Cyclone Vulnerability and Risk Analysis for Coastal Districts of Andhra Pradesh

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ABSTRACT

This paper is an attempt to analyze the mandal wise percentage population at risk due to vulnerability of cyclones in nine coastal districts of Andhra Pradesh using the Expert Decision Support System(EDSS) available with Andhra Pradesh State Development Planning Society(APSDPS) based on the latest data sets. The EDSS model is used to compute expected casualties due to cyclones by considering percentage area inundated, combined casualty rate for a wind speed of 235 kmph from the outputs of storm surge model and wind damage model, and population and number of existing cyclone shelters as inputs. The results indicate that out of 430 mandals in 9 coastal districts of Andhra Pradesh, the affected mandals due to cyclone with a wind speed of 235Kmph are 190. The percentage population at risk is categorised into 4 classes as, low, medium, high and very high in 55, 86, 31, and 17 mandals respectively. Out of the total population in 9 coastal districts, 11% of population is at risk (7% - rural and 4% - urban). Out of total rural population, 10% rural people are at risk. Further results shows that the existing cyclone shelters (664) can accommodate only 8% of rural people at risk and hence safe places shall be identified for the remaining 92% of the rural people at risk. This analysis enables the officials involved in disaster management and rescue operations to concentrate on the identified affected mandals of population at risk during cyclone event and also to identify safe places for evacuation during cyclones.

Keywords: *Vulnerability, Cyclone Shelters, Population and Risk assessment.*

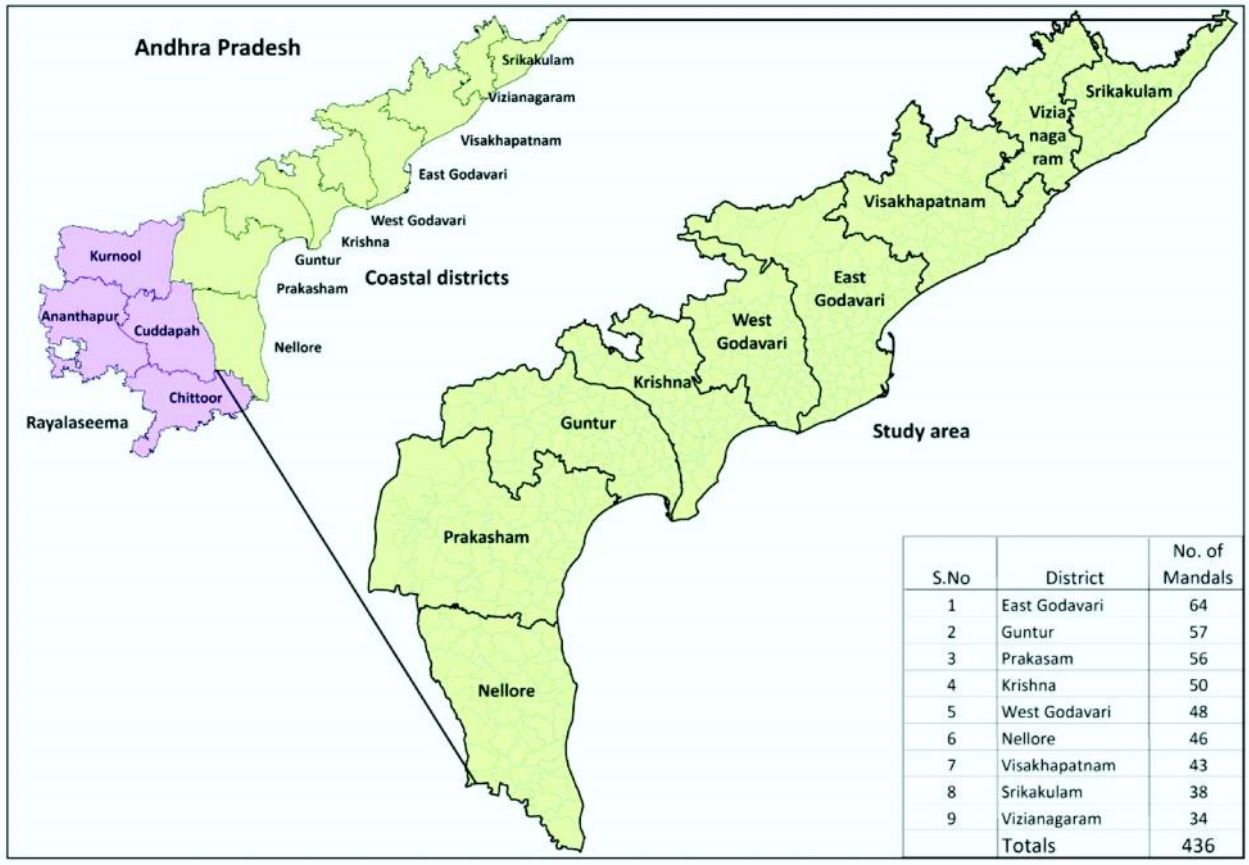
1. Introduction

Andhra Pradesh has about 974 km coastal line being the second largest of the states in India which runs through nine districts of Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam, and Nellore. The coastal Andhra Pradesh is highly vulnerable to cyclones with varying intensities. Past experience shows that certain parts of Andhra Pradesh coast are vulnerable to loss of life and property due to cyclone and storm surges and associated flooding as well as high wind speeds. More than 103 cyclones have affected Andhra Pradesh this century (www.nrsc.gov.in/ uim_2014_proceedings/papers_ppts/ UIM2014_US5_E), the recent being Hudhud Cyclone (8th October – 13th October, 2014). The state had suffered extensive damages in the past due to cyclonic storms of different intensities over the years. The coastal districts of Andhra Pradesh witnessed many cyclones resulting in loss of life and property. Moreover, when a storm surge develops threats to humans and property multiply as the sea water may inundate coastal areas which are already being subjected to torrential rains as it was the case during the severe November 1977, May 1990 and Nov. 1996 cyclones (disastermanagement.ap.gov.in/ website / APSDMP1.pdf and http://disaster management.ap.gov.in/website/cyclone.htm disaster management website). For example, the 1977 cyclone that was accompanied by a 5 m storm surge killed about 10,000 people and 0.2 million livestock besides causing enormous damage to property in the Krishna delta region. The 3 to 4 m storm surges occurred respectively in the 1990 and 1996 killed thousands of people and millions of livestock, besides damaging property in Godavari delta region (K. Nageswara Rao etal, 2009). In this background, it is necessary to identify the mandals vulnerable to cyclones and analyse the mandal wise percentage population at risk and expected casualties in nine coastal districts of Andhra Pradesh to enable the officials involved in disaster management and rescue operations to concentrate

on the identified affected mandals of population at risk during cyclone event and also to identify safe places for evacuation during cyclones. This paper, therefore, is an attempt to compute the affected mandals, mandal wise percentage population at risk and expected casualties due to cyclones by considering percentage area inundated, combined casualty rate for a cyclone with wind speed of 235 kmph from the outputs of storm surge model and wind damage model, and mandal wise population and number of existing cyclone shelters as inputs using Cyclone Vulnerability Module (CVM) of EDSS.

2. Study Area

Andhra Pradesh state is divided into 13 districts and 670 mandals for administrative purposes. It has two major regions namely Coastal Andhra and Rayalaseema. Coastal Andhra consists of 9 districts and Rayalaseema consists of 4 districts. The state has a total population of 4.95 crores, the population in the 9 coastal districts is 3.43 crores (69.3%) and in 4 districts of Rayalaseema the population is 1.52 crores (30.6%). Andhra Pradesh state has a vast coastline of 974 km and the total coastal area is spread over 92,906 sq. Kms in 9 coastal districts namely, Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam, and Potti Sree Ramulu Nellore. This makes coastal Andhra Pradesh highly vulnerable to cyclones with varying intensities. The coastal Andhra Pradesh is known for frequent tropical cyclones and associated floods and storm surges causing loss life and property. Therefore, the nine coastal districts of Andhra Pradesh is considered for the study in order to identify the cyclone affected mandals, mandal wise percentage population at risk and expected casualties due to vulnerability of cyclones in nine coastal districts of Andhra Pradesh state using the EDSS model available with APSDPS using the latest data sets. The map (Fig 1) shows the delineation of the study area and the number of mandals in each district.



S.No	District	No. of Mandals
1	East Godavari	64
2	Guntur	57
3	Prakasam	56
4	Krishna	50
5	West Godavari	48
6	Nellore	46
7	Visakhapatnam	43
8	Srikakulam	38
9	Vizianagaram	34
	Totals	436

Fig.1: Study area.

3. Overview of EDSS_ICZM:

The Integrated Coastal Zone Management (ICZM) component for Andhra Pradesh was formulated under Cyclone Hazard Mitigation Project (CHMP), initiated in 1999 with World Bank assistance. The focus of the component is to provide a system that minimizes impacts due to natural disasters like cyclone and to enhance sustainable development of the coastal zone. ICZM streamlines and provides a smooth platform to launch the disaster management plans and early warning systems.

APSDPS has an EDSS_ICZM, developed by Waterloopkundig Laboratorium (WL)| Delft Hydraulics, the Netherlands, under Andhra Pradesh Hazard Mitigation & Emergency Cyclone Recovery Project during the year 2002 for evaluation of possible scenarios for vulnerability and hazard mitigation and is helpful to the administrators in planning for long-term measures in the vulnerable areas. EDSS is a computer based system that links land use, socio-economy, resource and environmental management and cyclone vulnerability (Fig 2). It calculates effects of scenarios and policy measures on the people's income, environmental quality and vulnerability to cyclones. Aim of the EDSS is to assist the decision making with regard to measures and policies. Outcome of the EDSS indicates the criteria of equitable quality of life levels, environmental status and vulnerability. It calculates impacts on mandal level and shows spatial distribution of effects. The EDSS_ICZM is qualified for application on the entire Andhra Pradesh coast. The Godavari Delta has been used as a pilot study area for which the EDSS has been calibrated and for which alternative development scenarios have been developed (M. Marchand etal, 2006).

4. Methodology

From the literature it is clear that the coastal Andhra Pradesh is especially susceptible to damage due to storm surges and associated

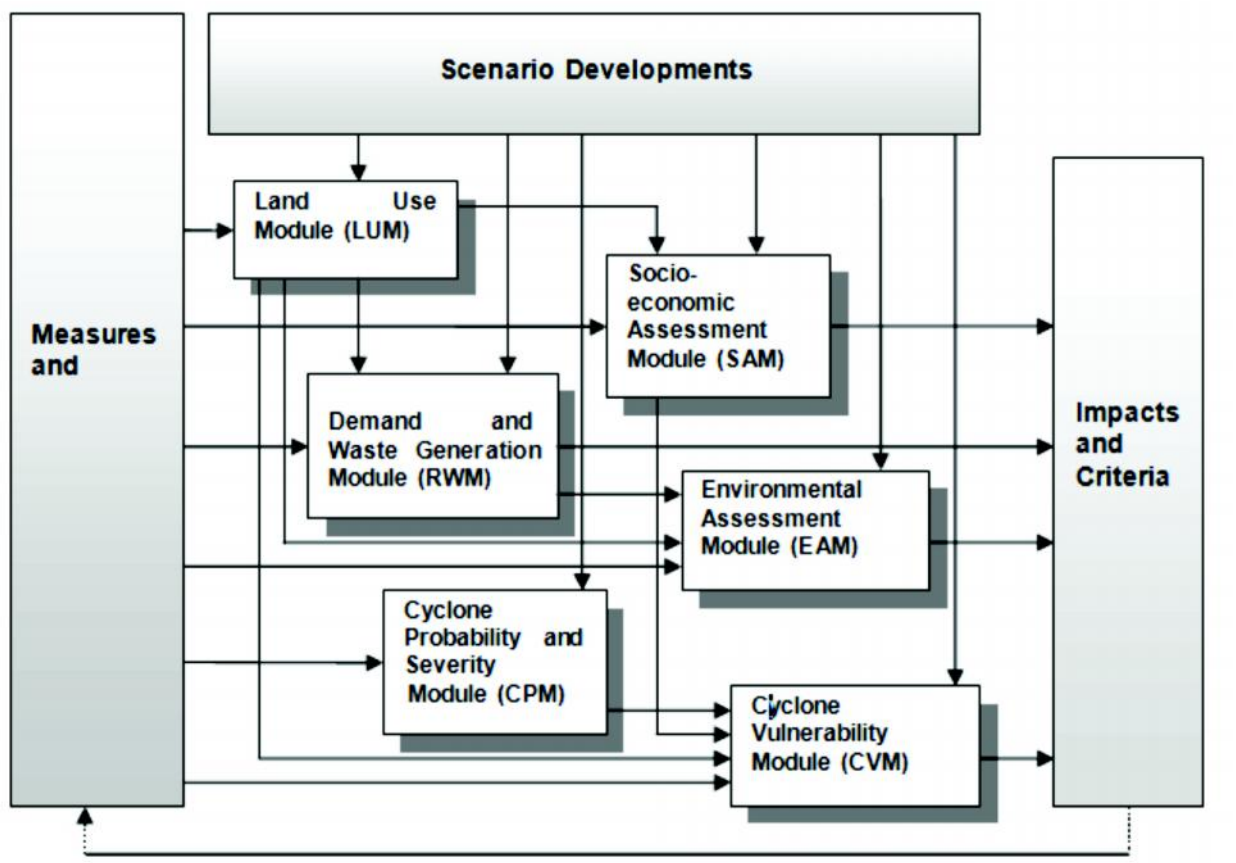


Fig.2: Overview of EDSS Module.

flooding as well as wind damage (Nageswara Rao etal, 2009). In order to account for this susceptibility in planning, the EDSS model provides calculations through which the vulnerability to storm surge and wind damage can be analysed. The steps adopted are given below.

- For each selected mandal the frequency of inundation, the maximum area inundated and the average inundation depth is assessed, based on the output of the Storm Surge Model (SSM) for cyclone with a wind speed of 235 Kmph.
- For each selected mandal the damaging wind speed has been assessed, based on the output of the Wind Damage Model (WDM).
- The outputs of SSM and WDM model are provided as inputs to EDSS model.
- EDSS Model: Mandal wise population, the frequency of inundation, the maximum area inundated and the average inundation depth assessed, the flood casualty rate, flooding probability, wind casualty rate are used as inputs by the CVM of the EDSS inorder to compute the affected mandals, mandal wise percentage population at risk(a function of population and area inundated) and expected casualties(a function of population, area inundated, flooding probability and combined casualty rate and number of existing cyclone shelters) as outputs. For each study mandal combined casualty rate which is a combination of flood casualty rate (based on average inundation depth) and wind casualty rate (damaging wind speed) is calculated by EDSS as intermediate outputs. The results of EDSS model are in the form of tables and GIS maps. The tabular output is shown in the form of spatial maps for better interpretation of results. The mandal wise percentage population at risk is categorised into 4 classes as, low, medium, high and very high.

5. Results and Discussion

The analysis is carried out at district and mandal levels using CVM of EDSS model. The district and mandal wise results are discussed in the subsequent sections.

5.1 District wise percentage population at risk

The district wise percentage population at risk in nine coastal districts of Andhra Pradesh are Srikakulam–8%, Vizianagaram–2%, Visakhapatnam–11%, East Godavari–17%, West Godavari –10%, Krishna–12%, Guntur–7%, Prakasam–9% and Potti Sree Ramulu Nellore–12%. The district wise percentage population at risk are shown in Fig 3 and from the analysis it is found that the percentage population at risk is higher in East Godavari district when compared to other districts.

5.2 Mandal wise analysis

5.2.1 Affected Mandals and status of cyclone shelters

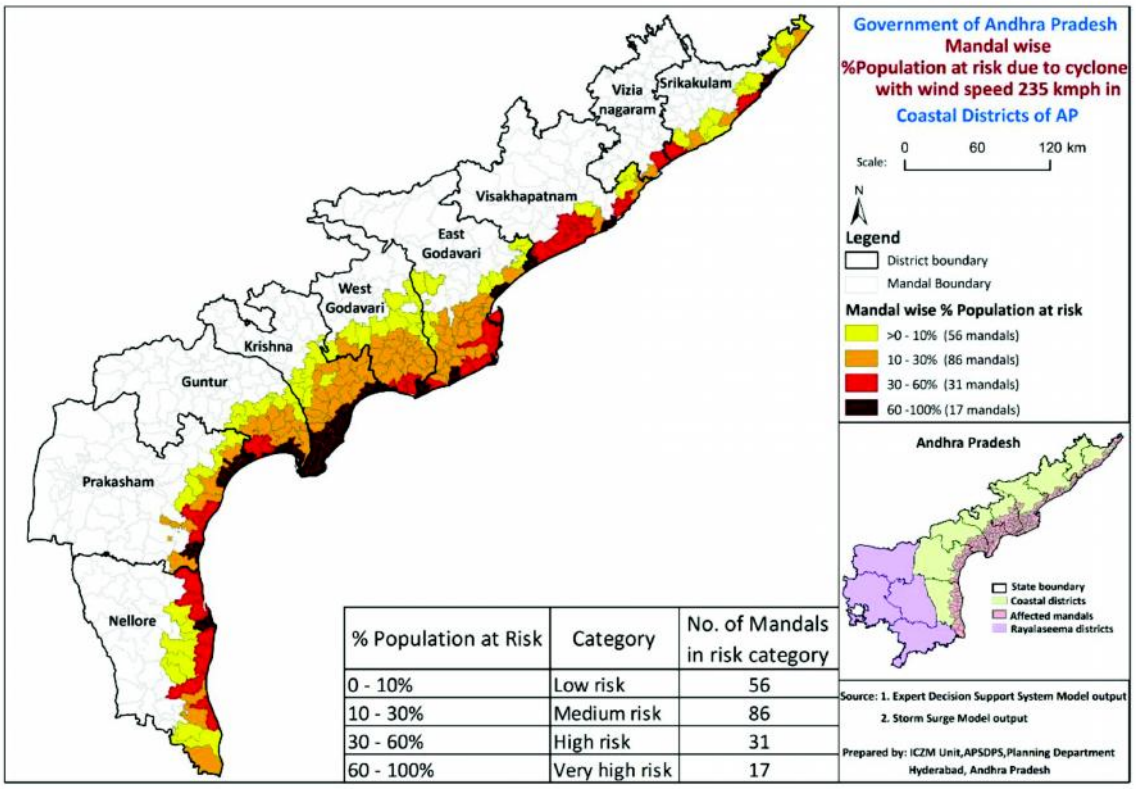
The results indicate that out of 430 mandals in nine coastal districts of Andhra Pradesh, the effect of storm surge inundation for cyclone with wind speed of 235 Kmph is felt by 190 mandals (Fig 4). The number of existing cyclone shelters covering different mandals in nine coastal districts of Andhra Pradesh are 664. Fig 5 shows the status of affected mandals with and without cyclone shelters thus necessitating the cyclone shelters in the affected mandals without cyclone shelters.

5.2.2 Mandal wise percentage population at risk

Mandal wise percentage population at risk in 190 affected mandals of nine coastal districts of Andhra Pradesh is shown in Fig 6. The percentage population at risk is categorised into 4 classes as, low, medium, high and very high in 55, 86, 31, and 17 mandals respectively. The Mandal wise percentage population at risk for Visakhapatnam district is shown separately in Fig 7.

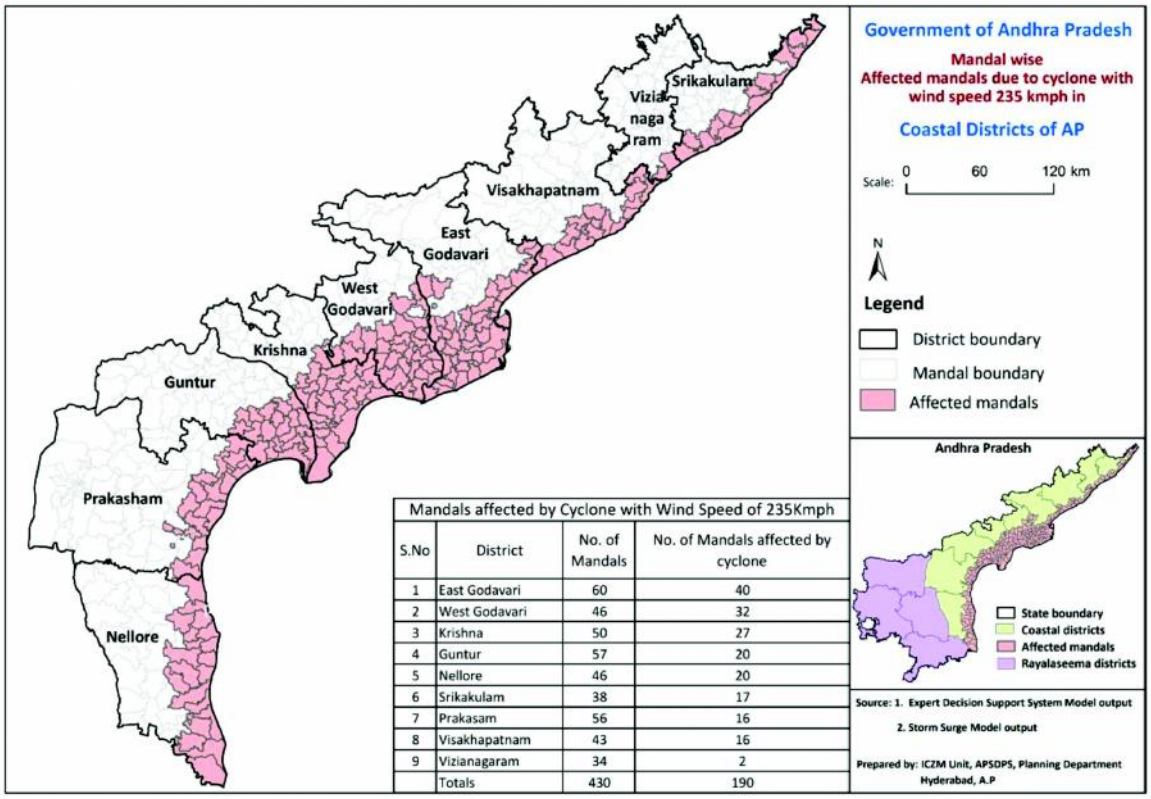
5.2.3 Mandal wise expected casualties

The total expected casualties in nine coastal districts of Andhra pradesh are 2113. The expected casualties in nine coastal districts is Srikakulam–89, Vizianagaram–12, Visakhapatnam–125, East Godavari–697, West Godavari–182, Krishna–282, Guntur–309, Prakasam–160 and Potti Sree Ramulu Nellore–257. The map showing mandal wise expected casualties is shown in Fig 8. The map showing expected casualties in Visakhapatnam district is given in Fig 9.



% Population at Risk	Category	No. of Mandals in risk category
0 - 10%	Low risk	56
10 - 30%	Medium risk	86
30 - 60%	High risk	31
60 - 100%	Very high risk	17

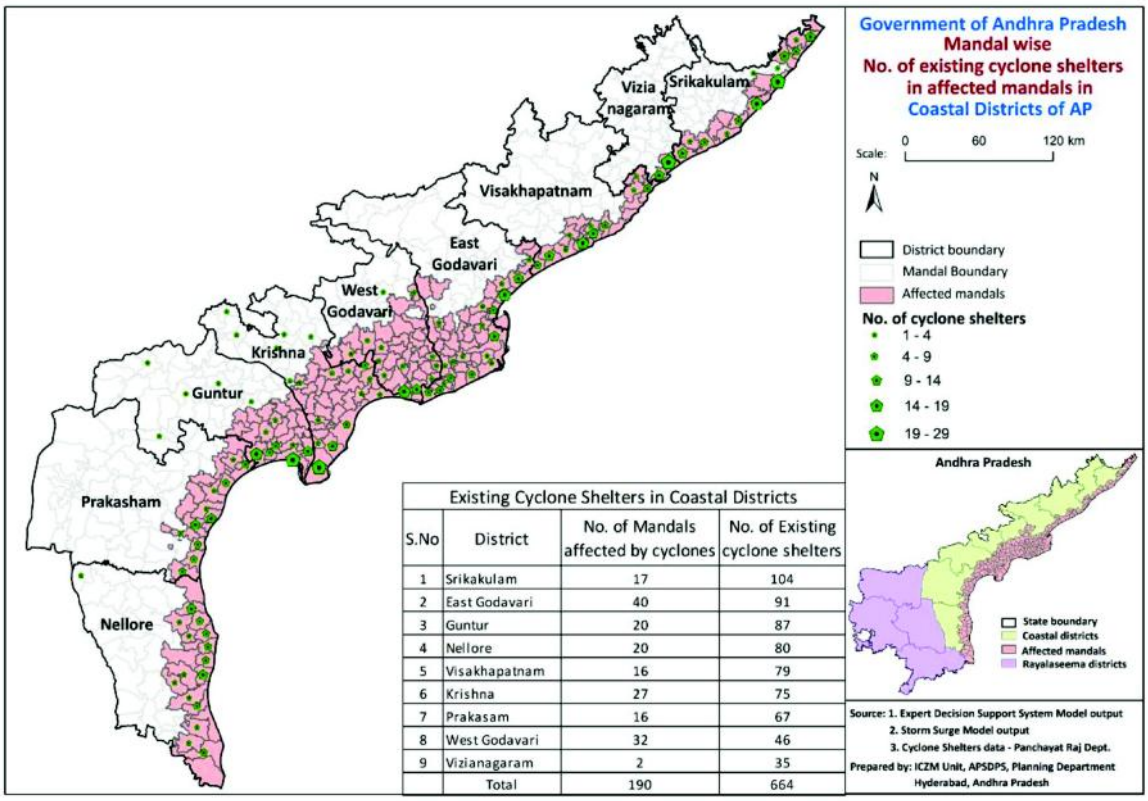
Fig.3: District wise percentage population at risk.



Mandals affected by Cyclone with Wind Speed of 235Kmph

S.No	District	No. of Mandals	No. of Mandals affected by cyclone
1	East Godavari	60	40
2	West Godavari	46	32
3	Krishna	50	27
4	Guntur	57	20
5	Nellore	46	20
6	Srikakulam	38	17
7	Prakasam	56	16
8	Visakhapatnam	43	16
9	Vizianagaram	34	2
	Totals	430	190

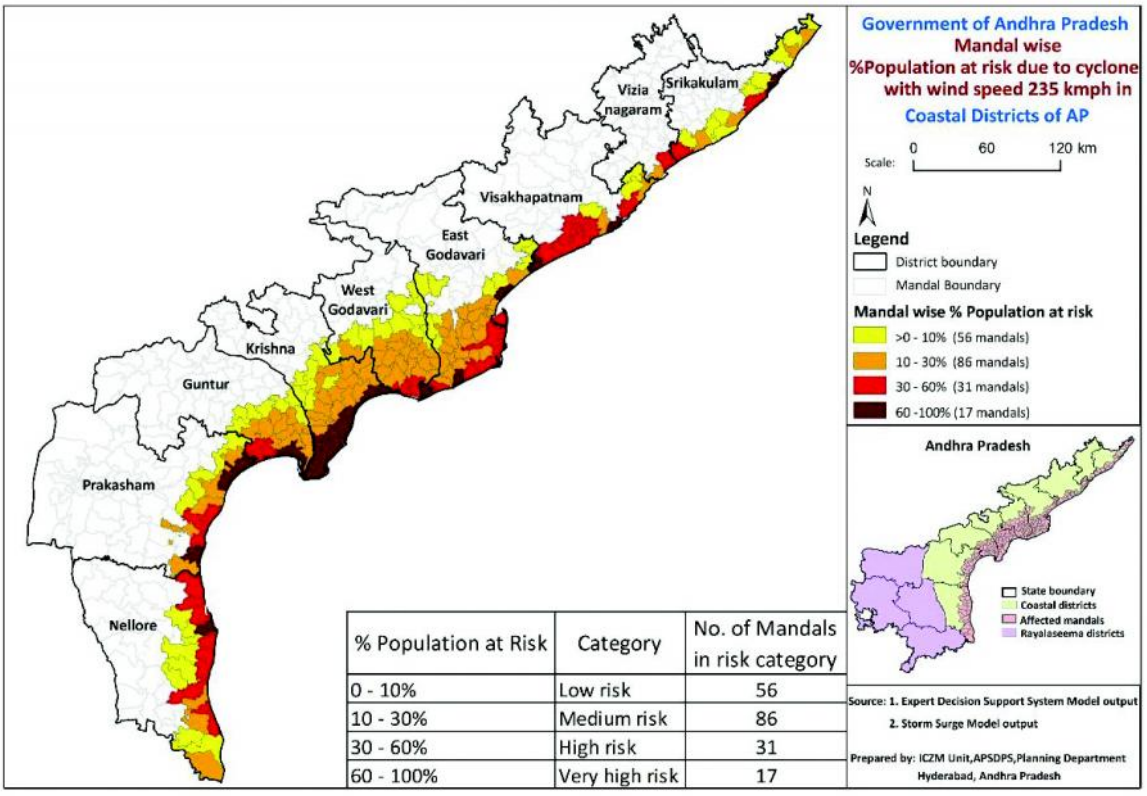
Fig. 4: Affected mandals due to cyclone with wind speed of 235 Kmph.



Existing Cyclone Shelters in Coastal Districts

S.No	District	No. of Mandals affected by cyclones	No. of Existing cyclone shelters
1	Srikakulam	17	104
2	East Godavari	40	91
3	Guntur	20	87
4	Nellore	20	80
5	Visakhapatnam	16	79
6	Krishna	27	75
7	Prakasam	16	67
8	West Godavari	32	46
9	Vizianagaram	2	35
	Total	190	664

Fig. 5: Number of existing cyclone shelters in affected mandals.



% Population at Risk	Category	No. of Mandals in risk category
0 - 10%	Low risk	56
10 - 30%	Medium risk	86
30 - 60%	High risk	31
60 - 100%	Very high risk	17

Fig.6: Mandal wise percentage population at risk for nine coastal districts.

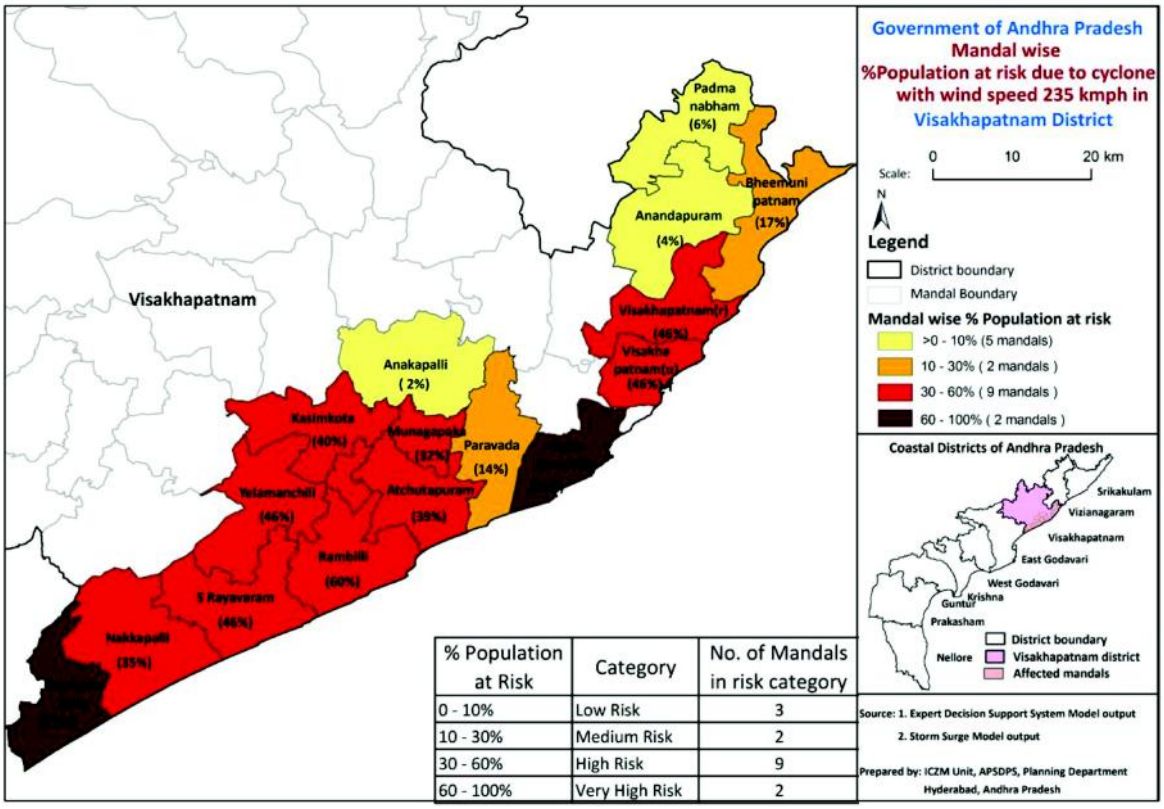


Fig. 7 : Mandal wise percentage population at risk for Visakhapatnam district.

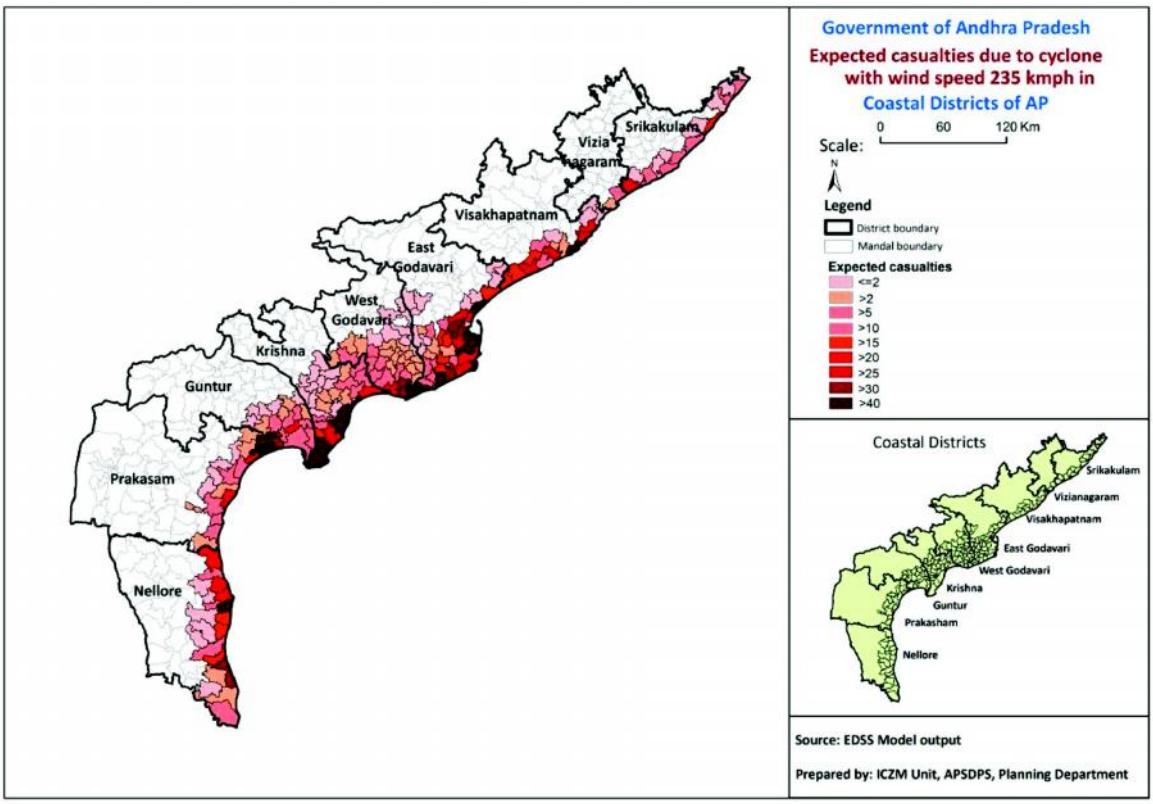


Fig. 8: Expected Casualties.

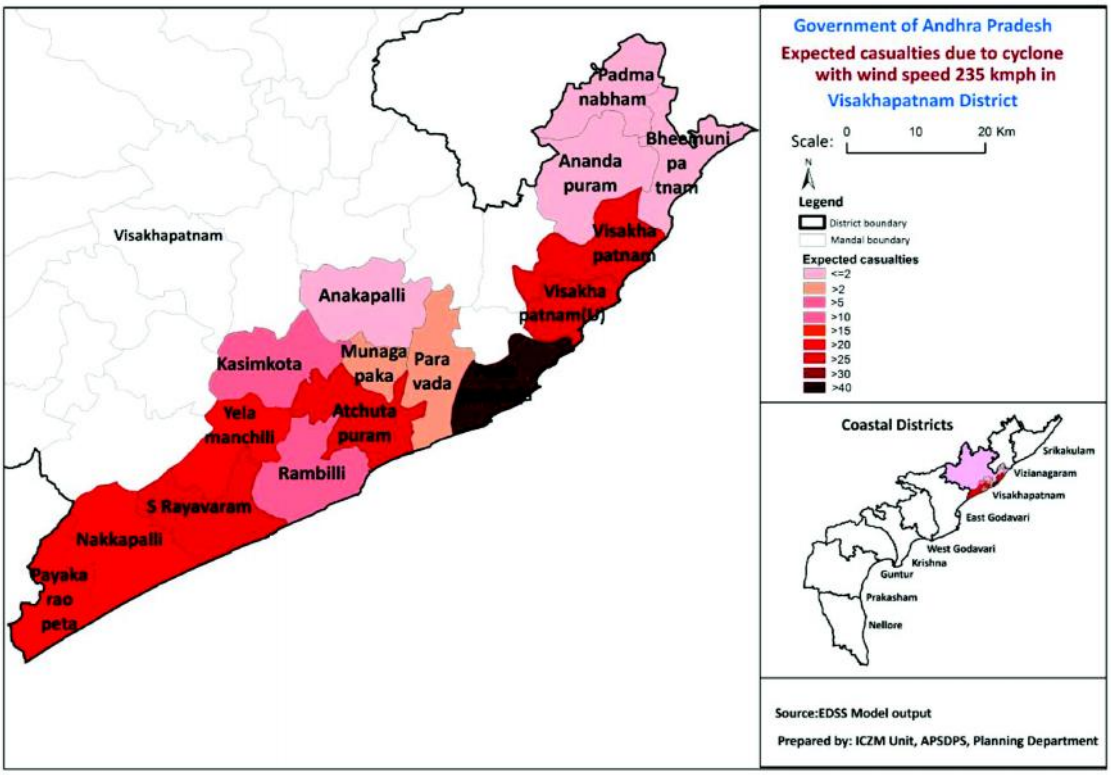


Fig.9 : Mandal wise Expected Casualties in Visakhapatnam district.

6. Conclusion

Out of 430 mandals in 9 coastal districts of Andhra Pradesh, the affected mandals due to cyclone with a wind speed of 235Kmph are 190. The percentage population at risk are categorised into 4 classes as, low, medium, high and very high in 56, 86, 31, and 17 mandals respectively (Fig 10). The expected casualties are 2113. Out of total population in 9 coastal districts, 11% of population is at risk (7% - rural and 4% - urban). Out of total rural population, 10% rural people are at risk as shown in Fig 11. The results shows that the existing cyclone shelters (664) can accommodate only 8% of rural people at risk and hence safe places shall be identified for the remaining 92% of the rural people at risk. This analysis enables the officials involved in disaster management and rescue operations to concentrate on the above identified affected mandals of population at risk during cyclone event and also to identify safe places for evacuation during cyclones.

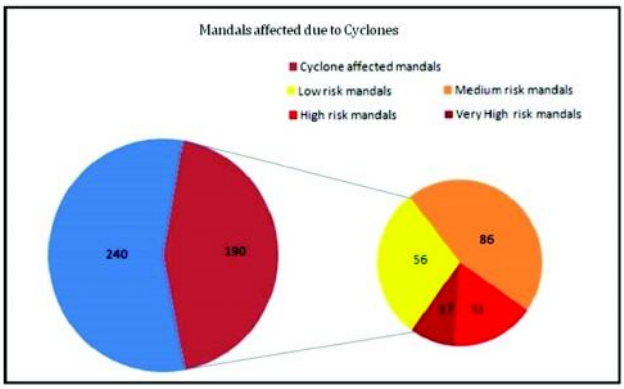


Fig. 10: Affected Mandals due to Cyclones.

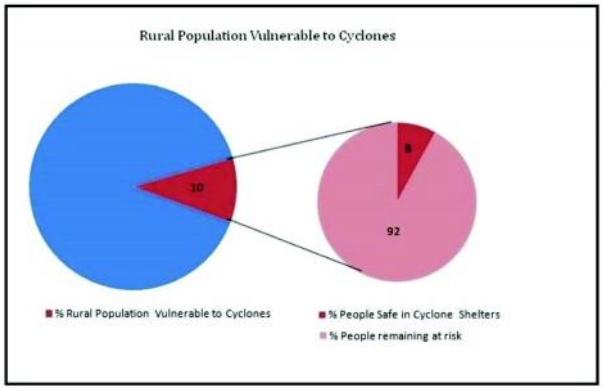


Fig.11: Rural Population Vulnerable to Cyclones.

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