spectral data for digital soil mapping. In A. E. Hartemink, A. McBratney, & M. L. Mendonça-Santos (Eds.), Digital soil mapping with limited data. Springer. Berlin, 193–202.

Borah, S. B., Sivasankar, T., Ramya, M. N. S, and Raju, P. L. N. (2018). Flood inundation mapping and monitoring in Kaziranga National Park, Assam using Sentinel-1 SAR data. *Environmental monitoring and assessment*, *190*, 1-11.

Gesch, D. B. (2009). Analysis of lidar elevation data for improved identification and delineation of lands vulnerable to sea-level rise. *J. Coastal Res*., *10053,* 49-58.

GSI and NRSC (2012). National geomorphological and Lineament mapping on 1:50,000 scale, Natural Resources Census Project, National Remote Sensing Centre, ISRO, Hyderabad.

Junger, L., Hohensinner, S., Schroll, K., Wagner, K. and Seher, W. (2022). Land use in flood-prone areas and its significance for flood risk management—a case study of alpine regions in Austria. *Land*, *11*(3), 392.

Kudrat, M., Sinha, A. K. and Manchanda, M. L. (2000). Multilevel soil mapping using IRS1C WiFS, LISS III and Pan data. Bangalore. Indian Space Research Organisation.

Membele, G. M., Naidu, M. and Mutanga, O. (2022). Examining flood vulnerability mapping approaches in developing countries: A scoping review. *International Journal of Disaster Risk Reduction*, *69*, 102766.

Mohamed, M. A. (2017). Analysis of digital elevation model and LNDSAT data using geographic information system for soil mapping in urban areas. *Natural Resources*, *8*, 767–787.

Mohammad, S. and Bishnoi, P. (2021). Use of GIS and Remote Sensing as Risk Reduction Techniques in Disasters with Special Reference of India. *International Journal of Environment and Climate Change*, *11*(1), 119-124.

Nithya, S. E. and Priyanka, S. (2019). Vulnerable area assessed due to flood in Cuddalore District by morphometric analysis method. *Int. J. Engin. Res. Tech*., *7*, 1-6.

Pareek, A. and Trivedi, P. C. (2011). Cultural values and indigenous knowledge of climate change and disaster prediction in Rajasthan, India. *Indian J. Tradit. Knowl.*, *10*, 183-189.

Saha, A. K., and Agrawal, S. (2020). Mapping and assessment of flood risk in Prayagraj district, India: a GIS and remote sensing study. *Nanotechnology for Environmental Engineering*, *5*, 1-18.

Sanyal, J. and Lu, X. X. (2004). Application of remote sensing in flood management with special reference to monsoon Asia: *Nat. Hazards*, *33*, 283-301.

Sen, A. and Chander, M. (2003). Disaster management in India: the case of livestock and poultry. *Revue scientifique et technique-office international des epizooties*, *22*(3), 915-930.

Silambarasan, P., Vanan, T. T., Kumaravel, N., Churchil, R. R., Vengadabady, N. and Rajkumar, N. V. (2022). Level of Adoption of Flood Disaster Mitigation Strategies by Livestock Farmers during Flood Disaster in Cuddalore District of Tamil Nadu. *Biological forum – An International Journal***,** *14*(2a), 420-424

WHO (2002). Disasters and Emergencies definitions Training Package. www.whointi disasters/ repol756.pdf

Younghun, J., Dongkyun, K., Dongwook, K., Munmo, K. and Seung, O. L. (2014). Simplified flood inundation mapping based on flood elevation-discharge rating curves using satellite images in gauged watersheds. *Water*, *6*, 1280–1299.

How to cite this article: P. Tensingh Gnanaraj, P. Silambarasan, Thanga Thamil Vanan, R. Richard Churchill and N. Vengadabady (2023). Flood Vulnerability and Livestock Production Risks Hazard Mapping of Flood-Prone Areas of the Cuddalore District of Tamil Nadu, India. *Biological Forum – An International Journal, 15*(5): 1124-1130.