

# Impact Assessment of Super Cyclone Hudhud on Coastal Region of Visakhapatnam, Andhra Pradesh, India, Using Remote Sensing and GIS Techniques

K.M.Ganesh, G.Jai Sankar, G.V.L.N.Murthy

**Abstract:** The characteristic of a rapidly rotating storm system of tropical cyclone have a strong winds, a spiral arrangements of thunderstorms and low pressure center. It has a large bodies of relatively warm water in classic form. A low pressure system was originates as Hudhud on 6<sup>th</sup> October 2014. The Hudhud is a very severe cyclonic storm on IMD scale and category 4 on Staffir-Simpson scale announced by the Indian Meteorological Department (IMD) department on 9<sup>th</sup> October 2014. On 12<sup>th</sup> October, 2014 at wind speed of 175 km/h hit the coast of Visakhapatnam by the Cyclone due to this the city and the neighboring districts were extensively damaged. Not only the changed the countryside of the port city, but also made it the first city in the country to be directly hit by a cyclone since 1891 according to the history of the IMD which were damage caused by cyclone Hudhud. The Normalized Difference Vegetation India (NDVI) is being used here as the remote sensing technique. The vegetation and non-vegetation part would separate by NDVI. The Arc GIS and ERDAS were used for the NDVI. The satellite data of 4<sup>th</sup> October 2014 shows before the storm and that of 20<sup>th</sup> October 2014 shows after the cyclone.

**Index Terms:** Hudhud, NDVI Classification Map, Change Detection, Shoreline changes, Edge Enhancement.

## I. INTRODUCTION

Any low pressure area with winds spiraling inwards is the Cyclone in meteorology, which rotates the dextral side in the Northern hemisphere and sinistral in the Southern hemisphere. Tropical cyclones, extra tropical cyclones and tornadoes are the variety of low pressure system types of Cyclone.

The cold-core polar storms which lie on the synoptic scale and the extratropical hurricanes are the largest of the low-pressure systems which in meteorology is a horizontal length of 1000 km or more. Mesocyclones and the polar lows that lie within the slightly mesoscale and the tropical storms have the warm-core cyclones. Intermediate in size have the subtropical cyclones.

The eye, eyewall and rainbands are within the cyclones. In the course of a 2 to 6 day life cycle the cyclones track is guided by its steering flow of the polar or subtropical jetstream. At the middle of a cyclone of its eye has a calmest part of the cyclone [1].

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**K.M.Ganesh\***, Department of Civil Engineering, S.R.K.R.Engineering College, Bhimavaram-534204, Andhra Pradesh, India, E mail: meherganesh.k6@gmail.com.

**G. Jai Sankar**, Department of Geo-Engineering, Andhra University, Visakhapatnam-530003, Andhra Pradesh, India.

**G.V.L.N.Murthy**, Department of Civil Engineering, Swarnandhra College of Engineering & Technology, Seetharampuram-534280, Andhra Pradesh, India.

## A. Meteorological History

An eye at its center has Hudhud underwent rapid intensification and developed on October 11. At midday of October 12, near 17.7°N 83.3°E. it made landfall over Visakhapatnam, Andhra Pradesh maintaining intensity. The High Wind Speed Recorder (HWSR) instrument of the Cyclone Warning Center in Visakhapatnam recorded the maximum wind gust as 260 km/h (160 mph). The telecommunication lines are disrupted and the Doppler radar was damaged, obstructing further inspections by the strength of the winds. Track and intensity of the storm shown in Fig.1.

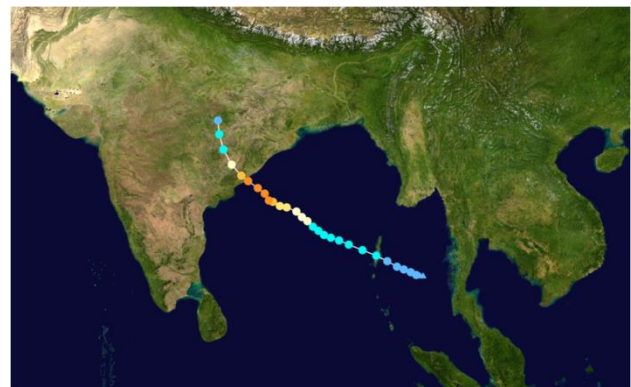


Fig. 1 Map plotting the track and intensity of the storm

## B. Location of the Area

In India which has a seaside Andhra, is a province of the state of Andhra Pradesh. The study area existing in the middle of Bay of bengal and the Eastern ghats of coastal districts of Andhra Pradesh. Fig.2 depicts the location area.

## II. MATERIALS AND METHODS

The techniques followed to achieve the objectives is discussed briefly in this section. Landsat 8 data is downloaded from the official website of USGS. It is prepared by performing layer stacking and subset for further remote sensing and GIS operations.

NDVI is performed and NDVI image is obtained for both the images. These Images are differenced to get the highlight map of change. Statistics are derived and calculated from its attributes itself. Then the NDVI image is classified according to standard classes and the areas of change as well as direction of change is evaluated.



Coming to shoreline band 5 image is very useful in delineating land and water. For that this band 5 image is sharpened and the two shorelines are digitized and the areas of change are detected and their direction is observed. Metrics and statistics are calculated and the objectives are achieved.

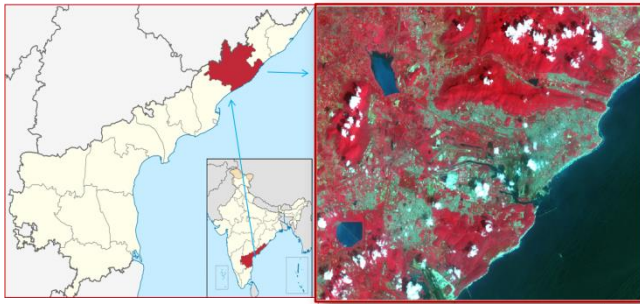


Fig.2 Landsat-8 Imagery of Study Area with 30 m resolution

The satellite imagery used is of LANDSAT 8 satellite. We obtain the images from the official USGS website by specifying the path –row of the study or specifying the location of area . The study area considered is ‘Visakhapatnam’ which has a path -141 and row -48 or latitude and longitude as 17.68 and 83.21 respectively. According to our selection landsat-8 imagery is downloaded on two different dates i.e 4<sup>th</sup> October, 2014 and 20<sup>th</sup> October, 2014. Having the data is not enough but it should be operated in apt environments that is softwares to get efficient results out of it. There are certain dedicated softwares that ensure us to give good results.

Out of the number of software’s present today, we have used two for our study. ERDAS IMAGINE (for image processing and image preparation), Arc GIS (for all GIS functions and processes) [2].

The NDVI is enumerated from reflectance mensurations in the red and near infrared (NIR) part of the spectrum:

$$NDVI = (NIR - RED) / (NIR + RED)$$

Where NIR is the reflectance of NIR radiation and RED is the reflectance of perceptible red radiation. The NDVI has been coordinated to many changeables such as crop nutrient shortage , final yield in small grains, and long-term water stress [3].

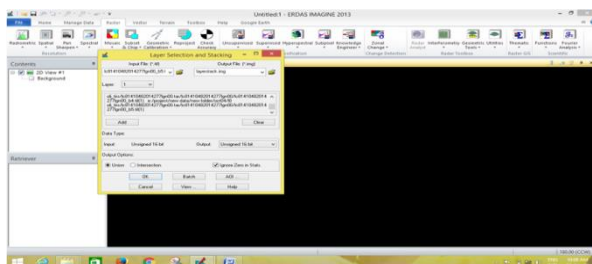


Fig.3 Figure showing layer selection and stacking dialog box

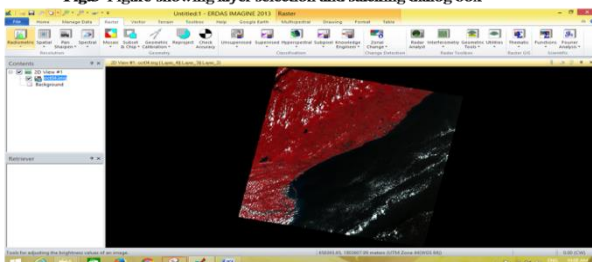


Fig.4 Layerstack Image

## A. Layer Stacking

We get data in forms of 12 bands which includes Thermal Infrared Imagery also. Therefore we have to prepare imagery

so as to work with it to get the desired results. In this case Layer Stacking has to be done. Fig. 3 shows the layer selection and stacking dialog box

- In the ERDAS IMAGINE software go to spectral enhancement and select layer stacking option.
- A window appears where the necessary bands(in this context band 2, band 3, band 4, band 5) are given as inputs
- And the output file is set and processed. This is shown in Fig. 4

## B. Subset of the image

The data acquired contains complete image with the given path and row. Hence the image has to be subsetted to our required area, for our convenience [4].

- For this shapefile containing our area of interest is generated
- Go to ‘Clip’ function in Data Management Tools in Arc Toolbox.
- The necessary inputs are given i. e main image and the clip extent.
- Clip extent is nothing but our Area of Interest.
- Then the output name is given and processed to obtain the subset.

Likewise Layerstacking and Subset is done for both the images and the data is prepared for further operations and analysis.

## C. Extracting NDVI Image

Take the image for which the NDVI analysis has to be performed (it should contain the infrared band also).

- In the input dialog box insert the bands at required input places
- Give the output file name
- Run the process. This is shown in Fig. 5

The input image is given and in band selection window the infrared and red bands are selected to do the band math i. e to perform NDVI [5]. NDVI worth span from -1 to +1. Positive worth indicate higher vegetation and negative values indicate no vegetation or most probably water. This is performed on both the images and NDVI images are kept ready [6]. This is shown in Fig. 6

## D. Image Differencing

- The NDVI imagery so obtained is given as inputs in Image Differencing tool of ERDAS 13 Software.
- Give the output for difference and highlight change images
- Run for the process to be carried out.



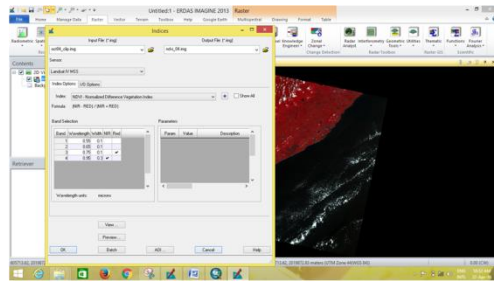


Fig.5 Inputs and Outputs are given in NDVI dialog box

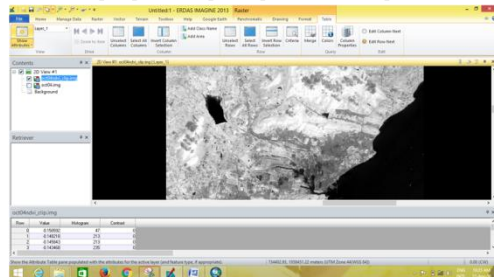


Fig.6 NDVI image with attribute values is obtained

We get two outputs, the difference image and highlight image. This is shown in Fig. 7. Where the difference image has pixels which are resulted from the difference between each pixel in each image and the highlight image highlights the changes between both the images. This is shown in Fig. 8

Both the difference image and highlight image are used to observe the changes that the cyclone brought to the city.

### E. Classification on NDVI images

We cannot simply rely upon the difference or highlight image to derive statistics and define the direction of change [7]. Hence NDVI image classification is done. Fig. 9 depicts window showing layer properties

- Add the Image to the workspace in Arc GIS.
- Go to the properties of Image from Table of contents.
- Under Symbology classify image manually with prior knowledge of ndvi values and their respective features.
- Give the colours for clear identification.
- Export as a layer to save the symbology given. (Fig.10,11 &12.)

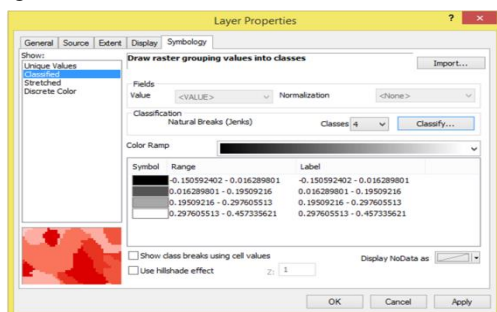


Fig.9 Window showing Layer properties

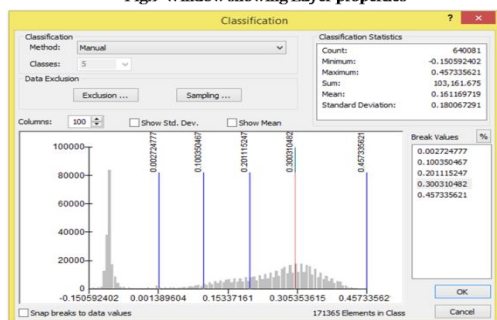


Fig. 10 Classification Window

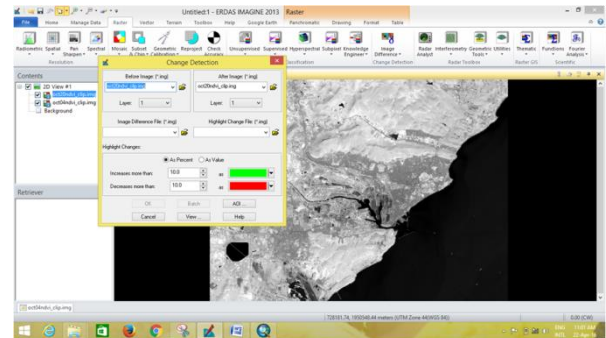


Fig.7: Image differencing dialog box

Row	Histogram	Class_Names	Color	Red	Green	Blue	Opacity	Area
0		0 Background		0	0	0	0	0
1		230036 Decreased		1	0	0	1	51225.6
2		359426 Some Decrease		1	0.84	0	0	73934.5
3		0 Unchanged		0.96	0.96	0.96	0	0
4		25377 Some Increase		0.5	1	0.83	0	6533.3
5		25942 Increased		0	0.39	0	1	4057.4

Fig.8 Attribute table of Highlight image

### F. Linear Edge Enhancement

Linear Edge Enhancement is carried out for differentiating coast and water i.e to get the exact shoreline for shoreline analysis [8]. Band 5 is best suitable for this purpose. Steps involved are as followed. (Fig.13, 14)

- Add the image to the workspace in ArcGIS.
- Open Image Analysis Window and the image is selected.
- In processing section take the necessary sharpening procedure.
- Click on filter and export the Enhanced Image.

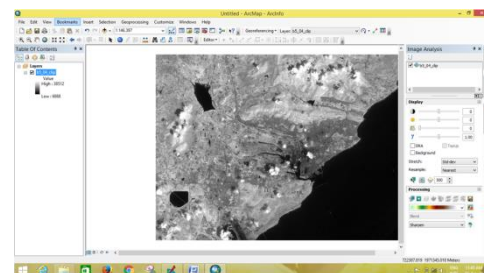


Fig.13 Image Analysis window with processing section showing filter option

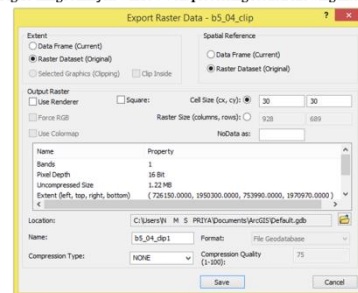


Fig.14 Export Raster Data window

### G. Digitization of shoreline, Areas of Erosion and

	FOR OCT 04 <sup>TH</sup> 2014 IMAGE	FOR OCT 20 <sup>TH</sup> 2014 IMAGE
HIGH	0.457336	0.422191
VALUE:		VALUE:
LOW	-0.150592	-0.20217
VALUE:		VALUE:

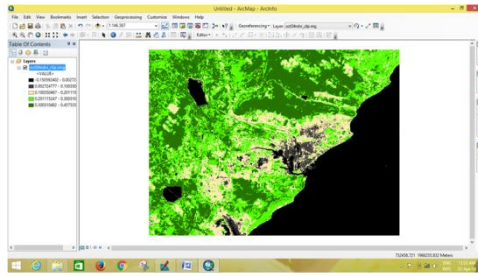


Fig.11 Classified Image before cyclone



Fig.12 FCC Image before cyclone.

## Deposition

The Enhanced Images are taken and shorelines are digitized first, then areas of change are detected using polygon features [9]. This is shown in Fig. 15

- The linearly edge enhanced pre-hudhud band 5 image is added to workspace in ArcGIS.
- New polyline shapefile for shoreline is created.
- Coordinate System is imported from the source image.
- By editing, digitization of shoreline is done. This is shown in Fig. 16
- Similarly the linearly edge enhanced post- hudhud band

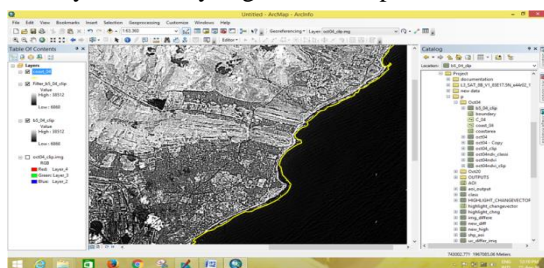


Fig.15 showing digitized coast line of 4<sup>th</sup> October, 2014

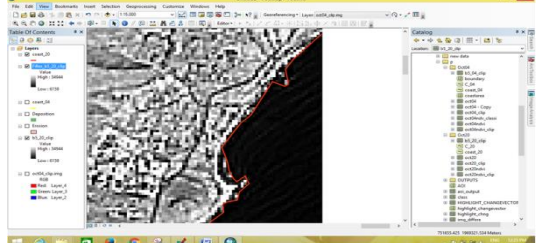


Fig.16 showing digitized coast line of 20<sup>th</sup> October, 2014

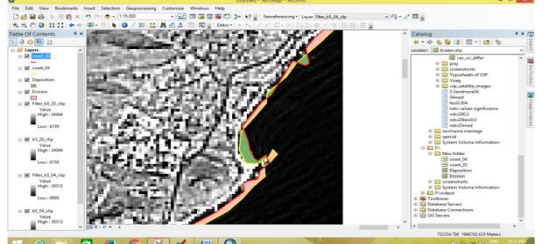


Fig.17 depicting the digitized areas of Erosion and Deposition.

5 image of 20<sup>th</sup> October 2014 is added and digitization of shoreline is performed with another shapefile.

- All the edits are saved and Stop Editing. This is shown in Fig.17

## III. RESULTS AND DISCUSSION

### A. NDVI values

The NDVI image is obtained after the NDVI is performed. Table 1 showing the classification based on NDVI values. The NDVI values oscillate between -1 to +1. Negative values indicate water, snow and clouds. (Fig. 18) Whereas positive values indicate soils and vegetation. (Fig. 19 and 20)

### B. NDVI Classification

TABLE 1 CLASSIFICATION BASED ON NDVI VALUES

S.NO	CLASS	NDVI VALUES RANGE	BEFORE AREA (SQ. KM)	AFTER AREA (SQ. KM)
1	WATER & CLOUDS	<0.01	162.225	169.989
2	SETTLEMENTS& BARREN LANDS	0.01-0.2	97.3071	159.200
3	SPARSE VEGETATION	0.2-0.3	154.228	222.4648
4	DENSE VEGETATION	>0.3	162.3124	24.4188

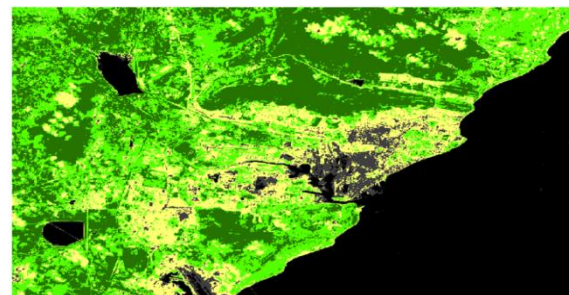


Fig. 18 NDVI classified image before cyclone

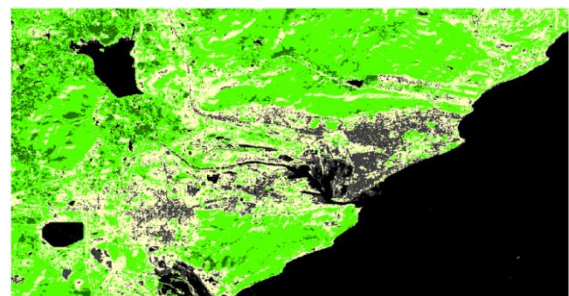


Fig. 19 NDVI classified image after cyclone



Fig. 20 FCC Image after cyclone



Before cyclone = 97.3071 sqkm  
After cyclone = 159.200 sqkm  
Change =  $(159.200 - 97.3071) = 69.8929$  sqkm  
% increase = 63.60 %

Overall vegetation decreased and sparse vegetation increased due to uprooting of large trees and other causes. Settlements & Barren lands increased due to removal of shrubs in unused lands and damaged buildings and their debris. Water increased due to heavy rainfall.

Extent of Erosion is measured using measure tool in Arc GIS Software (Fig.22)

For this purpose extent of erosion at different locations are measured using Measure tool in Arc GIS. The results are tabulated as in Table 2.

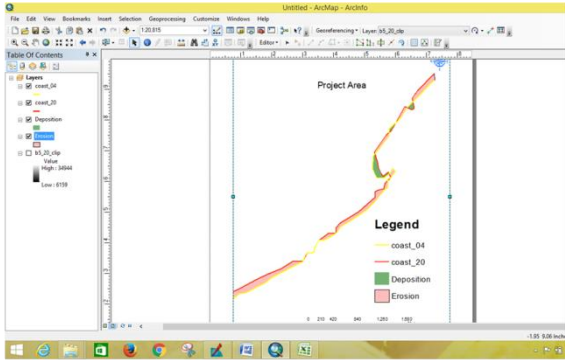


Fig. 21 Base map for erosion and deposition

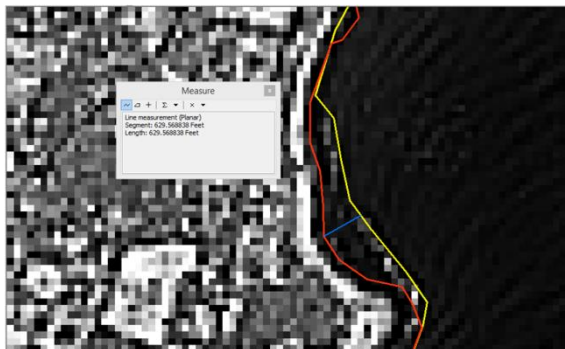


Fig. 22 showing measure of extent of erosion



Fig. 23 showing Erosion due to cyclone

#### Vegetation:

##### Sparse Vegetation Area:

Before cyclone = 154.228 sqkm  
After cyclone = 222.4648 sqkm  
Change =  $(222.4648 - 154.228) = 68.2368$  sqkm  
% increase = 44.24 %

##### Dense Vegetation:

Before cyclone = 162.3124 sqkm  
After cyclone = 24.4188 sqkm  
Change =  $(24.4188 - 162.3124) = 137.8936$  sqkm  
% decrease = 84.95 %

##### Total Vegetation:

Before cyclone = 316.5404 sqkm  
After cyclone = 246.8836 sqkm  
Change =  $(246.8836 - 316.5404) = 69.6568$  sqkm  
% decrease = 22.0056 %

##### Waterbody:

Before cyclone = 162.225 sqkm  
After cyclone = 169.989 sqkm  
Change =  $(169.989 - 162.225) = 7.764$  sqkm  
% increase = 4.78 %

##### Settlements & Barren lands:

TABLE 2 LIST OF EXTENTS OF EROSION AT DIFFERENT LOCATIONS ALONG COAST

S.NO	LOCAT ION	EXTENT (D IN METRES)	S.NO	LOCATIO N	EXTENT (D IN METRES)
1	L <sub>1</sub>	81.278	16	L <sub>16</sub>	97.419
2	L <sub>2</sub>	51.877	17	L <sub>17</sub>	130.084
3	L <sub>3</sub>	43.336	18	L <sub>18</sub>	29.386
4	L <sub>4</sub>	38.128	19	L <sub>19</sub>	202.553
5	L <sub>5</sub>	116.810	20	L <sub>20</sub>	111.241
6	L <sub>6</sub>	25.786	21	L <sub>21</sub>	104.166
7	L <sub>7</sub>	103.145	22	L <sub>22</sub>	82.255
8	L <sub>8</sub>	65.305	23	L <sub>23</sub>	44.632
9	L <sub>9</sub>	7.976	24	L <sub>24</sub>	10.831
10	L <sub>10</sub>	117.724	25	L <sub>25</sub>	5.360
11	L <sub>11</sub>	43.171	26	L <sub>26</sub>	6.691
12	L <sub>12</sub>	110.5	27	L <sub>27</sub>	16.374
13	L <sub>13</sub>	31.871	28	L <sub>28</sub>	4.203
14	L <sub>14</sub>	67.004	29	L <sub>29</sub>	67.564
15	L <sub>15</sub>	4.751	30	L <sub>30</sub>	50.488

Average Erosion along coast =  $\sum(d) / 30 = 62.396 \text{ m} = 204.711$  feet (approx.)

Maximum Erosion observed = 202.553 m = 664.543 feet (approx.)

Minimum Erosion observed = 4.203 m = 13.789 feet (approx.)

#### C. Impact of super cyclone Hudhud

Standing crops were yet to be accumulated when an alert was sounded in nine districts of Andhra Pradesh. To shift a half a million people in all over Andhra Pradesh, were shifted and put up in repose barracks by the local government. The radar and navigational aids were demolished and the runway at Visakhapatnam Airport was flooded. Due to the speed of the cyclone the roof of the workstation was split aside (Fig.23).

#### IV. CONCLUSIONS

Near to the coastal region of Visakhapatnam, severe damages were occurred due to cyclone Hudhud which guide to human loss, wound, road and house mutilates etc. Necessary step like expels the place when the government initiate hurricane bulletins and reach to the safe place as soon as viable, when the tropical cyclone comes. The effect assessment has been done

using the NDVI classification technique.

After a cyclone passes the area is calculated. Hence examined the impact that dense vegetation decreased but sparse vegetation increased, this is because of trees rootout. The trees are mostly infected during the cyclone. Due to the heavy rainfall the water level also increased. The debris or raw materials from the buildings caused the rising the area of settlement.

As erosion is caused and favoured by various factors we cannot estimate the extent of erosion by taking a random location. Therefore an average is calculated by measuring the extent of erosion at random locations along the coastline of Visakhapatnam. At some places it is as high as 200 meters while at some places it is as low as 4 meters.

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