Analysis of Cyclone Amphan in the Perspective of Disaster Management Cycle and Geospatial Assessment

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Abstract

Cyclone is a catastrophic disaster accounting for huge loss of lives worldwide, imposing a trail of destruction of resources and properties and causing fatalities. The present study elucidates the massive devastation incurred by the Super Cyclonic Storm Amphan and also focuses on the strategies and action taken under various stages of disaster management in the context of the Cyclone Amphan. As we proceed with our analysis, the evidence of various comparative studies of this cyclone with some of the previous ones depicts the effects of the implementation of proper crisis management techniques and community based disaster preparedness to sub side the hazardous aftermath of such severe cyclones. Another aspect of this study is the impact analysis of the cyclone on the vegetation of the affected study area with the application of Remote Sensing and Geographical Information System (RS-GIS). It represents a significant variation in the pre-cyclone and post-cyclone scenes. As the study correlates the management methods with impact assessmentand the possibilities of futuristic work on the same are broadened herewith.

Keywords: *Cyclone Amphan; Management; Geospatial Analysis*

1. Introduction

Amphan, a super cyclonic storm as described by IMD was a category 5 tropical cyclone (according to Saffir-Simpson Hurricane Wind Scale-SSHWS) that originated over the southeastern part of the Bay of Bengal (BoB) about 1020km to the southeast of

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Visakhapatnam of Andhra Pradesh where a warm sea surface temperature between 32°-35° C were recorded in the basin and a low vertical wind shear were present. The catastrophic storm was the strongest tropical cyclone to strike the Ganges Delta since the 1999 super cyclonic storm in Odisha to have formed over the Bay of Bengal(Wikipedia). It is required to incorporate proper management strategies to overcome the adverse circumstances provided by the massive cyclone. Disaster management is a conceptual framework involving a coordinated and integrated infrastructure of planning, arranging and implementing measures to deal with humanitarian aspects for preparedness, response and recovery from the unfortunate consequences of a disaster (Shah, 2011).

In the context of Global disaster management, 1972 the World Meteorological Organization (WMO) established a Tropical Cyclone Project (TCP) to assist in improvising the detection and forecasting of cyclones, estimating landfall and execute preparedness and prevention measures. The WMO and Economic and Social Council for Asia and Pacific (ESCAP) jointly operates in countries adjoining the Bay of Bengal and the Arabian Sea to coordinate the cyclone management activities (imdahm.gov).

With respect to National disaster management Govt. of India, in 1969 suggested the setup of the 'Cyclone Distress Mitigation Committee' in respective states to minimize the casualties and property damages. In recent times, the government of India has initiated National Cyclone Risk Mitigation Project (NCRMP) to address the issues of cyclone risk in the country. It aims at taking suitable structural and non-structural measures to mitigate the effects of cyclones in the coastal states and UTs of India (ncrmp). With this background, the present research work is carried out to analyse the fruitfulness of disaster management adopted for cyclone Amphan.

2. Methodology

The present study contains two distinct patterns of working methodology. One part is the detailed review of the cyclone Amphan with respect to disaster management cycle and another part is the Geospatial observations and discussions on the effect of vegetation in the study area.

2.1 Study of disaster management: The part of the study of disaster management contains three main phases: Pre-disaster, where the warnings issued by IMD about the formation of cyclone, place of origin, development were studied along with tracking the path and

monitoring the advancements. During disaster contains various actions undertaken by concerned authorities at the time of the event and post-disaster studies were mainly based on the impacts of the cyclone in the affected areas and what measures were taken to overcome the crisis. A review was made on relief operations where the activities of concerned authorities were discussed.

2.2 Impact assessment: Damage caused due to Amphan in several sectors were assessed by a graph depicting economic losses faced due to the cyclonic storm which includes houses, agricultural lands, irrigation and embankments/dykes, fisheries, roads including rural roads and culverts/bridges, buildings, power sector, industries. A comparative study of Amphan with some of the previous cyclones which had wrecked Bengal many times, was conducted on several aspects.

2.3 Locational details of the study area: The coastal districts of West Bengal i.e., South and North 24-Parganas, Jhargram, East and West Midnapore, Kolkata, Howrah and Hooghly witnessed maximum impacts of the cyclone. The present study is focused into a part of the coastal area of Jhargram district (Figure 1), West Bengal. Geographically, it is located at 22.305°N and 86.98°E. It is surrounded by West Midnapore district in the east, Bankura at the north, and Orissa and Jharkhand at the west.

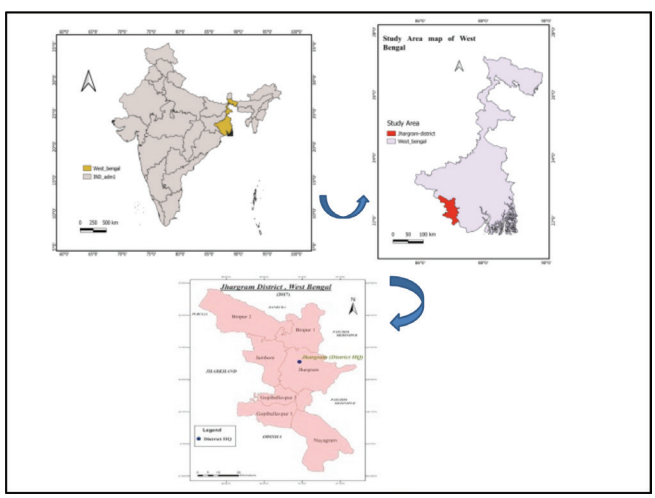

Figure 1: Study Area Location

2.4 Geospatial Analysis

2.4.1 Satellite image procurement: The primary work started with searching for satellite images in the USGS earth explorer. Putting co-ordinates, date range and cloud cover in the search criteria, images from Sentinel-2 satellite were obtained as seen in Figure 2(a). Two sets of images were downloaded i.e., pre-disaster images, before the arrival of the cyclone on 12th May, 2020 and post-disaster images, after the cyclone passed on 27th May, 2020.

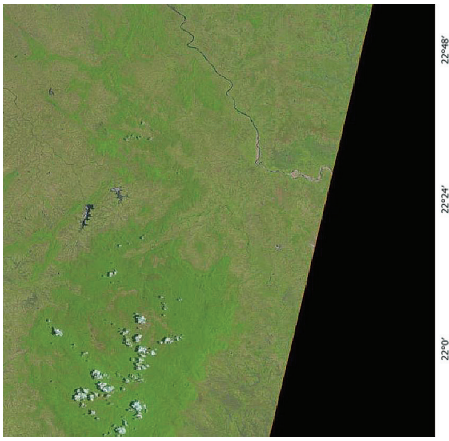

Figure 2(a): Sentinel -2 Satellite image of the study area

(Source: USGS earth explorer)

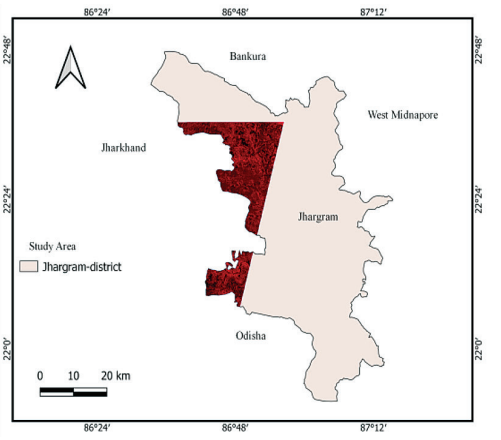

Figure 2(b) represents portion of the satellite image covering the Jhargram district, West Bengal

Both the images were processed in the Quantum GIS (QGIS3), an open source software platform and the study area was extracted like Figure 2(b)from the satellite imageries. The main objective was to calculate the Normalized Difference Vegetation Index (NDVI) of the study area in pre-disaster and post-disaster manner and observe and analyse the difference of classes of vegetation cover in terms of light, moderate and dense.

2.4.2 Calculation of NDVI: NDVI is a quantification of vegetation to monitor drought, forecast crop production and determines the state of plant health based on how plant reflects light at specific frequencies. This is measured by using two bands the near infrared (NIR) band and red band.

NDVI= NIR-RED/NIR+RED…… eq. 1

Where, NIR represents reflection at the near-infrared spectrum and RED represents reflection at the red range of the spectrum. Healthy vegetation reflects more near infra-red and green light than other wavelengths and absorbs more red and blue light (Bhatta, 2008).

For sentinel 2 satellite images, bands required for calculation of NDVI are Band 8 and Band 4.

2.4.3 Calculation of area: The area covered by each classes were calculated by raster classification in QGIS and the significance of the changes in area were justified statistically by t-test.

3. Results and Discussions

3.1 Disaster Management Cycle of Cyclone Amphan

India's coastal areas of east and west are vulnerable to cyclonic storms. Hence, the implementation of proper and effective disaster management actions can alleviate the hazardous aftermath of a disaster like cyclone. As part of any disaster management plan, there should distinctly be three phases: pre-disaster, during disaster and post-disaster (Figure 3).

Figure 3: Phases of Disaster Management (Jain, 2018)

3.1.1 The Pre-Disaster Management phase focuses on mitigation, preparedness and response for the upcoming crisis. In case of disasters like a Cyclone, the Indian Meteorological Department (IMD, issues warnings and monitors the development of

the cyclonic storm. IMD has made a commandable advancement by the application of remote sensing techniques with the help of satellite image interpretation to analyse the intensity and forecast of tropical cyclones (TC). The cyclonic development of Amphan was monitored with the help of satellite images from INSAT 3D and 3DR, polar orbiting satellites including Scatterometer Satellite (SCATSAT), Advanced Scatterometer (ASCAT)etc. (Figure 4)and from ships & buoy observations in the region. Doppler Weather Radars (DWR) installed by IMD at Visakhapatnam, Gopalpur, Paradip and Kolkata, tracked the cyclone development from 18th May midnight to 20th May. Various numerical weather prediction models developed by Ministry of Earth Science (MoES) and Dynamic Statistical models of IMD were deployed in-house to predict the formation, development, path of movement and landfall.

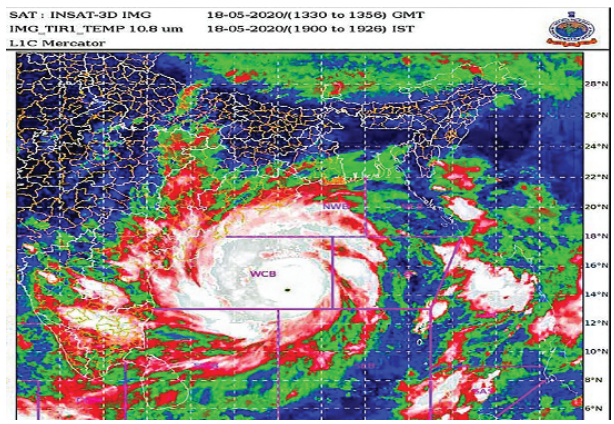

Figure 4: An IMD satellite image showing formation of Amphan in the Bay of Bengal

(Source: PTI)

A four stage warning system was developed and issued for Amphan based on the observed track of it over the Bay of Bengal (Figure 5).

- The first bulletin released at 08:45 hrs IST of 16th May (104 hrs prior to landfall), Pre-cyclone Watch for West Bengal-north Odisha coasts was issued and followed by an upgraded warning, Cyclone Watch, issued at 20:30 hrs IST of 16th May (92 hrs prior to landfall).
- Cyclone Alert (Yellow Message) for West Bengal and north Odisha coasts was issued at 08:40 hrs IST of 17th May (80 hrs prior to landfall).

- Cyclone Warning (Orange Message) for West Bengal and north Odisha coasts was issued at 08:45 hrs IST of 18th May (56 hrs prior to landfall).
- Post landfall outlook (Red Message) for interior districts of Gangetic West Bengal, Assam and Meghalaya was issued at 23:30 hrs IST of 19th May (17 hrs prior to landfall) (RSMC, IMD 2020).

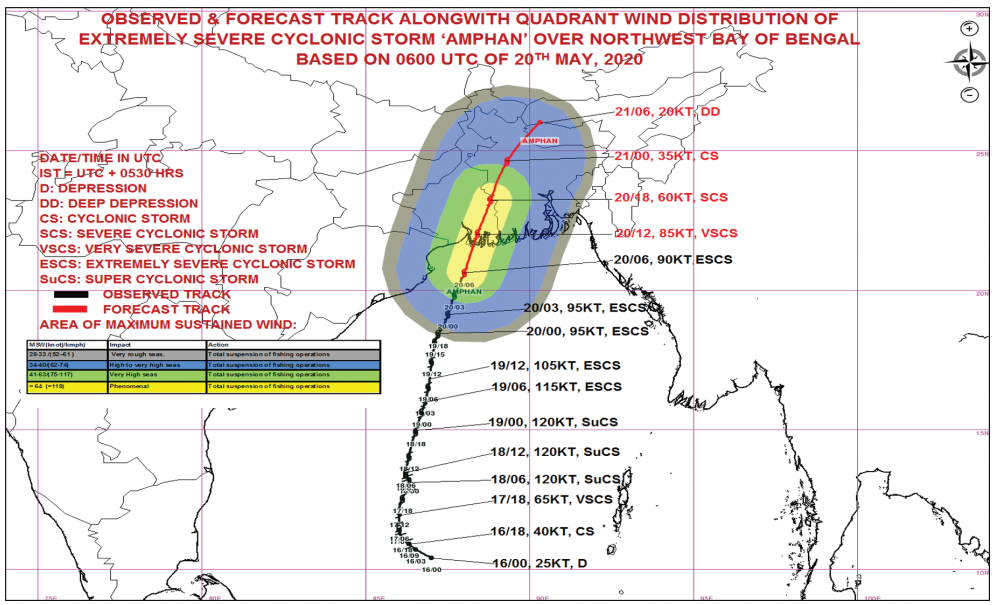

Figure 5: Observed Track of cyclone 'Amphan' over Bay of Bengal (16-21 May, 2020)

(Image source: IMD)

As a major activity during pre-disaster stage, approximately 3 lakh people from coastal areas. Were evacuated to safer places. Alert messages were sent to the Municipal Corporations, Panchayat and Block development offices. Global Maritime Distress Safety System (GMDSS) bulletins were issued by Marine Weather Services at New Delhi for the deep sea sailors and fishermen, officials of ICG were prepositioned along the coastal areas of the Bay of Bengal and advisories were released to restrict their movement. Updates of the advancements of the cyclonic storm were uploaded on the official platforms of IMD and disaster management agencies like NDMA, NDRF etc. Chiefs of IMD and NDRF jointly held a press conference to convey the detail information about the cyclonic storm to the mass media community.

3.1.2 Disaster management, the major activity is emergency disaster response. During Amphan, central and state Govts, disaster management teams and metro logical departments issued guidelines regarding the activities at the time of cyclone (Bandyopadhay, 2014). The power supply was cut in the high alert areas to prevent any unfortunate incidents. The department of electricity of Government of West Bengal kept a vigil over the situation and monitored the occurrence of electric pole fall-off and tearing of electric wires on waterlogged roads. A 24x7 control room headed by the Chief minister Mamata Banerjee, was set up at the administrative building (Nabanna) where the CM herself was present (Figure 6) the whole night of the disaster monitoring actions in the vulnerable areas.

Figure 6: The Chief Minister at the Control Room set up at Nabanna

(Source: ANI)

3.1.3 The post-disaster management is the most significant phase where activities are carried out for Recovery, Rehabiliation and Reconstruction (Shukla, 2013). After the landfall of Cyclone Amphan, the Sunderbans region and the coastal districts of South Bengal experienced the maximum and the worst impacts. Relief operations began after the deadly cyclone passed by. Both, state and central teams (Figure 7 and 8), were deployed

to carry out the rescue activities such as clearing the blockage of roads due to falling of trees, restoration of electricity and drinking water supply etc.


Figure 7 and 8: Rescue operations by NDRF and SDRF teams

(Source: newschrome.com)

The NDRF teams evacuated 7650 livestock to safer places. Teams removed 7392 uprooted trees, 1150 electric poles and cleared 3152.5 Kms of road (NDRF). Total 05 columns of Indian Army, and 20 teams from Indian Coast Guard and were deployed for relief and restoration job. Many social groups and NGOs took great initiatives in providing the necessary items such as food, drinking water, clothes, and medicines to the response centres. over the affected areas of Kolkata and South 24 Parganas. The Prime Minister Mr. Narendra Modi, after an arial survey of the affected areas, announced a 10 billion immediate relief package for West Bengal.

3.1.4 Impact and Damage assessment: The areas of the affected districts witnessed some major impacts: the gusty winds uprooted a large number of trees blocking roads, mud houses and many buildings collapsed, power and telecommunication infrastructures were completely disrupted as the wire heads and lamp-posts fell off, and the agricultural fields were inundated with saline sea-water and crops were damaged. According to a report, the super cyclonic storm claimed 98 lives in West Bengal. The aerial picture in (Figure 9) shows the inundated areas as a result of torrential rainfall accompanied by high speed gusty winds.

Figure 9: An aerial view of the areas majorly hit by Amphan

(Source: telegraphindia.com)

Based on damage assessment by Govt. of West Bengal after visiting the affected areas it reveals that housing and industrial sectors faced the major financial loss followed by agriculture, horticulture, urban infrastructure (Figure 10) and many others which amounted to a total loss of ₹1,02,442 core.

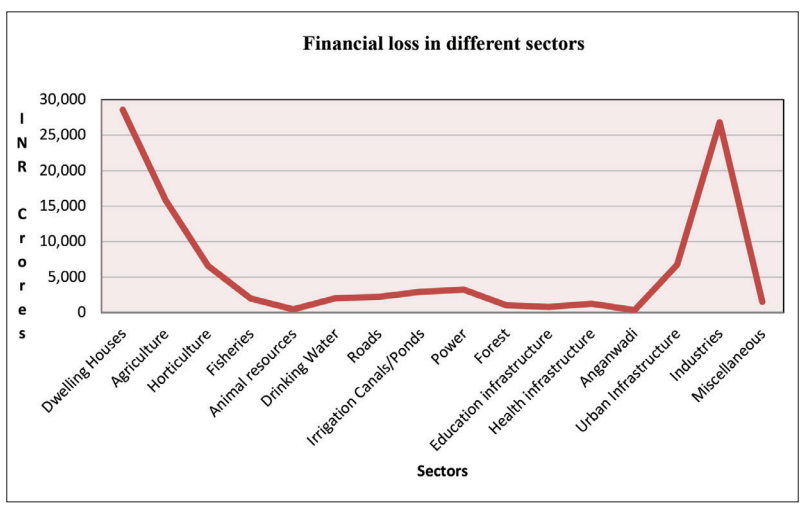

Figure10: Impact on Economics in various sectors

(Source of the Data: Government of West Bengal 2020)

Comparing the number of deaths starting from Super Cyclone 1737 to Cyclone Amphan, it is found that there is a drastic reduction in deaths after 2009, (Figure 11) which demonstrates the holistic improvement of disaster management in minimising loss of life.

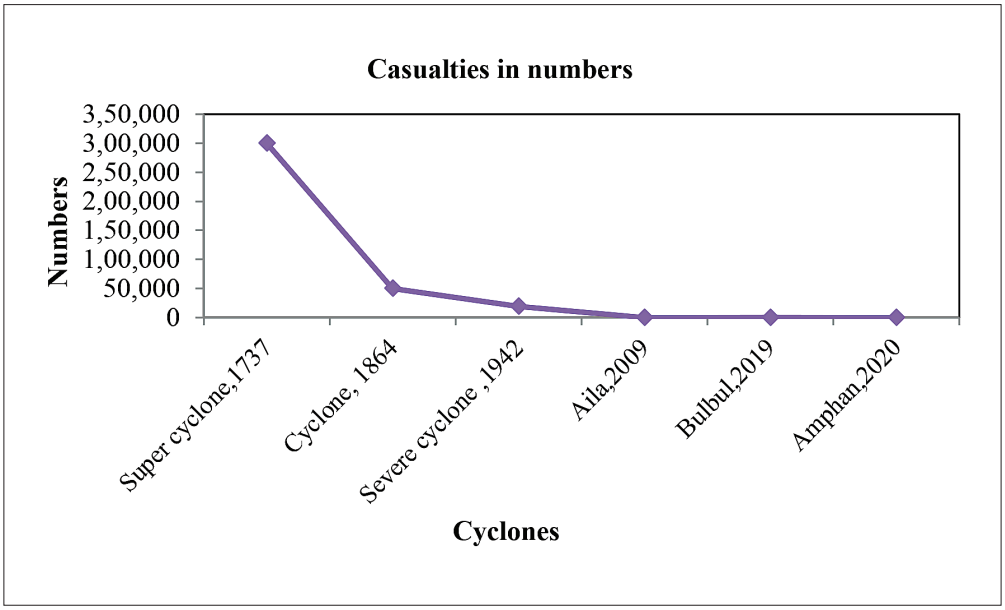

Figure 11: Graph representing causalities from past centuries (1737-1942) upto (2009-2020)

(Source: wbdmd.gov)

The past decade has seen a significant increase in the frequency of severe cyclones. A comparative study has been made while observing the aftermath of the major cyclones West Bengal faced in the past decade. Figure 12 exhibits the wind speed and Figure 13 shows some major impacts of the three cyclones Aila (2009), Bulbul (2019) and Amphan (2020).

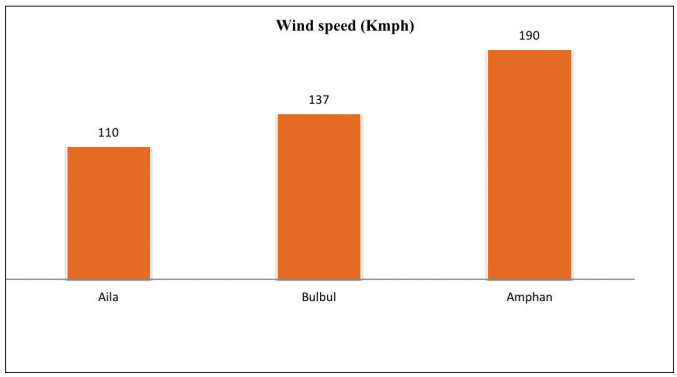

Figure 12: Maximum wind speed of the major cyclones in the past decade

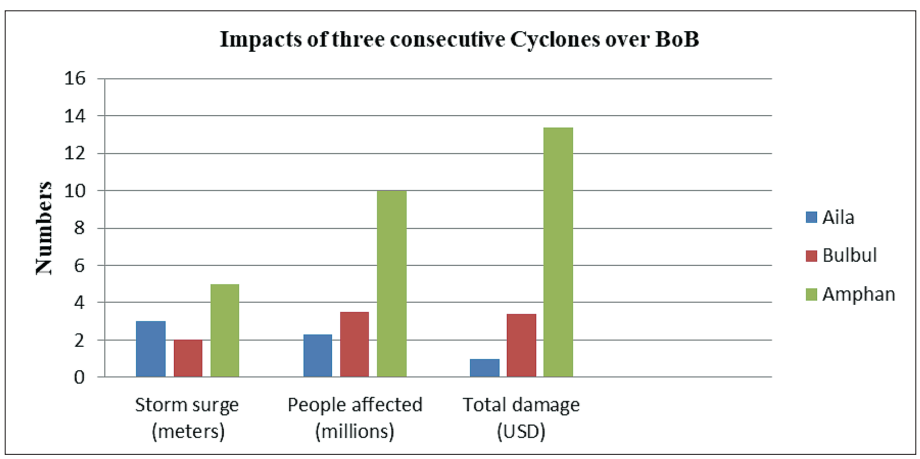

Figure 13: Comparative assessment of the impacts of the three cyclones Aila, Bulbul and Amphan

High wind speed and storm surge of cyclone Amphan principally resulted in the greater number of casualties in terms of people affected and infrastructural damage but pro-active response in disaster management definitely led to significant reduction in loss of life.

3.2 Geospatial observations

The vegetation index of the study area was measured in the QGIS3 software and the followings were observed (Figure 14)

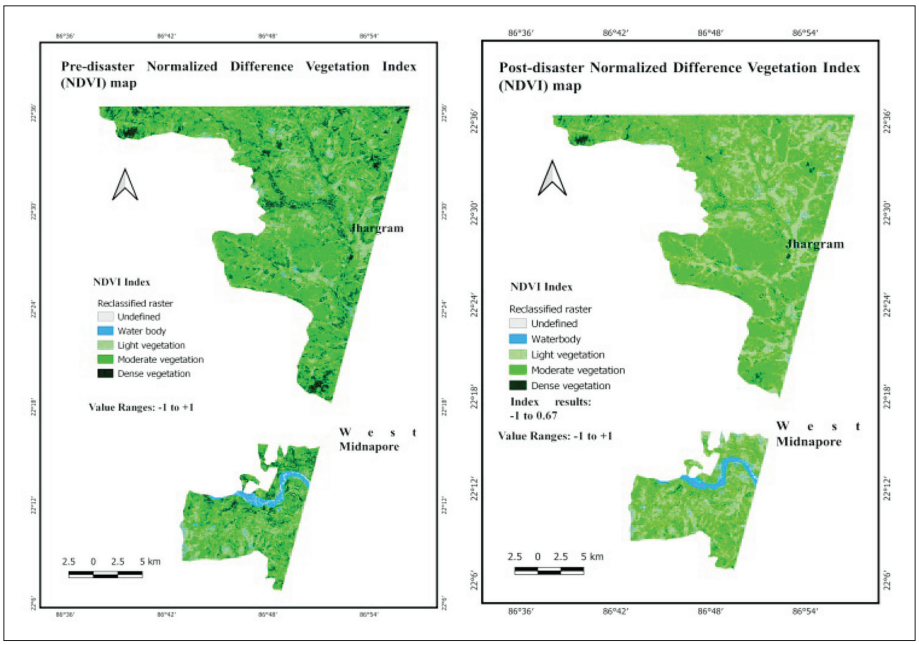

Figure 14: The Pre-disaster and Post-disaster NDVI Map of the study area showing the difference in vegetation index

3.2.1 Observations: Values of pre-disaster and post-disaster NDVI with corresponding colour and state of vegetation are represented in Table 1.

Table 1: Values of Pre-disaster and post-disaster NDVI with corresponding colour and state of vegetation

Colour Index	NDVI values		Type of vegetation
	Pre-Amphan	Post-Amphan	
Light green	0.325	0.254	Presence of light/dispersed vegetation
Green	0.521	0.597	Presence of moderately dense vegetation
Deep green	0.767	0.672	Presence of highly dense vegetation

In pre-Amphan scenario, the images obtained few days prior to the cyclone landfall and the NDVI value ranges from 0.325 to 0.767 representating dispersed to highly

dense vegetation. In post-Amphan scenario, the NDVI indices drops down to 0.254 – 0.672 range. This indicates significant damage to the dense vegetation due the effect of Amphan cyclone. (Table 1).

3.2.2 Area Analysis: In order to carry out the assessment of areal extent of damage to the vegetation reclassification of raster data in QGIS followed by area calculation of different types of vegetation are performed (Table 2).

Table 2: Area of different vegetation in pre-disaster and post-disaster with their significance of changes

Types of Vegetation	Area (Sq. Km)		Changes in Area (%)	t-test (α=0.05)
	Pre-disaster	Post-disaster		
Light/dispersed Vegetation	113.02	134.49	18.99 increase	not significant
Moderately Dense Vegetation	334.89	340.21	1.58 increase	not significant
Highly Dense Vegetation	59.82	14.41	75.91 decrease	significant

The difference in the area of each class of vegetation exhibits the changing pattern. Table 2 shows that areas of light vegetation has been increased approximately 19% and moderate vegetation content grew by 1.58% in the post-cyclone times. But the dense forest areas are showing a massive decrease of 75.91%. The t-test at 0.05 level is showing not any significance in the areas of light and moderate vegetation but it is significant in case of dense vegetation. Hence, this study highlights an important observation that the abundance of dense plantations (deep forests) has diminished at larger rate resulting more areas exposed with light, dispersed vegetation due to Cyclone Amphan. With the degradation of the dense forest areas, some endemic plant species might have been lost forever and this can affect the ecosystem as well as the environment of that region.

4. Conclusion

The study exhibits the damage caused by the Cyclone Amphan in the state of West Bengal and also shows that severe casualties could be abated with the help of a

comprehensive crisis management method which comprises of early disaster warning, timely forecasting, prediction of almost accurate landfall, spreading awareness in the designated sectors, and undertaking every possible mitigation measures. It also highlighted on the severity of the loss of plantations. The calculated index of vegetation showed that due to the super cyclone Amphan, the dense forests with perennial flora were hugely affected.

Therefore, from the present analysis of Cyclone Amphan it is concluded that the incorporation of a competent management network can easily resurrect a disaster hit region and soon bring it back to normalcy. Since there is an abrupt destruction of vegetation, the only possible solution of this misery is to initiate large reforestation.

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