CHAPTER 3

CASE STUDY OF TWO MAJOR CYCLONES IN ODISHA, INDIA

(ODISHA SUPER CYCLONE, 1999 AND CYCLONE PHAILIN 2013)

3.1 Several natural disasters wreaked havoc in the poverty-ridden state of Orissa Succession of. The state experienced a severe flood in the august, 1999 affecting six coastal blocks. Next disaster was the severe cyclonic storm on 17-18th October 1999, which hit the coastal district causing widespread and unprecedented damages to life and property. This was followed by the most severe super cyclonic storm on 29-30 th October, 1999 that ravaged all the coastal districts in general. Jagatsingpur, Kendrapara, Cuttack, Khurda and Puri in particular were severely affected. The super storm was followed by torrential rains raging from 447mm to 955mm rainfall from 29th October to 1st November causing very high flood in baitarini, budhabalanga, and salandi river basins, which severely affected and marooned very vast districts of Jajpur, Bhadrak, Keonjhar, Balasore and Mayurbhanj. At landfall point near paradip coast on 29th October, 1999 the wind velocity touched a maximum of 270 to 300 Kms. After hitting the Paradip coast, the cyclonic storm with tidal wave of 5 to 7 meters[7] height ravaged the coastal districts of Jagatsingpur, Kendrapara, Khurda and Cuttack. The state capital Bhubaneswar and the commercial hub of the state, Cuttack was completely devastated. All surface communications, telecommunications, proper supply and water supply were totally disrupted for more than 48 hours even in the state capital. The country has not witnessed a calamity of such rare severity during the current century.

3.2 CYCLONES

3.2.1 **Cyclone.** Cyclone is a region of low atmospheric pressure surrounded by high atmospheric pressure resulting in swirling atmospheric disturbance accompanied by powerful winds blowing in anticlockwise direction in the

[7] NCAR -Super Cyclone-99 final.PDF

Northern Hemisphere and in the clockwise direction in the Southern Hemisphere. They occur mainly in the tropical and temperate regions of the world. **Fig 3** shows a typical tropical cyclone.

Figure 3: Tropical Cyclone

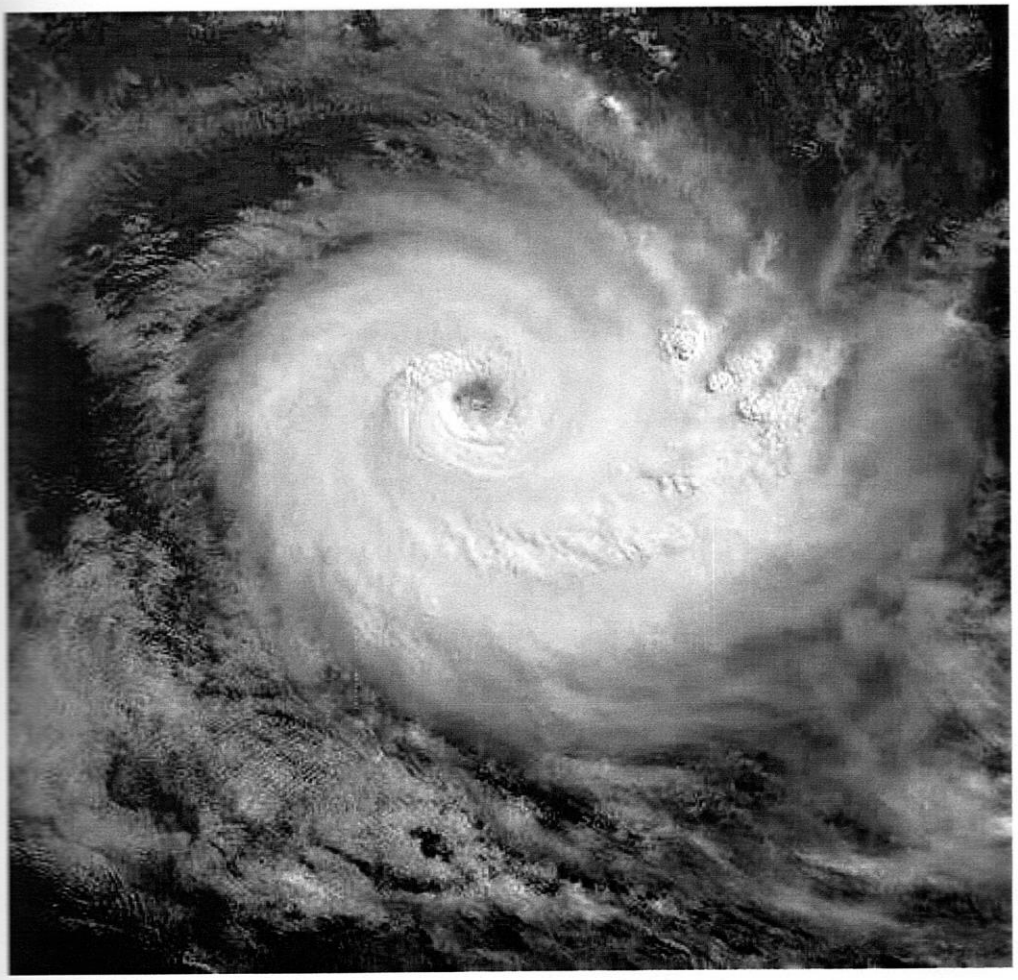

Figure 3: Tropical Cyclone

Source : http://en.wikipedia.org/wiki/Cyclone

Cyclones are called by various names in different parts of the world as mentioned below:-

(a) Typhoons in the Northwest Pacific Ocean.

(b) Hurricanes in the North Atlantic Ocean, the Northeast Pacific Ocean.

(c) Tropical cyclones - The Southwest Pacific Ocean and South East Indian Ocean.

(d) Severe cyclonic storm- The North Indian Ocean.

(e) Tropical cyclone -The Southwest Indian Ocean.

(f) Willie-Willie in Australia.

(g) Tornado in South America.

3.2.2 Cyclones are generally accompanied by strong winds which cause a lot of destruction. In some cases it is accompanied by heavy downpour and also the rise in the sea which intrudes inland, thereby causing floods. Super-cyclone with wind speed of 260-300 km/hour hit the 140 kilometer coast of Orissa with a storm surge created in the Bay-of-Bengal with water level 9 metres higher than normal. The super storm travelled more than 250 km inland and within a period of 36 hrs[8] ravaged more than 200 lakh hectares of land, devouring trees and vegetation, leaving behind a huge trail of destruction. The violent cyclone was merciless and broke the backbone of Orissa's economy and killed thousands and devastated millions.

[8] World disaster report 2001

3.2.3 **Cyclone Formation.** Cyclone formation has three distinct phases, **Fig 3**, which are described below:-

(a) **Formation and initial development state** In this phase four important conditions need to be satisfied for formation of a cyclone.

These conditions are described as below:-

(i) A warm sea temperature in excess of 26 degree centigrade, to a depth of 60 meters, which provides abundant water vapour in the air by evaporation.

(ii) High relative humidity facilitates condensation of water vapor into droplets and clouds, releases heat energy and induces drop in pressure.

(iii) Atmospheric instability (an above average decrease of temperature with altitude) encourages considerable vertical cumulus cloud convection when condensation of rising air occurs.

(iv) Coriolis force (force due to the earth's rotation) ensures inducing of cyclonic wind circulation around low pressure centers.

Figure 4: Cyclone formation

Source: en.wikipedia.org/wiki/**Cyclone**

(b) **Fully matured** The matured cyclone consists of a spiral pattern of highly turbulent giant cumulus thundercloud bands. These bands spiral inwards to form a concentrated dense cloud which becomes the core. This core is formed around a calm zone and is called the **eye**. The outer circumference of this dense cloud is called eye wall.

(c) **Weakening or decay** When the cyclone hits the land, on the cyclone moves to a higher altitude or when there is the interference of another low pressure. Now the cyclone begins to weaken as soon as its source of warm moist air is abruptly cut off.

3.2.4 **Cyclone Warning.** In the case of cyclones; low pressure, development and the likely path of the cyclone can be detected hours or days before it causes damage. The satellites track the movement of these cyclones

based on which the people are evacuated from areas likely to be affected. It is difficult to predict the accuracy of likely site of landfall. Accurate landfall predictions can give only a few hours' notice to threatened population. India has one of the best cyclone warning systems in the world. The India Meteorological Department (IMD) is the nodal department for wind detection, tracking and forecasting cyclones. Cyclone tracking is done through INSAT satellite. Cyclone warning is disseminated by several means such as satellite based disaster warning systems, radio, television, telephone, fax, high priority telegram, public announcements and bulletins in press. These warnings are disseminated to the general public, the fishing community especially those in the sea, port authorities, commercial aviation and the government machinery. Terminology used in North Indian Ocean for different intensity of tropical Cyclones is as given below:-

(i)	Low	<17 kt.
(ii)	Depression	17-27 kt.
(iii)	Deep Dep.	28-33 kt.
(iv)	Cyclonic Storm (CS)	34-47 kt.
(v)	Severe Cyclonic Storm	48-63 kt.
(vi)	Very Severe Cyclonic Storm	64-119 kt.
(vii)	Super Cyclonic Storm	>119 kt (221 kmph).

3.3 Socio Economic and Physical Profile of Odisha

3.3.1 Physical Characteristics.

NCAR (1999), states, Odisha is situated in the northeastern part of Indian peninsula. It is surrounded by West Bengal on the Northeast, Bihar on the north, Andhra Pradesh on the Southeast, and Madhya Pradesh on the west and Bay of Bengal on the east. The State may be

broadly divided into four geographical regions as northern plateau, central river basin, eastern hills and coastal plains. In view of the study of the Odisha super cyclone 1999, a profiling has been done based on 1991 census. Figures of 2011 census will be examined to see the changes in socio economic profile. Gupta and Sharma (1999), studied the profile of Odisha as follows:-

(a) Odisha can be divided into three broad regions-The coastal Plains, The middle mountainous country and the plateaus and rolling uplands.

(b) It has a coastline of 529-km. The coast is bulged in the middle from Brahmagiri (on Chilika Lake) to Chandbali, where the Mahanadi, Baitharani and Brahmani form a **Delta. The coast from Chandbali to Subharnarekha forms a concave shape, causing serious storm surge problem.**

(c) **Ports** There is one natural harbor-Paradip port (the deepest natural port in India). Chandbali and Gopalpur are also being developed as medium ports and Dhamra is being developed as a fishing port.

(d) **Population** Population was 31.6 million in 1991 census and 35.5 million in 1999. 86.57% of people live in villages and 65.5 % are in the Below Poverty Line (BPL). Children consist one third of this population. The sex ratio in the state that is the number of females per 1000 males, declined from 981 in 1981 to 971 in 1991. The fertile coastal belt is thickly populated. As of 2001 India census,[9] Paradip had a population of 73,633. Males constituted 58% of the population and females 42%, due to rapid migration of young industrial workers to the area. Paradip has an average literacy rate

[9] http://en.wikipedia.org/wiki/Paradip

of 73%, higher than the national average of 59.5%: male literacy is 79%, and female literacy is 65%. 12% of the population is under 6 years of age.

(e) **Climate** Odisha has a Tropical climate with rainfall averaging 200 annually. Cyclones in Bay of Bengal affect Odisha and bring rains in the period Jul-Aug and oct-nov.

(f) **Natural Vegetation** Odisha had the_highest percentage of forest, which however is declining drastically. This is partly due tribal population practicing extensive shifting cultivation and rampant deforestation.

(g) **Agriculture** NCAR (1999), finds, Compared to Punjab, Haryana, Maharashtra, Tamil Nadu and Andhra Pradesh, agriculture is not practiced widely in Odisha. However it accounts for 43.4 %[10] of the states income. Infrastructure and support in Orissa's agriculture sector is also underdeveloped. It suffers from inadequate irrigation facilities. Average of coastal districts in agriculture is higher than overall state average.

(h) **Education** Literacy has increased from 34.2% in 1981 to 49.1 % in 1991. It was 48.55% in 1999 against 55.1% which is the national literacy. It was 48.55% in 1999 against 55.1%[11] which is the national literacy percentage. Maximum literacy is in the coastal districts.

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[10] NCAR -Super Cyclone-99 final.PDF

[11] Gupta and Sharma in Orissa Super Cyclone (1999).

3.3.2 **Socio Economic Profile** Gupta and Sharma (1999), explained, that in spite of abundant natural resources, i.e. minerals, forest and marine, it is one of the poorest states next only to Bihar. Every year due to floods, cyclones and drought; land in fertile and delta area is devastated and suffers great setbacks. The states income and per capita income has increased slowly compared to national figures thus practically making Odisha poorer. Length of road network has increased, however, quality of roads and transportation are yet to improve. Fourteen out of thirty districts don't have National or state highway. Lack of road building materials in coastal areas results in higher construction cost of roads. The rail network is also woefully poor. Maternal and Infant mortality rate is very high. The coastal areas have a very high density of houses, due to higher population in these areas and lesser economic development in inland regions. 80% of the houses are Kutcha or makeshift. Electricity is available in 19% of rural houses. Only five % of the population benefit from public distribution system.

3.3.3 **Profile of Coastal Odisha** On the eastern part of the state, lies the coast plain. It extends from the Subarnarekha river in the north to Rushikulya river in the south. The lake Chilika is part of the coastal plains. The plains are rich in fertile silt deposited by the six major river flowing in the Bay of Bengal , Subarnarekha , Budhabalanga , Baitarani , Brahmani , Mahanadi and Rushikulya . The Central Rice Research Institute (CRRI), a Food and Agriculture Organization recognised rice gene bank and research institute, is situated on the banks of Mahanadi in Cuttack . The coastal plane can be divided into three zones-the Salt tract, the arable tract and sub-montane tract. This region is the combination of several **deltas** of varied sizes and shapes formed by the major rivers of Odisha, they are:-

(a) The Subarnarekha

(b) The Budhabalanga

(c) The Baitarani

(d) The Brahmani

(e) The Mahanadi

(f) The Rushikulya

Therefore, the coastal plain of Odisha is called the "Hexadeltaic region" or the "Gift of Six Rivers". Coastal Odisha is inhabited by people whose livelihood is dependent on agriculture and labour, fishing and services. 71 to 90 % of houses have **thatched roof.** 15 % of houses in coastal area only have **concrete roof**. 47 to 8 % of houses have mud walls depending on region. 03 to 37 % of houses have brick walls.

3.4 Odisha Super Cyclone, 1999

3.4.1 Physical Characteristics of the Super Cyclone

The Odisha Super Cyclone had a diameter of 200 km with landfall point between Erasama and Balikuda. The storm intensity was cat 5 in Saphir Simpsons Hurricane Wind Scale (SSHWS) scale and 6.5 in Beuforte Scale and touched a speed of 260-300 kmph. The affected areas had rainfalls ranging from 400 mm to 867 mm for 3 days with the turbulent sea sometimes rising to a height of 7-10 m. Orissa has one large lake; Chilika lake near Ganjam. In addition DELTAS and rivers are bodies that give minimum resistance to wind and help increasing the speed of wind. The **intensification** of the cyclone is described in **Table 2** on the next page.

Date	Cyclone
25-10-99	**Well marked low pressure area formed over North Andaman sea 251200 Coordinated Universal Time(UTC).**
26-10-99	Intensified rapidly inti a **cyclonic storm** centered at 0830 hrs, 350 km of Port Blair. Moving in North West direction.
27-11-99	Emerged in East central Bay of Bengal. Intensified further into a **Severe Cyclonic Storm (SCS).** Centered at 0830 hr 750 km south east of paradip port.
28-10-99	The SCS moved North West , intensified into **Very SCS** and lay centered at 0230 hrs 550 km South East of Paradip. The Very SCS intensified into a **Super Cyclone Storm** at 281800 130 km South East of Paradip.
29-10-99	The Super Cyclone Storm lay centered at 0230 hrs 90 km south of Paradip. Moved North west by 290300 UTC 25 km South east of Paradip. It made land fall between 1030 and 1230 between Erasama and Balikuda (Jagatsinghpur Dist). Moved Northwards and weakened into a Severe Cyclonic Storm by 290900, lay centered close to Cuttack and became almost stationary by 291200.
30-10-99	The Severe Cyclonic storm weakened into cyclonic storm and at 300830 hrs and lay centered near Bhubaneshwar.
31-10-99	The cyclonic storm further weakened into a depression at 311130 hrs to reach Chandbali coast and weakened further.

Table 2: Movements and Intensification of the Super Cyclone

Source: Gupta and Sharma, Orissa Super Cyclone,1999.

3.4.2 **Forecast and Intimation of the Super Cyclone.** Kalsi, (2006), states, on 25 October, 1999, the Andaman and Nicobar (A&N) Administration was informed by IMD Head Quarters Office about the formation of a depression. On intensification into a cyclonic storm, Cyclone Warning Bulletins were sent by IMD's Area Cyclone Warning Center (ACWC), Kolkata to the Chief Secretary, A&N Islands starting from the afternoon of 26 October. The warning bulletins indicated strong gale wind speed reaching 70-80 kmph, uprooting tree branches and damaging kuchha houses in the Andaman and Nicobar Area. The bulletins contained advice to fishermen not to venture into sea. Six cyclone warning bulletins were issued by ACWC, Kolkata to A& N administration. However, the 6th warning issued at 0915 hrs (IST) of 27 October indicated that adverse weather was no longer expected over the A&N islands. The fact that the system posed a potential threat to the Indian coastline was informed to all senior functionaries of the Government of India and Chief Secretaries of the States of Andhra Pradesh, Orissa and West Bengal three days in advance. Regular cyclone warning bulletins by ACWC, Kolkata and CWC, Bhubaneswar commenced from the late evening of 27 October. The bulletins indicated further ongoing intensification of the cyclonic storm, occurrence of gale winds varying from 100 kmph to 200 kmph. in Heavy to very heavy rainfall in the coastal districts was forecast. Fishermen were advised not to venture into the sea. As the system approached Orissa coast and intensified into a super cyclonic storm, the warnings were upgraded to indicate gale wind speeds reaching 240-260 kmph, storm surge reaching 7-10 metres.[12] The track along with speeds and point of landfall is summarized in Figure 3 and 4 below.

[12] http://metnet.imd.gov.in/mausamdocs/15711_F.pdf

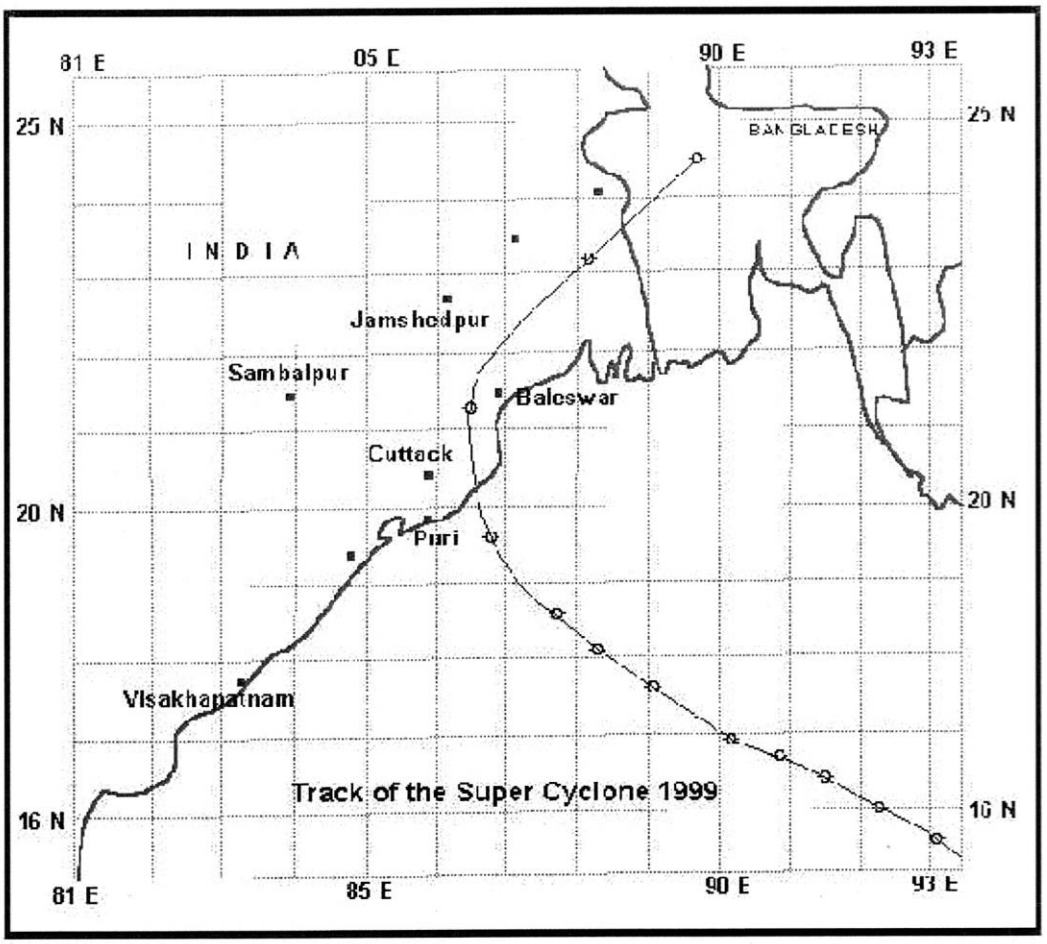

Figure 5: Track of Super Cyclone

Source: NCAR -Super Cyclone-99 final.PDF

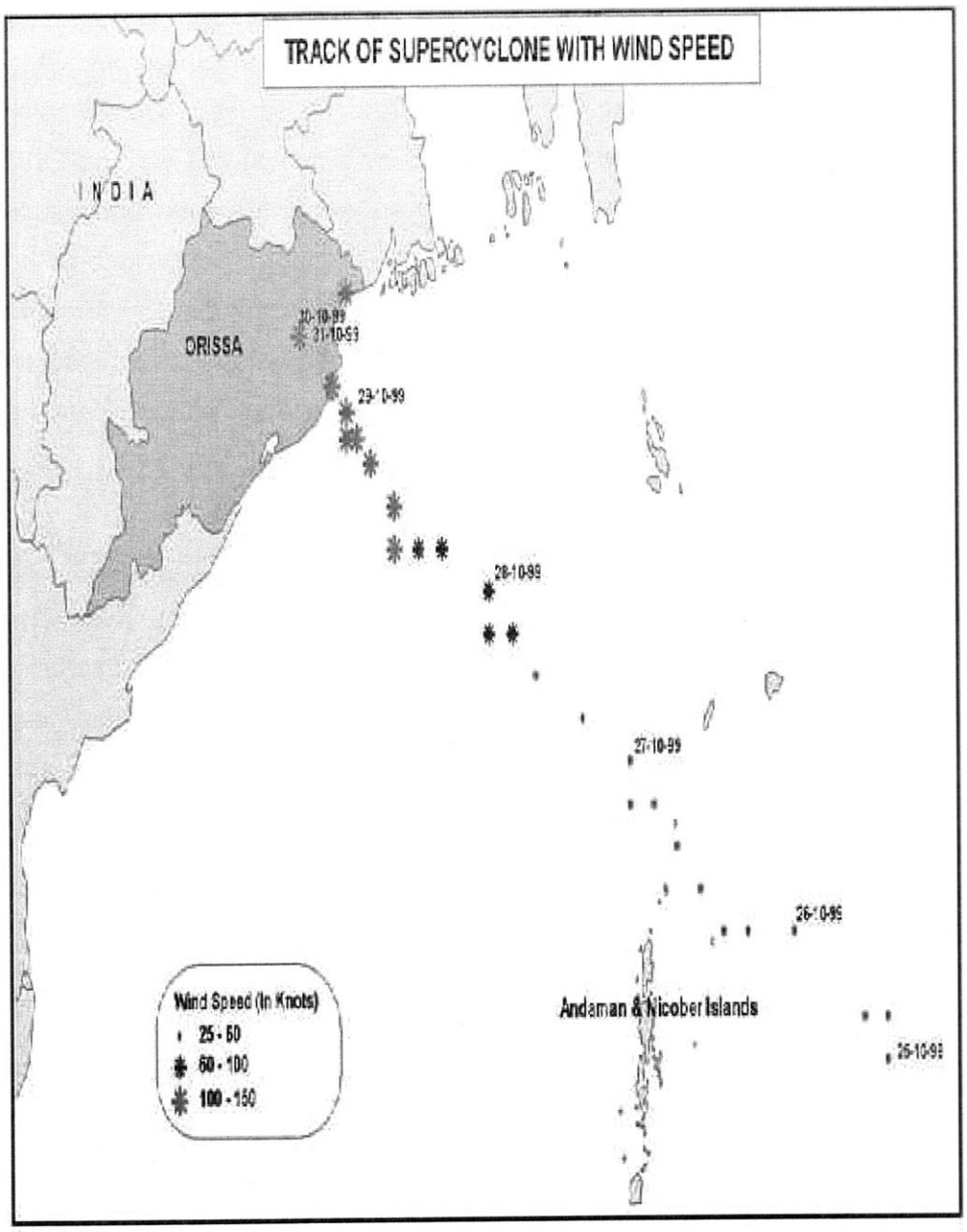

Figure 6: Track of Super Cyclone with Wind Speed

Source: NCAR -Super Cyclone-99 final.PDF

3.4.4 The IMD officials personally interacted with the senior functionaries of the State Governments at Kolkata, Bhubaneswar and Visakhapatnam. IMD's warnings were widely disseminated through the print media, Doordarshan and AIR. DG and Dy DG (cyclone warning), IMD were in close touch with Cabinet Secretary and other functionaries of the Govt. of India throughout the storm period and provided regular updates at the meeting of the National Crisis Management Committee (NCMC). On 30 October, 1999, DG, IMD briefed the Union Cabinet, at its emergency meeting chaired by the Hon'ble Prime Minister. India Meteorological Department's forecasts were very accurate and given well in advance.

3.4.5 **Physical Vulnerability.** Odisha Cyclone, 1999[13], states, the cyclone caused heavy torrential rain over southeast India, resulting in floods in the low-lying areas. The storm surge was 26 feet (8 meters). It struck the coast of Odisha, traveling up to 20 km inland. 17,110 km² (6,600 mi²) of crops were destroyed, and an additional 90 million trees were either uprooted or had snapped. Approximately 275,000 homes were destroyed, leaving 1.67 million people homeless. Another 19.5 million people were affected by the super cyclone to some degree. A total of 9,803 people officially died from the storm, with 40 others still missing, though estimates of the dead and missing have been as high as 15,000. The number of human casualty district wise is given in **Fig 5. 8, 119 of those fatalities were from the Jagatsinghpur district.** Another 3,312 people were injured. 2,043 out of 5,700, or 36% of the residents of Padmapur perished. The number of domestic animals fatalities was around 2.5 million, though the number of livestock that perished in the cyclone amounted to only 406,000. The high number of domestic animal deaths may have possibly had to do with around 5 million farmers losing their livelihood. The damage across fourteen districts in India resulted from the storm was approximately $4.5 billion (1999 USD, $5.1 billion 2005 USD). As fishing is a predominating occupation, loss to the

[13] http://en.wikipedia.org/wiki/1999_Odisha_cyclone

fishermen was very high. 9085 fishing boats were lost and 22143 nets were lost.[14]

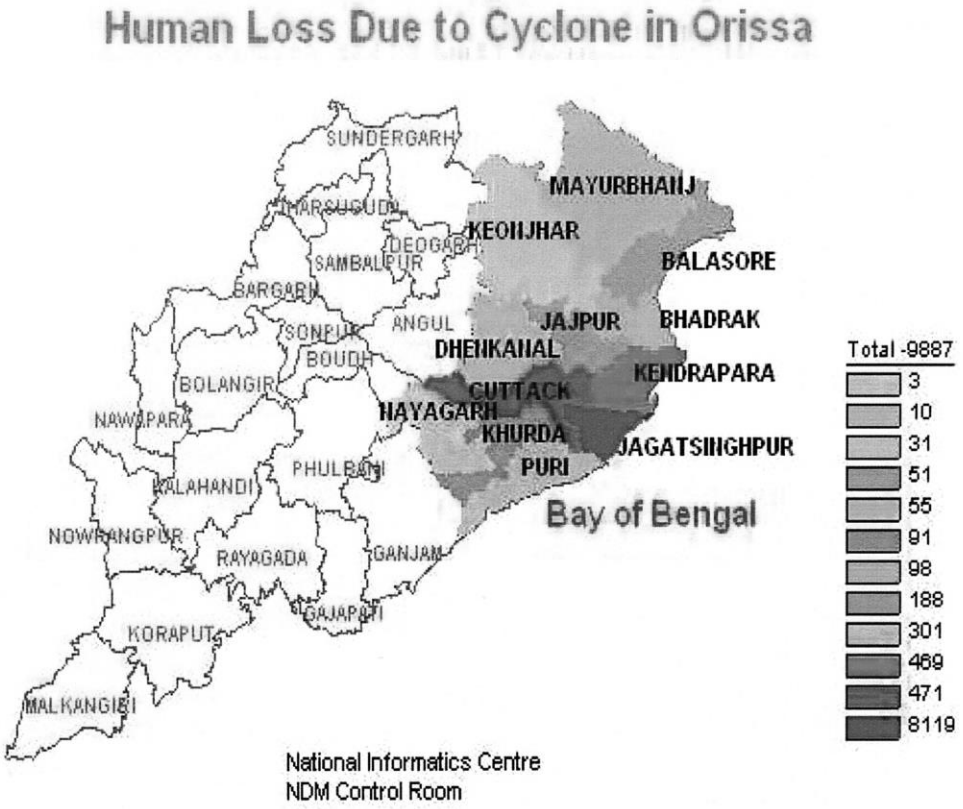

Figure 7: Human Loss Odisha Super cyclone

Source: NCAR -Super Cyclone-99 final.PDF

Gupta and Sharma (1999), noted that, Twelve districts in Odisha and two districts in West Bengal fell within the 200km radius of the Super cyclone. Eight coastal districts were severely affected with maximum loss of lives at Jagatsinghpur, they are:-

(i) Jagatsinghpur.
(ii) Kendrapara.
(iii) Cuttack.

[14] http://en.wikipedia.org/wiki/1999_Odisha_cyclone

(iv) Khurda.

(v) Bhadrak.

(vi) Puri.

(vii) Jajpur.

(viii) Balasore.

Mayurbhanj, Keonjhar, Dhenkkanal and Nayagarh were partially affected.

3.4.6 **Social Vulnerability** Paradip in Jagatsinghpur was the worst affected area with maximum number of reported loss of life. The population data of **Jagatsinghpur** in 1991 is not directly available as the district was formed in 1993. However, figures have been taken from Orissa special review 2010, which is based on 2001 census. The figures are the closest available to 1999 and is as below[15]:-

(a)	Population	:	10,14,242
(b)	No of Males	:	5,13,134
(c)	No of females	:	5,01,108
(d)	Rural population	:	9,38,150
(e)	Urban population	:	76,092
(f)	Children	:	7.82%
(g)	Aged	:	10.89 %

3.4.7 NDMG(2008), Odisha had just 23 shelters for evacuation, of which, just three were in Jagatsinghpur. They were capable of sheltering only about 42000 people. Loss of life is primarily because of inadequate number of safe shelters

[15] http://orissa.gov.in/e-magazine/orissa review/2010/december/engpdf/116-119.pdf

capable of withstanding high speed winds. The above data shows. In addition as more than 50% of the population of Jagatsinghpur is women(50%), Children(7.82%) and elderly people (10%) who need help during evacuation. 12,124 houses were washed away, 199,428 houses collapsed and 48,355 houses collapsed partially. 95 % of rural dwellings thus were destroyed fully or partially in Jagatsinghpur (Paradeep).

3.5 **Economic Vulnerability** The Port of Paradip founded by Raghavendra, is the primary port in Odisha, and one of the largest on India's east coast. Paradeep port town which took the major brunt has the following economic infrastrurcture:-

(a) Paradeep Phosphates Limited, a fertilizer company height.

(b) Paradeep Plastic Park Limited.

(c) IFFCO- Fertilizer Plant.

(d) Essar Steel's Pellet plant.

(e) Indian Oil marketing terminal.

(f) Bharat Petroleum Corp. Ltd. - marketing terminal.

(g) Hindustan Petroleum Corp. Ltd. - marketing terminal.

(h) Cargill's edible oil plant.

(i) Indian Oil Corporation Limited IOCL.

(j) Skol Breweries Ltd, (Unit- East Coast Brewery).

3.5.1 Commercial crops like sugarcane, jute, cotton, soybean, groundnut and potato are produced in the state along with pulses, paddy are the major cereals crop cultivated in about 75.7% of the cropped area, followed by pulses with 10.6% and oilseeds with 6.9%. Odisha also has a yield of 13.7 quintal per hectare. 80% of the houses are Kutcha or makeshift.

3.5.2 **Power and Communication sector.** Gupta and Sharma (1999), explain that, the power and telecommunication sector towers and infrastructure are exposed and disrupted during natural calamities like cyclone, storm earth quake etc. Damage to transmission towers during the Super Cyclone was limited, however, disruption due to snapping of conductors and falling trees was severe. This affected the power distribution system. As many as 39 towers of 220 KV and 130 KV were sheared off and fell. Bhubaneshawar, Cuttack and coastal districts did not have power supply. Similarly communication failure and blackout was experienced. Power failure will lead to water shortage as pumping will not take place. Paradip was devastated and the damages are as follows:-

(a) 12,809 : Rural Roads.
(b) 444 : PWD roads.
(c) 1090km : Canal.
(d) 1052 : Canal Breaches.
(e) Main road link between Odisha and rest of country damaged.
(f) Eleven State highways damaged and NH-05 also damaged.
(g) Railway track between Vishakhpatnam-Bhubhaneshwar and Howrah was not usable due to damage of tracks and embankments.
(h) In Paradip port, the conveyor belt, power transmission systems, warehouses and roads were extensively damaged. Fortunately the port did not suffer much damage.
(i) Water supply and irrigation were severely affected.
(j) 4 lakh cattle were killed.
(k) 1.84 hectare agricultural crop area damaged.

3.6 Vulnerability Profile-Gopalpur

3.6.1 A Very Severe Cyclonic Storm (VSCS) PHAILIN originated from a remnant cyclonic circulation from the South China Sea. The cyclonic circulation lay as a low pressure area over Tenasserim coast on 6th October 2013. It lay over north Andaman Sea as a well marked low pressure area on 7th October. It concentrated into a depression over the same region on 8th October near latitude 12.00N and longitude 96.00E. Moving west-northwestwards, it intensified into a deep depression on 9th morning and further into cyclonic storm (CS), '**PHAILIN**' in the same day evening. Moving northwestwards, it further intensified into a severe cyclonic storm (SCS) in the morning and into a VSCS in the forenoon of 10th Oct. over east central Bay of Bengal. The landfall site and area affected by Phailin is given in **Fig 8**. The VSCS, **PHAILIN** crossed Odisha & adjoining north Andhra Pradesh coast near **Gopalpur (Odisha)** around 2230 hrs IST of 12th October 2013 with a sustained maximum surface wind speed of 200-210 kmph gusting to 220 kmph[16]. **Table 3**, gives details of intensification of the cyclone.

[16] http://imd.gov.in/section/nhac/dynamic/phailin.pdf

10th oct 13morning to 11th morning	Rapid intensification. Speed increased from 45 to 115 knots.
12 oct 13	Landfall at 115 knots (215 Kmph), Central pressure 940 hpa with pressure drop of 66hpa at center compared to surrounding.
	It caused very heavy to extremely heavy rainfall over Odisha leading to floods, strong gale and storm surge.
	Maximum rainfall over north east sector of system center at time of landfall. 24 hr cumulative rain of 380mm received over Banki in Odisha.
	Maximum storm surge of 2-2.5m experienced at Ganjam. Saline water inundation extended to 01 km.
	Numerical weather.prediction (NWP) and dynamical statistical models provided good guidance with respect to genesis, track, & intensity.
	IMD accurately predicted genesis, intensity, track, point and time of landall.and adverse weather like heavy.rain heavy rainfall, gale wind and storm.surge 4 to 5 days ahead.

Table 3: Movements and Intensification of Cyclone Phailin

Source: http://imd.gov.in/section/nhac/dynamic/phailin.pdf

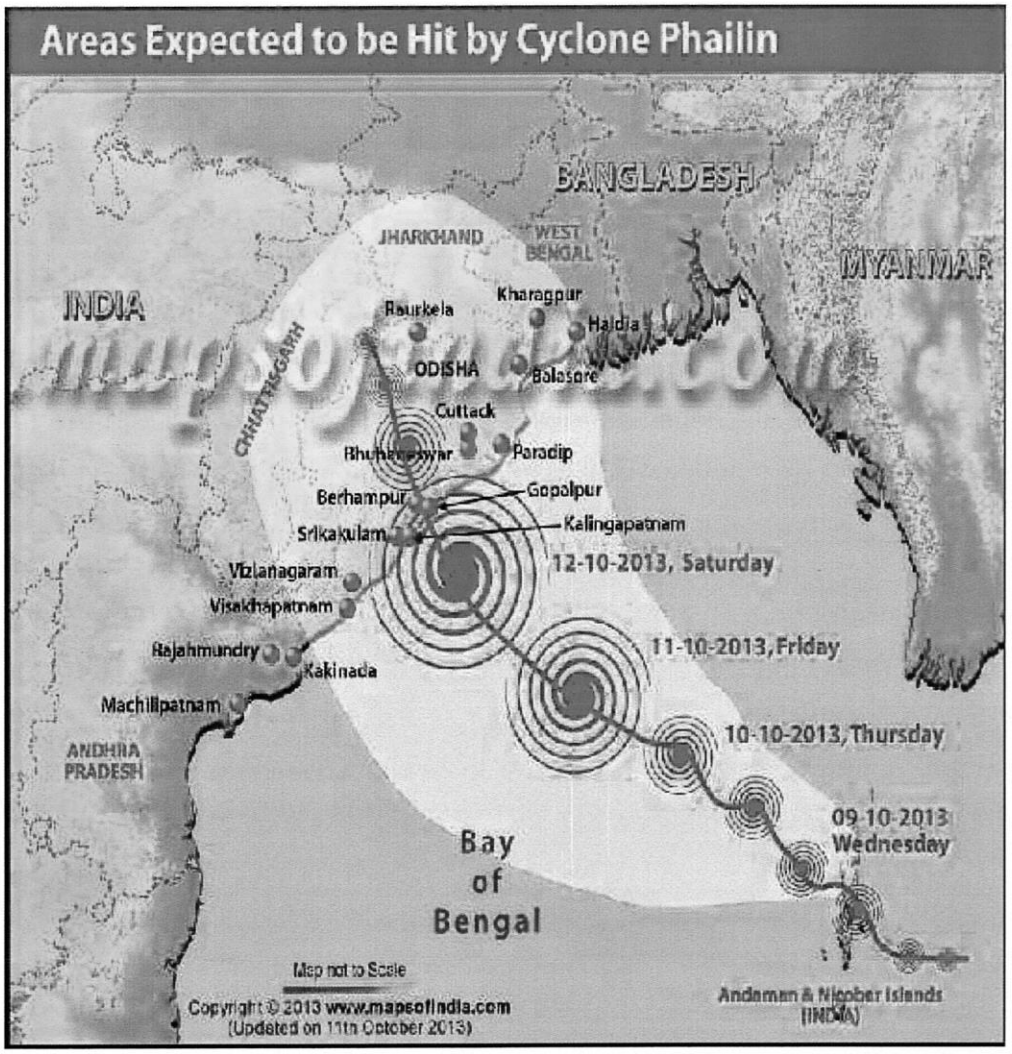

Figure 8: Land Fall Site and Area Affected by Phailin.

Source: http://in.yhs4.search.yahoo.com/yhs/search? hspart=iry&hsimp= yhs-fullyhosted_.....Dvosteran&p=track+phailin

3.6.2 **Ports** Gopalpur is a town and a Notified Area Council on the Bay of Bengal coast in Ganjam district in the southern part of Odisha, India. Once a commercial port, it is now a famous sea beach and tourist destination around 15 km from Berhampur. The reconstruction of the port is under progress.

3.6.3 **Population** As of 2001 India census, Gopalpur had a population of 10880. Males constitute 50% of the population and females 50%. Gopalpur has an average literacy rate of 51%, lower than the national average of 59.5%: male literacy is 59%, and female literacy is 42%. In Gopalpur, 12% of the population is under 6 years of age.

3.6.4 **Physical Characteristics of Phailin** The Phailin Cyclone had an eye diameter of 16 km and overall diameter of 500 km[17] with landfall near Gopalpur. The storm intensity was cat5 in Saphir Simpson Hurricane Wind Scale (SSHWS) and touched a speed of 215 km. The affected areas had rainfalls ranging from 380 mm with the turbulent sea sometimes rising to a height of 2-2.5m, IMD report (2013). The area inundated by flood is shown in **Fig 9**.

[17] http://en.wikipedia.org/wiki/Cyclone_Phailin

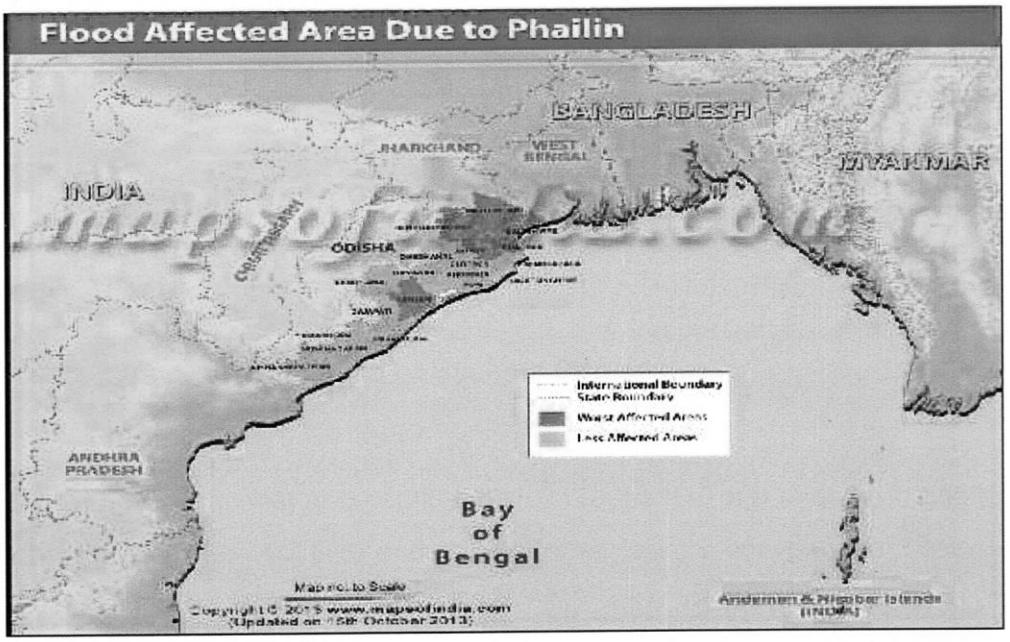

Figure 9: Flood affected area due to Cyclone Phailin.

Source:http://www.mapsofindia.com/maps/mapinnews/cyclone-phailin.html

3.6.5 MOES, GoI (2013), explains, The VSCS PHAILIN was monitored & predicted continuously since its inception by the IMD. The forecast of its genesis on 8th, its track, intensity, point & time of landfall, as well as associated adverse weather like heavy rain, gale wind & storm surge were predicted exceedingly well with sufficient lead time which helped the disaster managers to maximize the management of cyclone in an exemplary manner. At the genesis stage, the system was monitored mainly with satellite observations, supported by meteorological buoys and coastal and island observations. As the system entered into the east central Bay of Bengal moving away from Andaman & Nicobar Islands, it was mainly monitored by satellite observations supported by buoys. On 12th October, when the system lay within radar range, the DWR at Visakhapatnam was utilized and continuous monitoring by this radar started from 0630 hrs IST of 12th when the system was at about 310 km east-southeast of

Districts Affected	**13**	**Blocks Affected**	**110**
Panchayats Affected	**1924**	**Villages Affected**	**15,315**
Cities Affected	**39**	**Affected Land**	**405,199 hectares**
Affected Population	**10,000,000 (approx)**	**Death Reported**	**25**
Most Affected District	**Ganjam**		

Table 4: Fact Sheet Impact of Cyclone Phailin

Source: igsss.org/newsevents/phailin-cyclone-situational-report

Visakhapatnam coast and continued till 2330 hrs IST of that date. In addition, the observations from satellite and coastal observations conventional observatories and Automatic Weather Stations (AWS) ware used. While coastal surface observations were taken on hourly basis, the half hourly INSAT/ Kalpana imageries and every 10 minute DWR imageries, available microwave imageries and scatterometry products were used for monitoring of Phailin. IMD continuously monitored, predicted and issued bulletins containing track & intensity forecast at +06, +12, +18, +24, +36, +48, +60, +72, +84, +96, +108 and +120 hrs or till the system weakened into a low pressure area. The above structured track and intensity forecasts were issued from the stage of deep depression onward.

3.6.6 **Physical Vulnerability.**

The Asia-Pacific region experiences nearly 60% of the world's natural disasters. India, on account of its geographical position, climate and geological setting, is the worst affected place in the South Asian region. Floods and drought, earthquakes and cyclones devastate the country with grim regularity year after year. Many of the people along the coast are subsistence fishermen and farmers, who live in mud-and-brick or thatched huts. Normal life was thrown out of gear in 13 districts of coastal Odisha under the impact of very severe cyclonic storm Phailin accompanied by heavy rains and heavy winds lashing the most of the coastal of districts. The lack of drinking water and proper sanitation facilities increased the risk of spreading of epidemic. Cyclonic storm Phailin slammed Gopalpur in Odisha on 12th Oct'13, triggering heavy rains and strong winds with speed reaching up to 200 km an hour. The cyclone made landfall near Gopalpur-on-Sea at around 9 p.m., about 20 km away from Berhampur on Saturday, and the heavy rain and gale left behind 2.5 lakh 'kutcha' and 'semi-pucca' houses damaged and uprooting thousands of trees across roads. Most of the rivers in southern Odisha such as Mahanadi, Baitrani, Budhabalanga, Rishikuli, Baitarani, Burabaran, Sarangi are overflowing causing floods in Baripada, Bhadrak, Ganjam, Nayagarh, Kurda and Baleswar district. Five gates of Hirakud dam were opened in Sambalpur district. **Table 4** above gives the fact sheet of impact of Cyclone Phailin.

(a) Extensive damage to 'kaccha' houses. Partial disruption of power and communication lines. Extensive damage to agricultural crops. More than 2-3 lakh mud-houses damaged in Ganjam district. Telecom services have also suffered a major blow. The high wind speed also left the antennae at several places twisted and snapped, further affecting mobile services. The food and grain storage systems are damaged which may lead to greater food security crisis in coming days. At present the District Administration

and Government is providing initial relief food assistance in the shelter camps. Thousands of mud and thatched houses are fully or partially damaged. Around 110 blocks under the 13 districts are in critical situation. Government has evacuated families to safer areas where they live in either open or in crowded shelters. Livelihood- Around 15,315 villages are affected. The cyclone caused losses of crops and most of the agriculture lands are submerged. In some cases saline water entered in the farm land which may lead to soil infertility. Loss of fodder may add to the miseries as the domestic animals will be impacted heavily. The districts affected are:-

(i) Balasore.

(ii) Bhadrak.

(iii) Mayurbhanj.

(iv) Keonjhar.

(v) Dhenkanal.

(vi) Jajpur.

(vii) Cuttack.

(viii) Jagatsinghpur.

(ix) Kendrapara.

(x) Puri.

(xi) Khurda.

(xii) Nayagarh.

(xiii) Ganjam.

(xiv) Gajapati.

3.6.7 **Social Vulnerability** Brahmapur, the closest city to the point of landfall suffered devastation triggered by gale winds, with fallen trees, uprooted electric poles and broken walls in various places of the city. However, there were no reports of damage to property or life according to the city police. As of 18 October, 44 people have been reported dead from Odisha. Hit hardest by the cyclone, the coastal village Gopalpur, district Ganjam was estimated to have suffered a loss of at least Rs 3,000 crore in the nature's fury which had deprived lakhs of people of their livelihood and damaged 2.4 lakh houses. Gopalpur is famous for health environment. As of 2011 India census, Gopalpur had a population of 10,800. Males constitute 50% of the population and females 50%. Gopalpur has an average literacy rate of 51%, lower than the national average of 59.5%: male literacy is 59%, and female literacy is 42%. In Gopalpur, 12% of the population is under 6 years of age, Wikipedia, Cyclone Phailin (2013). Demographi of Gopalpur is as below:-

(a)	Population	:	10,800
(b)	No of Males	:	5400
(c)	No of females	:	5400
(d)	Rural population	:	8448
(e)	Urban population	:	2352
(f)	Children	:	12%
(g)	Aged	:	12%

3.6.8 UNEP (2013), elucidates that, Odisha initiative has led to the construction of **200 new cyclone shelters,** operating in places such as schools and community centers to ensure regular maintenance. Cyclone shelters have proven to be useful as 75 shelters operated by the Indian Red Cross provided safety to

more than 100,000 people during Phailin. Odisha had 500 shelters[18] including schools, place of worship etc. With some shelters holding up to 500 people. 1303 Primary Schools (863 double storied) and 1122 High Schools buildings have been constructed in Cyclone affected districts. Most of these buildings have been designed to serve as cyclone shelters. 1014 Primary School Buildings have been constructed with DFID assistance[19] in the cyclone affected districts. A multipurpose shelter in Ganjam is illustrated in **Fig 8**. At PM High School, one among the three in the town, arrangements were made in terms of food, water, diesel generators and bedding. Its four large classrooms resembled dormitories, occupied by those who felt comfortable in its care. Govt of Odisha decided after the Odisha super cyclone, to build 500-1000 shelters along the 500km coast. 40 cyclone shelters were to be built by OSDMA. Various other agencies also would be constructing the required shelters. These shelters should have animal mounds nearby for safety of cattles. Chilika lake is the biggest lake in Odisha and is near Gopalpur.

Figure 10: Multi Purpose Cyclone Shelter,Ganjam

Source: http://www.unep.org/pdf/UNEP_GEAS_NOV_2013.pdf

[18] http://en.wikipedia.org/wiki/Cyclone_Phailin
[19] Chap V ews cwds odisha.pdf

3.6.9 **Economic Vulnerability** Once a commercial port, Gopalpur is now a famous sea beach and tourist destination around 15 km from Berhampur. The reconstruction of the port is under progress. Gopalpur has one university: Berhampur University, one research Institute, four medical/dental colleges, five Engineering colleges, three management institute and many more institutions. Two industries namely Indian Rare Earth and Gopalpur SEZ.

3.6.10 **Power Transmission** Business Standard (2014), notes, Phailin had battered nearly 1600 km of 11 KV lines in Ganjam district while 241 km of 33 KV lines were badly damaged. Transmission lines were designed considering the **design wind zone V (wind speed of 50 m/sec or 180 kmph) where as wind speed in phailin touched 220 kmph**. 80 per cent of 33/11 KV lines were damaged due to the cyclone[20]. People in the district had to cope up without electricity for weeks, it took over two months to achieve full restoration of the power infrastructure. Odisha Power Transmission Corporation Ltd (OTPCL) took up replacement of 300 distribution sub-stations and 54 extra high tension towers. Besides, 13,000 km of low tension lines had to be repaired. Having suffered loss of about Rs 1,000 crore in power infrastructure due to cyclone Phailin, Odisha government has decided to take up 'disaster proofing' of the system in some parts of worst-hit Ganjam district. In the initial phase, the power distribution system would be made in Berhampur, Chatrapur and Gopalpur towns, official sources said on Sunday. The cost of the project will be around Rs 300 crore with more than one lakh consumers to reap the benefits, a senior official at the energy department said. The PGCIL, which has introduced similar system in certain cities, agreed to take up the matter in three towns in Odisha. While total underground cabling of the power lines will be a costly affair, the state government has decided to go for different options like, limited underground cabling, setting up of Narrow Based Lattice Structure (NBLS) Towers and putting

[20] **http://www.business-standard.com/article/economy-policy/cea-asks-for-final-report-on-power-infra-damaged-by-phailin-114032900522_1.html**

up of H poles, which are robust to withstand gale speed of 300 plus kilometers per hour. The very severe cyclone hit the Ganjam coast with a speed of about 220 km and virtually destroyed the power infrastructure in the district,[21].

3.7 **Profile Comparison - Jagatsinghpur and Gopalpur** The profile of both Jagatsinghpur and Gopalpur is given in **Table 5** below. The table brings out the fact that IMD before 2003 was able to give accurate warning or bulletin by 24 hrs whereas in the case of cyclone Phailin the advancements in technology had given four days of lead time for the preparation and pre-disaster activities to be activated to mitigate the damage. In the 1999 super cyclone it was seen that the number of shelters in the entire state was 23 and in Paradip, Jagatsinghpur had only 03. Each shelter with maximum 1500 capacity could protect very less people. Thus lack of timely warning, preparedness and lack of shelters could have resulted in more casualties. In addition the wind speed, surge height etc. in respect of super cyclone was very high. The presence of Delta, lack of vegetation and rivers also resulted in the winds gaining speed due to lack of friction. The cyclone generally slows or weakens after 08 hrs of landfall but above conditions enabled it to remain strong for 30 hrs, linger near shore and wreak havoc on land.

3.7.1 There are huge differences between the super cyclone of 1999 and Phailin. "It (the 1999 one) was a super cyclone with a wind speed of more than 260 kmph. This time it was only 210 kmph. In 1999, the storm surge (rise of waves on the shore) was 7-10 metres and this time it was just 3.5 metres. This time the cyclone hit a steep area. Paradip, with its port and major rivers such as Mahanadi, is a deltaic area. So the inundation was 35 km. This time it was estimated at 600 m. in addition cyclone Phailin had landfall during **low tide**

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[21] **http://indianexpress.com/article/india/india-others/odisha-to-adopt-disaster-proofing-power-system/**

hence storm surge was not too high. Also, now IMD has better technology which helps issue 'early' forecasts and for the first time the IMD calculated the likely area of inundation before cyclone Phailin. A comparison of damages that occurred in both disasters is annexed (**Annexure 4**)

3.7.2 Still there is room for improvement. Cyclone forecasts are best when data are measured from the ocean - while India does it using sensors on floats in the sea, the US of A conducts twice daily aircraft reconnaissance, sometimes using five aircraft, of the eye of the storm in the ocean and around it using radars attached to the belly of aircraft to get accurate initial data. Aircraft reconnaissance of the eye of the hurricane may remain a far cry in India.

Sl No	Description	Jagatsinghpur	Gopalpur
1	Population	10,14,242	10800
2	Male	5,13,134	5400
3	Female	501,108	5400
4	Children	7.82%	12%
5	Rural Population	938,150	8440
6	Urban Population	76,092	2352
7	Wind Speed	260-300kmph	215 kmph
8	Surge Height	7-10 m	2-2.5 m
9	Human Casualty	9803	23
10	Livestock	406,000	
11	Houses Destroyed	275,000	250,000
12	Rainfall	400-867 mm	380 mm
13	No of Cyclone Shelters	23	500
14	Distance travelled by waves	20 km	600m
15	Category- SSHWS	5	5
16	Advance Warning IMD	24 hrs	120 hrs
17	Districts affected	12	14

Sl No	Description	Jagatsinghpur	Gopalpur
18	Industries	More	Less
19	Loss suffered	450 Crore	3000 Crore
20	Early Warning	24 hrs	120 hrs
21	Diameter of Cyclone	400 km	500 km

Table 5: Profile and impact comparison Jagatsinghpur and Gopalpur.

Source: Prepared by author from preceding paragraphs

3.8 Odisha State Disaster Management Authority.

3.8.1 Orissa State Disaster Mitigation Authority (OSDMA) was set up by the Government of Orissa as an autonomous organization on 28th December 1999 (in the intermediate aftermath of the Super-cyclone in 1999). It was registered under the Societies Registration Act, 1860 on 29.12.1999 as a non-profit making & charitable institution for the interest of the people of Orissa, with its headquarters at Bhubaneswar and jurisdiction over the whole State under the Department of Revenue. Subsequently, the name of the Authority was changed from Orissa State Disaster Mitigation Authority to **Orissa State Disaster Management Authority OSDMA)**.

3.8.2 **Aims and objectives of OSDMA .** The Authority has the mandate not only to take up the mitigation activities but also the relief, restoration, reconstruction and other measures. These activities cover the entire gamut of disaster management including preparedness activities :-

(a) Coordinate with the line departments involved in reconstruction.
(b) Coordinate with bilateral and multi-lateral aid agencies.
(c) Coordinate with UN Agencies, International, National and State level NGOs.

(d) Network with similar and relevant organizations for disaster management.

3.8.3 **Conclusion** The case studies of Odisha super cyclone (1999) and Cyclone Phailin has brought out contrasting figures. After the disaster of 1999 the OSDMA was set up. The loss of lives in 1999 was 8900 and above. OSDMA was instrumental in taking lot of steps like training the local population to increase their awareness, building multipurpose shelters, schools which also served as shelters during a disaster, upgrading communication facilities. IMD also modernized their Early warning network. An effective EWS along with good response from the concerned authorities helped bring down the loss to double digits.