Characteristic Features of Very Severe Cyclonic Storm TITLI and Disaster Management Aspects

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ABSTRACT

A very severe cyclonic storm (VSCS) TITLI crossed north Andhra – South Odisha coast near Palasa, Srikakulam district during 04:30 to 05:30 hrs IST of 11th October, 2018. Gale force winds of 140 to 150 kmph gusting to 165 kmph were experienced at the time of the storm crossing the coast. Highest rainfall recorded in 24 hours ending at 0830 hrs IST of 11th October was 38 cm over Vajrapukotturu in Srikakulam district of Andhra Pradesh followed by 23 cm over Mandragarh district in Odisha. Extensive damages occurred in Srikakulam and eastern half of Vizianagaram districts in Andhra Pradesh and Ganjam, Gajapathi and Rayagada districts of Odisha. The intensity of the storm is gauged on the basis of maximum sustained wind speed associated with the storm. In comparison, TITLI storm was less intense than the VSCS HUDHUD cyclonic storm that crossed the coast close to Visakhapatnam on 12th October, 2014. Hurricane winds of 150 to 180 kmph gusting to 200 kmph with peak wind in gust of 260 kmph for one second at 10.42 hrs IST were experienced in Visakhapatnam on 12th October, 2014. Exceptionally heavy rainfall of 49 cm was recorded at Yellamanchili in Visakhapatnam district on 13th October, 2014. The death toll was 61. Extensive damages occurred in Visakhapatnam, Vizianagaram and Srikakulam Districts.

Keywords: *Cyclones, Heavy rains, Gale force winds, Gusting to, Sustained surface winds and Storm surge.*

1. Introduction

Natural disasters do occur over land due to extreme weather events. Disasters due to cyclones are very destructive since they are associated with storm surges, gale speed winds and flooding due to torrential rains. Indian maritime states face several destructive cyclonic storms those form over the Bay of Bengal and Arabian Sea. The intensity of a cyclonic storm is decided by its maximum sustained surface wind (Merrill, 1984).

Storm surge is the most destructive element which in general occurs only in association with a very severe cyclonic storm. At the time of inner-storm area crossing the coast, storm winds associated with cyclones push waters of the sea on to the coast and the sea level rises abnormally. The inverted barometric pressure nearly raises 1cm of sea level for each hpa of pressure fall at the centre of the cyclone. As a result of storm surge, the sea water enters and inundates low lying areas of coastal region, causes drowning of human beings and livestock, erodes beaches and embankments, destroys vegetation and reduces soil fertility. There is no protection against these storm surges except the total evacuation from places likely to be inundated by sea water.

The second destructive factor is torrential rain, sometimes- heavy, very heavy and extremely heavy in intensity due to cyclone. Heavy and prolonged rains due to cyclone may cause riverine floods and inundate low lying areas, resulting in loss of life and property. The floods can wash away rail tracks, bridges and roads.

The high-velocity gale force winds (of a minimum of 34 knots or 65 kmph or more) associated with cyclones cause extensive loss of property to agriculture and infrastructure. Eye at the centre of the storm is associated only with very severe cyclonic storms. The region over which the eye of storm passes, experiences violent winds twice, once before the eye crosses and another time after its passage. It takes about one hour for the eye to move across a place. These are due to strong winds in the wall-cloud region surrounding the eye.

Absolute calm air or very light wind and clear to partly cloudy sky are experienced during that period which we usually call, "the lull before the storm". Violent winds with very rapid and dangerous shifts, terrific squalls and Heavy to Very Heavy rains precede and follow the passage of the eye of the storm for 6 to 8 hours. Violent winds can blow off all kutcha structures; blow off tiled roofs and asbestos sheets. They cause severe damage to crops in the fields and even uproot trees and electric poles and cause complete failure in telecommunication, power supply and blockage of roads and rail traffic.

2. Brief History of Very Severe Cyclonic Storm (VSCS), TITLI (Storm Track 07-13 Oct-2018)

A low pressure area was formed over the Southeast Bay of Bengal and adjoining North Andaman Sea on 7th October, 2018. It concentrated into a Depression over east central Bay of Bengal at 0830 hrs IST of 8th October 2018 and lay centered near latitude 14.0°N and longitude 88.8° E about 690 km southeast of Kalingapatnam (Andhra Pradesh). The system moved west northwestwards and intensified into a Deep Depression and lay centered at 2330 hrs IST, 8th October 2018 near latitude 14.5°N and longitude 87.6°E, 560 km southeast of Kalingapatnam (Andhra Pradesh).

The system intensified into a cyclonic storm TITLI over west central Bay of Bengal and lay centered at 1130 hrs IST09th October 2018 over West-Central (WC) Bay of Bengal near latitude 14.8°N and longitude 86.7°E, about 530 km southeast of Gopalpur (Odisha) and 480 km east-southeast of Kalingapatnam (Andhra Pradesh). The cyclonic storm TITLI over WC Bay of Bengal intensified into a Severe Cyclonic Storm at 0530 hrs IST of 10th October 2018 over WC Bay of Bengal near latitude 16.0°N and longitude 85.8°E, about 370 km south-southeast of Gopalpur (Odisha) and 310 km southeast of Kalingapatnam (Andhra Pradesh). Severe Cyclonic Storm intensified into a Very Severe Cyclonic Storm and lay cantered at 1130 hrs IST of 10th October 2018 over WC Bay of Bengal near latitude 16.8°N and longitude 85.6°E, about 280 km south southeast of Gopalpur (Odisha) and 230 km southeast of Kalingapatnam (Andhra Pradesh).

The VSCS TITLI moved north-northwestwards and lay centered at1730 hrs IST of 10th October 2018 (Figure 1) over WC Bay of Bengal near latitude 17.5°N and longitude 85.3°E, about 200 km south-southeast of Gopalpur (Odisha) and 150 km southeast of Kalingapatnam (Andhra Pradesh). The TITLI crossed north Andhra – South Odisha coast (near latitude 18.8°N/longitude 84.5°E) across Vijrapukottur mandal near Palasa town of Srikakulam district between 0430 to 0530 hrs IST of 11th October, 2018. The system moved north-eastwards and weakened into a depression by 11.30 hrs IST. The system finally weakened into a low pressure area by 0830 hrs IST/13th October (Figure 1).

The life of the Very Severe Cyclonic Storm (VSCS), TITLI was about 6 ½ days from the time of its formation as a low pressure area over southeast Bay of Bengal and adjoining north Andaman Sea on 7th October, 2018 till its dissipation over Gangetic West Bengal and adjoining Bangladesh and North Bay of Bengal on 13th evening. There was rapid intensification of TITLI cyclonic storm to very severe cyclonic storm over sea in 24 hrs period between 9th to afternoon of 10th October. It travelled over a distance of about 1650 km, with 950 km over the sea and 700 km over land. It gained its intensity till it crossed coast due to abundant supply of moisture from warm sea for 4 days and rapidly weakened and dissipated in 2 ½ days over land due to short supply of moisture and high frictional resistance offered to storm winds over land.

2.1 Salient features of TITLI

As shown in Figure 2, TITLI crossed north Andhra –South Odisha coast (near latitude 18.8°N/longitude 84.5°E) across Vijrapukottur mandal near Palasa town of Srikakulam district between 0430 to 0530 hrs IST of 11th October, 2018. Gale winds of 140 to 150 kmph gusting to 165 kmph were experienced at the time of storm crossing the coast.

The VSCS caused extensive damage over south Odisha and adjoining north Andhra Pradesh districts of Srikakulam and eastern half Vizianagaram, due to strong winds and floods caused by heavy to very heavy and extreme rainfalls.

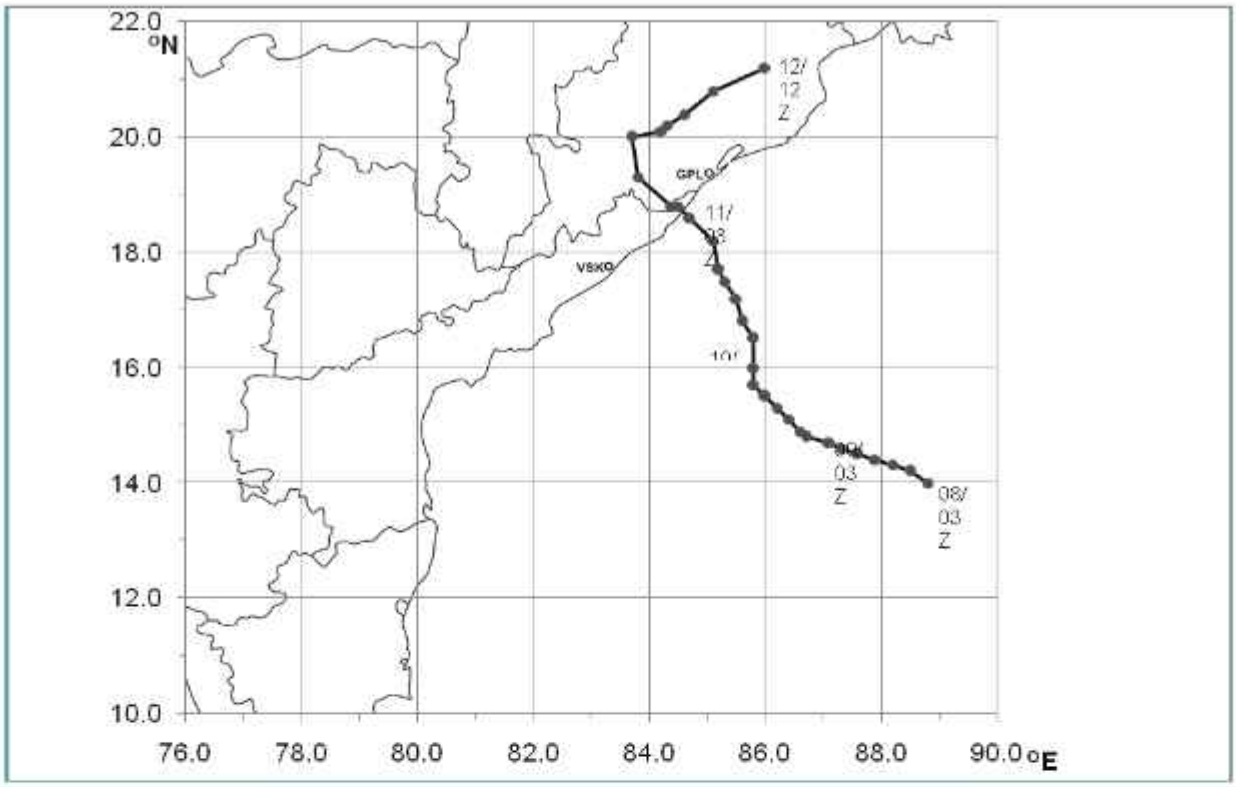
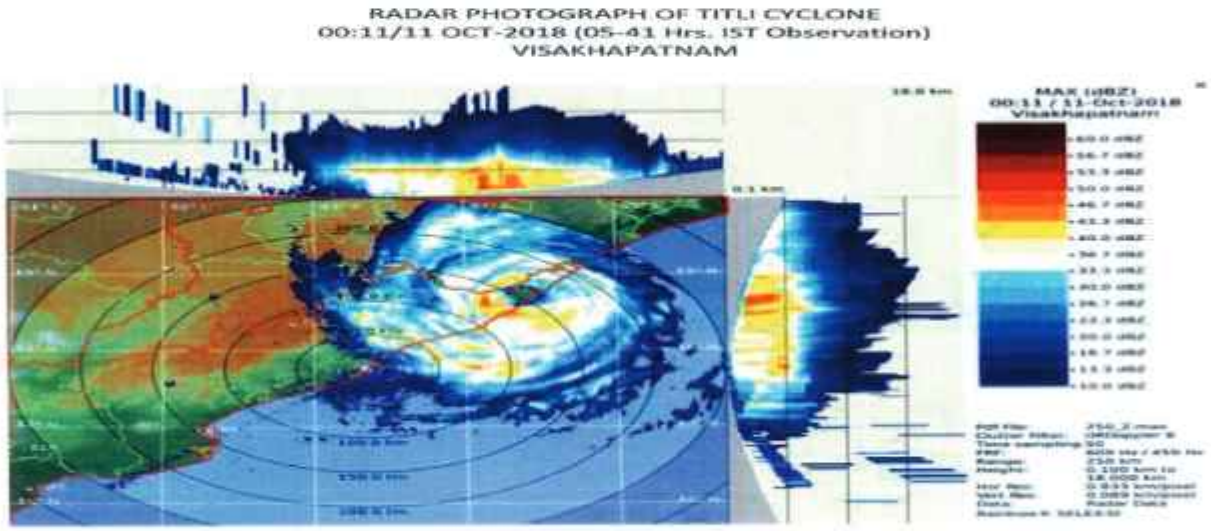


Figure 1: Track of Very Severe Cyclonic Storm TITLI.



Centre of the Storm : Latitude 18.72°N / Longitude 84.37°E.
About 152 KM north east of Visakhapatnam.

Circular 'EYE' diameter	:	26 Kms
Diameter of Eye-Wall	:	About 85 Kms.
Area of Coverage of Storm:		NNW-SSE direction : 315 Km
		SW – NE Direction : 250 Km
Significant Feature	:	End of eye about to cross over North Andhra Coast.

Figure 2: VSCS Titli Crosses Andhra Pradesh coast.

2.2 High winds

Based on Doppler Weather Radar Visakhapatnam, cloud imageries and synoptic observations of Gopalpur and Kalingapatnam, the following can be well inferred. Due to the passage of inner storm area (the eye and inner ring of hurricane winds of 85km diameter) hurricane winds of 140 to 150 kmph occurred between 0200 to 0800 hrs of 11th October over Ichapuram, Kanchali, Kaviti,

Sompeta, Mandasa, Palasa and Vajrapukothur mandals of Srikakulam district of Andhra Pradesh and Gajapathi, Ganjam, Rayagada, Nayagarh and Kandamal districts of South Odisha. These places were worst affected by storm winds.

In association with the passage of outer area of storm, Nandigam, Meliaputti, Santhabommali, Tekkali and Pathapatnam mandals of Srikakulam district and remaining districts of south Odisha were affected worse due to gale winds of 60 to 70 kmph. Remaining areas of Srikakulam and eastern half of Vizianagaram district were affected badly by nearly gale winds of 50 to 60 kmph during the same period. After the landfall, strong winds (40 to 50 kmph) were experienced in Srikakulam and eastern half of Vizianagaram districts from morning to evening of 11th October. However, gale winds of 60 to 80 kmph prevailed over south Odisha till the mid-night of 11th October as the storm moved over and rapidly weakened into a deep depression over it by midnight. As per climatology of cyclones over the area, in the post-monsoon month of October, strongest winds and rainfall activity occur to the north of the storm centre. Akin to this, it may be noted that at 0530 hrs IST of 11th October, Gopalpur observatory which is at a distance of 60kms northeast of storm centre at that time recorded surface wind from easterly direction of 102 kmph and whereas Kalingapatnam observatory at a distance of 70kms south-southwest of storm centre recorded westerly wind of 56 kmph. Both the stations are located in the outer area of storm.

It is reported that a minor storm-surge of about one meter height above the astronomical tide had inundated low lying areas at the time of landfall at places to the north of it.

2.3 Heavy rains

In Srikakulam district, light to moderate rains started from the night of 10th October, 2018 and intense spells of rain (2 to 3cm/hr) started from mid-night of 10th and continued till morning of 11th and thereafter moderate rains occurred till the evening of 11th October. Vajrapukotturu 38 cmNandigama 37 cm, Kanchili (29 cm) and Palasa (28 cm) 24 cms at Ichapuram, 23 cm at mandasa Srikakulam district in Andhra Pradesh. However, extreme intense spells of rain (5 to 10 cm/hr) occurred between midnight of 10th till the morning of 11th October, over the mandals covered by (can be corroborated from the (Figure 3) Narsannapeta to Ichapuram along the coast and Narasnnapeta to Sompeta in the northwest. Cloud tops of heights 9 to 11 km were observed by radar around the storm centre during the period of passage of storm over the coast (Figure 2). Cumulative rainfall of 20 to 35cm occurred over the area mentioned above on 11th and 12th October. Heavy rain falls also occurred in the remaining parts of the district varying between 10 to 13cms during the same period. Extreme Heavy rainfall fall of 24cms (237.6mm) recorded at Ichapuram in 24 hours ending at 0830 hrs IST of 11th October.

In the eastern half of Vizianagaram district, light to moderate rains occurred from 10th night to the morning of 11th and moderate to heavy rains (2 to 11 cm) occurred from 11th morning till evening (Figure 4). In the western half of Vizianagaram district only light rain occurred from 10th midnight to 11th evening. Cumulative rainfall totals of 11th& 12th October varied from 4 to 11cms in the eastern half and only 1cm recorded in the western half of Vizianagaram.

Based on IMD report, in Odisha heavy to very heavy rains occurred at many places with extremely heavy falls at isolated places on 11th& 12th October. On 11th October, extremely heavy rainfall recorded at Mahendragarh 23cm, R.Udayagiri 22cm, Mohana 22cm in Gajapathi district and at Purushothampur 21cm in Ganjam district.

2.4 Damages caused by TITLI

Due to storm winds and heavy spells of rains followed by inundation of low lying areas and flooding in rivers caused extensive damages to the property and infrastructure in Srikakulam and Vizianagaram district of North Coastal Andhra Pradesh and in Southern districts of Odisha.

2.4.1 Odisha

Death toll in Odisha was mainly in Gajapathi district.12 persons died due to landslide of a hillock as they took shelter under it due to heavy rain on 10th October 2018 night. Heavy rains caused

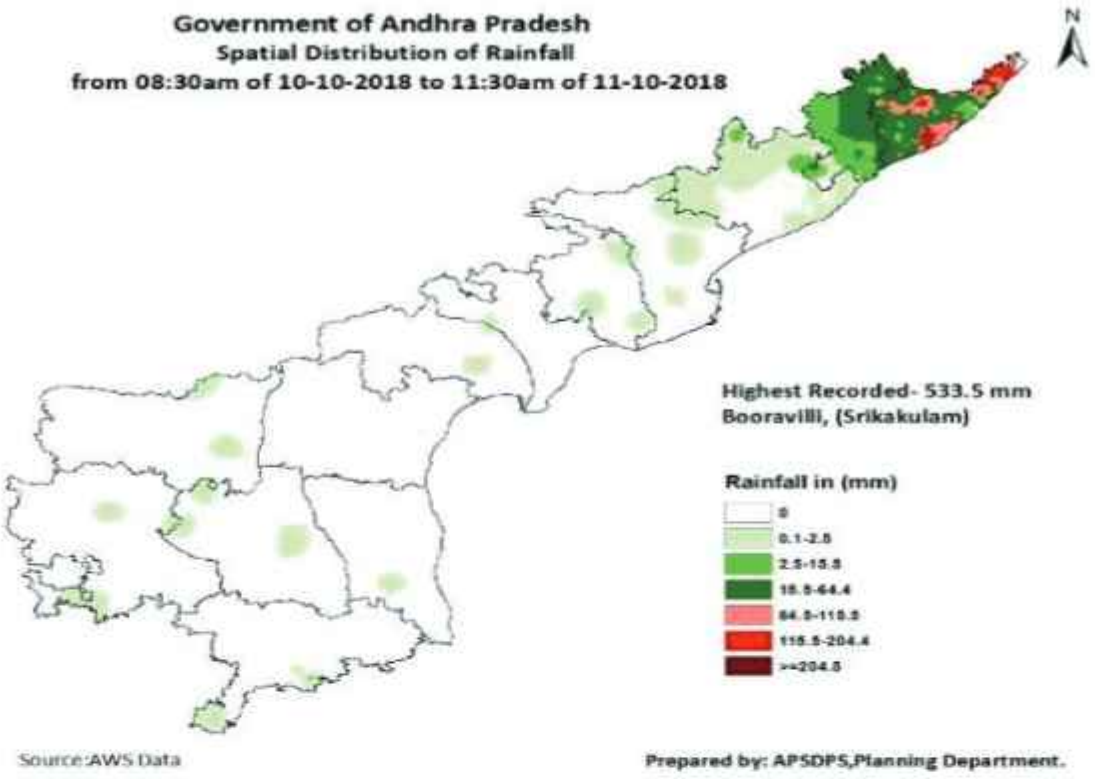


Figure 3: Spatial distribution of Rainfall in Andhra Pradesh.

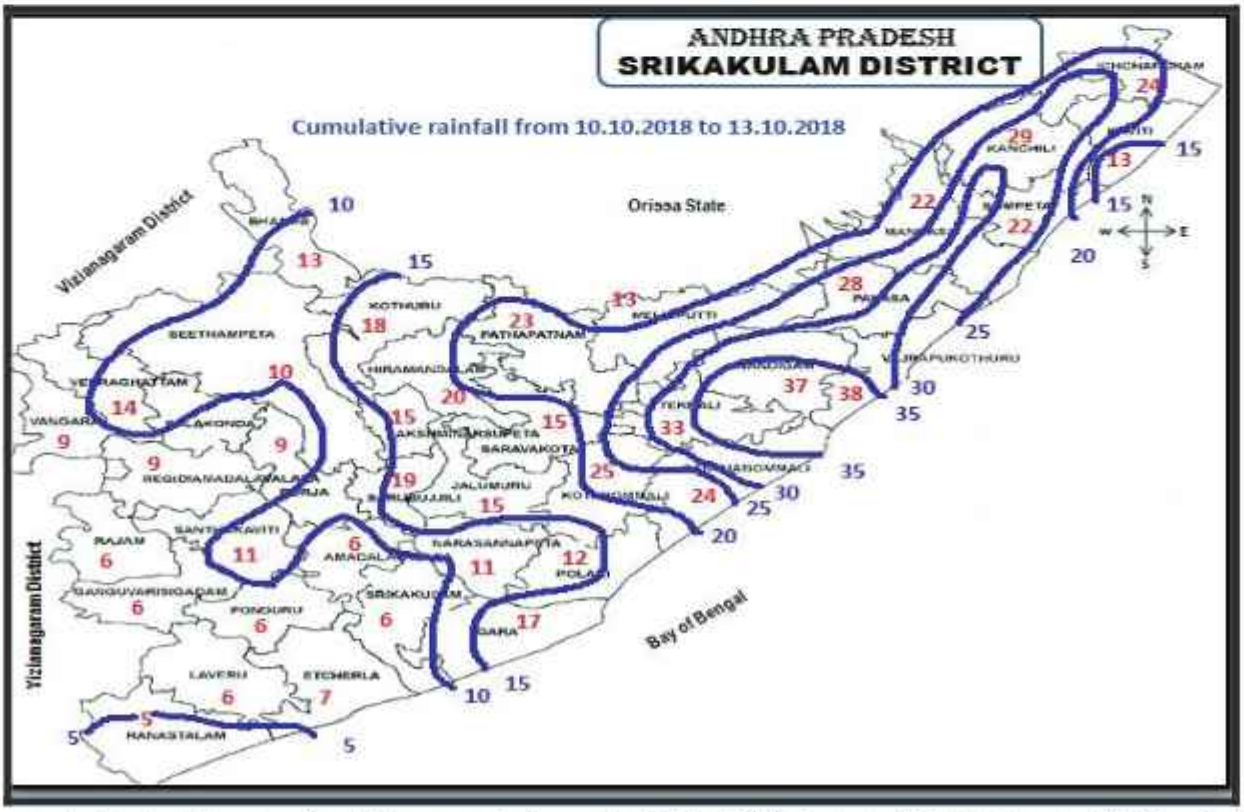


Figure 4: Iso-hyetal map depicting cumulative rainfall in Srikakulam district due to VSCS- TITLI during the period 10.10.2018 to 13.10.2018.

flooding in rivers Rushikulya and Bodo and they affected Ganjam district and whereas Vamsadhara and Mahendratanaya rivers affected Gajapathi and Rayagada districts.

2.4.2 Srikakulam and Vizianagaram districts of Andhra Pradesh

Life came to stand still in Srikakulam and parts of Vizianagaram district for about 2 to 3 days as thousands of people faced untold hardships with lack of power, water and food. Some of them lost their livelihood mainly due to loss in horticulture (Figurer 5). It is reported that about 200 cashew industrial units were damaged and about 30000 workers lost their job. Several fishermen's boats were damaged and some lost their nets.

As per reports of Government of Andhra Pradesh, 7 persons died in Srikakulam district. Estimated total loss was Rs.3435 crores. Significant losses occurred were: Horticulture crop 1000 crores and other Agriculture Crops 800 crores. Electricity Department 500 crores, Panchayat Raj, Roads &Buildings, Irrigation and Rural Water Supply 100 crores each.

Villages affected in the districts were 1802 and about 3774 houses were damaged completely. 700 kms stretch of roads were damaged. Coconut, Cashew and Banana grown on 30000 acres in Srikakulam district were badly damaged as 80% of the trees were uprooted (Figure 5). About 12000 electric polls collapsed and about 40,000 poles were erected to restore power supply and several communication towers were damaged.

Figure 5: Flattened coconut trees at Amallapadu -Kambalarayudupeta.

Traffic came to a standstill for about 18hrs on 11th October on National Highway between Ichchapuram and Narasannapeta of about 100 km distance as flood waters over flowed at many places over roads and blockage occurred due to fall of trees over roads. Many goods trucks and lorries turned topsy-turvy by the gale winds. As a preventive measure, train services were suspended between Khurda Road and Vizianagaram junction.

Due to heavy rains in south Odisha (and as the rivers originated there), floods occurred in Vamsadhara, Mahendratanaya and Bahuda affected Srikakulam district whereas Nagavali river affected both Srikakulam and Vizianagaram districts during the period from 11th to 13th October, 2018.

3. Disaster Management

3.1 Awareness Generation

Public awareness generation will serve to empower people with knowledge about the role and responsibilities of the state. It is essential to prepare communities to deal with disasters in a manner that people's lives and properties are protected and to ultimately become resilient (Rao, 2001). Targeting schools, colleges and all educational institutions is a very important part of awareness. However, the effort has to be sustained through constant updating, upgrading and mock drills. It is most important to note that awareness will help in the application of the constantly evolving knowledge of science and technology as well as research and development.

3.2 Management of Cyclones

3.2.1 Structural measures

Structural measures involve construction of cyclone shelters, construction of cyclone resistant buildings, road links, bridges, canals, drains, saline embankments, communication and power transmission networks etc.

3.2.2 Non-structural

Non-structural measures include early warning dissemination systems, management of coastal zones, awareness generation and disaster risk

management and capacity building of all the stakeholders involved.

These measures are being adopted and tackled depending on the requirements of different states under National Cyclone Risk Mitigation Project (NCRMP) being implemented through World Bank Assistance.

It is important to note that IMD forecast system provides a time lead of 120 hours. The forecasts are in 4 stages topped by pre-cyclone watch, cyclone alert, cyclone warning and Post-landfall outlook bulletins. As the system approaches the coast and within the Radar range, the hourly bulletins are issued to give precise indications of the storm's movement, speed, direction, cone of uncertainty besides the other essential storm characteristics which information aids the forecasters to provide more precise information. All the relevant disaster managing agencies, state revenue, relief and rehabilitation are informed of in time by all possible modes of information with redundancy to give the disaster managers to take suitable and timely rescue measures.

IMD perseveres to provide bulletins, warnings, suggested actions for possible damages in association with the cyclone. Every cyclone teaches new lessons. HUDHUD and TITLI are also unique based on their inner dynamics and motion characteristics. Communication platforms and frequencies of issuance of bulletins are improving by the day thanks to the availability of more modes of communication transmission and IMD mandates to improvise.

The forecast accuracy improved for the past 5 to 6 years and hence the confidence of the public and the disaster managers in receiving the IMD forecasts. The disaster management teams, the NDMA, the NDRF, Army, Navy and OSDRAF had zeroed in on time at the expected areas of damages. Thus, reduced the damages and rescued people in various ravaged area. In case of both TITLI and HUDHUD, the Chief Minister and other administrative machinery plunged in to giving directions to the grass-root executors of the relief plans. Immediate plans for restoration roads, power, clearance of the trees, drinking water supply, food, actions to safeguard river embankments, measures at the places where breaching of streams happened due to floods.

Above all, the IMD warnings were followed by the disaster managers, governments, public and others of various sectors.

As an example, various measures taken by the Srikakulam District administration and the disaster management teams during TITLI are given below as an insight in to the concerted and coordinated efforts of the involving agencies.

3.3 Highlights of the relief operations

In order to provide immediate relief to the affected people, the District Administration keeping in view of the magnitude of the damage, constituted the following numbers of Department wise Enumeration Teams:

Agriculture	385
Horticulture	157
Animal Husbandry	67
Fisheries	39
Housing	128
Industries	4
Forest	22
Handlooms & Textile	4
Excise	6

Similarly, the following numbers of teams were formed for Relief Operation:

Deployment of Rescue Team:	
Central Forces	
NDRF (6 teams)	180
NAVY (2 teams)	10
Helicopter (Navy)	01
State Government	
Fire (14 teams)	540
APSDRF(9 teams)	445
District police mobile teams	43
Boats	22
Officials Deployed:	
No.of IAS Officers	29
No.of IFS Officers	7
No.of spl. Dy.Collectors	120
Officers deployed from other Districts	120
No.of Constituency Level Officers	10

No.of District Officers	60
No.of Manda/ Municipal Level Officers	44
No.of GP/Ward Level officers	1257
No. of Medical Teams	649
Medical Officers Deployed	649
Paramedical personel	1,755
No.of Medical camps conducted	2,979
No.of Animal Husbandry camps	428
No.of Medical health awareness camps	1,694

The following numbers of relief materials were also used:

Food packets supplied	19.06lakhs
Water packets	44.00lakhs
Milk supplied	62000lts
Biscuit packets	1,09lakh
Cooked foodthrough MDM	34,54,236
Essential commodities	
Rice at free of cost	9,891 MTs
RG Dall at free of cost	346.80 MTs
Potato at free of cost	331.80 MTs
Onion at free of cost	340.10 MTs
Sugar at free of cost	174.40 MTs
Palm oil at free of cost	347.90 MTs

The officers and workers worked round the clock and it took about 14 days for restoration of the cyclone ravaged infrastructure. The pace with which the relief, rescue and rehabilitation works were undertaken by Government of Andhra Pradesh and also the personal involvement in taking initiatives before, during and after the TITLI cyclone are exemplary. Services rendered by Central and State Government and other non-government organizations are also commendable.

3.4 Measures to be taken

In general, the following measures should be taken during different phases of disasters in order to cope with those:

3.4.1 Pre disaster

(a) Provide cyclone forecasting, tracking and warning systems.

(b) Construction of cyclone shelters, cyclone resistant buildings, road links, bridges, canals, drains etc.

(c) Establishing Early Warning Dissemination System (EWDS), and Capacity building for coastal communities.

(d) Mock drills, and training of local population and police by NDRF and SDRF.

(e) Plantations of strong rooted trees, canopies, mangroves and proper vegetation cover which act as first line of defense.

(f) Proper drainage system throughout the city to discharge the water as soon as possible to avoid flood like conditions.

(g) Use of NAVIC and RESOURCESAT-2 for disseminating coastal information and helping in disaster management.

(h) Implementation of National Cyclone Risk Mitigation Project.

3.4.2 During disaster

a) Cautionary advice put out on social platforms urging people to stay safe can reduce the number of casualties as seen in Chennai during recent cyclone Vardha.

b) Social media and the Internet, speedy official and community messages, creating online groups and sharing messages offering help and advice.

c) Perception of people decides the intensity of disaster. If people take necessary proactive steps to deal with disaster then even the severe disaster can be dealt with minimum damage.

d) Delivery of food and health care via mobile hospitals, with priorities to women child & elders.

e) Protection of the community and their evacuation and quicker response.

3.4.3 Post disaster

a.) It is vital that the learning from each event is shared nationally, and the capacity of officials and communities to manage disasters built continuously.

(b) Among the securities available to individuals in many countries is insurance against property losses.

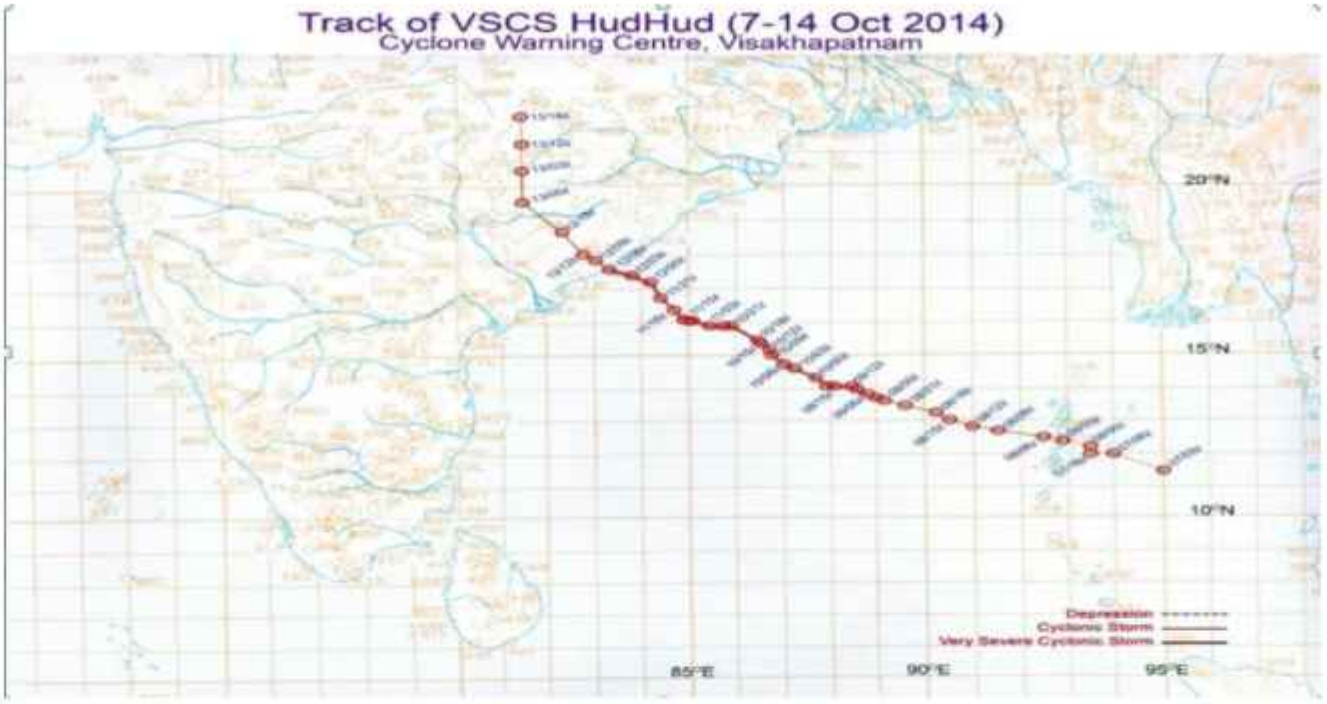


Figure 6: Track of Very Severe Cyclonic Storm HudHud.

Viable policies should be made available in India too.

c) Providing alternative means of communication, energy and transport just after the disaster.

3.5 Suggested measures for the future

Based on the experience gathered during the disaster managements of past cyclones, especially TITLI and HUDHUD, it is suggested that the following measures should be implemented in future:

(i) Beefing up of the alternative communication system is very vital to safeguard the community at a possible risk. Satellite telephony and community radio services are to be reinforced with public-volunteer synergy.

(ii) Keeping the alternate power sources in place is very much essential. Battery-enabled devices need be kept in full charge mode. With a lot of lead time in disaster warning by the IMD, public and authorities in the anticipated areas of cone of uncertainty may be suggested to keep ready with their communication and safety equipment.

(iii) As was observed during the VSCS "Titli", contemporary generation are very much eager to convey their 'how-about and what about' condition to their kith and kin who are away, through the easiest mode of communication, the mobile. So, all the mobiles need be recharged to use sparingly in the crucial hours of the disaster. Alternate robust materials may be used to for the electrical and the mobile towers to withstand gale force winds.

(iv.) The improved forecast services increase community confidence in the rendered forecast services. IMD's forecast services are an improvement in continuum and there is still room for improvement, as it holds for every field. The impact based forecast is an exercise in that direction. Micro-targeting in regard to area specific forecasts are on the positive direction and more refinement endeavors are giving fruitful results vis-à-vis minimization of fatalities, loss to property and structures.

(v) Further improvements in coordination, concerted efforts of the service authorities including state and district revenue, relief, rehabilitation in addition to the NDRF, NDMA upon reception of the IMD forecasts will take us a long way in making the forecast service and early warning system a flawless endeavor to reach unto the last person in the community at large risk of the disaster and in hazard mitigation.

4. Conclusions

The following inferences are made from this study:

(a) Like the VSCS HUDHUD of 12th October 2014 (Figure 6), TITLI (11th October 2018) crossed the Andhra Pradesh coast as VSCS (Figure 2). Hurricane winds of 140 to 150 kmph gusting to 165 kmph were experienced at the time of storm crossing the coast in case of TITLI, whereas in case of HUDHUD (IMD, 2014), winds of 150 to 180 kmph gusting to 200 kmph with peak wind in gust of 260 kmph for one second at 10.42 hrs IST were observed. TITLI was less intense than HUDHUD.

(b) The highest rainfall recorded in case of TITLI while crossing the coast was 38cm in Vajrapukotturu (Srikakulam district) (Figure 4) whereas in case of HUDHUD it was 41cms in Yelamanchili (Vishakhapatnam district).

(c) The area of damage in Andhra Pradesh was less mostly confined to Vizianagaram and Srikakulam districts in the case of TITLI whereas in case of HUDHUD, Vishakhapatnam, Vizianagaram, and Srikakulam districts were affected.

(d) The total death toll was 25 (7 in Andhra Pradesh and 18 in Odisha) in TITLI cyclone whereas in case of HUDHUD, the number was 61.

(e) The central pressure in TITLI was 998hPa whereas in HUDHUD, it was 950.3hPa.

(f) The height of surge in case of TITLI was about 7 ft (about 2 m) at Bavanapadu and surrounding villages of the coastline whereas in HUDHUD, it was 2m at Jalaripeta and Mangamuripeta.

Acknowledgements

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