
UNIT 8 CYCLONE: CASE STUDIES

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8.0 LEARNING OUTCOME

After studying this Unit, you should be able to:

- understand the destructive nature of tropical cyclones;
- discuss the causes and impacts of these particular cyclones;
- analyse the response mechanism; and
- learn about the lessons derived from these case studies.

8.1 INTRODUCTION

In this Unit, we shall discuss two cases of highly destructive tropical cyclones that affected India's two maritime states, that is Orissa and Gujarat, on the east coast and the west coast respectively, in the past decade. A brief study of the more recent Hurricane Katrina of U.S.A is also included. All the three storms created history in terms of loss of lives, and destruction / damages to properties. Characteristically, the storms were, however, very different from each other. One was the Super Cyclonic Storm (SuCS) that struck Orissa coast towards the end of October in 1999, and the other was Very Severe Cyclonic Storm (VSCS) that struck Gujarat coast in June 1998 at the end of the cyclone season and specially in the beginning of the monsoon season. The profiles of the two States are also different. While Gujarat is more industrialised and less agricultural State with more number of affluent people, Orissa is less industrialised and more agriculture based state with a large number of poverty ridden people. In terms of hazards, Orissa is comparatively more hazardous in the context of cyclones, being frequently affected by intense cyclones and with almost the entire coast falling in the high surge-prone zone. On the other hand, Gujarat is infrequently affected by intense cyclone but with high surge potential. Hurricane Katrina presents a noteworthy case when the storm having traversed a long track struck the highly vulnerable area of New Orleans in the State of Louisiana in U.S.A catching the administration and the people without

adequate preparedness in spite of awareness and warnings. The damage was colossal. There are some lessons that we in India can draw from this episode.

8.2 CASE STUDIES

8.2.1 Orissa Super Cyclonic Storm of October, 1999

i) Profile of the State

Orissa has a long-coastline of 529 km. extending from the marshes of Ichhapuram in the south to the east of river Subarnarekha in the northeast. Seven districts namely Ganjam, Khurda, Puri, Jagatsinghpur, Kendrapara, Bhadrak and Balasore are bordering the entire coastline from south to northeast. Chilka Lake makes a portion of the coastline in the south. The emergence of big rivers like the Subarnarekha, the Mahanadi, the Baitarani and the Brahmani with their numerous small tributaries passing through the State made the coastal configuration more jig-zag. The ocean close to north Orissa coast is very shallow making it an ideal place for high storm surge generation.

The State's total population is 35.5 million (3.6% of country's population of which about 65.5% belongs to the category of Below Poverty Line). Orissa is more rural compared to country's average (86.5% lives in villages). Coastal Orissa is densely populated having a population density of more than 409 persons per square km. Orissa is primarily agricultural, even today, despite its vast natural resources of raw material for industries. Illiteracy is quite high. Prime occupations of the people of coastal Orissa are mainly agriculture and fishing. Most of the rural houses are built with thatched roofs having great vulnerability to strong winds. Majority of the houses are made of mud-wall having vulnerability to heavy rain and flood.

Orissa is a disaster prone state, frequently affected by floods, droughts and cyclones. The historical records suggest that the state was affected by about 70 to 75 cyclones of which 20 to 23 became severe during 1891 to 2000. The coastal area is located in the high annual rainfall zone of over 150 cm. Probable maximum storm surge increases from southwest to northeast from about 3 meters near Gopalpur to about 9.5m near Balasore. Analysis suggests that more than 55% of cyclones that form in the Bay of Bengal struck Orissa and West Bengal coast. The state is affected by severe cyclones mainly during May and June and end of September to November with the highest frequency in October. Some of the intense cyclones, which had taken high toll of human life in Orissa in about past 150 years, are listed below.

Date	Landfall point	Death
October, 1831	Balasore	22000
September, 1885	False Point	5000
November, 1942	Kendrapara	20000
October, 1971	Paradip	10000
October, 1998	Ersama	9893

In October 1999, the State was affected by two cyclones in quick succession with a gap of only 11 days. The first cyclone of October 17-18, 1999 was a very severe cyclonic storm with an estimated wind speed of about 200 kmph. It crossed coast near Gopalpur in the midnight of 17th October affecting four southern coastal districts with its maximum impact on Ganjam district. This was followed by a much intense cyclone – a super cyclonic storm with an estimated wind speed of about 260 kmph, which struck the Orissa coast, south of Paradip on 29th morning severely affecting

12 coastal districts of the state. In the known history of tropical cyclones affecting Orissa, probably this was the most intense cyclone ever to strike Orissa coast. Two very severe cyclonic storms striking the same area in quick succession of 11 days, is a rare event.

ii) History of the Cyclone

The system generated as a low pressure area far away from the Orissa coast over the Gulf of Siam and its neighborhood on October 24, 1999 about 550 km. east of Port Blair. Moving westward across Malaysian Peninsula, it emerged in the North Andaman Sea as a well-marked low-pressure area in the morning of 25th October. It concentrated into a depression by the same evening over the same area. Moving in a westnorthwesterly direction it intensified into a cyclonic storm when it was located about 350 km northeast of Port Blair. By 27th morning the system further intensified into a severe cyclonic storm when it was located about 750 km southeast of (16° N, 29° E) Paradip. Continuing to move in a west northwesterly direction, it intensified into a very severe cyclonic storm by the evening of 27th when it was located about 570 km southeast of Paradip. It attained its peak intensity of super cyclonic storm (wind speed more than 220 kmph) by the midnight of October 28th near 19.3 N and 87.0 E when it was about 100 km. southeast of Paradip. It crossed the Orissa Coast between Ersama and Balikuda near Sherabadi southeast of Paradip between 0930 and 1200 IST of 29th October. After crossing coast though it weakened slightly and lost its super cyclonic storm intensity but it remained very severe over the land for about another 24 hours till the morning of 30th when it weakened further into a cyclonic storm and was located near Bhubaneswar. Remaining either stationary or moving slowly it hovered over the same area and finally weakened into a depression close to Chandbali by the afternoon of 31st. Moving in a southeasterly direction, it emerged into the sea again but weakened slightly and was located off the north Orissa coast as a well marked low pressure system on 31st evening. Taking a loop and moving in a southerly / southwesterly direction it became unimportant only on 5th November, off Andhra Pradesh coast.

The tropical cyclone was of exceptional strength. It was estimated through a globally accepted satellite technique devised by an American Scientist, V.F. Dvorak in 1975. This technique divides the intensity of a cyclone in a scale of 8, known as, T-Scale. The Orissa super cyclone under discussion was of T-7 intensity from 2330 IST of 28th to 0830 IST of 29th October 1999. Corresponding estimated wind speed was 140 kts (about 260 kmph). The pressure at the center is another measurement of cyclone's intensity. The lower is the pressure from the normal, higher is the intensity. The normal pressure of the area on the days when cyclone struck Orissa coast should have been around 1010 hPa (Hectopascal) but the lowest pressure estimated for the cyclone was 912 hPa, which is a remarkably low value of pressure for the area and was only estimated earlier in the case of the Andhra Pradesh cyclone 1977. As mentioned earlier, Andhra Pradesh cyclone was the severest cyclone so far observed in the Bay of Bengal. Earlier record of the lowest pressure of T.C. that struck Orissa coast near Falls Point in September 1885 killing 5000 people was 919 hPa.

The height of the associated storm surge estimated by India Meteorological Department (IMD), according to their operational model estimate was 6-7 mt. which by any standard was dangerous. The surge was not only high but forceful (due to very strong wind force) to penetrate deep inland. Reports suggest that surge penetrated upto 35 km inland in some sectors causing saline water inundation. The eye diameter in this cyclone at its most intense stage as reported by Paradip radar was small (about 20 km), as expected in the case of intense cyclones. Due to quasi-stationary nature of the cyclone system and its comparatively large size, the area received exceptionally heavy rain for 3 days starting from 29th October. During the 72 hours period of 29th to 31st October 1999, Paradip reported 94 cm of rain. During 30th and 31st Chandbali reported 61 cm of

of rain. This shows that most parts of coastal Orissa received more than 50 centimeter of rain during 29th to 31st October leading to the unprecedented and prolonged flooding of the area causing large scale damage to lives and properties; specially to the agriculture and horticulture crops.

iii) Forecasting and Warning

The cyclonic system was tracked with the help of conventional observations, INSAT (satellite) observations and Cyclone Detection Radars at Paradip and Visakhapatnam. The system generated far away from the coast in the Gulf of Siam and was tracked from the very beginning with the help of satellite pictures. As per standing practice the alerts and warnings were issued by the India Meteorological Department (IMD) 48 and 24 hrs in advance respectively to the disaster management authorities as well as to all concerned officials and to the public. Thereafter, warnings were repeated providing the latest position of the cyclone several times in a day. The ports and fishermen were regularly warned starting from the depression stage of the storm. There was good media coverage about the advancing cyclone. However, the anomalous nature of the track of the cyclone, specially while it was over land, could not be predicted correctly by any of the available forecast models either in India or abroad. It should be noted that the overland behaviour of this cyclone was exceptional in the sense that it maintained its status as a severe cyclonic storm for about 20 hours after crossing coast and thereafter remained a cyclonic storm for about 36 hours. It was only in the afternoon of 31st October that it weakened into a depression whereas it had crossed the coast in the forenoon of 29 October 1999.

iv) Special Characteristics of the Cyclone

- It was a cyclone of great intensity; a super cyclonic storm.
- It struck the same area, which was affected by a very severe cyclonic storm only 11 days earlier, a rare event.
- It was the most intense cyclone ever to strike Orissa coast.
- Estimated maximum surface wind speed was as high as about 260 kmph (140 kts).
- Estimated central pressure was as low as 912 hPa.
- Slow movement close to the coast over the ocean impacted the area for a long time with unprecedented wind force and torrential rains.
- The Cyclone hovered, over the same area of coastal Orissa, moving slowly or remaining stationary for about 60 hours maintains high intensity and lashing the area mercilessly
- Exceptional heavy rainfall for prolonged duration (3-4 days).
- High storm surge (6 to 7 mt).
- Crossed coast close to the time of high tide.

v) Causes of Unprecedented Damage/Destruction

- Exceptional nature of the cyclone; great intensity of super cyclone level; stationary / slow moving after crossing coast but still maintaining severity.
- Struck 11 days after a very severe cyclone, which struck the same area when Government agencies were still busy in relief and rehabilitation work that arose out of the first cyclone.
- Prolonged exposure of structures and vegetations to very strong winds.
- Extensive flooding for several days due to exceptional heavy rain over the area because of the large size and near-stationary nature of the cyclone.

sectors washing away everything in its way.

- High population density of poor people of the area.
- Poorly constructed houses and non-engineered infrastructures.
- Agriculture-intensive coastal areas
- Inadequate preparedness especially to tackle two severe cyclones in quick succession.
- Inadequate infrastructure facilities to combat cyclone disaster compared to the magnitude of the calamity.
- Reluctance of people to move out of the places in spite of early warnings.
- Reluctance to learn lesson from the past disasters.

vi) Impacts

Area affected

Twelve districts of Orissa and two districts of West Bengal (Midnapore and South 24 – Parganas) were affected by the super cyclone. Eight coastal districts of Orissa viz., Jagatsinghpur, Kendrapara, Cuttack, Khurda, Bhadrak, Puri, Jajpur and Balasore were severely affected. The Jagatsinghpur district through which the center of the cyclone passed bore the maximum impact of the cyclone and was the worst affected. The other four partially affected districts were Mayurbhanj, Keonjhar, Dhenkanal and Nayagarh. Khurda, Puri, Cuttack and Kendrapara, among the most agriculturally rich and prosperous districts, were completely devastated by the strong winds, storm surge and heavy rain, while Jajpur, Bhadrak, Keonjhar and Balasore districts were severely affected by the floods induced by heavy rains. The districts of Puri and Khurda were also affected by the previous cyclone, which struck Orissa coast eleven days earlier.

Loss of Lives and Damages to Properties

As per official figures, 9893 people lost their lives. Unofficial figures suggest more deaths. Most of these casualties were from the Jagatsinghpur District. 15.6 million people were affected by the cyclone. The loss estimated by Orissa government was about 6228-crores of rupees, which did not include the loss to the central government properties like Railways, Telecommunication etc. According to some other estimate (Economic Times 1/4/2001) total financial loss due to the cyclone was over ten thousand crores of rupees, making it one single cyclone related disaster of rare occurrence in India.

8.2.2 Gujarat Cyclone of June, 1998

Profile and Overview

i) Profile of the State

With a population of 4.13 crores (5 percent of country's population) in 1991 and area of 1.96 lakh square km, Gujarat ranks tenth in respect of population and seven in respect of area amongst the States of India. Urban Population is 34.5 percent compared to 25.7 percent of national average. It is the fourth amongst the States in the country in respect of urbanisation. Gujarat has the longest coastline of 1600 kms along western parts of India extending from Lakhpat in the north to Valsad in the south. Except the Narmada, the major rivers like Mahi, Sabarmati and Tapi flowing through the States are not perennial. Density of population in coastal areas, where cyclone struck coast, specially in Kutch is less compared to the other coastal areas. Main professions of the people living in the affected areas are fishing, industry, trade, commerce and agriculture. Major crops like

the affected areas are fishing, industry, trade, commerce and agriculture. Major crops like Groundnut, Cotton, Bajra, Jowar are kharif crops grown during monsoon and post-monsoon period. Roofing patterns and material used for the construction of houses vary from district to district and also from urban to rural areas but majority of the houses even in rural areas of coastal districts are made of tiled roofs and stone walls. Though the highest number of cyclones that form in the Arabian Sea strike the Gujarat coast yet their frequency is less compared to the States located along the east coast. During the period 1891 to 1998, twenty-three cyclones struck the Gujarat coast of which 15 were of severe category. The Porbandar Cyclone of October 1975 with estimated wind speed of 210-220 kmph was the severest cyclone to strike Gujarat coast, though human casualties in that cyclone were less than 100. Except the small part of the coast bordering the Gulf of Kachchh, the remaining coastal areas are less surge prone. The slope of ocean bed immediately after the coast is quite steep except along the Gulf of Kachchh region and tides are very high. The area falls under semi-arid zone with an average annual rainfall of less than 60cm.

A Very Severe Cyclonic Storm (VSCS) forming in the beginning of monsoon season in the Arabian Sea struck Gujarat coast in the early hours of June 9, 1998. The system crossed Gujarat Coast about 25 km north of Porbandar affecting about 12 districts of Gujarat State with different degrees of intensity. Its maximum impact was over Porbandar, Jamnagar, Rajkot and Kuchchh district from where most of the damages were reported. Human casualties were mostly in the surge hit areas of the Kandla Port. Kuchchh residents do not have any living memory of such an event and the residents of the other affected districts have a fading memory of the cyclone of 1975. This resulted in lack of preparatory measures on the part of the public, even though the cyclone warnings through radio reached many villagers. The cyclone of October 1975 had intensity slightly higher (estimated wind speed of about 210 kmph) than that of the present one, but it weakened quickly and passed through Gujarat State northeastward without re-emerging in the Gulf of Kuchchh. The emergence of the 1998 cyclone in the Gulf of Kuchchh and its second landfall again near Kandla Port made the difference in its impact from that of 1975 cyclone. The human casualties in connection with the present cyclone were around 1173 with another about 2000 people missing. Human casualties in the case of 1975 cyclone were only about 85. While the 1998 cyclone generated a surge of about 3m inundating thickly populated residential areas of ports, the 1975 cyclone made landfall at a place where surge inundation was not significant.

ii) History of the Cyclone

The cyclone originated as a low pressure area over the southeast Arabian Sea and its adjoining areas of Lakshadweep in the evening of 2nd June 1998. It concentrated into a depression by the afternoon of June 4th and quickly intensified into a deep depression by the same evening over the southeast Arabian Sea. The system further intensified into a cyclonic storm by 5th evening, moved in west-northwesterly direction and by 6th morning it was about 560kms southwest of Goa. It became a severe cyclone by 6th afternoon. It moved in a northwesterly direction and on 7th morning it was located at about 650 kms (14.5 N, 68 E) west-southwest of Goa. By 7th evening it further intensified into a very severe cyclonic storm when it was about 400 km southwest of Veraval in Gujarat. Recurring and changing its course to north-northeasterly direction it crossed Gujarat coast about 25 km north of Porbandar in the early hours (0500 IST) of 9th and at 0830 IST of 9th it was located at about 50 km north-northeast of Veraval over the land in Saurashtra region of Gujarat. It emerged into the Gulf of Kutchchh and again crossed coast near Kandla Port towards the evening of 9th and weakened into a cyclonic storm. Keeping its north-northeasterly course, it weakened into a depression by 10th morning when it was centered at about 50 km northeast of Jodhpur. It further weakened into a low pressure area over Punjab and its adjoining areas of Himachal Pradesh by 10th night.

iii) Associated Weather

From satellite observations, the cyclone was classified as T-5.0 in Dvorak's T-scale at the time of its peak intensity, which it attained on 8th June mid-day. Corresponding wind speed was estimated to be about 90 Kts (167 kmph). As per a survey report based on damages sustained by structures in the affected area, wind speed could have been 160-170 kmph at the time of cyclone crossing coast. The IAF station at Jamnagar reported wind speed of 90 Kts towards the afternoon (1430 IST) of June 9. Near Kandla Port, wind speeds were estimated to be 120 to 140 kmph at the time of its second landfall. The cyclone travelled over a distance of 270 kms in Saurashtra and Kutch before entering into southeast Rajasthan. Rainfall of various intensities accompanied the cyclone, with heavy falls confined within a zone of 30 km from the center. There were no reports of exceptional heavy rains. Since the cyclone affected the area in a very dry season and moved out of the area quickly, the rainfall did not contribute much to fresh water flooding. Kandla creek area, in particular the Sogoul Channel, experienced 3m of surge. The damages caused by storm surge in the ports of Kandla and Navlakhi in the Gulf of Kutch were extensive.

iv) Forecasting and Warning

The system was first located in the southeast Arabian Sea far away from Gujarat coast. It was tracked from its formation to dissipation stage by the combined use of conventional meteorological observations, satellite observations (INSAT) and Cyclone-Detection-Radar (CDR) observations at Bhuj. CDR provided observations when the cyclone came to Radar range (400 Km). Bhuj radar reported clearly visible eye from 0530 IST to 0730 IST of June 9 when it was crossing coast indicating that it was a Very Severe Cyclonic Storm at the time of crossing coast. (VSCS)

IMD's office at Ahmedabad, responsible for issuing cyclone warnings to Gujarat, issued Cyclone Alerts and Warnings starting from the 7th June 1998 indicating the intensity of the cyclone, its ongoing intensification and the expected weather. Fisheries warnings started even earlier than 7th June. Ports were adequately warned. Nevertheless it seems there were communication gaps between the affected population and the State administrative machinery about the severity of the system; may be mainly due to difficulty in accessing the affected people on account of inclement weather. However, many coastal villagers, on hearing radio warnings about the cyclone, took precautionary measures by themselves and fishermen in such villages did not venture into the sea during the cyclone period.

v) Characteristics of the Cyclone

- Severest cyclone to strike coast after Porbandar cyclone of 1975.
- Generated high wind speed of 160 to 170 kmph.
- Generated storm surge of about 3m high in the Gulf of Kutch region, not experienced earlier.
- Heavy rainfalls were confined in a very narrow zone of 50 to 60 km with no report of exceptional heavy rain.
- Struck coast during very dry period with moderate rainfall. As such, there was no significant fresh water flooding.

vi) Causes of Destruction

- Most casualties (more than 95%) were due to drowning by storm surges (coastal inundation).
- Occurrences of surge in comparatively thickly populated Port and Salt Pan areas with people having no knowledge of storm surge.

- Infrastructure and house damage outside surge-affected area were due to collapse of roofs, falling of trees, electric and telephone poles due to strong winds.
- Inexperience of the people about cyclone impact because the cyclone occurred 23 years after the earlier such cyclone in the area.
- Communication gap due to non-anticipation of the severity of the system and inaccessibility of the affected areas in inclement weather.
- Since heavy rainfalls were confined to a very narrow zone the popular anticipation of very severe cyclonic storm was weak.
- Standard procedure to inform villagers about the danger by State administration did not work.
- Inadequate preparedness. Unlike areas like A.P. where cyclones are an annual event, there was little preparedness to deal with surge damage in coastal Gujarat either in the form of cyclone shelters or other preparedness measures.
- Reluctance of people to move to safer places.

vii) Impacts

Area Affected

About 12 districts of Gujarat were affected by the cyclone with varying degrees of intensity. The Saurashtra and Kutch regions of Gujarat were worst hit. Porbandar, Jamnagar and Kutch districts were worst affected districts, which accounted for 90 per cent of the losses of lives and properties.

Damages Caused

According to a Government report, 1173 people lost their lives, another 1774 person were missing and more than 2.5 lakh houses were destroyed or damaged. The total extent of damage to the state of Gujarat was estimated to be of the order of Rs. 190 crores. The port town area of Kandla, which has residential complexes towards northeast of the dock, alone accounted for about 900 dead, mostly due to drowning by storm surge. Most of the casualties were due to drowning by storm surges and only a few deaths were due to collapse of buildings, falling trees, electric and telephone poles due to strong winds. The storm surge carried away large number of saltpan workers, locally known as Agaries, who were working in the saltpans and were living in the squatter settlements of port workers. Large number of migrant labourers working in the area were affected whose exact numbers were not known. About 3500 people have been officially reported injured. Actual number might have been more. The houses and industrial buildings in some pockets of the 3 worst affected districts suffered extensive damage. Industrial infrastructures along Kandla- Anjar Corridor and Kalyanpur, Porbandar Taluk, were affected mostly due to strong winds. This being the lean season for agriculture, where most crops are grown during monsoon and post monsoon season, the destruction of crops was insignificant. The cyclone being a fast moving one and smaller in size, the rainfall amounts over the area were not very large. Moreover this being very dry period when lands were parched and rivers and rivulets were dry, the rainfall did not contribute to any significant fresh water flooding like what happened in Orissa.

8.2.3 Hurricane "Katrina" of August, 2005 In U.S.A

Hurricane "Katrina" was a very powerful hurricane that caused extensive and severe devastation over an area of about 2.30 lakh square kilometers i.e. an area equivalent to that of Karnataka and Kerala put together. Katrina has been judged as the worst natural disaster in the history of U.S.A

as it is estimated to have caused damage amounting to 100 billion dollars. At its peak on 29 August, 2005, it packed fierce winds of speed around 280 kmph with gusts of 320 kmph and impacted the southern States of Louisiana, Mississippi and Alabama there destroying the city of New Orleans and its neighborhood almost totally, even though it had lost some of its fury by the time it made a landfall on Louisiana-Mississippi border judging by the low value of its central pressure measured as 915 HectoPascal, it was the third most intense hurricane to strike USA in recorded history even at the time of landfall.

Katrina originated over the Bahamas in the Atlantic Ocean southeast of Florida State on 24 August 2005 and passed over Miami in Florida causing large scale flooding, putting one million residents in darkness by loss of electricity and 11 deaths even at that initial stage. Moving westward in the Gulf of Mexico for the next 2 days, it started turning towards north mid-gulf and then continued due north hitting New Orleans on 29 August in the forenoon giving rise to a 10 metre high storm surge which is the highest storm surge ever recorded in U.S.A. The hurricane left around 50 lakh persons without electricity and it took over 2 months to restore power. The search for the dead was officially terminated five weeks later by which time the actually counted death toll was 1185 i.e. 964 in Louisiana and 221 in Mississippi.

The city of New Orleans is below the sea level and is protected by embankments which they call levees. Water is constantly pumped out even on normal days. With electricity shut off, the pumps stopped working adding to the misery leashed by the torrential rains from the skies and the storm surge from the sea. With damaged oil pipelines from nearby drilling sites spilling oil, the waters in the city were a mix of sea water, oil and sewage.

Evacuation had already been ordered and all those with the means to move started leaving with the result that all exit roads were jammed by vehicles. On certain main highways there were traffic jams extending to 100 km and beyond. About 30 percent of the population of New Orleans were poor who had no means to evacuate and most of them were assembled in a large stadium which, it turned out, was not sufficient to accommodate the incoming swarms of people. This created resentment, which turned ugly as time rolled on. In the meantime looting started in the city and it turned into a serious law and order problem. At that stage as the police (or whatever were left of them with many having left their duties to look after families) were not able to control the situation, military was called in but they also found the situation very ugly because the impatient or unsocial elements resorted to fire arms. (It may be added that there are a very large number of fire arms with private citizen in USA because no license is needed to possess the arms.) Price escalation was the next problem to follow as demand rose against scarcity. Drinking water and petrol were the most scarce and prices were unbelievable.

Communications were the worst hit-in fact totally absent. Even the enquiry centers became silent. Internet was disrupted. Whatever was left of the communication infrastructure was overloaded and jammed.

U.S. Government's emergency system (both the federal Government and the State Government) responded. The armed forces, the National Guards, and the State Guards were called up but it was realised that quite a number of these were on duty elsewhere such as Iraq. Therefore others had to be called. This delayed their deployment. The State legislatures and the US Congress immediately voted funds for the emergency response. NGO's pitched in with men, material and funds.

Initially, U.S.A. was reluctant to accept donations and aid from foreign countries, especially from those countries whose financial resources are limited. However this policy was revised as the reports of the damage grew more and more grim and U.S.A. perhaps for the first time in recent

history, accepted foreign aid, which poured in from all over the world. India also sent 5 million U.S. dollars and plane loads of blankets and medicines. The city of New Orleans was so much destroyed that it is doubtful if it will ever be any thing near to what it was before Katrina's visit.

Lessons from Katrina for us in India

This grave tragedy and the response it received from the Government and the people of U.S.A. throws up some important issues from which we, in India can take useful lessons particularly at this time when the disaster management system in India is taking a new shape in the form of National Disaster Management Authority and similar authorities at the State and District levels. The following are the points that need consideration in this regard.

- Demographic analysis should be conducted for the large cities vulnerable to cyclones and economically weak sections of society, and their areas should be identified. For them, special plans have to be ready for protection, feeding or evacuation because they would need full support whereas the affluent sections would need only assistance.
- There should be no delay in calling up military and para-military assistance. This is because in such a grave situation, the police (which is local) will not be able to do the job as they will certainly be worried about their families. On the other hand, the military forces move from their camps and their families are generally at their home stations. Therefore they can work with undivided attention and can be on duty for longer hours.
- Alternate Command/Control centres should be identified for each large city vulnerable to cyclones so that there is no break in the chain of command if the centre in the affected city goes out of service. In New Orleans when the local enquiry services stopped, the work was transferred to call centers in India who earned appreciation from U.S. citizens for the prompt and continuous service. We may identify such contingent arrangement so that the queries from the affected people can be entertained. This would help in avoiding worry, confusion and panic to a great extent.
- One fallout of a disaster is that the large number of dead bodies has to be located, identified and last rites performed. This is an item least discussed under disaster preparedness or disaster management but needs to be faced everytime a major disaster strikes. In U.S.A., there are private companies that take up this work and do it creditably. In case of the Katrina disaster, a company known as Kenyon International Emergency Services was hired to do this job and are reported to have completed the work ably. In India, this work is finally done by NGOs with the help of police but at a late stage. Training to NGOs and police with the help of some of those international experienced emergency handling companies in locating, identifying and conducting last rites properly may be considered.

8.3 ACTION TAKEN BY THE STATE GOVERNMENT

8.3.1 Orissa Super cyclone

Warnings were issued well in time from IMD's Cyclone Warning Centres at Calcutta and Bhubaneswar (starting from 26th October 1999). The Crisis Management Group in the Ministry of Agriculture started daily meetings from 26th October itself and senior officials of the vulnerable states (Orissa, West Bengal and Andhra Pradesh) were advised to take preparatory measures to combat the expected cyclone threat. The National Crisis Management Committee (NCMC) under the Chairmanship of the Cabinet Secretary met at New Delhi on 27th and 28th to review the various preparatory measures taken at the Central and State level.

As a preparatory measure, rail services were cancelled. Three wings of the defense services were alerted. The Ministry of Health deputed a team of doctors. Port authorities, Power, Telecom, Media and Energy sectors were alerted. Govt. of Orissa was in touch with the local Meteorological Office. On October 28th, the State Cabinet reviewed the state of preparedness.

Immediately after cyclone's landfall, rescue and relief work started with the help of defence personnel (Army, Air Force and Navy). The Government of Andhra Pradesh and CARE India started initial relief work. The Central Government started responding immediately after the event in rescue and relief operations. High-level co-ordination meetings were held at the Center and in the State to take actions on rescue and rehabilitation work. Judging the gravity of the situation, Prime Minister and other Senior Cabinet Ministers visited the State between 1st and 5th November 1999. A Central Team visited the state on 3rd November to assess the magnitude of damage and quantum of assistance required.

In view of the disastrous impact of the super cyclone, the Central Government declared the event as a calamity of 'Rarest severity'. The Prime Minister released additional funds from the National Calamity Relief Fund immediately after his visit to the affected area. In response to Chief Minister's urgent request the volunteers and relief materials were rushed to the State. A High Power Task Force was constituted on the directive of the Prime Minister with Defense Minister as its Chairman with specific terms of reference to prepare a comprehensive action plan for rehabilitation in the cyclone affected areas and to co-ordinate relief operations undertaken by various agencies. Besides, all out efforts by the Central and State Governments, States other than Orissa and also International organisations extended their helping hand by providing financial and material support for relief and rehabilitation work. International and National NGO's and Voluntary Organisations made large-scale contribution in the relief and rehabilitation work. By the end of November 1999, major power, telecommunication and rail and road communication were restored.

8.3.2 Gujarat Cyclone

It seems, though the cyclone warnings were issued by the Meteorological office at Ahmedabad but the standard procedure for passing on the information from district collector level to village level did not work properly in this particular case and a communication gap occurred may be due to overlapping of responsibilities or underassessment of the danger from storm surges and about the severity of the system. The inaccessibility of the salt worker and fisher-folk population scattered along the coast was also a reason for delay in communicating the cyclone warnings. However it seems, some of the villagers and fishermen heard the radio warnings and took adequate precautions by not venturing into the sea. On receipt of cyclone warnings, district administration evacuated people from low lying pockets like Medha creek in Okhamandal taluka. Some people from the surge affected area of Kandla and Navlakhi ports were also evacuated.

As soon as the cyclone crossed the coast and the magnitude of the calamity was clear to the State officials, the services of the three wings of defence services were pressed into service for search, rescue and relief operations. While the Air Force was involved in the aerial survey and aerial drop work the Navy assisted cyclone affected ships and coastal vessels and in relief work. The Army was involved in setting up temporary shelters and relief camps and in the distribution of food packets in rain affected areas. NGO's and socio-cultural organisations took part in rescue and immediate relief operations.

Compensation and ex-gratia relief were paid to the victims as per government rules. Relief was also provided in the form of cooked food, food grains, clothes and utensils in the relief camps. Drinking water supply was arranged to the affected population by tankers. Medical teams were dispatched to different Talukas of the cyclone-hit regions. NGO's were involved extensively during

relief and post-relief phases for the purpose of storage of relief materials, cleaning of debris, restoration of electricity and water supply system and for many other essential work. Repair, reconstruction and rehabilitation work was later organised by the State government, Kandla Port Authorities and IFFCO with the help of State and Central financial assistance.

8.4 LESSONS LEARNT : THE WAY AHEAD

The probability of very intense cyclones striking the cyclone prone states like Orissa and Gujarat, causing severe destruction of life and property, is always there. As such State's planning machinery must take this fact into consideration in developmental activities and land-use planning in the coastal areas.

There is a great need to create adequate infra-structural facility to fight dangerous cyclones (such events may occur in future also). Education and training of coastal population and disaster management officials should be a continuing process to increase the awareness about dangers of cyclone and benefits of quick response to warnings.

There is a great need of undertaking some of the known structural and non-structural, long and short term disaster mitigation measures (like construction / identification of shelters, construction of dykes, embankments and check dams and creation of coastal forestry).

Instrumental measurements of wind speed and storm surges are essential components for judging the strength of a cyclone. This information is essential for forecasting and warnings. There is no substitute to actual measurements. Ordinary wind instruments do not work in high wind speed and the present network of High Wind Speed Recorders and Tide Gauges for measuring storm surge are inadequate. The improvement in this respect needs urgent attention.

The future will no doubt see more improvement in observing, communication and forecasting system. Better techniques may be developed for cyclone forecasting which may increase the accuracy of forecasts about the time and place of landfall. In spite of the ongoing worldwide efforts, an appreciable improvement in such forecasts will take time.

Principal lesson learnt from the past events is that the greatest progress can be achieved by developing better coordination between various components of cyclone warning system and by better preparedness and response. Meteorologists, Disaster Management Officials, Media and Public need to further enhance coordination to reduce the harmful effects of tropical cyclones. Establishment of the Disaster Management Authority at the National and State levels is the step in the right direction.

The actions that need to be taken in case of a cyclone threat can broadly be divided into four classes, viz., (i) immediately before the cyclone season; (ii) when cyclone alerts and warnings are issued; (iii) when evacuations are advised; and (iv) when the cyclone has crossed the coast.

These are listed below:

Before the Cyclone Season

- Check the house; secure loose tiles, carry out repair works for doors and windows;
- Remove dead woods or dying trees close to the house; anchor movable objects like loose tin sheds, loose bricks, garbage cans, sign-boards etc. which can fly in strong winds;
- Keep some wooden boards ready so that glass windows can be boarded if needed;
- Keep a lantern filled with kerosene, match box or lighter, flash lights and enough dry cells;
- Keep a first aid box handy;

- Demolish condemned buildings;
- Keep some extra batteries for transistor radio;
- Keep some dry non-perishable food ready for emergency use; and
- Keep essential medicines for yourself and your family members.

When Cyclone Alerts and Warnings are On

- Listen to radio and TV;
- When you have heard about a cyclone keep monitoring the warnings. This will help you for preparing yourself for cyclone emergency;
- Pass on information to others;
- Don't pay any heed to rumours;
- Believe in official information;
- Do not spread rumours;
- When a cyclone alert is on for your area, continue normal working but listen to the radio warnings and act accordingly;
- Remember that a cyclone alert means that the danger is within 24 hours. Keep alert;
- When your area is under cyclone warning get away from low-lying beaches or other low lying areas close to the coast;
- Leave early before your way to high ground or shelter gets flooded;
- Do not delay and run the risk of being marooned;
- If your house is well built on high ground, take shelter in the safer part of the house. However if asked to evacuate, do not hesitate to leave the place;
- Board up glass windows;
- Provide strong suitable support for outside doors;
- If you do not have wooden boards handy, paste paper strips on glasses to prevent splinters. However, this may not avoid breaking windows;
- Get extra food, which can be eaten without cooking. Store extra drinking water in suitably covered vessels;
- If you are to evacuate the house, move your valuable articles to upper floors to minimize flood damage;
- Have kerosene lantern, flashlights or other emergency lights in working conditions and keep them handy;
- Make provision for children and adults requiring special diets;
- If the center of cyclone is directly passing over your place, there will be a lull in the wind and rain lasting for half an hour or so. During this time do not go out because immediately after that very strong winds will affect the place from opposite direction;
- If cyclone is affecting you, switch off electrical mains in your house; and
- Remain calm.

When Evacuation Is Instructed

- Head for the proper shelter or evacuation points indicated for your area;
- Do not worry about your left over property;

- At the shelter or relief camp, follow instructions of in charge; and
- Remain in shelter or relief camp, until informed to leave.

Post-Cyclone Measures

- One should remain in shelter until informed to return home;
- Get inoculated against infectious diseases immediately;
- Strictly avoid any loose and dangling wire from the lamp post;
- If you are to drive, drive carefully; and
- Clear debris from your premises immediately.

8.5 CONCLUSION

In this Unit, we have discussed two cases of notorious tropical cyclones that affected India within the last decade. One case of hurricane from U.S.A. is also described which had some lessons for us in India as well. One case study relates to the Super Cyclonic Storm that struck Orissa coast in October 1999 with an unprecedented intensity and devastating impact. This cyclone devastated the entire coastal Orissa creating history in terms of death and destruction. The other case was a Very Severe Cyclonic Storm that struck Gujarat coast in June 1998 causing large loss of lives and properties. While describing the different aspects of these tropical cyclones, their special characteristics and reasons for such destruction have been brought out. Lessons learnt from such disaster events have been discussed. Some of the do's and don'ts in the case of cyclone threats are also given.

8.6 KEY CONCEPTS

HectoPascal (hPa)	:	Unit of measuring atmospheric pressure.
IFFCO	:	Indian Federation of Farmers Cooperatives.
Quasi Stationary	:	More or less stationary; showing little movement; hovering around the same area.
Response	:	In the present context, it means clear perception on the part of recipients of warnings, Government and public about tropical cyclone

8.7 REFERENCES AND FURTHER READING

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8.8 ACTIVITY

- 1) List the reasons for the heavy loss of lives and properties in coastal Gujarat due to cyclones. Suggest significant steps in combating cyclone disaster.
- 2) "Action taken by the State Governments in the case of Gujarat and Orissa Cyclones of 1998 and 1999 were satisfactory". Discuss the statement on the basis of your observation and study.
- 3) List the prominent Do's and Don'ts to be observed during i) cyclone season; and ii) when cyclone alert or warning has been issued.
- 4) Discuss the lessons, if any, to be learnt for India from the Katrina hurricane that devastated New Orleans area in U.S.A. in August 2005.