Disaster & Development

Volume 10 • Issue 01 • January to June 2021 ISSN : 0973-6700

nidm
Resilient India - Disaster free India

Journal of the National Institute of Disaster Management, New Delhi

Disaster & Development

Journal of the National Institute of Disaster Management, New Delhi

nidm
Resilient India - Disaster free India

Mailing Address

Disaster & Development
National Institute of Disaster Management
Ministry of Home Affairs
Government of India
Plot No. 15, Pocket 3, Block B, Sector 29, Rohini, New Delhi 110042

Disaster & Development

Journal of the National Institute of Disaster Management, New Delhi

Volume 10, Issue 01, January to June 2021

ISSN: 0973-6700

Disaster & Development Journal is published two times a year by

Kamlesh Hiranandani
KAM Studio
5/56-57 Main Shanker Road,
New Delhi - 110060
Email: kam@kamstudio.net
www.kamartgallery.com

Printed and Published by Major General Manoj Kumar Bindal, Executive Director on behalf of National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Govt. of India, Plot No. 15, Block B, Pocket 3, Sector 29, Rohini, New Delhi 110042

Contents

Volume 10, Issue 01,
January to June 2021

Editor-in-Chief

Disaster impacts are increasing and becoming more complex due to different factors, including climate uncertainties. Traditional disaster risk reduction approach is under pressure. We need to be more proactive in risk reduction and need to find innovative approaches. We can see that the number of catastrophic disasters and their consequences have been increasing in spite of the advancement of technologies.

2004 Indian Ocean Tsunami had a lead-time more than two and half hours, but the early warning information could not reach the people and communities in most affected countries. Therefore, there is a need for educational knowledge, research and practice in DRR. Effective disaster management requires trained manpower to deal with complex situations effectively and speedily to reduce the impact of disaster on human life and property. It is necessary to continuously undertake measures to build capacity amongst those who are handling disaster prevention, mitigation, preparedness, response, reconstruction and also creating awareness amongst people. Therefore, capacity building needs to encompass all resources available within a community, society and organisation to reduce the level of risk or the effects of a disaster.

We are delighted to announce the publication of the Journal of Disaster Development's 10th Issue (Volume 1). We're also ecstatic that the journal has been drawing submissions from a wide range of advanced and developing DRR&R techniques. The range of contributions from various methodologies will aid the journal's worldwide objectives. The journal's current issue features research on all aspects of disaster risk reduction and resilience. The papers have been examined by experts in the field of catastrophe management who have several years of experience and knowledge. I am optimistic that this issue will assist readers in better understanding hazards, related risks, as well as in promoting disaster risk reduction and resilience amongst different stakeholders.

Major General Manoj Kumar Bindal, VSM

Editorial Note

There are presently no countries or communities that are unaffected by one or the other type of disaster. It is, however, feasible to mitigate the impact of these occurrences using disaster risk-reduction and resilience measures. Citizens preparedness is important for lessening the consequences of hazards that cannot be controlled, since they aim to increase the local communities' ability to respond in the case of a disaster.

An increase in the magnitude, frequency and geographic distribution of disasters has been recently demonstrated, particularly for those related to climate change. Records show that between 1994 and 2013, floods were the most frequent event (43% of all events registered), affecting approximately 2.5 billion people and caused the greatest material costs and losses. In the same period, earthquakes and tsunamis caused the highest number of fatalities, estimated at around 750,000, with tsunamis being twenty times more lethal than earthquakes. These statistics demonstrate the critical multi-hazard environment to which the global population is exposed. The combination of human and economic losses, together with reconstruction costs, makes disasters both a humanitarian and an economic problem.

Each article includes a detail study of how the offered approach might be used to reduce the impact of disasters. The NIDM journal "Disaster & Development" is published biannually with the major contributions from several scientists, researchers, academics, disaster managers, institutions etc. We are grateful to everyone who helped us realize our goal of publishing a journal issue focusing on enhancing Disaster Risk Reduction and Resilience.

Surya Parkash, Ph.D.

Global Climate Change and Its Impact at Regional Level, Policies and Practices for Disaster Resilient Society

Niranjan Sahoo[1]*, Biren Kumar Behera[2], Uday Chatterjee[3], Biswajit Pahanta Singh[4]

Abstract

With the rise in global population and numbers of anthropogenic activities, an abruptly spike in average global temperature has been witnessed on global scale but its vulnerability and cumulative impacts at regional level has put its habitants and livelihood at stake. It's obvious that climate change has a direct impact on emerged disasters. Extra weathering rise in temperature is paving the way for the melting of ice caps, drought, rise in temperature intensifying more powerful storms along with torrential downpour and flood, coastal inundation owing to rise in sea level subsequently. The prime objectives of the chapter are to draw a general illustration by comparing climate change and resulted disasters. It focuses on regional analysis to out the real consequences of climate change. Another objective of the chapter is to find out potential threats in future and practice policies for disaster resilient society. Secondary data from different government sources, UN climate change department, World Meteorological Department, NIDM, climate and disasters related issues from the newspaper article etc. were collected and analyzed by using simple statistical tools to find out resulted disaster and its impacts at regional level. The northern hemisphere is experiencing more heat owing to the dominance of landmass and it has witnessed many warm years after 1990, since climate statistics have been monitored and documentation began in 1861 and also expected increase in the global mean temperatures in coming years. At least 7,348 recorded disasters occurred around the world and the number has doubled in the last 20 years with 1.19 million deaths and an USD of 1.63 trillion economic losses. Ice is melting, in coastal bastion inundation of flood

[1] **Niranjan Sahoo,** Assistant Professor, Jayoti Vidyapeeth Women's University, Rajasthan, India
* Corresponding Author Email: niranjansahoo@jvwu.ac.in, niranjansahoo743@gmail.com
[2] **Biren Kumar Behera,** Department of Geography, Utkal University, Odisha, India
[3] **Uday Chatterjee,** Assistant Professor, Bhatter College, Dantan, Bengal, India
[4] **Biswajit Pahanta Singh,** Department of Geography, Ravenshaw University, Odisha, India

owing to sea level rise and drought in the interior parts which suffer from water scarcity etc. agriculture and food security deeply get threaten and keep habitants at stake in the era of climate change and hence some policy and practices at different level need to be addressed for disaster mitigation.

Keywords: *Climate Change, Adoptability, Disasters Management, Mitigation, Resilient.*

1. Introduction

The industrial revolution emerged as a new paradigm with the rise in global population and to necessarily meet the needs of human beings, in the era of urbanism and economic development. An abrupt spike in the average global temperature has been witnessed due to the rising numbers of anthropogenic activities, as well as industrialism. Thus, vulnerability and cumulative impacts at regional level have put the habitants and their livelihoods at stake. The rise in sea level has subsequently been a result of the extra weather activities that have helped in the rising temperature and thus, paving the way for melting of the ice caps, as well as intensifying more powerful storms along with torrential precipitation which further has resulted in flooding and coastal inundation. The tropical belts, torrid, temperate and frigid zones across the countries have been experiencing disasters related to the change in climate. The climate change has put up a great threat upon the various landscapes such as mountains, coastal belts, plains and desert, and the inhabitants, ecology and economy shall be pushed into vulnerability. The northern mountainous region, desert, coastal belts etc. comprise India's physiographic divisions. Inundating coastal regions, amid profound seasonal irregularity, the plains lives and livelihood of the inhabitants will be affected. Since industrialism exploded, the climate change has become profound, especially in the tropical belt.

This paper is a research-based on some case studies, personal observations on climate change phenomena and how propounds impacts falling on the rest of the seasons present very supportive evidence regarding the matters of climate change and disasters related to it. In India, empirical model was in use, in a practical way, which was necessary for estimating the value of climate change and resulting disasters by analyzing and monitoring spatial-temporal characteristics of elements of weather.

2. Climate Change and Issues Concomitant to Disasters

The average global temperature has witnessed a growth at a rate of 1.9 degree Celsius since 1990, thus making the 21st Century as the era of climate change. This era of climate change has been the witness to the rise in the mean temperature on the global scale, the melting of ice caps and rise in the sea level, thus exposing the coastal belt inhabitants to greater vulnerability (Sahoo and Satpathy, 2020). Amid the rise in temperature on global scale, it has also been paving ways for the melting of ice caps, droughts, intensifying frequent devastating storms along with torrential downpour as well as flash floods, as well as the coastal inundation owing to the rise in sea level subsequently. Especially in tropical belts, climate change disasters have been on the rise across all the countries. Changes are temperature and certain properties in elements of weather have been showcasing how the change in climate is in full swing, and its cumulative impacts are being reflected in the form of natural disasters. Some natural disasters in the recent times, such as the cyclones Idai and Kenneth, the Australian Wildfires, the East African drought, the South Asian flash floods, and the dry corridor in Central America are some of the major attributes in this regard, and have been the appropriate indicators of the climate change.

2.1. Climate Change and Health Disaster-The Coronavirus Issue

As coronavirus is recent origin, we still lack in adequate evidence that whether climate change has helped in the outbreak of COVID-19 or not, but numerous foregone researches have alters how we relate to other species on Earth and that matters to our health and put our health at risk.

Substantial rise in global temperature pushes as the planet heats up, animals big and small, on land and in the sea, are headed to the poles to get rid of the heat. That creates an opportunity for pathogens to get into new hosts. Deforestation, which takes place for the sake of agricultural purposes, is the single most dominant factor of habitat loss globally. Loss of habitat forces animals to migrate and other animal likely to be contacted with other animals or people and share germs large livestock farms can also serve as a source for spillover of infections from animals to people. With the population explosion and more food demand, the human attre bound to explore the more food but it creates an ecological imbalance researchers claim that the owing to meat based food being high on demand corona has emerged in China. We have many reasons to

take climate action to improve our health and reducing risks for infectious disease emergence is one of them.

2.2 Climate Change, Air Pollution and Coronavirus

Looking at the ongoing corona crisis and its symptoms which is getting worse owing to air pollution has been a focal aspect in corona research among researchers. Recent researches from Rachel Nethery, Xiauo Wu, Francesca Dominica and other colleagues at Harvard Chan have found that people who dwelling in places with poor air quality are more suspect to die in corona. People who are exposed to more air pollution and who smoke face worse respiratory infections than those who are breathing cleaner air, and who don't smoke (Wu, Xiao et al., 2020).

Climate change has acts as an effective favorable factor in spreading some infectious diseases, including Lyme disease, waterborne diseases such as Vibrio para-haemolyticus which causes vomiting and diarrhea, and mosquito-borne diseases such as malaria and dengue fever. To help limit the risk of infectious diseases, we should do all we can to vastly reduce greenhouse gas emissions and limit global warming to 1.5 degrees.

We have seen a trend of greater emergence of infectious diseases in recent decades. Most of these diseases have entered into people from animals, especially wild animals. This trend has many causes. We have massive concentrations of domesticated animals around the world, some of which can be home to pathogens, like the flu, that can make people sick. We also have massive concentrations of people in cities where diseases transmitted by sneezing may find fertile ground. And we have the ability to travel around the globe in less than a day and share germs widely.

In the past century we have our demands upon nature, such that today, we are losing species at a rapid pace unknown since the dinosaurs, along with half of life on earth, went extinct 65 million years ago. This rapid dismantling of life on earth owes primarily to habitat loss, which occurs mostly from growing crops and raising livestock for people. Owing to lack of land resources and fewer food sources to feed on, animals find food and shelter where people are dwelling, which subsequently leads to disease spread.

Another major cause of species loss is climate change, which can also change where animals and plants live and affect where diseases may occur. Historically, we have grown as a species in partnership with the plants and animals we live with. So, when we change the rules of the game by drastically changing the climate and life on earth,

we have to expect that it will affect our health. To combat climate change; we need to drastically decrease greenhouse gas emissions. Generating electricity from low-carbon energy sources like wind and solar decreases harmful air pollutants such as nitrogen oxides, sulfur dioxide, and carbon dioxide that lead to more heart attacks and stroke as well as obesity, diabetes, and premature deaths that put further strains on our health care systems.

Climate change has been the single most dominant factor which has been reflected as a multi-faceted cause of disasters. These environmental disasters are the extreme events induced by nature that have exceeded the tolerable magnitude and have made human lives very difficult, resulting in colossal losses in property, human and animal lives, not to mention, the destruction of environment and settlements. Severity and frequency of disasters have been on the rise at a rapid rate under the influence of the global climate change (Sahoo and Satpathy, 2020). Climate change owing to changes in temperature spike has affected different landscapes such as mountains, coastal areas, plains and deserts. The impact of the climate change at the aforesaid landscapes has been affecting the ecology, people and their economy.

3. Climate Change and Impact at Regional Level

The vulnerability to natural disasters caused by climatic changes is determined by the many factors, mainly by the region's geographical location, topography, nature of landscape, etc. and these factors later may have a big impact on economic and social infrastructure and affect the lives of the people who have been dwelling in the region. The authors have broadly discussed the impact of climate change and its impact at four major areas such as mountains, coastal, desert and plains as the climate primarily focuses on the climate change and its effects. Figure 1 shows the impact of climate change at different regional level.

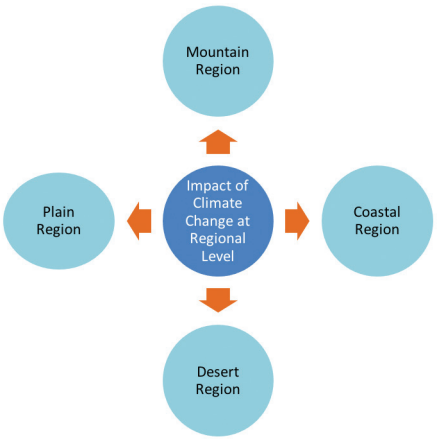


Figure 1: Impact of Climate Change at Regional Level

This section further reiterates the spike in the average global temperature and how it leads to melting of ice caps, which further leads to rise in sea level, and surge in storms because of the increased sea level. The melting of glacial bodies in mountainous landscapes heavily affects the surrounding environment, putting its habitants at a greater risk. In coastal regions, the natural disasters are a combined effect of two phenomena, rise in sea level and an obvious storm surge which has been intensified due to the rise in sea level as well as the increase in average temperature. Both the phenomena leave the footprints of the disasters across the coastal bastion, not to mention the coastal inundation which has been affecting the lives and livelihood of the coastal dwellers because of the spike in temperature. The authors have focused on the four major aforesaid landscapes, in a bid to find out the impact of the climate change on them.

3.1 Mountain Ranges

Many issues have been raised because of the average spike in global temperature. A research revealed that up to a quarter of the global mountain glacier mass could disappear by 2050 and up to half could be lost by the year 2100 (Kuhn, 1993a; Oerlemans, 1994; and IPCC, 1966b).

Many studies have been carried out during the period 1999-2001, in an attempt to find the link between the climate change and melting of glaciers. In the valley of

Himalayas, the glaciers have retreated approximately by one kilometre since the Little Ice Age (Mool P.K. et al., 2001a). The Chinese Glacier Inventory, was a study carried out by the Chinese Academy of Sciences had reported that during the last 24 years, there had been a 5.5% shrinkage in volume of China's 46,928 glaciers, equivalent to the loss of more than 3000sq. km of ice. The study has predicted that if the climate continues to change at this extent, then two-thirds of China's glaciers would have disappeared by 2050, and almost all of them would be gone by 2100.

Older studies on selected glaciers of the Indian Himalayas had indicated that most of the glaciers were retreating discontinuously since the post-glacial time. Of these, the Siachen and Pindari Glaciers were retreating at a rate of 31.5m and 23.5m respectively (Vohra, 1981.) Gangotri glacier has been retreating at an average of 18m per year (Thakur et al., 1991). The Milam Glacier in the Kumaon Himalaya had been monitored to have been retreating at an estimated rate of 9.1m per year between 1901 and 1997 (Shukla and Siddiqui, 1999). The snout of DokrianiBamak Glacier in the Garhwal Himalaya had been monitored to have been retreated 586m between the period 1962 to 1997 (Dobhal et al., 1999). The average retreat had been estimated at a rate of 16.5m per year.

There has been much supportive evidence for assuming that the glaciers melting at an unprecedented rate as an indication of climate change. Valley glacial retreats and shearing of glaciers cause avalanches which pose a serious threat to the inhabited regions in the mountainous landscapes. In mountain valley regions, glacial retreats have been causing vivid impacts on both ecology and tourism-based economy of the region since the natural beauty of the glacial region has been degraded. For example, the Northern Mountain ranges of India are glacial. If the glaciers melt owing to the cumulative impact of climate change, then it will lose its relevance on being a hub of tourism and thus affect the local economy badly. Thus, from ecological perspective, the flora and fauna indigenous in these regions would be wiped out amid prevailing inhospitable climate and hence, apart from environmental disasters, impact of climate change will result in the downfall of the local economy.

3.2 Coastal Regions

The coastal regions have been usually densely populated and also served as hubs of tourism, economic activities, etc. and hence rise in the sea level will not only depopulate the area by making the climate refugee but also affect the local economy badly. Rise in

the global sea level has been in the limelight for the researchers for quite some time now. Global mean sea level has risen about 8-9 inches since 1880, with about a third of that coming in just the last two and half decades. The rise in sea level has been mostly owing to a combination of melt water from glaciers and the ice sheets, as well as the thermal expansion of the sea water as it gets warmer. In 2019, the global sea mean level had been recorded as 3-4 inches above the 1993 average, which was the highest annual average in the satellite record (1993-present). The sea level has been recorded to rise 0.24 inches in 2019 as compared to it was in 2018. Amidst the rise in temperature and warm up in the sea surface, the intensification of more powerful storms has been putting the habitants of the coastal regions at risk, as the coastal regions has been influenced by maritime climate and vulnerable to three types of disasters namely cyclone, tsunami and storm surge. Global temperature and global mean sea level have been highly parallel to each other and have continued to rise till date. This has been instrumental in the range of impacts including increased risk of floods and submergence, salinization over the standing crops, the surface and the groundwater as the potential human and ecosystem impacts because of these disasters have been significant in the 21st century, although they have remained mostly uncertain. The actual impacts depend on a range of factors which are human-controlled, such as coastal land use and management approaches. The rise in sea level will only directly impact the coastal zone, and such changes raise significant concern due to the high concentration of natural and socio-economic values located there. Coastal belts have been a hub of tourism, trade and other lucrative economic activities. Thus, there is competition in between humans being in a bid to explore coastal region in an era of climate change as the lives and livelihoods get badly affected after being hit by such unpredictable, devastating and frequent disasters in the coastal bastion. Such sea based natural hazards have turned into catastrophic disasters as a consequence of these disasters goes on to hamper both the economy and ecology of the region to a great extent. This has been expected to increase by 50% by 2030, and the people may come face to face with the threat of extinction. To add this, each year, 10 million people experience coastal floods due to storm surges and landfall of cyclones, and 50 million will be at risk by 2080 (Nicholls, 2004). "Urbanization is an important trend and large coastal cities having more than 10 million people are projected to be affected with many smaller cities and towns clustered close to the coastline shall be under threat (Nicholls, 1995a; Small and Nicholls, 2003). The coastal zone is a major focus of human

habitation and economic activity, as well as being important ecologically (Holligan and deBoois, 1993; Turner et al., 1996; Sachs et al., 2001)."

India has a long coastline of 7,517 km. Nine states and four Union Territories come under the coastal region of India. The east coast lies between the Eastern Ghats ecosystem and the Bay of Bengal. The west coast strip extends from the Gulf of Cambay in the north Kanyakumari Five hundred and sixty million people live in this coastal region. One hundred and seventy-one million people in these coastal regions have been directly affected by the floods and cyclones followed by torrential rain. In addition, approximately 4million comprising of 8,64,550 fishermen households have been affected by these disasters. Further, climate change related to sea level rises has been instrumental in increasing the vulnerability of the coastal ecosystem by posing a threat to many coastal cities, urban centres and coastal populations in developing countries."Satabhaya village located on the coastal district of Kendrapara in Odisha is a victim of climate change and has been prone to natural calamities like the deposition of sand dunes causing great havoc to inhabitants since climate change. Coastal inundation due to storm surge and tidal inundation into the coastal plains makes agriculture, especially the rice belt of eastern Odisha, infertile. In Odisha, coastal plains, especially eastern coastal district of Odisha, areas are inundated with saltwater for months, thereby making the landmass infertile for generations" (Sahoo and Satpathy, 2020).

3.3 Plain Regions

The plain landscapes being fertile in nature and best suited for the practice of agriculture and have provided a hospitable climate for human habitations. In India, over 70% of rural households depend upon agriculture as their principal means of livelihood. Agriculture along with fisheries and forestry, have accounted for one third of the nation's GDP and is the single largest contributor. As per the Census of 2011, 263 million people are engaged in agriculture sector and over half of them are agricultural labourers. In the era of climate change, irregularities in seasonal cycle in general and erratic nature of monsoon in particular, have been the major problems for agriculture, which is the primary sector in India. The production has been on a setback as the crops are unable to cope with the changing nature of climate and hence low production has become a regular occurrence. If a disaster occurs and impacts agriculture, the livelihoods of all these people are affected, pushing them into the trap of poverty. In case of Indian

context, plain landscape is a physiographic division out of rest, on which agriculture based human settlement is predominantly found and colossal loss of people and animal and economy has been recorded because of the frequency in natural disasters owing to climate change.

4. Climate Change and Agriculture

The practice of agriculture takes place by taking into account of relief feature, climate of certain geographic area and hence, Climate change and agriculture are interrelated processes, both of which take place on a global scale. Adverse effects of climate change affect agriculture practice climate both directly and indirectly. Which can take place through changes in precipitation pattern; temperature range (Heat wave) changes in atmospheric Carbondioxide and ground-level ozone accumulation and anthropogenic activities help in propound effect of climate change. In 2010, agriculture, forestry and land-use change were estimated to contribute 20-25% of global annual emissions. According to an estimation done by the European Union's Scientific Advice Mechanism In 2020, that the food system as a whole contributed 37% of total greenhouse gas emissions, and that this figure was on course to increase by 30-40% by 2050 due to population explosion and dietary change among populace.

The agricultural sector is a driving force in the gas emissions and land use effects thought to cause climate change. In addition to being a significant user of land and consumer of fossil fuel, agriculture contributes directly to greenhouse gas emissions. through practices such as rice production and the raising of livestock. According to the Intergovernmental Panel on Climate Change, the three main causes of the increase in greenhouse gases observed over the past 250 years have been fossil fuels, land use, and agriculture. The agricultural food system is responsible for a significant amount of greenhouse gas emissions.

4.1 Desert Region

Deserts have been sparsely inhabited than those of the other landscapes, owing to inhospitable environment, scanty rainfall and sand topography which restrict agricultural practices. Ongoing climate crisis in the deserts have made the inhospitable climate further harsh on the desert dwellers. Global warming has had much effect on

the world's already hot deserts, but even small changes in temperature or precipitation drastically impact plants and animals living in deserts. The incidence of droughts has been increasing because of the global warming and results in the drying up of the water holes. Desserts are mainly found in the western part of the continents and have direct impact of trade wind on the climate of deserts. So, in the era of climate change and changes in the wind pattern have a direct impact on the deserts.

Population growth and greater demand for land have been posing serious threats to combat this problem. It has been assumed that temperature rise has been a contributor in the increasing number of wildfires, which alter desert landscapes by eliminating slow-growing trees and shrubs and replacing them with fast growing grasses. Irrigation used in the agriculture, may, in the long term, lead to increase in the salt levels in the soil thus, becoming infertile. Grazing animals can destroy many desert plants and animals. Potassium cyanide used in gold mining may poison wildlife. Off-road vehicles, when used irresponsibly, can cause irreparable damages to the desert habitats. Oil and gas production may disrupt sensitive habitats. Similarly, deserts have been used for nuclear testing grounds and have been affected because of the nuclear waste dumped afterwards.

5. Policies and Practices for Disaster Resilient Society

A set of policy actions, researches, strategies, plans, legal norms and operating programmers should be reinforced in view of reducing the level of risk and vulnerability of disasters. Amid the rise in population and to meet the bundle of human wants, international policy making bodies such as UN, ILO (International Labor Organization), and International Food Organization, climate preventive policy and region-specific approaches in collaboration with grassroots level activists for disaster resilient society are in urgent need. The United Nations Framework Convention on Climate Change (UNFCCC) approaches climate risk reduction from two perspectives; first is about mitigation or reduction of greenhouse gas emissions to stabilize concentration levels at a safe level by which global temperature rise may stabilize and the second perspective aims at adaptation, or adjustment, to climate driven change. According to the Intergovernmental Panel on Climate Change (IPCC), Global policies are to keep global warming below 2°C while emissions of carbondioxide (CO_2) and other greenhouse gases

(GHGs) must be halved by 2050 (compared with 1990 levels).The first and foremost objective as remedies to climate change is to stabilize atmospheric greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system in the long term. Initiative to combat climate change is very much essential and subsequently spike in temperature and result issues such as ice or valley glacial melt, coastal inundation, desertification in plain and desert may have a minimal impact after undertaking proper measures. Figure 2 shows the Policies for Disaster Resilient Society.

The first policy should be on GHGs to give a breakthrough to temperature rise. Some ages old policies and practices should be revisited, reformed and implemented pertaining to finance, environment, education and society. The Concern of Human Rights is also not properly addressed. It is necessary to develop coastal environment, legal institutes and socio-economic practices to formulate draft management plans, consult local people, implement pilot projects and feasibility studies as well as train personnel for the projects. Most of the training development and awareness programmers are lacking in practical aspects of financial capacity and trained human resources.

6. Financial Aspect

Financial aspect is a focal point in the matter of disaster management. The financial aspect includes post disaster mitigation, resource mobilization, effective relief distribution, restoration of loss in agriculture through crops insurance etc. Financial aspect in policy making that has command over other aspects like socio-economic vulnerabilities proliferation caused in a post-disaster situation are not similar across all social classes. For example, the poor hold a lower berth financially in society and at the time of disaster rehabilitation and mitigation, and the authorities should prioritize them. The proper policy should be put in place and specific vulnerabilities of different areas and people should be addressed in financial aspect so that resource mobilization begins at the grassroots level. “The specific agro-ecology of excessive water during the rainy season and ingress of salinity from the sea has generated a great deal of genetic diversity in rice for traits such as submergence tolerance, salinity tolerance and deep-water floating types (Siddiq et al., 2006).”An integrated approach for management of agriculture in coastal areas may be developed and adopted using the Integrated Coastal

Agriculture Management Guidelines (FAO 1998). The PMFBY scheme is a multi-peril crop insurance scheme introduced in January, 2016. It follows an 'area basis approach' with seasonal activities under the consideration of a broad set of risks spanning various stages of crop development and post-harvest losses due to natural calamities. States and union territories have been entrusted by the State-Level Coordination Committee on Insurance to notify the insurance unit such as village/village panchayat or any other equivalent unit for major crops. Research suggests climate change helping early blooming fields to early ripping the crops and subsequently loss in total grains at the production time and hence short span seasonal harvestable crops having short span life period should be adopted in the climate affected regions across the country. The maximum premium payable by the farmers is 2% for all kharif food and oilseed crops, 1.5% for rabi crops, and 5% for annual commercial and horticultural crops (Tripathy, 2020). Development of flood-resilient agriculture is one of the possible solutions. Research on short-duration crops for disaster-prone zones of India has become essential. Farmers in most parts of India adopt mono-cropping as they are at the mercy of monsoon. Developing the capabilities of farmers by providing inputs to opt for multiple-cropping and cultivating short-duration crops is a practical solution for risk reduction. To feed up of the bulk of population, it is very much essential to practice new climate resilient practice in agriculture.

7. Social Aspect

Some prolonged impacts of disasters may lead to deep concern on social issues such as poverty and poverty may force the affected community to go in search of work for their survival and in the end, they will be forced to leave their proveniences for interstate migration. Such consequences are found in disaster pronged states such as Odisha, Bihar and Uttar Pradesh.

Developing nations like India still lack behind in education, social awareness and it may enhance disaster-related discrimination. If a person or a certain community on account of their cast, religion, creed, gender and socio-political ideology face any discrimination at the time of mitigation, preparedness, rehabilitation and recovery in disaster management, then it is called as Disaster Discrimination and hence social paradigm acts as hindrance in disaster management. There have been some notable examples found at the time of cyclone in Puri district of Odisha, and in order to avoid

such social paradigms, respective authorities should take the matter into consideration. In the recent flood disaster that happened in Kerala, the Keralites came in support of each other by practicing religious orthodoxy. Most communities in the society are also not readily involved in mitigating animal suffering during disasters for lack of proper training to deal with emergencies (Heath and Linnabary, 2015). Lack of proper training among different communities in society such as agricultural community, and fishermen community, may lead the people to proliferate their social and financial issues after disasters. An effective preparedness is partnership between government strategies and individual and societal behaviors and it should be done in collaboration with each other (Berman and Redlener, 2006).

8. Environmental Aspect

In the environmental aspects of disaster management, issues pertaining to environmental degradation, settlement in the disaster-prone should be looked after and policy and practices in relation to environmental management and assessment in bid to restore its lost glory should be reinforced. The coastal forests of eastern India are being destroyed year after year by the catastrophic cyclones formed in the Bay of Bengal. Coastal forestry not only hinders the speed of the wind but acts as an ecological heritage in the coastal biodiversity.

The National Centre for Coastal Research (NCCR), in its report submitted to the Ministry of Earth Sciences (July, 2018) has revealed that between 1990 and 2016, approximately 34 per cent of the Indian coastline (2246.49 km) has been eroded and this has been primarily due to anthropogenic factors which have augmented the natural process of coastal change. As per the report submitted by NCCR, it has estimated that the decline of 59.18sq.km of mangroves took place between 1972 and 1975 and 1980 and 1982.India has lost about 40% of its mangroves in the last century. The post-Sendai Framework has established the inter connection between pre-disaster risk reduction through building community resilience and post-disaster rehabilitation in a larger framework of disaster governance (Tripathy, 2020). Thus, widespread forestation across cyclone prone coastal bastions should be undertaken with community participation. In the era of climate change and amid degradation of the natural environment, bunches of stern environmental policy are yet to be carried out at the grassroots level. Amid global climate change and change in landscape must have a vivid impact on emerging disasters

in certain locations, looking at the degree of susceptibility at present and to vulnerability in future, sorts of research, action plans for the disaster management and mitigation should be in priority on behalf of the government. Laws pertaining to settlement in the coast should be addressed and slum areas found in the coastal areas should be looked after as they have close proximity to the seas and they are more susceptible to the tsunami, cyclone, and storm surge. Since, lower income and lower educated levels live in coastal cities, they are not willing to give up their livelihood activities like fisheries and they have no idea regarding sustainability of their occupation which is a major issue (Silva et al., 2011).

Depopulation in climate change time should be properly put under observation. Under the supervision of UN's climate change monitoring body special attention should be paid at climate refugees as the people suffer from the loss of their settlements to the marine transgression and they are forced to inhabit at other locations.

9. Educational Aspect

Education is another important aspect in disaster management, as it makes people aware. It will be very much useful in case of eradication of social paradigms and practice of religious orthodoxy in the disaster management context. Many countries are taking significant steps in the field of education for Disaster Risk Reduction (Petal, 2008). Region-based and disaster specific new research institutions should be established in a bid to promote studies about identification of risk zone.

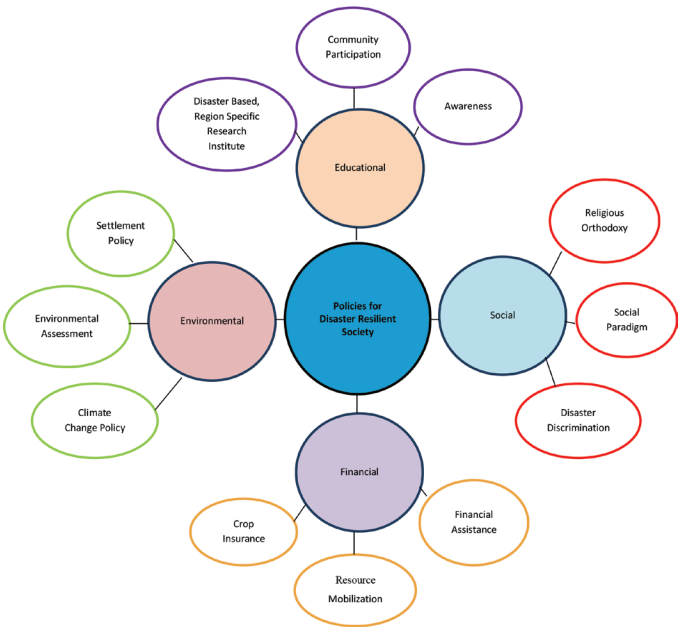


Figure 2: Policies for Disaster Resilient Society

Most of the policies are outdated and practices are age old in nature. In order to ensure more effective implementation of ultimate policy goals, the policies need to be reviewed and updated. An efficient system for monitoring and impact assessment of policy implementation needs to be developed. Ensuring stakeholder participation in policy formulation is of vital importance. Good management practices need to be followed at all times in order to ensure adequate policy implementation. The policies must include specifically detailed contingency plans for coping with disasters along with guidelines on how such a plan is to be effectively made.

10. Conclusion

The authors of the chapter, by using some qualitative and quantitative analysis, have found that climate change indicators are more profound. Authors' observations on seasonal cycles, especially in the coastal bastion of eastern India are quite astonishing. If there is a cyclone in the Bay of Bengal, just before the onset of monsoon, then there

will be irregularities in the normal seasonal cycle and will affect the rest of the climatic phenomena. For example, the Asian monsoon usually begins its onset on the Malabar Coast by on June 5 but, if a cyclone takes place, then, an erratic nature of monsoon will be reinforced. Subsequently, other seasons would be faced with irregularities, like, a late monsoon, early retreat of monsoon, and late winter etc. is. It's quite obvious that climate change has direct impact on emergence of natural disasters.

Undoubtedly, the northern hemisphere is experiencing more heat owing to the dominance of landmass and it has witnessed many warm years after 1990, since climate statistics have been monitored and documentation began in 1861 and also expected increase in the global mean temperatures in coming years. Climate change threatens different landscapes such as mountainous, coastal, and plain and phenomena like melting of ice, in coastal bastion, the inundation of flood owing to sea level rise and drought in the interior parts which suffer from water scarcity etc. Adaptation to climate change is a challenge for all countries. From a global perspective, the adaptation challenge is greater for developing countries. They are more vulnerable to climate change because their economies are more dependent on climate-sensitive sectors, such as agriculture, fishing, and food security may be deeply threatened, keeping habitants at stake in the era of climate change and hence some policies and practices at different levels need to be addressed for disaster mitigation. Coastal zone regulations are outdated and need to be revised and each responsible party, such as local-level and provincial-level officers and coastal communities should be involved indecision making and formulating strategies and implicating at grassroots level (Samaranayake, 1995). Therefore, this research has analyzed all the individual factors of elements of weather, and it can be helpful in planning a better strategy for resilience during extreme events of climate change for disaster resilient society. Climate change also plays a pivotal role in the outbreak of diseases like corona. From the aforesaid analysis corona being air transformable virus so, In places like New Delhi where air pollution is a common issue and the quality of air is in degraded state we have to pay particular attention to individuals who may be more vulnerable than others to polluted air, such as the homeless and people those residing in slum area may need more attention. Reducing air pollution caused by burning fossil fuels like coal, oil and natural gas also helps keep our lungs healthy, which can protect us from respiratory infections like corona virus.

We also need to take climate action to prevent the next pandemic. For example,

preventing deforestation a root cause of climate change can help stem biodiversity loss as well as slow animal migrations that can increase risk of infectious disease spread. The recent Ebola epidemic in West Africa probably occurred in part because bats, which carried the disease, had been forced to move into new habitats because the forests they used to live in had been cut down to grow palm oil trees. Communicate clearly to the public that the Covid-19 pandemic does not change the imperative to evacuate, given the substantial risks of remaining in place during extreme climate-driven hazards. Use existing community pandemic-communication channels to disseminate critical information. We can make many smart investments to avert another outbreak.

Increase the number of available shelter sites, with lower occupancy per site, more separated spaces within sites, and more space per shelter resident with standard shelter-registration information for all persons entering, to facilitate contact tracing in case Covid-19 is diagnosed in persons who used the shelter. We need to do everything we can right now to slow the spread of this disease, and that means we need to follow the advice that public health experts are telling us regarding on social distancing and good hand hygiene. Provide electricity subsidies and extend moratoriums to prevent electricity and water shutoffs for people with pandemic-related unemployment and economic hardships to allow them to remain in their homes. We can make our workforce healthier and more climate-resilient through scaling-up our investments in low-carbon technologies in a bid to boost our economy. Ensure effective alternatives to minimize heat exposure if designated cooling centers or popular indoor, air conditioned venues are closed.

A sustainable Endeavour towards disaster resilient society, experienced and well-trained administration are necessary to stay prepared against any impending disaster which may strike at any time and destroy the lives of people, environment and economy. Looking at the above aforesaid illustration, undoubtedly new policy and practices are very much needed for disaster resilient society. Animal meat and more sustainable animal husbandry could decrease emerging infectious disease risk and lower greenhouse gas emissions. The developing nations, like India need to be more concerned on the disaster mitigation to save both its people and economy, but India being second populous nation in globe it lacks behind as per reckonings.

References

1. Baker RE, Wenchang Y, Vecchi GA, Metcalf CJ, Grenfell BT. Susceptible supply limits the role of climate in the early SARS-CoV-2 pandemic. Science2020 May 18 (Epub ahead of print).
2. Berman D. A. Redlener I. (2006) National Preparedness Planning: The Historical Context and the Current State of the US Public's Readiness, Journal of International Affairs, Spring/Summer, Vol 59(2) 87-105.
3. Dobhal, D.P, Gergan, J.T., Thayyen, R.J. (1999) 'Recession of Dokriani Glacier, Garhwal Himalaya' - An overview. Symp. On snow, ice and glaciers. In A Himalayan Perspective. Geol. Survey India, Abst. Vol. 30-33p. FAO Guidelines. (1998). Part B: Integration of Agriculture into Coastal Area Management in: Integrated Coastal Area Management and Agriculture, Forestry and Fisheries. Rome: Food and Agriculture Organization of theUnited Nations.
4. Friel, Sharon; Dangour, Alan D.; Garnett, Tara; et al. (2009). "Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture". The Lancet 374 (9706): 2016–2025. Doi: 10.1016/S0140-6736(09)61753-0. PMID 19942280. S2CID 6318195 Heath, S. E., & Linnabary, R. D. (2015). Challenges of Managing Animals in Disasters in the US. Animals, 5(2), 173–192.
5. Holligan, P. and de Boois, H. (eds.) 1993. Land-Ocean Interactions in the Coastal Zone (LOICZ). Science Plan. International Geosphere Biosphere Program, International Council of Scientific Unions, Stockholm, 50pp. IPCC, (1996b) 'Climate Change 1995 'Impacts, Adaptation and Mitigation of Climate Change: Scientific and Technical Analyses'. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental panel on Climate Change.
6. Kuhn, M., (1993a) 'Possible future contribution to sea level chane from small glaciers'. In: Climate and Sea Level Change: Observations, Projections and Implications (Eds.R.A. Warrick et al.) Cambridge University press, Cambridge, UK. 134-143.
7. Li Y, Tokura H, Guo YP, et al. Effects of wearing N95 and surgical facemasks on heart rate, thermal stress and subjective sensations. Int Arch Occup Environ Health 2005; 78:501-509.
8. Matny, L. (2000) 'Melting of Erth's Ice Cover Reaches New High'. In Worldwatch News Brief, 06 March 2000.
9. Milius S (13 December 2017). "Worries grow that climate change will quietly steal nutrients from major food crops". Science News. Retrieved 21 January 2018.
10. Mool, P.K., Bajracharya, S.R., and Joshi, S. P., (2001a) Inventory of Glaciers, Glacial Lakes and Glacial Lake Outburst Floods, Monitoring and Early Warning Systems in the Hindu Kush Himalayan Region: Nepal, ICIMOD & UNEP RRC-AP.
11. Nicholls, R.J., 1995a. Coastal Megacities and Climate Change. Geojournal, 37(3), 369-379
12. Nicholls, Robert J., (2004). Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socio-economic scenarios, Global Environmental Change 14 (2004) 69–86
13. Oerlemans, J., (1994) Quantifying global warming from the retreat of glaciers. Science 264, pp 243 – 245.
14. Petal, M. Ch. 6.1 Disaster Risk Reduction Education. In R. Shaw & R. Krishnamurty(Eds.), Disaster Management: Global Challenges and Local Solutions. Universities Press, India. 2008 (18) (PDF) Education in Disaster Risk Reduction. Available from https://www.researchgate.net/publication/312489763_Education_in_disaster_risk_reduction.
15. Salas RN, Solomon CG. The climate crisis — health and care delivery. N Engl J Med 2019;381(8):e13-e13
16. Sahoo N., Satpathy M. (2020) Disasters and Climate Change Adaptability at Odisha Coast. In: Singh A., Fernando R.L.S., Haran N.P. (eds) Development in Coastal Zones and Disaster Management. Disaster Research and Management Series on the Global South. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-15-4294-7_12
17. Samaranayake, R. (1995). Resources Volume for Tertiary Level Education and Training in Coastal Zone Management. Colombo: Coast Conservation Department.
18. Sarkodie, Samuel A.; Ntiamoah, Evans B.; Li, Dongmei (2019). "Panel heterogeneous distribution analysis of trade and modernized agriculture on CO2 emissions: The role of renewable and fossil fuel energy consumption". Natural Resources Forum. 43 (3): 135–153. doi:10.1111/1477-8947.12183. ISSN 1477-8947. Section 4.2: Agriculture's current contribution to greenhouse gas emissions, in: HLPE 2012, pp. 67–69
19. Small, C. and Nicholls, R.J., 2003 A Global Analysis of Human Settlement in Coastal Zones, Journal of Coastal Research, in press.
20. Silva, S. d., Sellamuttu, S. S., Kodituwakku, D. C., & Atapattu, S. (2011). Governance Performance in Integrated Coastal Management. Colombo: IUCN (International Union for Conservation of Nature) Sri Lanka Country Office.
21. Shukla, S.P, Siddiqui, M.A., (1999) 'Recession of the snout front of Milam Glacier, Goriganga valley, District Pithoragah, Uttar Pradesh. In Symp. On snow, ice and glaciers'. A Himalayan Perspective. Geol. Surv. India, (In: Abst. Vol.), 27-29p.

22. Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, de Haan C (2006). Livestock's long shadow: environmental issues and options(PDF). Food and Agriculture Organization of the UN. ISBN 978-92-5-105571-7. Archived from the original(PDF) on 25 June 2008.
23. Thakur, V.C., Virdi, N.S., Gergan, J.T., Mazari, R.K., Chaujar, R.K., Bartarya, S.K., Philip, G., (1991) Report on Gaumukh. The snout of the Gangotri glacier (Unpublished Report submitted to DST, New Delhi). "The Food Gap: The Impacts of Climate Change on Food Production: a 2020 Perspective"(PDF). 2011. Archived from the original(PDF) on 16 April 2012.
24. Tripathy S. (2020) Farmers, Climate and Disaster Management in a Coastal Region. In: Singh A., Fernando R.L.S., Haran N.P. (eds) Development in Coastal Zones and Disaster Management. Disaster Research and Management Series on the Global South. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-15-4294-7_7
25. Vohra, C.P., (1981) Note on recent glaciological expedition in Himachal Pradesh. Geol. Survey of India. Sp. Vol., 6, 26-29p.
26. Wu X, Nethery RC, Sabath BM, Braun D, Dominici F. Exposure to air pollution and COVID-19 mortality in the United States: a nationwide cross-sectional study. April 5, 2020 (https://www.medrxiv.org/content/10.1101/2020.04.05.20054502v2. opens in new tab). Preprint.
27. Zscheischler J, Westra S, van den Hurk BJJM, et al. Future climate risk from compound events. Nat Clim Chang 2018;8:469-477.

Comprehensive Landslide Vulnerability Zones in Ranni Taluk, Pathanamthitta District, Kerala, Using Remote Sensing & GIS Techniques

Neenu S Pillai[1], Athira Mohan P M[1], Aswathy Mohan P M[1] and Akshara Sundaresan[2]*

Abstract

Landslide is known to be one of the most dangerous natural hazards. The present study aims to comprehend landslide vulnerability zones in Ranni Taluk, a small forest division, north of Pathanamthitta district, Kerala using Geo-Spatial techniques. The factors determining the landslide vulnerability such as rainfall, vegetation, slope & aspect, geology, geomorphology, soil, drainage density, lineament, land use/ land-cover, road density and elevation of the given area varies according to its geographic setting. These factors are interdependent and have major and minor effects upon other factors. Remote Sensing (RS) and Geographic Information System (GIS) techniques are adopted to prepare the base thematic layers of the above factors and the weightage was assigned to each factor based on its potential in triggering landslide. Based on assigned weights, a weighted overlay analysis was performed to demarcate the vulnerable areas. The study reveals that around 50% of the total study area possess moderate to very high landslide vulnerability and only 19% of the study region possess very low vulnerability. Thus, a vulnerability assessment stresses the importance of strengthening the participation of local body government towards developing better disaster management plans for the study area.

Keywords: *Landslide vulnerability, Influencing Factor, Weighted Overlay, GIS and Remote Sensing.*

[1] **Neenu S Pillai, Athira Mohan P M, Aswathy Mohan P M,** M.Sc.Geography, SSUS Kalady, Ernakulam, Kerala, Indiad
[2] **Akshara Sundaresan,** M.Sc. Applied Geography and Geoinformatics, Central University of Karnataka, Kadaganchi, India
* Corresponding Author Email: aksharasumi@gmail.com

1. Introduction

The term landslide refers to the downward sliding movement of huge quantities of land masses and earth particles. The sliding movement of the rock masses occurs from a higher level to a lower level, mostly in steep sloping areas. Landslide, a type of mass wasting, are the most destructive event which is caused due to any down slope movement of soil and rocks under the direct influence of gravity. According to the United States Geological Survey, there are 5 modes of slope movements such as falls, topples, slides, spreads and flows. Based on the geological material and type of ground movements, it encompasses another classification as rock falls, mudflow, debris flow, earth subsidence and slope failures. Landslides can occur anywhere in the world. They are more widespread than any other extreme events. Landslides can be the result of both natural phenomenon and human activities. It results in an incalculable loss of life and property. Mud flow and Debris flow are the most common type of landslides identified in Kerala. According to World Health Organization, from the year 1998 to 2017, about 4.8 million people were affected by landslide hazards, including an estimated 18,000 deaths.

In Kerala, landslides are more common in the localized areas of the Western Ghats, where the region depicts steep slopes and over-saturated soil character due to the huge amount of rainfall received. The total area of the Kerala state is 38,863 square kilometers from which 40% of the land lies in the high lands regions forming the western slopes of the Western Ghats. Almost all districts except Alappuzha falls within this region making them landslide vulnerable areas. The topography of the region shows rugged hills with steep slopes with the rest of the soil and earth materials. The slope of the Western Ghats are generally steep to very steep with highly intended plateau edges, having more than 25 degree slope (Kerala State Disaster Management Authority). The most recent landslide events of Kerala includes Puthumala landslide in Wayanad and Kavalappara in Malappuram district during 2019. On the 6th of August 2020, another most destructive landslide occurred in Pettimudi, which is a hamlet in Rajamala ward under Munnar village in Idukki district of Kerala.

Vulnerability analysis is an important part of hazard analysis, which is confronted with complexity, uncertainty factors and other characteristics (Ting Liao et al., 2011). In the present study, a detailed description and analysis of landslide vulnerability assessment of Ranni taluk in Pathanamthitta district was performed by analyzing various geophysical parameters.

2. Study Area

Ranni is a small village in the Pathanamthitta district of Kerala, India. For this study, we have taken the entire taluk, which covers over an area of 1004.61 square kilometers from which 708 square kilometers comes under forest cover which is exactly the 70% of the total area (Census of India, 2011). It provides a complete green environment to Ranni. The word Ranni is derived from a similar Malayalam word called "Rani" which means the "Queen", so the region is locally known as "Malanadinte Rani" which means the "Queen of the eastern hills". The exact geographic location of the region is at 9° 22' 0"N latitude and 76° 46' 0"E longitude and the average elevation of the area is about 131m above the mean sea level and also even higher towards the east.

The river Pamba known for its sacredness related with Sabarimala temple flows through this region and the famous Hindu temple Sabarimala is situated in this taluk. It is one of the largest taluks in Kerala having great forests, hills and rivers. The total population of the region is identified to be 1,64,463 people from which 79,010 are the male population and 85,453 female population (District Census Handbook Pathanamthitta, 2011). The region exhibits a wet climate commonly. The area receives SW monsoon during June to August and NE monsoon during October to November exactly like the rest of the state. During the summer season, from March to May the area receives thundershowers occasionally. Other than this climatic condition, the region shows a cooler climate towards east, because of the higher elevation.

Pathanamthitta district is identified to be the 3rd most landslide prone district in Kerala after Idukki and Palakkad. About 6.41% of the district is vulnerable to the occurrence of landslides (Kerala State Management Plan Profile by KSDMA). According to Kerala State Disaster Management Authority, Ranni is one of the most landslide prone taluk in the state (Figure 1).

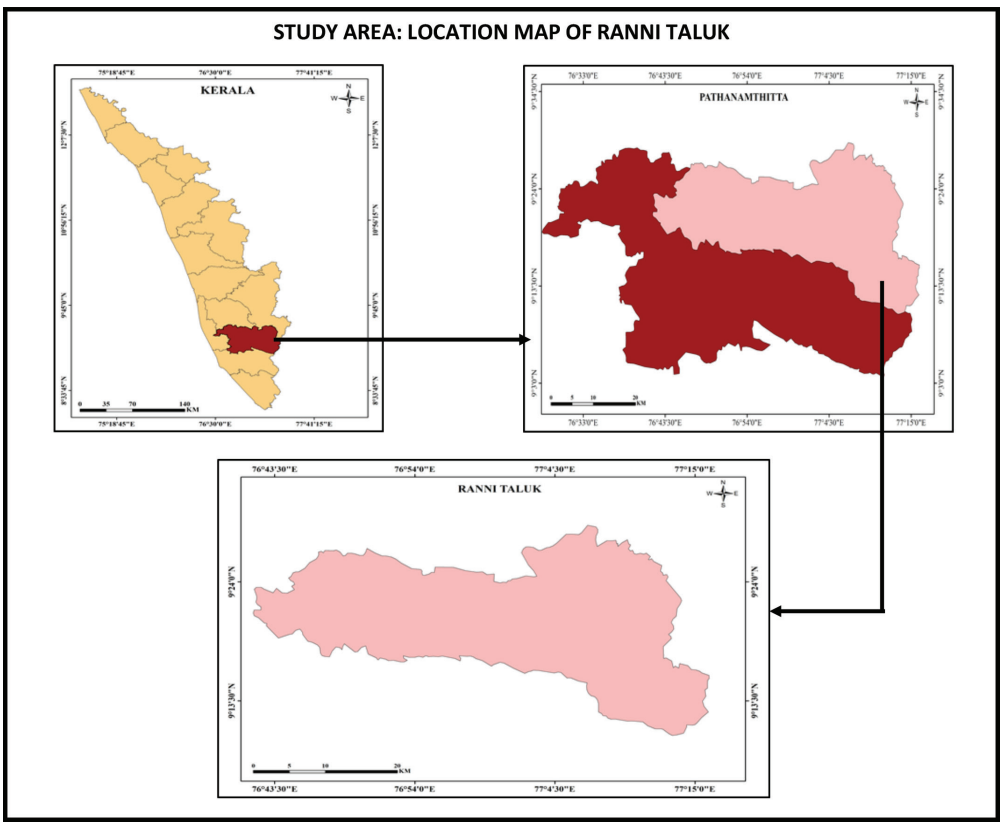


Figure 1: Location Map of Ranni Taluk

3. Methods and Methodology

Weighed overlay analysis was used to identify the potential landslide prone areas in Ranni Taluk. For the present study, the factors identified are Slope, Aspect, Elevation, Geology, Geomorphology, Rainfall, LULC, Lineament, Road density, Drainage density and Normalized Difference Vegetation Index. The spatial data sources were derived from Geological Survey of India maps; Satellite images (Landsat 8) and Tropical Rainfall Measuring Mission (TRMM). In the Arc GIS 10.3 setting, these thematic layers were converted to a raster format with a resolution of 30m and subjected to weighted overlay analysis. The Multi Influencing Factor Technique was used to assign weights to individual parameters. The weighted overlay method is a straight forward method for determining

the evolution of landslide risk in a given region. This method is based on the premise that the conditions that resulted in the previous landslides would recur in the future in other locations, resulting in new landslide prone areas. The graphical representation of the methodology followed in the present study is represented in Figure 2.

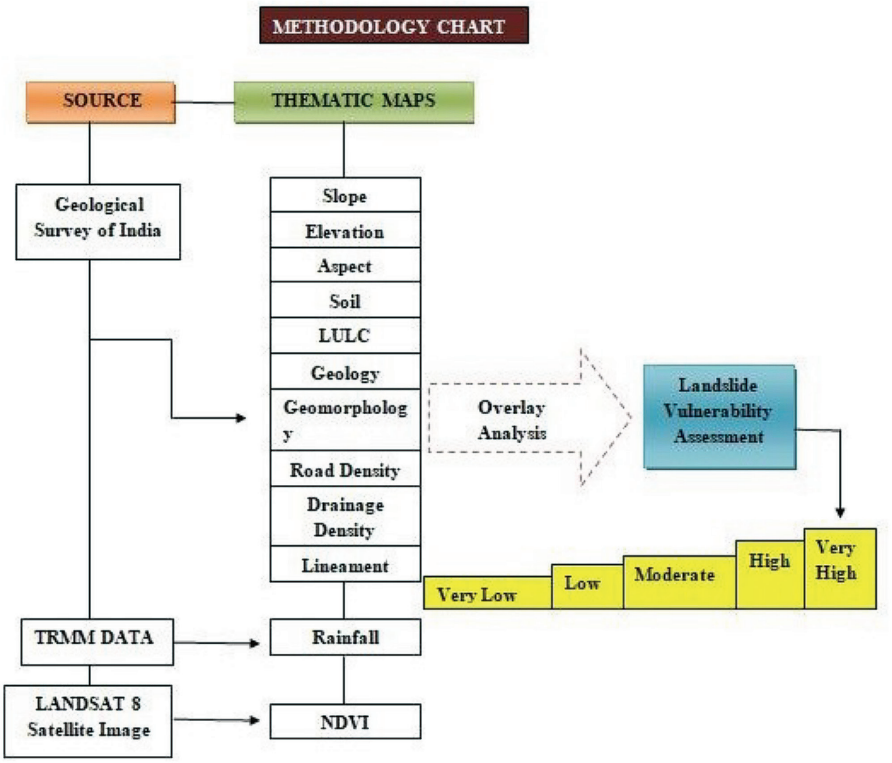


Figure 2: Methodology Chart

4. Result and Disscusion

4.1 Digital Elevation Model

DEM is a valuable tool for the topographic parameterization, especially for erosion and drainage analysis, hill-slope hydrology, watersheds, groundwater flow and contaminant transport studies (Walker and Willgoose, 1999; De Vantier and Feldman, 1993; Jenson and Domingue, 1988).

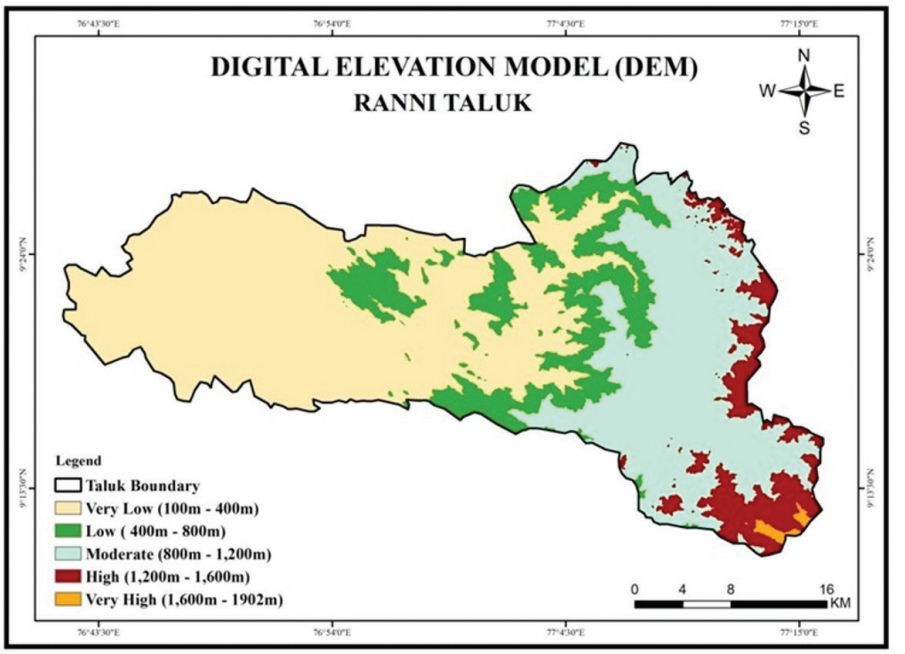


Figure 3: DEM of Ranni Taluk

The elevation trend of Ranni increases from east to west (Figure 3). The contour data of the study area is collected first from Open DEM that provide spatial data as vector layers. The extracted contours were processed in a GIS based software like ArcGIS, to get the output.

4.2 Slope & Aspect

Aspect identifies the downslope direction of the maximum rate of change in value from each pixel to its neighbors. Aspect can be thought of as the slope direction. The values of the output raster will be the compass direction of the aspect, represented by a hue (color). Slope represents the rate of change of elevation for each digital elevation model (DEM) pixel. Slope represents the steepness of the surface and is symbolized into three classes that are shown using color saturation (brightness) (pro.arcgis.com).

The rate of slope increases towards the west (Figure 4). The slope map was prepared using the DEM result in ArcGIS software. The aspect map shows the direction of the

slope dip (Figure 5). It was prepared using the resulting slope map. Both the maps are a result of the raster processing in ArcGIS software.

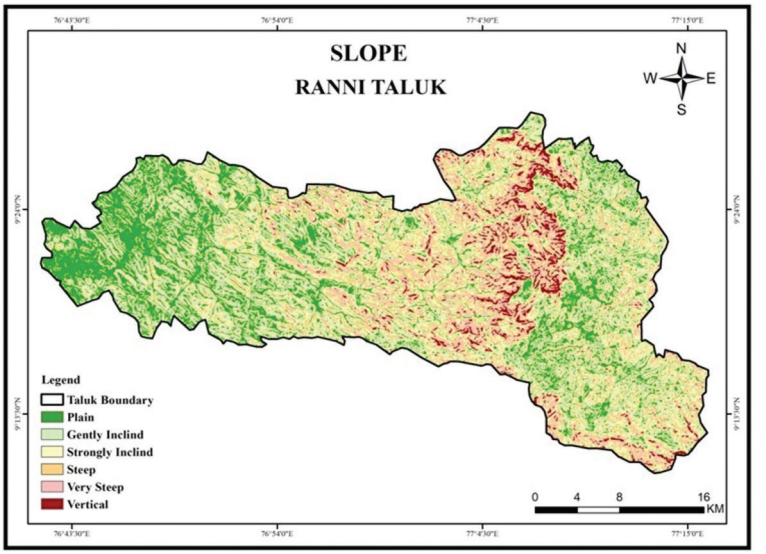


Figure 4: Slope of Ranni Taluk

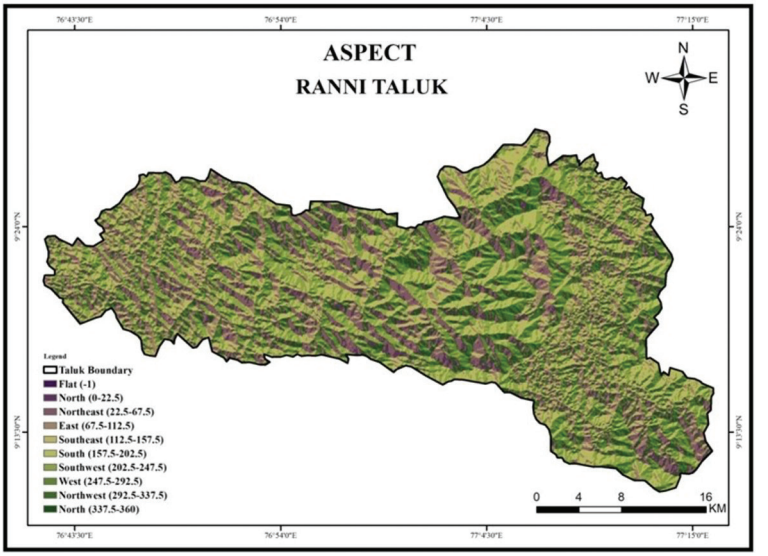


Figure 5: Aspect of Ranni Taluk

4.3 Drainage Density

Hortan (1932) first proposed drainage density as a useful measure of the linear scale of landform elements in stream eroded topography. Drainage density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. It is a measure of how well or how poorly a watershed is drained by stream to length of overland flow. Rugged regions or those with high relief will also have a higher drainage density than other drainage basins if the other characteristics of the basin are the same. Drainage density can affect the shape of a river's hydrograph during a rain storm. Rivers that have a high drainage density will often have a more, flashy hydrograph with a steep falling limb. High densities can also indicate a greater flood risk. High drainage densities also mean a high bifurcation ratio. A high frequency ratio and high drainage density indicates a higher probability of landslide while, on the other hand, lower drainage density with a less frequency ratio exhibits a lower landslide probability (B Mandal & S Mandal, 2016).

The main rivers that drain this region are Achankovil, Manimala and Pamba. The vector data for the rivers that drains the Ranni area was extracted firstly from Bhukosh. Then using this layer, the drainage density of the area was determined. The drainage density trend of Ranni varies mostly from high to very high (Figure 6). This could be one among the other reasons for an increased landslide susceptibility in this place.

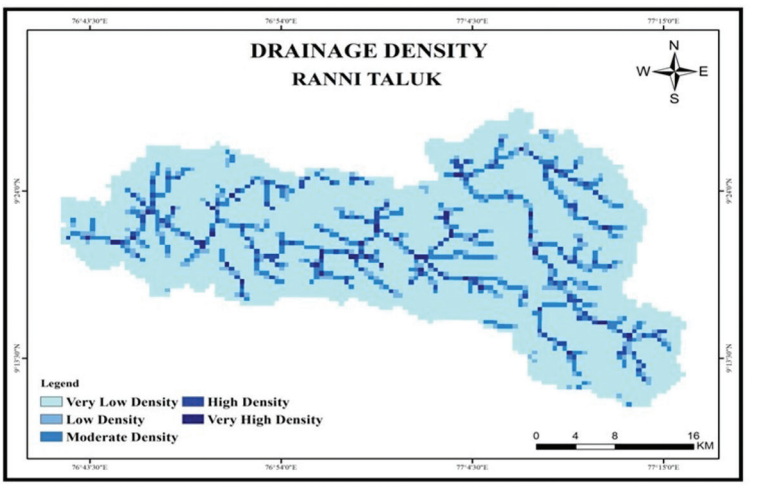


Figure 6: Drainage Density of Ranni Taluk

4.4 Lineaments

Geological structural features, such as the discontinuities that may be detected on satellite imagery as lineaments, in many cases control landslide occurrences. Lineament may represent the plane of weakness where the strength of the slope material has been reduced, eventually resulting in slope failure (Norhakim Yusof et al., 2011).

The lineament information about the study area was extracted from Bhukosh in the official site of Geological Survey of India. From the identified lineaments 4 proximity buffer was created for 250 meters, 500 meters, 750 meters and 1000 meters. The lineament trend of Ranni is high given the taluk being the southern part of the Western Ghats. The density of the lineaments and the possibility of landslides are directly proportional, thus making its study inevitable while analyzing the landslide trends of Ranni (Figure 7).

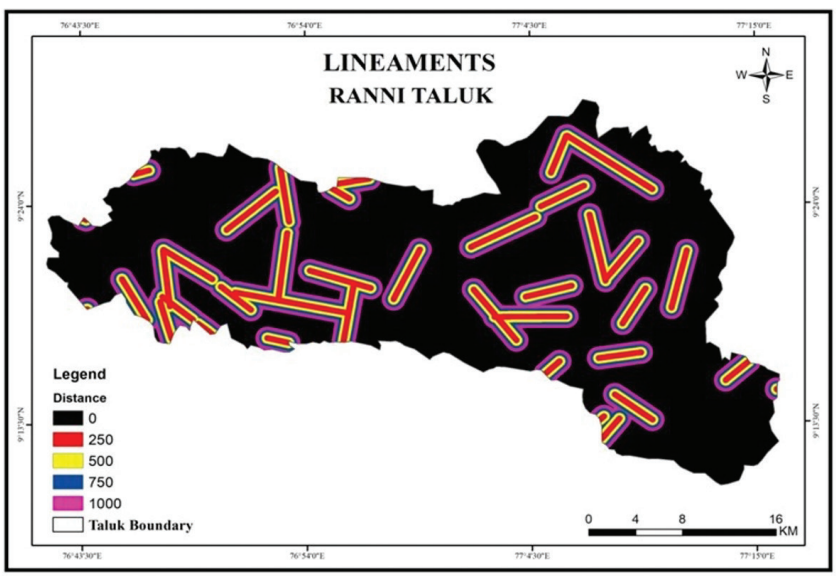


Figure 7: Lineament of Ranni Taluk

4.5 Normalized Difference Vegetation Index (NDVI)

The normalized difference vegetation index (NDVI) is a simple graphical indicator that can be used to analyze remote sensing measurements, often from a space platform,

assessing whether or not the target being observed contains live green vegetation. The NDVI is calculated from these individual measurements as follows:

NDVI = (NIR-Red) / (NIR+Red)

Where, Red and NIR stand for the spectral reflectance measurements acquired in the red (visible) and near infrared regions, respectively. These spectral reflectance are themselves ratios of the reflected over the incoming radiation in each spectral band individually, hence they take on values between 0.0 and 1.0.

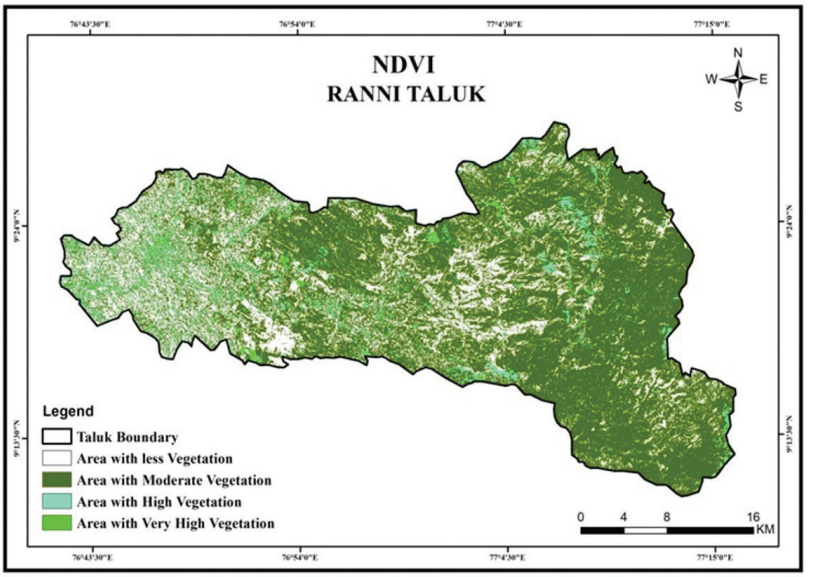


Figure 8: NDVI of Ranni Taluk

In general, the NDVI of Ranni (Figure 8) shows the presence of a very thick and healthy vegetation. This can be due to the presence of reserved forests in these regions, that is, towards the east and the large agricultural fields in the west. The use of NDVI in landslide studies will help us understand about the substantial loss that can occur to the greenery of an area. It will also help to get a clear picture of the agricultural conditions of the region before and after the event.

4.6 Soil

Landslides are primarily caused by changes in water content and stresses in the unsaturated region. Soil characteristics like clay content contributes to the stresses in the unsaturated region. Landslides are to be blamed for the landslide vulnerability in those areas that have a presence of clay, especially in the hilly area. Due to the complicated topography of the hilly area, clay plays a significant role in causing slope failure and landslides. The most prominent soil types found in this region are; Clay, Gravelly clay, Gravelly Loam and Loam (Figure 9). The highland regions are composed of clayey soils and the plains are composed of loamy soils.

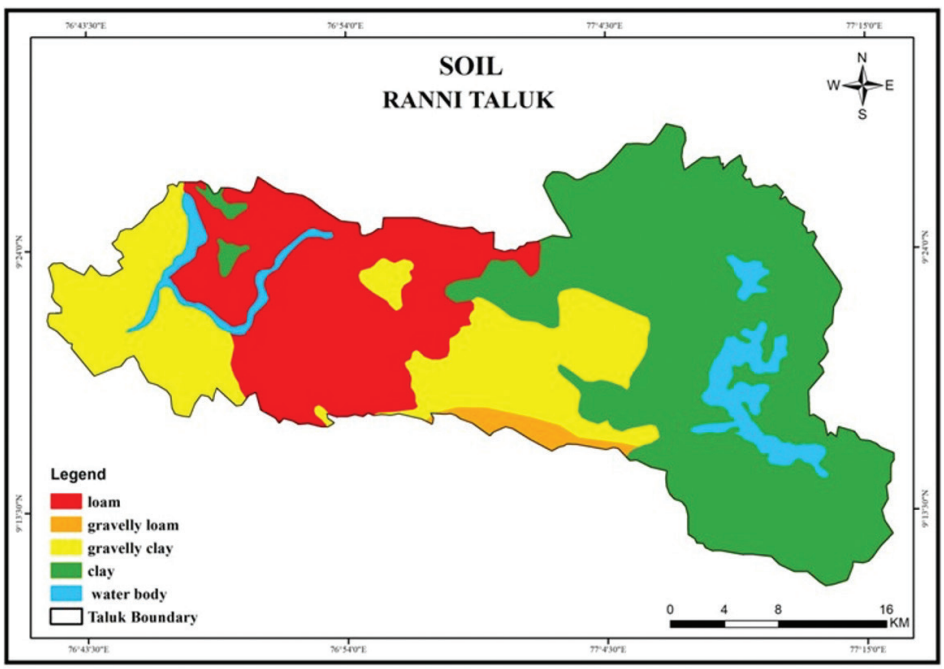


Figure 9: Soils of Ranni Taluk

4.7 Geology

The term "geology" refers to the physical characteristics of the material. Different layers of the earth or rock may have different strengths and hardness, or the earth or rock may be fragile or broken. Geology is the general characteristics of sediments, rocks, and rock types present in the stratigraphic divisions of the earth. Precisely, the study of rocks and their formation is called geology. It helps in understanding and describing the physical characteristics of rock units such as their color, grain size, texture or composition. Geology also helps in understanding porosity, permeability, water saturation, etc., and other petro physical properties of rocks. In this map (Figure 10), the major geological forms of Ranni comes under the Charnockite group.

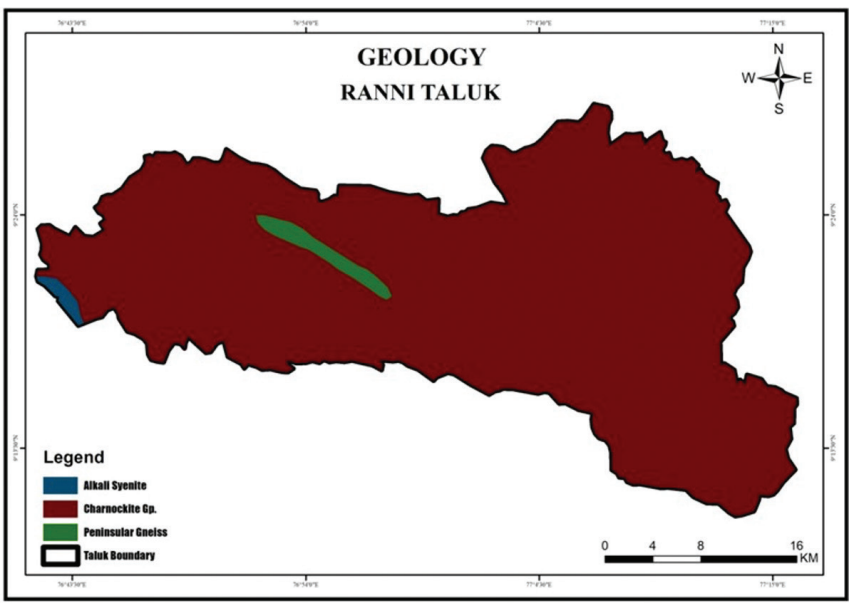


Figure 10: Geology of Ranni Taluk

4.8 Geomorphology

Geomorphology is the study of landforms, their processes, form and sediments at the surface of the Earth (and sometimes on other planets). Study includes looking at landscapes to work out how the earth surface processes, such as air, water and ice, can

mold the landscape (www.geomorphology.org.uk). The landscape of Ranni is primarily composed of highly dissected hills and valleys followed by a flat Pedi plain to the west (Figure 11). The famous Pamba Basin Hydro Electric Project is located here.

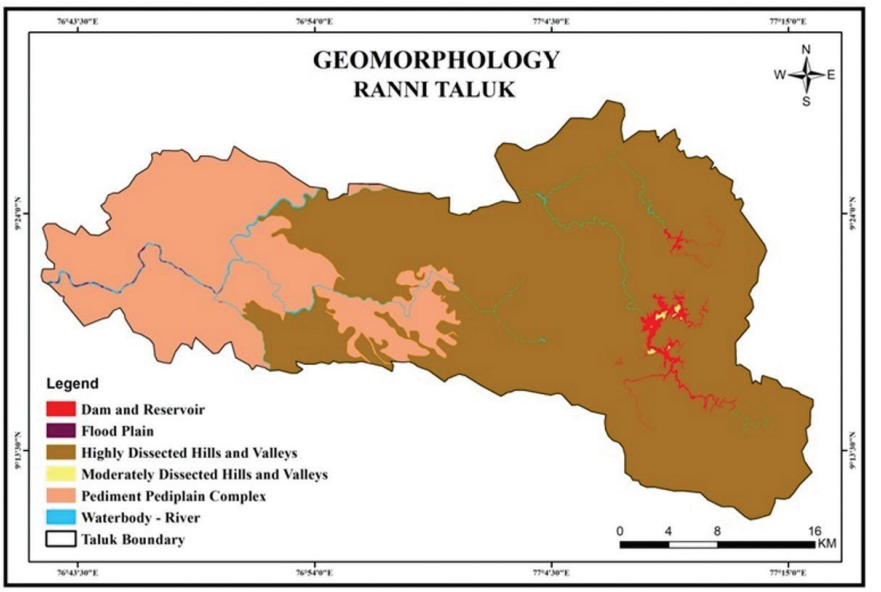


Figure 11: Geomorphology of Ranni Taluk

4.9 LULC

Land cover and land use changes are one among the four major global environmental issues, together with biodiversity, atmospheric composition and climate change (Walker and Steffen, 1997; Walker, 1998). Therefore, it is always important to monitor land use change within a certain period of time and predict patterns of future land use changes on a spatial basis (Nurmiaty, etal., 2014). Mapping is the most efficient method for projecting changing land use (Mani, 2012). Standard visual interpretation methods were applied to identify and interpret the land use pattern of the area and various land use classes delineated includes Agricultural lands, Built up, Forest, Natural/Semi natural grassland & grazing land, Wastelands, Water body and Wetlands (Figure 12). The dominant land use is of Forests and Agricultural lands. (Suresh S., etal., 2018). More

than half of the area is covered by Forest. The prominent settlement areas are located towards the west of the taluk, mostly along the river banks. These settlements are surrounded by agricultural lands.

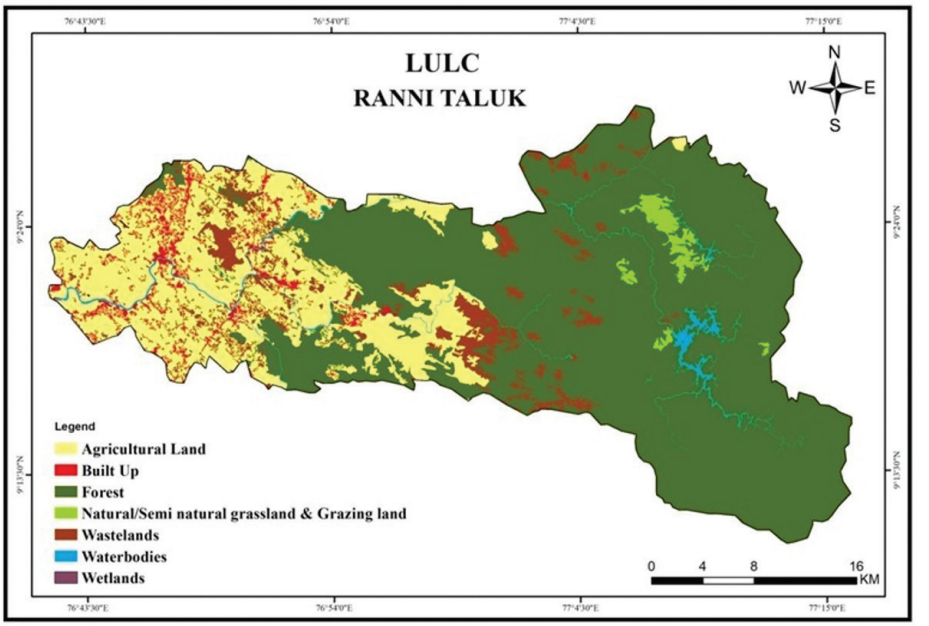


Figure 12: LULC of Ranni Taluk

4.10 Rainfall

Rainfall is the primary triggering agent for landslides and is often used for prediction of slope failures. However, the relationship between rainfall and landslide occurrences are very complex. Great efforts have been made on the study of regional rainfall-induced landslide forecasting models in recent years; still, there is no commonly accepted method for rainfall-induced landslide forecast (Shibiao Bai, et al., May 13). In this paper, rainfall data for the study area was obtained from the TRMM data and was analyzed using the IDW interpolation tool from ArcGIS (Figure 13).

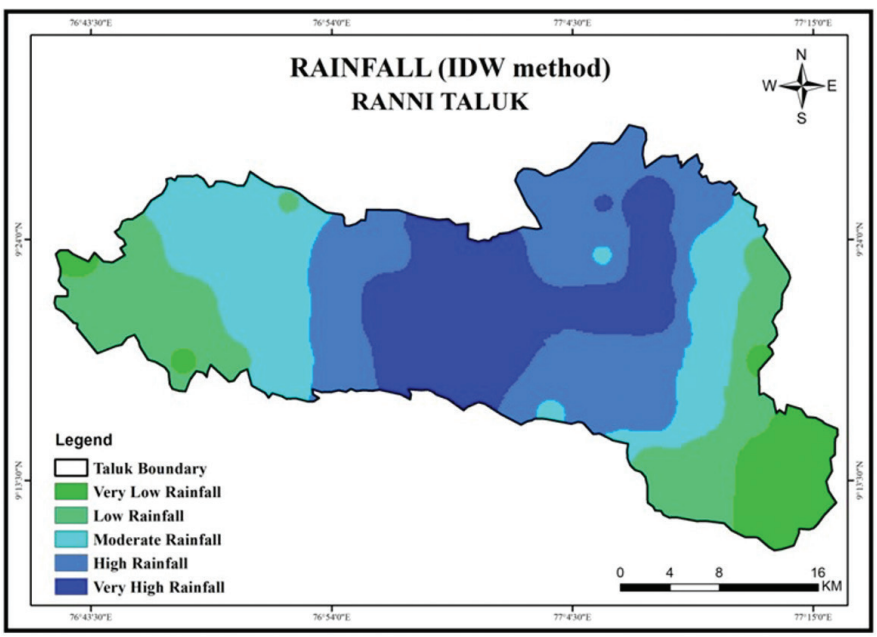


Figure 13: Rainfall Map of Ranni Taluk

4.11 Road Density

Road density is a simple indicator of the concentration of roads in an area. The road density can be determined for road segments that have characteristics that are attributed, like road segments within a 100 meter buffer of stream channels. The road

network connectivity is high in the western side of Ranni taluk (Figure 14). This can be easily correlated with the location of built up areas and settlement sites on the same side. The road network ensures better connectivity of the human population.

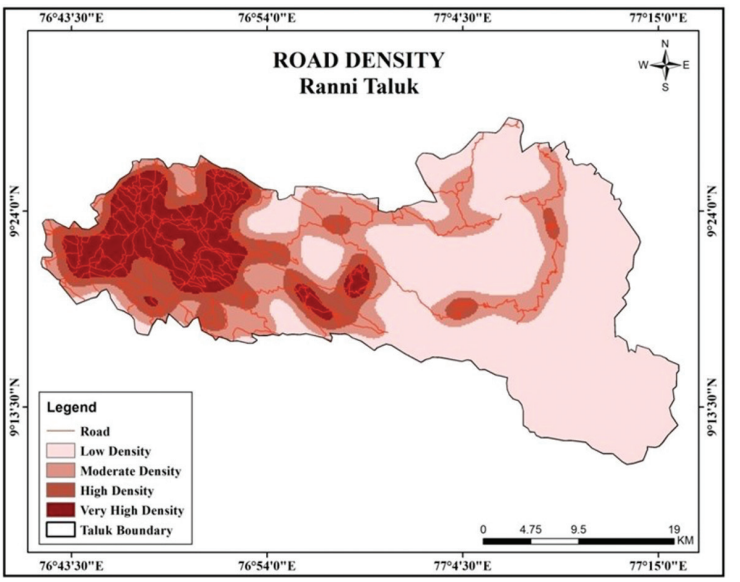


Figure 14: Road Density of Ranni Taluk

4.12 Weighted Overlay Analysis for Landslide Vulnerability Assessment

As mentioned in the methodology section, elevation, slope, aspect, geology, geomorphology, soil, drainage density, lineament, land-use/land-cover, road density and rainfall are the parameters considered for the present study. Based on how these parameters influence the landslide vulnerability, these parameters were given ranks accordingly.

4.12.1 Classification of Weighted Parameters Influencing the Vulnerable Zones:

The rank classification for the selected factors influencing landslide vulnerability ranges from 1 to 5. For the slope, elevation, rainfall, aspect and road density, the ranking is given in ascending order, from very low to very high, in which rank 1 show very low landslide vulnerability while rank 5 indicates very high vulnerability. Other factors like

NDVI, drainage density and lineament displays a descending ranking pattern. So the chances of occurrences of landslide is high in lower rank values and it becomes low towards higher rank. The parameters of landslide vulnerability assessment like geology, LULC, soil and geomorphology, the ranking is based on the specific characteristics of each parameters.

Table 1: Classification of Parameters used for Weighted Overlay Analysis

Sl. No.	Factor	Class	Rank	Weight
1	Slope	Very Low	1	10
		Low	2	
		Moderate	3	
		High	4	
		Very High	5	
2	Elevation	Very Low	1	10
		Low	2	
		Moderate	3	
		High	4	
		Very High	5	
3	Geology	Charnockite	5	8
		Peninsular Gneissic	4	
		Syenite	2	
4	LULC	Water Body	1	8
		Agriculture	1	
		Forest	3	
		Waste Land	4	
		Built Up	5	
		Natural/semi natural Vegetation	2	
5	Soil	Gravelly Clay	3	8
		Clay	2	
		Gravelly Loam	5	
		Loam	4	

6	Rainfall	Very Low	1	12
		Low	2	
		Moderate	3	
		High	4	
		Very High	5	
7	Aspect	Very Low	1	5
		Low	2	
		Moderate	3	
		High	4	
		Very High	5	
8	Drainage Density	Low	4	5
		Moderate	3	
		High	2	
		Very High	1	
9	NDVI	Area with Less Vegetation	4	8
		Area with Moderate Vegetation	3	
		Area with High Vegetation	2	
		Area with Very High Vegetation	1	
10	Road Density	Low Density	1	8
		Moderate Density	4	
		High Density	3	
		Very High Density	2	
11	Geomorphololgy	Dam & Reservoir	5	10
		Flood Plain	4	
		Highly Dissected Hills and Valley	2	
		Moderately Dissected Hills and Valleys	1	
		Pediment pediplain	3	
12	Lineament	0	1	8
		250	5	
		500	4	
		750	3	
		1000	2	

4.13 Landslide Vulnerability Zones

The result of weighted overlay analysis was mapped and classified into five classes as Very low, Low, Moderate, High and Very high based on the vulnerability of landslide. The result (Table 2) shows that, 201.12 sq.km area comes under very low landslide vulnerability, 338.57 sq.km area comes under low vulnerability, 240.25 sq.km area comes under moderate vulnerability, 144.98 sq.km comes under highly vulnerability and 109.71 sq.km comes under very high vulnerability areas. The map given (Figure 15) shows the vulnerable areas. The villages to the west, such as, Ayroor, Angadi, Ranni, Cherukole, parts of Pazhavangady and also the highly sloping areas of the Chittar-Seethathode village in the east. The vulnerability reduces from the central region towards the north.

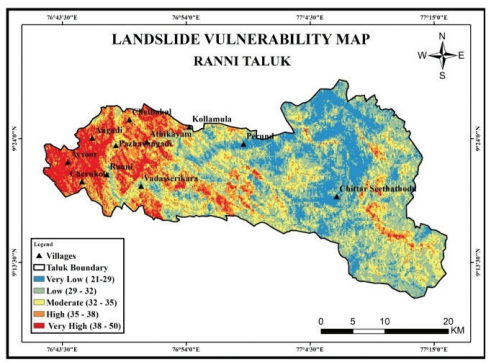


Figure 15: Village wise Landslide Vulnerability Map of Ranni Taluk

The given classifications were then converted using ArcGIS software and the area was calculated within these five classes. The areas of each class are tabulated below:

Table 2: Areas under each Vulnerability Class

Class	Area (in sq. km)	Area (in %)
Very Low	201.12	19.43
Low	338.57	32.72
Moderate	240.25	23.22
High	144.98	14.01
Very High	109.71	10.60

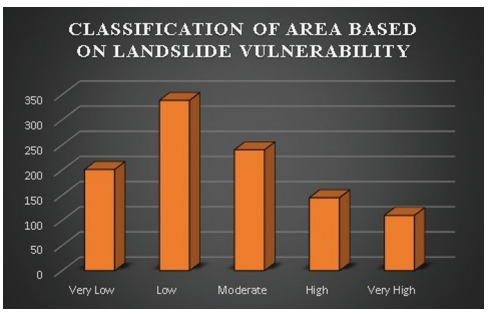


Figure 16: Areas under each Vulnerability Class

The graphical representation (Figure 16) implies the classification of areas based on landslide vulnerability. The graph clearly shows that 32.72% of area comes under lower chances of landslide vulnerability which comprises a large portion of the study area.

5. Conclusion

This paper attempts to conduct a landslide vulnerability assessment using the GIS and remote sensing tools effectively. According to a report released by the Kerala State Disaster Management Authority (KSDMA), Ranni taluk is a landslide prone area. Therefore, this study puts forward the Landslide vulnerability assessment and Micro zonation of Ranni taluk. Twelve parameters affecting landslides were analyzed using weighted overlay method. Slope failure in the eastern part of the Ranni increases the risk of landslides. However, in the western parts being relatively low sloping, yet are highly vulnerable due to the presence of anthropogenic factors. This is mainly due to changes in land use and the structural characteristics of the soil and geology. So it is more likely that there will be a soil piping phenomenon similar to landslides here. Studies by Center for Earth Science Studies (CESS) have identified Ranni as a highly prone area for soil piping in South Kerala. Therefore, this study indicates that more studies are intended towards this area in relation to future studies in soil piping and soil erodability.

Reference

1. Anju Kailas, Greena Shajan, Nikhila P, Shijo Joy, Geeja K George, Dr. Vinu Prakash (2018). Landslide Hazard Zonation (LHZ) Mapping of Attappady, Kerala using GIS, International Research Journal of Engineering and Technology, 3808 – 3812.
2. Anu Simon and Mohankumar K, (2004). Spatial variability and rainfall characteristics of Kerala. Earth Planet Science, 211–221. Census of India (2011). District Census Hand Book 2011- Pathanamthitta.
3. Dananjaya P.K.V.S and Edirisooriya K.V.D, (2020). Landslide Vulnerability and Risk Assessment: A Study at Kiriketioya Belihuloya Watershed. Journal of Social Sciences and Humanities Review (JSSHR), Vol. 4, No. 3 (114-125).
4. Dutta P.J., Sarma S. (2013), "Landslide susceptibility zoning of the Kalapahar hill, Guwahati, Assam state, India, using a GIS-based heuristic technique", International Journal of Remote Sensing & Geoscience, 49-55.
5. Jishnu E S,Ajith Joseph K, Sreenal Sreedhar, George Basil (2017). Hazard Mapping of Landslide Vulnerable Zones in a Rainfed Region of Southern Peninsular India- A Geospatial Perspective, International Research Journal of Engineering and Technology (IRJET), 1350–1357.
6. Kerala State Disaster Management Authority. Kerala state disaster Management Plan Profile, Government of Kerala, 1-67.
7. National Centre for Earth Science Studies (2016). Studies on "The Soil Piping in the Highlands and foothills of Kerala to avoid the disaster, Government of Kerala.
8. Ramakrishnan S S, Sanjeevi KumarV, M.G.S.M. Zaffar Sadiq, Arulraj M and Venugopal K (2002). Landslide Disaster Management and Planning a GIS based Approach, Indian Cartographer, 192 – 195.
9. Raveendran, Dr. Mani, Aneesh, (2015). "Landslide Hazard Zonation and Vulnerability Assessment of Western Ghats-A case study in Devikulam Taluk of Idukki District", International journal of research and applied sciences, 185-189.
10. Suresh S, Rajesh S and Mani K (2018). Delineation of Groundwater Potential Zones in Devikulam Taluk, Idukki District, Kerala, Using Remote sensing, GIS and MIF Techniques, Eco Chronicle, 159-168.

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

Srimanta Gupta[1]*, Indrani Bhattacharya[1], Raju Thapa[2] and Harjeet Kaur[2]

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

[1] **Srimanta Gupta, Indrani Bhattacharya,** Department of Environmental Science, The University of Burdwan, West Bengal, India
[2] **Raju Thapa, Harjeet Kaur,** National Institute of Disaster Management, Ministry of Home Affairs, Government of India
* Corresponding Author Email: srimantagupta@yahoo.co.in

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.

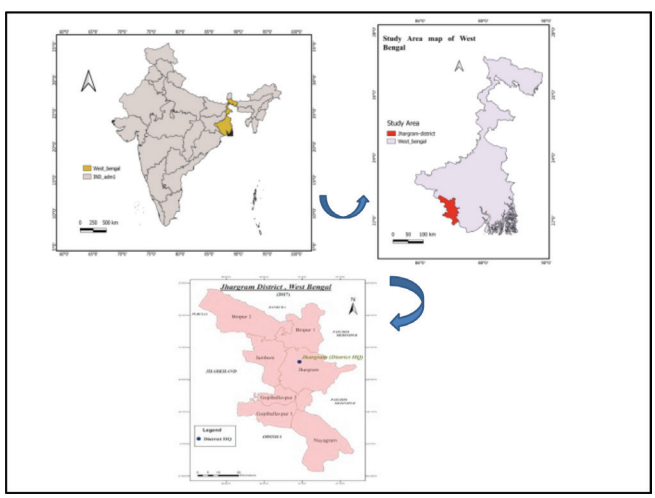


Figure 1: Study Area Location

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.

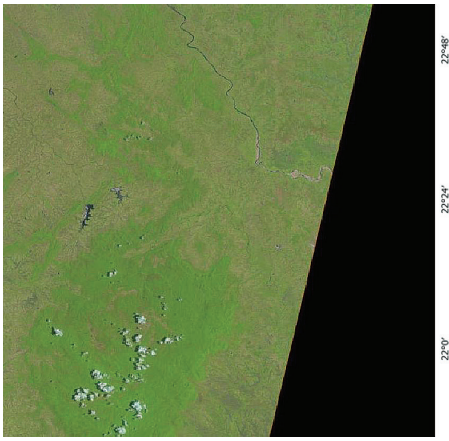


Figure 2(a): Sentinel -2 Satellite image of the study area

(Source: USGS earth explorer)

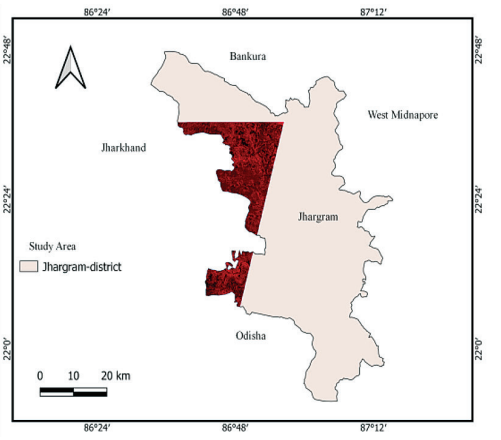


Figure 2(b) represents portion of the satellite image covering the Jhargram district, West Bengal

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.

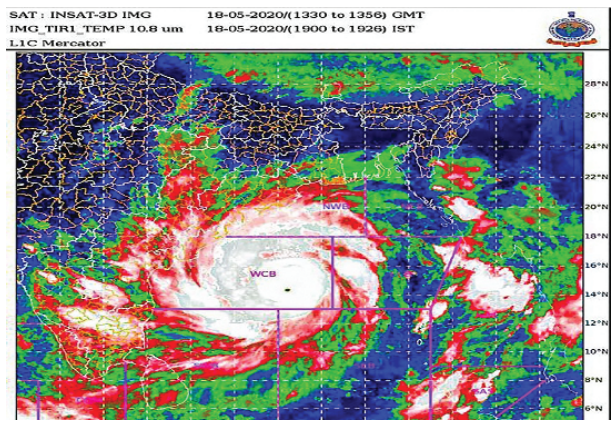


Figure 4: An IMD satellite image showing formation of Amphan in the Bay of Bengal

(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).

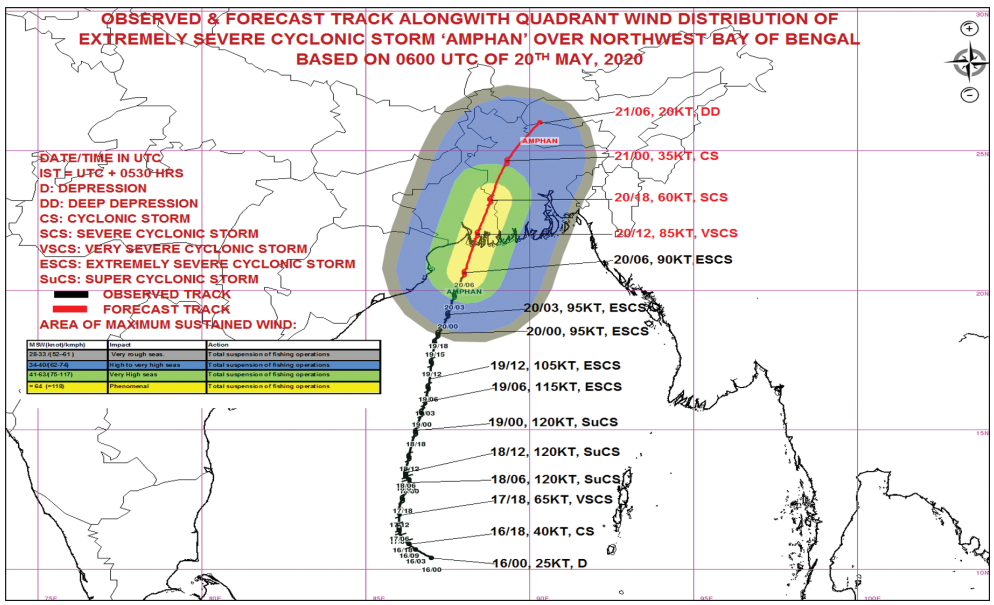


Figure 5: Observed Track of cyclone 'Amphan' over Bay of Bengal (16-21 May, 2020)

(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.

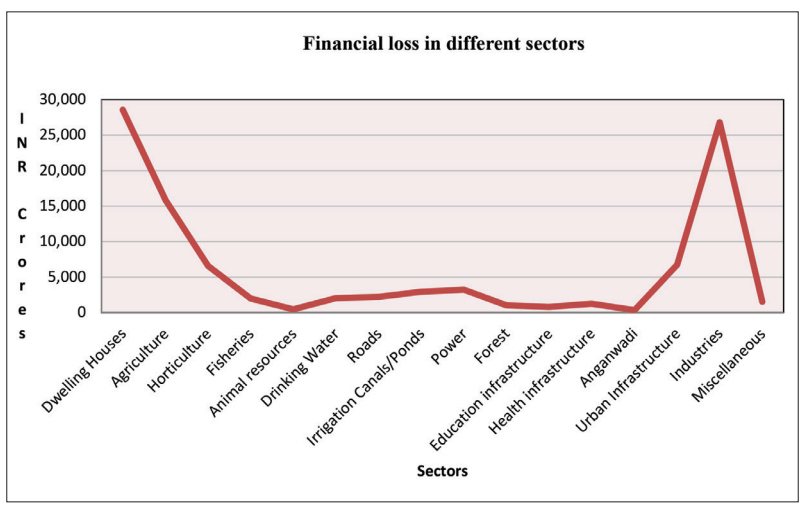


Figure10: Impact on Economics in various sectors

(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.

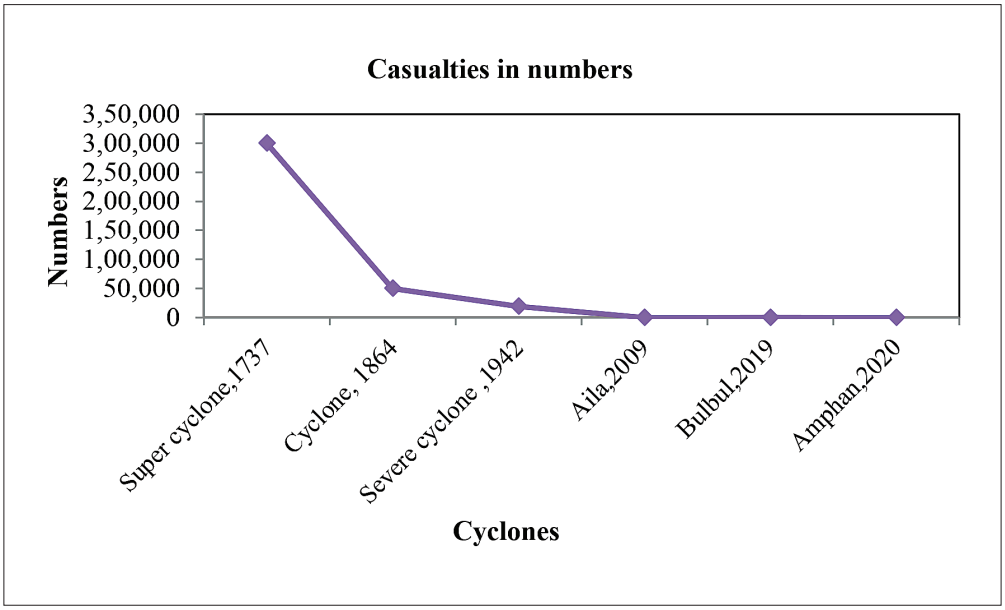


Figure 11: Graph representing causalities from past centuries (1737-1942) upto (2009-2020)

(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).

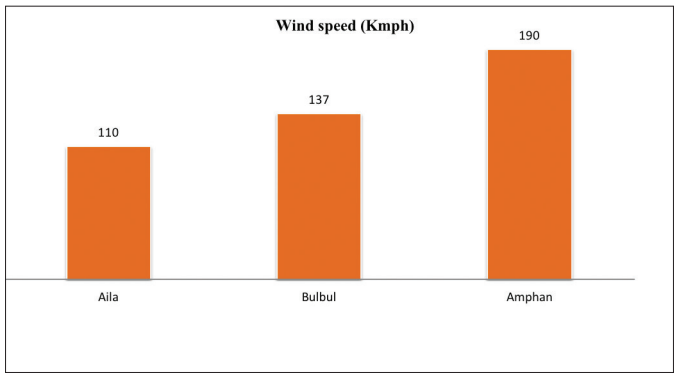


Figure 12: Maximum wind speed of the major cyclones in the past decade

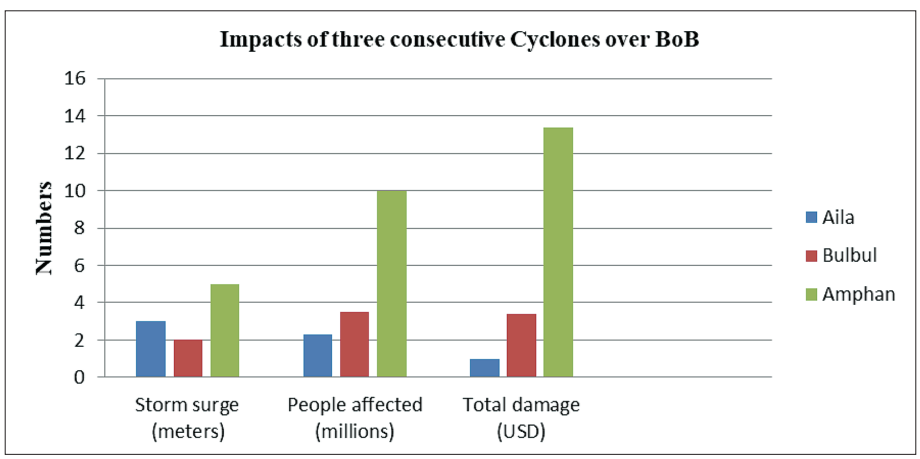


Figure 13: Comparative assessment of the impacts of the three cyclones Aila, Bulbul and Amphan

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)

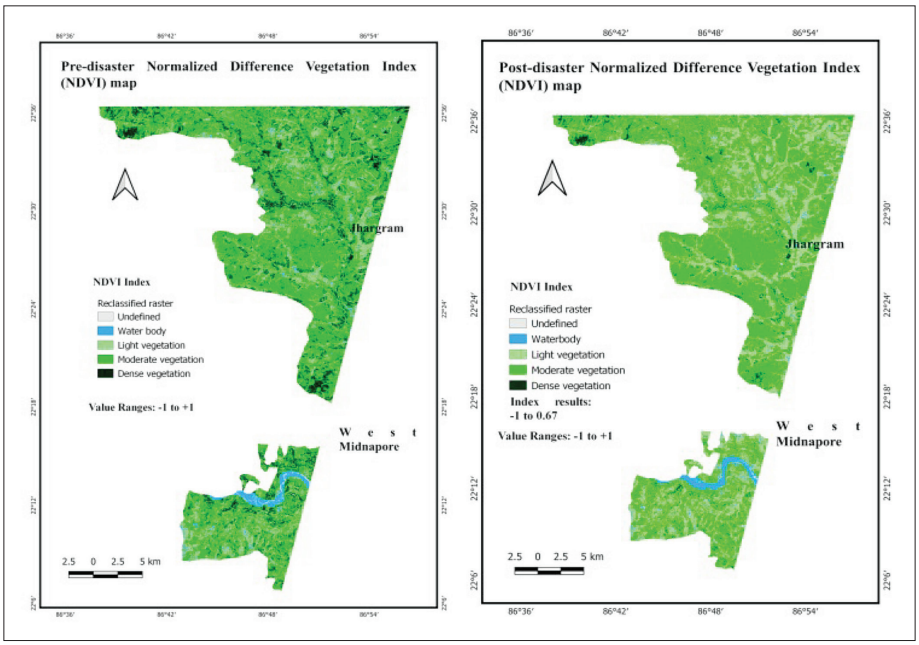


Figure 14: The Pre-disaster and Post-disaster NDVI Map of the study area showing the difference in vegetation index

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.

Acknowledgement:

Authors express their deep sense of gratitude to the Dept. of Environmental Science, The University of Burdwan for providing us opportunity to carry out the research work. Authors are also thankful to the DST Govt. of India for financial support through DST-FIST scheme and the reviewers for their critical reviews and valuable suggestions for the betterment of the manuscript.

References:

1. Bandyopadhay B.K (n.d).Technology for Early warning system, Indian Meteorological Department. Retrieved from https://nidm.gov.in/easindia2014/err/pdf/ses
2. Bhatta B (2008) Remote Sensing and GIS, Oxford University Press. Vol 1 ISBN-13: 978-0-19-569239-6
3. Cyclone Amphan. (n.d.). Retrieved from Wikipedia, the free encyclopedia:https://en.wikipedia.org/wiki/Cyclone_Amphan
4. Disaster Prevention and Preparedness. (n.d).Retrieved from http://www.imdahm.gov.in/cycdisasters.htm
5. EarthExplorer. (n.d.). Retrieved from USGS: https://earthexplorer.usgs.gov
6. Effect of Cyclone Amphan in India. (n.d). Retrieved from Wikipedia.https://en.wikipedia.org/wiki/Effects_of_Cyclone_Amphan_in_India
7. Historical records of 3 most devastating cyclones, which formed in the Bay of Bengal and made landfall on the coast of West Bengal. (n.d). Retrieved from Natural Disaster: Cyclone http://wbdmd.gov.in/pages/cyclone.aspx
8. Introduction. About NCRMP.(n.d.). Retrieved from National Cyclone Risk Mitigation Project https://ncrmp.gov.in/about-ncrmp/
9. Jain M. K (2018), Disaster Management: A Study of An Institutional Arrangements in Rajasthan with Special Reference to Kota district. University of Kota, Rajasthan
10. Shah A. J. An overview of disaster management in India, Disaster Management an Human Health Risk II.WIT Transactions on the Built Environment, Vol 119. ISSN 1743-35.P-76
11. Shukla S (2013). Disaster Management: Managing the Risk of Environmental Calamity. International Journal of Scientific Engineering and Research .Vol I issue 1
12. Super Cyclonic Storm "AMPHAN" over southeast Bay of Bengal (16-21 May,2021):Summary.(n.d.) RSMC Tropical Cyclone, Indian Meteorological Department Retrieved from https://internal.imd.gov.in/press_release/20200614_pr_840.pdf
13. Super Cyclone Amphan 2020.(n.d.).Retrieved from Operation.http://www.ndrf.gov.in/operations/super-cyclone-amphan-2020

Assam Model of COVID-19 Response: Strategies, Challenges and Way Forward

Julfikar Ali[1], Himani Tiwari[2]* and Nafisa Khatoon[3]

Abstract

Assam, the largest state of North-East India, has been reeling under the devastating impacts of the COVID-19 Pandemic since March 2020. The annual floods associated with systematic (e.g., Japan Encephalitis, Dengue and Malaria) and cascading risks (e.g Landslides) further increased the vulnerability. The Assam model of COVID-19 response has been acknowledged by the health experts, policy makers and administrators and it has become a source of inspiration for other states as well. Assam government's three T's (Test, Treat, Transport) formula, ruthless quarantine policy, programs like Assam Cares Outreach Program, COVID-Plus and Infectious Disease Surveillance Program helped to reduce the spread of the virus. In this research, a thorough survey and review of the government reports, journals, research papers and newspapers have been systematically conducted. However, there remain many challenges that need to be addressed to ramp up the preparedness and response efforts. The current research includes the best practices, challenges faced by the Government of Assam and way forward in responding to this Public Health Emergency amidst other disasters in the time-period from March 2020 to May 2021.

Keywords: *COVID-19, response, complex disaster, government, Assam State Disaster Management Authority (ASDMA)*

1. Introduction

India is reeling under the devastating impact of the COVID-19 Pandemic since March

[1] **Julfikar Ali,** Research Analyst, Lead Tech Management Consulting Pvt. Ltd.,
[2] **Himani Tiwari,** Research Analyst, Institution for Disasters, Emergency & Accidents (IDEA)
* Corresponding Author Email: himanitiss@gmail.com
[3] **Nafisa Khatoon,** Young Professional, Karnataka State Livelihood Mission

2020 and we still have not got a grip on the situation (Kumar et al., 2020). Assam, the largest state in North-East India holds no exception. Since the first COVID-19 case was reported in Assam on March 31, 2020, the pandemic continues to severely impact all the sectors and segments of society (Choudhury, 2020). Undoubtedly, the healthcare infrastructure already coupled with several challenges is under tremendous stress. According to the Raghuram Rajan commission states wise, Assam has 0.48 beds per 1000 people, which is way below the national average of 1.13 beds per thousand people. Lack of health insurance, medicine & PPE kit, underdeveloped health infrastructure and inaccessibility issues are some of the other common challenges faced in the state (Priyanka raj, 2020). The complex disaster scenario in Assam like Baghjan Gas Leak resulting in massive fire from May 27, 2020, to November 2020, annual floods associated with systematic risk like Japanese Encephalitis, Dengue, Malaria and cascading risk like landslides were also witnessed amidst the ongoing Public Health Emergency (Agarwala, 2020; Guha, 2020) This further exacerbated the response efforts and has questioned the health delivery system of the state.

Central to a holistic response, comes the role of good governance. Good governance involves efficient and innovative management of the available resources, effective decision-making, leadership and a bottom-top approach (Mishra and Singla, 2020). For containing the spread of COVID-19 and managing other disasters, the state government plays an indispensable role and its pro-activeness governs the efficiency of response (Dowerah, 2020). The local governance plays a frontline role in coordinating the response and bridging the gap between the vigorous response needed and the local realities (Dutta & Fischer, 2021).

This paper focuses on the "Assam Model" of managing the pandemic and other disasters from March 2020 to May 2021. Assam's battle against COVID-19 spearheaded by the Assam Health Ministry included several measures from setting up the isolation wards, quarantine centers, community surveillance to issuing new guidelines for relief camps management to handle both the disasters (PRS, 2020). There are several examples of both best practices and challenges faced in managing this scenario under the leadership of the Government of Assam (WHO, 2020). However, the lack of proper documentation remains a major challenge. To fill this gap, this paper aims to document and analyze the steps and strategies of the Government of Assam in handling the COVID-19 Pandemic and other disasters. It is important to keep track of the COVID-19

response in Assam that is currently reeling under the devastating impact of multiple hazards. In this research, a thorough survey and review of the government reports, journals, research papers, and newspapers have been systematically conducted to document the steps taken by the government in managing COVID-19 and the complex disaster scenario. The aim of this paper is twofold: to highlight how the Assam government handled the pandemic and other disasters and to analyze the structural and institutional mechanism involved for the same. A comprehensive review and analysis would help maintain a database of best practices, challenges faced and lessons learnt amidst the COVID-19 response. This would help in dealing with future emergencies more efficiently and effectively.

2. Study Area and Demography

Assam is the largest state of North-East India, encompassing a population of 3.1 crores of which 1.59 crores are males and 1.52 crores are females with a population density of 397/km^2 (Census, 2011). Out of the total population, 86% population live in rural areas and 14% population live in urban areas of the state. Serving as the doorway to the other six north-eastern states, the GDP of the state is Rs 3.24 lakh crore (MOSPI, 2020). The Human Development Index value of the state stands at 0.614 (Global Data Lab, 2018). The state is also prone to floods every year, which cause massive devastation to life and property. Figure 1 shows the study area.

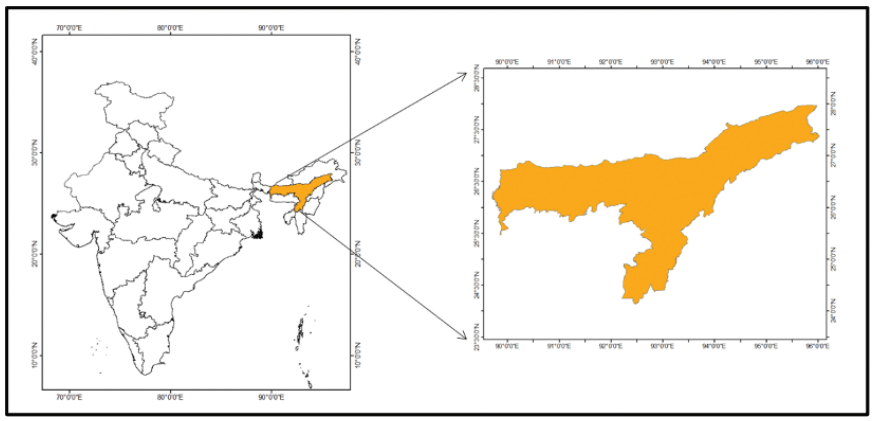


Figure1: Study Area, Assam, India

3. Healthcare System of Assam

The healthcare status of a state is an important indicator of socio-economic development like availability of beds per 1000 patients, health insurance, and availability of medicine, doctors, nurses, PPE kits, and ventilators. The economic survey 2021 shows that Assam has fared well in terms of per capita healthcare as compared to the other states. About 6.4% of the total expenditure has been allocated to healthcare which was much higher than the state-wise average allocation (5.3%) (PRS, 2021). However, there are several challenges like the dearth of human resources, scarcity of beds and hospitals. For every 10,000 population in Assam, there are just 5 Allopathic and Ayush doctors and 15 nurses and midwives. A total of only 20 health workers do not even fulfill the criterion of the lower limit of 23 given by the World Health Organization (WHO) (Kalita, 2021). Table 1 shows the public health facilities and beds in Assam. Also, Assam has a deficit of 28% Community Health Centres (CHCs), 21% Sub-Centres, 1% Primary Health Centres (PHCs) against the sanctioned numbers (MoHFW, 2017). Accessibility to these facilities is another matter of concern. About 31.7% of the primary health centres and 16.8% of the sub-centres are located beyond the 10 km radius and 3 km radius of the village respectively (IIPS, 2010).

Table 1: Number of public health facilities and hospital beds in Assam

No. of Public health facilities					No. of beds available in public facilities	Rural hospitals (Beds)	Urban hospitals (Beds)
Primary Health Center (PHC)	Community Health Center (CHC)	Sub-District Hospital (SDH)	District Hospital (DH)	Total			
1007	166	14	33	1220	19115	10944	6198

(Source: National Health Profile, 2018)

Hospitals and other health facilities are vital assets to communities on a day-to-day basis. Its importance and vitality manifolds during times of a public health emergency or any disaster (Paul et al., 2019). COVID-19 is a live example of it, which has questioned the resilience of the healthcare system. It has posed several challenges for the hospitals

and staff on multiple fronts like the risk of exposure to COVID-19, dearth of hospital beds and health workers, oxygen support, ventilators and equipment like Personal Protective Equipment (PPEs) (Dutt, 2021).

4. Assam and COVID-19

The first COVID-19 case in Assam was reported on March 31, 2020 (Barak Bulletin, 2020). As of May 20, 2021, a total of 347001 COVID-19 cases and 2433 deaths have been reported so far (Government of Assam, 2021).

Table 2: Top 5 most COVID-19 affected districts and 5 least affected districts according to number of positive cases till May 20, 2021

Top 5 districts with highest number of COVID-19 Cases	Positive cases	Bottom 5 districts with lowest number of COVID-19 Cases	Positive Cases
Kamrup Metro	11548	Majuli	97
Kamrup Rural	4083	West Karbi Anglong	197
Dibrugarh	3982	Chirang	276
Nagaon	3482	Charaideo	333
Cachar	2893	Dima Hasao	375

(Source: https://nhm.assam.gov.in/)

4.1 Assam Government's Strategy in Managing COVID-19

Assam Government has adopted a very strong containment cum quarantine policy since the beginning of the detection of the very first case, and since then the government has been working on capacity development and implemented multi-faceted strategies to fight against COVID-19. Strong political will, able and experienced administrators and committed health and frontline workers are the backbone of Assam in minimizing the risk of COVID-19 and bringing stability 4.2 to the lives of the people of Assam.

4.2 Three T's Formula and Quarantine Policy

A huge number of Assamese are working in different parts of India therefore there was an apprehension in the minds of the health experts and administrators that once the lockdown is relaxed then there would be an influx of people particularly migrants

(Das, 2020). To handle this situation, the Government took very prompt action in a very calculated manner with close coordination of Health, Police, and Transportation departments along with local administration to contain the affected people at the border of the state. Strict institutional quarantine centers were constructed in all major districts and followed three T's formula i.e. Test, Treat, and Transport (Das, 2020). Initially, it has been noticed that a maximum number of COVID-positive cases were detected in quarantine centers. Owing to the effectiveness of quarantine centers in the early detection of positive cases, now administration started developing quarantine centers at the block and local level and also equipped local institutions such as Primary Health Centers (PHCs), Auxiliary Nurse Midwives (ANMs), and Accredited Social Health Activist (ASHAs) workers with adequate resources to discharge their responsibility more effectively and segregating patients by accelerating testing (Kalita, 2021).

4.3 Personnel Management and Authorization to Local Institutions

Indian Health Infrastructure has been facing the issue of shortage of trained health professionals even before the COVID-19 pandemic and often North-Eastern States are lagging below the national average. To fill this gap, Assam has especially trained 700 final year MBBS students and 2000 final year nursing students to provide adequate human resources and reduce the pressure on health infrastructure (Das, 2020). In addition to this, by taking a lesson from the first phase of COVID-19 and to improve the capacity and capability of her health infrastructure, in September 2020, the health department of Assam recruited 1000 additional nurses and 215 Intensive Care Unit (ICU) technicians and equipped them with all relevant tools and technology (Talukdar, 2021). Authorization to home quarantine committees was constituted at multiple levels such as urban local bodies, apartment and village level to file a complaint with the local police in case of violation of COVID rules and home quarantine guidelines (Talukdar, 2021). The government has also launched Covid Suraksha App for monitoring the home quarantine and reaching out to the patients (DEB, 2020).

To broaden the social welfare net, the state government started providing Rs1000 for the families not being covered under National Food Security Act, 2013, and local Institutions and urban local bodies were given the responsibility of identification of right kind of benefits and proper distribution of monetary assistance (Paul, 2020). To outreach the migrants and patients stranded outside of the state, a very unique kind

of initiative called the Assam Cares Outreach Program was taken by the then Health Minister Himanta Biswa Sarma. Under this initiative, the administrations reached out to migrants to provide monetary assistance to the lakhs of Assamese people, particularly patients (who wish to return their homes) and were stranded outside the state (Saha, 2020). Through this program, the administration was able to assess the total number of patients located stranded outside the state, mapped them, and created a database system by collecting relevant information such as their travel history and medical history, financial status to track their real-time movement (Northeast, 2020).

4.4 Three 'S' Formula i.e. Surveillance, Segregate and Save the Lives

A massive community surveillance program has been initiated by the health department of Assam by deploying the Accredited Social Health Activist (ASHAs), Auxiliary Nurse Midwives (ANMs), Anganwadi Workers (AWWs), and Village Pradhans along with doctors, community health officers, and lab technicians (WHO-India, 2020). This is popularly known as the Infectious Disease Surveillance Program (IDSP) Team working with the support of local administration. Their key responsibilities include taking random samples of people for the COVID-19 test, spread awareness using ICT while conduct door to door surveys for the identification of diseases other than COVID-19 such as Severe Acute Respiratory Infections (SARI), Influenza, Japanese Encephalitis, fever and malaria. Because of this mass surveillance program, the health department has covered more than 30,000 villages across the state and detected the diseases at the earliest. This program is also known as COVID-19 Plus and was executed with the help of the World Health Organization (WHO-India, 2020). Screening teams took random samples of people who are at a high risk of exposure to COVID-19 like marketplaces, bus stands, police personnel, etc., and conducted door to door surveys. Once the symptoms got detected, they immediately segregated them and began the treatment on the severity level of the patients (Partnership, 2020). As some prominent health experts stated that *"while conducting door to door surveys it has been noticed that people are suffering massively from other diseases as mentioned above consequently state administration intervened immediately and started segregating these people who are very vulnerable and prone to COVID-19. In the initial phase, we collected more than 50000 samples within 10 days. Indeed, it has improved that confidence among the common people by reaching out to them at the earliest".*

Owing to the success of community surveillance in the earliest detection of the symptoms, the government has extended the program as Assam Target Surveillance Program (ATSP) and collected COVID test samples at multiple levels such as a) truck parking and unloading bays including rail yard, god owns, etc. b) Hotel Staff where people are being quarantined c) family members of the health and frontline workers (DHFW, 2020). Lastly, it has generated huge relevant data that helped the experts, administrators, and policymakers to strategize the future course of action and extend the capacity and capability of the health infrastructure and judicious use of limited resources in a more systematic manner.

Non-Government Organizations in collaboration with the state government, are helping the government of Assam in the implementation of various schemes. For instance, remote health care advisory interventions through a project Sarathi, a dedicated telephonic health information system started in 2010, and the child development call center to provide healthcare-related information for pregnant women (Health and Family Welfare, 2021).

Sanjeevni mobile medical care unit in collaboration with the government of Assam were set up to provide healthcare services along with basic lab testing checkups to the rural people (Health and Family Welfare, 2021). Likewise, Oil India Limited, in partnership with Piramal Swasthya, has also supported Mobile Medical Care through its initiative called Sparsha and made primary healthcare services accessible to the vulnerable sections of the society (The Sentinel of the land, 2019). Piramal Foundation, in collaboration with NITI Aayog's aspirational district initiative, is striving to promote and strengthen health and nutritional parameters and also disseminating information about the covid-19 pandemic (CSR, 2019).

4.5 Production and Procurement Strategy

As far as the availability of oxygen and essential medicines like Remdesivir is concerned, the Assam Government has put a very sound procurement policy in place. It has increased its production capacity and also mandated private producers like Premier Cryogenics Ltd to expedite oxygen production by providing all kinds of materialistic and logistic support. There are a total of 10 oxygen plants in operation in the state with a capacity of 67MT production per day (Desk, 2021). Because of this Assam's storage capacity has increased to 468MT since then and it has been increasing making it a surplus state and

even supplying oxygen to neighboring states as well such as Meghalaya, Arunachal Pradesh, Manipur, Mizoram, Tripura and Nagaland (Times, 2021). Concerning the availability of essential medicines like Remdesivir injection, the health department has regulated very strictly and ensured adequate availability of Remdesivir Injection. In one of his interviews, the then Health Minister Himanta Biswa Sharma stated that "the health department has a stock of 25000 of Remdesivir Injection while 1000 kept for non-Assamese people" (Bureau, 2021).

On the other side, the experts and policymakers have stated that the Assam model has been successful considerably because of previous policy initiatives like Ruthless Quarantine Policy, Assam Cares Programme, Assam Target Surveillance Program (ATSP), and Infectious Disease Surveillance Programme (IDSP), and so on (Das, 2020). This has increased the capacity and capability of health infrastructure and health workers along with local administration. That's why they can detect the symptoms at the earliest before it could become a severe case and reduce the burden on health infrastructure. Lastly to equip with and to respond effectively, Assam is the first state which has imported 50,000 Personal Protection Equipment (PPE) kits from China at the earliest (DEB, 2020).

4.6 Complex Disaster Scenario in Assam

Assam battled the fury of the devastating floods and the COVID-19 Pandemic together in the year 2020, hence twinning the burden on the health infrastructure (Simonovic et al., 2021). Assam floods, 2020 affected about 5474 villages, 5 million people and killed 149 people (ASDMA, 2020). Further, floodwaters also washed away the bridge connecting Doomdooma to Baghjan, increasing the vulnerabilities of the 2500 families already affected due to the Baghjan oil field fire (Akhtar, 2020). The floods also exacerbated the systematic risk (like Japanese Encephalitis that affected about 318 people and killed 51 as of September 9, 2020) and cascading risk (like landslides) (Karmakar, 2020).

4.7 Relief and Recovery Efforts by the Government of Assam

Assam State Disaster Management Authority (ASDMA) set up about 1662 relief distribution centers and 627 relief camps as per the COVID-19 protocols (ASDMA, 2020). The government also issued new guidelines for reducing the capacity of relief camps and ensuring food and safe drinking water facilities (The New Humanitarian, 2020). NGOs like Red Cross India, Oxfam India also supplied tarpaulin sheets, food,

water, and other relief materials to the relief camps (ICRC, 2020). Compensation schemes, embankment and flood risk reduction program of ASDMA in collaboration with the World Bank and Asian Development Bank are included under ASDMA's post-disaster response (ADB, 2020). However, despite the efforts of the state government; the complex disaster scenario increased the socio-economic vulnerability of 70% of the agriculture-dependent population in Assam (ASRLM, 2020).

5. Challenges

Floods in Assam increased the risk of diseases like dengue, malaria, and Japanese Encephalitis. COVID-19 fear acted as a barrier to treat these diseases as efforts to destroy the mosquito breeding sites were being hindered (IFRC, 2020). Also, infrastructure failures, lack of awareness among the communities in rural Assam and following COVID-19 protocol in the flood scenario obstructed the efforts of the health care workers (Choudhury, 2020). Children and women were the worst affected by the floods amidst COVID-19, inaccessibility to clean water and sanitation facilities emerged as a major challenge (UNICEF, 2020). Also, the reluctance of the community in relocating to the relief camps due to the fear of being infected with COVID-19 also delayed the relief efforts (The Guardian, 2020). Akhtar (2020) stressed on the less disaster preparedness level of the state in managing floods despite being highly vulnerable to it and the lack of a multi-hazard approach which pushes the state to the brink of socio-economic ruin.

The frontline workers; Accredited Social Health Activists (ASHAs), Auxiliary Nurse Midwives (ANMs) and Anganwadi Workers (AWWs)have been working tirelessly during the COVID-19 outbreak to limit the spread of the virus. Many of them have lost their lives in serving the community. Despite their valuable contribution, they are not being looked after well and are deprived of the facilities like sanitation and hygiene, food, water and insurance. They are not only underpaid but heavily overworked which makes them even more vulnerable (Kabra, 2021).

6. Recommendation

A multi-hazard approach at the implementation level in dealing with different disasters simultaneously is the need of the hour. Also, coordination and partnership with the

various non-governmental organizations (NGOs), community based organizations (CBOs), and civil society organizations (CSOs) need to be properly managed over a platform. It should be mandatory for the hospitals and healthcare facilities to have operational disaster management plans with clearly mentioned standard operating procedures (SOPs) to manage complex hazard and mass casualty scenarios. Regular check-ups and assessments by the concerned officials need to be conducted.

It is seen that addressing the grievances of the community health workers (ASHA, ANM, and AWW) is more of a 'lip service'. We do not have a robust and accountable Grievance Redressal System. Due to COVID-19, the responsibilities of the community health workers have increased many folds and so are the challenges they are facing. Presently, there is not a combined feedback system available for these Frontline Workers, hence there is a need to have a combined 'Social Listening System' where their grievances can be communicated and truly worked upon.

7. Conclusion

COVID-19 has posed unprecedented challenges in Assam and the second wave has aggravated the situation further. Earlier the health of COVID patients deteriorated after 4 to 5 days in the first COVID-19 wave but in the second wave, it was within 24 hours. The third-wave of COVID-19 is predicted to cause insurmountable challenges for the healthcare sector. Therefore, it requires strategies for policy action and long-term planning after taking lessons from the challenges faced in the response efforts during the pandemic in the time period from March 2020 to May 2021.

The Assam model has been acknowledged by health experts, policymakers, and administrators and it has become a source of inspiration for other states as well. Assam government's three T's (Test, Treat, Transport) formula, ruthless quarantine policy, programs like Assam Cares Outreach Program, COVID-Plus and Infectious Disease Surveillance Program helped to reduce the spread of the virus. The role of non-governmental organizations cannot be under-estimated and they have played a key role at all levels right from the preparedness level, execution of the plan, and monitoring and surveillance as well. Various initiatives such as project "Sarathi", Sanjeevi Mobile Healthcare Unite, Project Sparsha, and in collaboration with NITI Aayog's aspirational district, etc. are being acknowledged by the people of all walks of life. But still, lots need

to be done as far as COVID-19 is concerned. Moreover, there is a need to follow the multi-hazard approach to effectively manage complex disasters and the need to have Hospital Disaster Management Plans in place to manage the mass casualty scenarios.

Building capacity and capability of health infrastructure is a prerequisite to fight against the deadly COVID-19 along with effective risk communication to their people. The ongoing pandemic has shown the commitment of our doctors and frontline workers and their service towards humanity. There is a saying that there is no health without health workers and COVID-19 has taught a lesson that a resilient health system can be achieved through its strong health workforce. Therefore, to equip them with the latest tools and technologies, train them and protect them is the need of the hour not just amidst the ongoing pandemic but for the future as well. It is high time to introspect the challenges faced, learn the lessons and ramp up the preparedness and response efforts to create a culture of safety and resilience.

Acknowledgement

This study "Assam Model of COVID-19 Response: Strategies, Challenges and Way Forward" is the outcome of the generous help and support by a large number of personalities and we are deeply indebted to all of them. Our sincere thanks to all our family members for their trust and cooperation!

References

1. Agarwala, T. (2020, June 8). Assam gas leak: Why it's tough to plug, and what threat it poses to the area. The Indian Express. https://indianexpress.com/article/explained/assam-gas-leak-why-its-tough-to-plug-and-what-threat-it-poses-to-area-6447810/
2. Akhtar, M. (2020, July 2). As floods wash over Assam, state government left facing a Cascade of disasters. The Wire. https://thewire.in/environment/assam-floods-covid-19-japanese-encephalitis
3. Asian Development Bank. (2021, April 26). 38412-033: Assam integrated flood and riverbank erosion risk management investment program - Project 2. https://www.adb.org/projects/38412-033/main
4. ASRLM. (2020). Livelihoods Tracking System | Assam State Rural Livelihoods Mission (ASRLM). https://assamlivelihoods.in/agriculture.aspx
5. Assam budget analysis 2020-21. (2021). PRS Legislative Research. https://prsindia.org/budgets/states/assam-budget-analysis-2020-21
6. Assam state disaster management authority. (2020). Assam Disaster Management Authority. https://www.asdma.gov.in/cumulative_reports.html
7. Bhattacharjee, J. (2020, April 20). COVID19: The state of health care facilities in India's north east. ORF. https://www.orfonline.org/expert-speak/covid19-the-state-of-health-care-facilities-in-indias-north-east-63889/
8. Bureau, P. (2021, April 26). Assam Has 25,000 Doses Of Remdesivir: Himanta. Retrieved from Time
9. Census of India Website : Office of the Registrar General & Census Commissioner, India. https://www.censusindia.gov.in/vital_statistics/AHSBulletins/AHS_Factsheets_2011_12/Assam_Factsheet_2011-12.pdf

10. Choudhury, R. (2020, July 23). Assam health workers “Borrow” Boats to reach to flood-victims amid COVID. NDTV.com. https://www.ndtv.com/india-news/assam-floods-health-workers-borrow-boats-to-reach-out-flood-victims-2267910
11. Choudhury. (2020, April 1). Assam’s first COVID-19 patient visited Delhi’s Nizamuddin, avoided tests. NDTV.com. https://www.ndtv.com/india-news/coronavirus-pandemic-assam-first-covid19-patient-had-visited-delhi-nizamuddin-avoided-tests-2203907
12. CSR, I. (2019, June 19). Piramal Foundation Partners with Assam Govt to Improve Quality of Education in 5 Aspirational Districts.
13. Dowerah, S. (2020, April 5). Coronavirus outbreak: Led by HimantaBiswaSarma, Assam medical fraternity takes a LEAP of faith in fight against COVID-19-Health news ,Firstpost. Firstpost. https://www.firstpost.com/health/coronavirus-outbreak-led-by-himanta-biswa-sarma-assam-medical-fraternity-takes-a-leap-of-faith-in-fight-against-covid-19-8224021.html
14. Dutt, B. (2021, April 17). India’s health system has collapsed. Hindustan Times. https://www.hindustantimes.com/opinion/indias-health-system-has-collapsed-101618558934636.html
15. Dutta, A., & Fischer, H. W. (2021). The local governance of COVID-19: Disease prevention and social security in rural India. World Development, 138, 105234. https://doi.org/10.1016/j.worlddev.2020.105234
16. DEB, R. (2020, June 23). “The Assam model”: The fight against Coronavirus that nobody is talking about. Observer Research Foundation .
17. Desk, S. D. (2021, April 21). Assam Health Minister Offers Remdesivir Vaccine to Northeastern States, Says 25,000 Vials in Stock. Retrieved from The Sentinel of this land, for its people .
18. DHFW. (2020). A Targeted Surveillance Drive in the name of Assam Targeted Surveillance Program. Guwahati: Govt of Assam.
19. First corona case in Assam: 52-year-old tested positive in Silchar medical college. (2020, March 31). Barak Bulletin. https://www.barakbulletin.com/en_US/first-corona-case-in-assam-52-year-old-tested-positive-in-silchar-medical-college/
20. The Guardian. (2020, July 20). Flooding in Assam and Nepal kills hundreds and displaces millions. the Guardian. https://www.theguardian.com/world/2020/jul/20/flooding-assam-nepal-displaces-millions-coronavirus
21. Guha, N. (2020, July 30). Assam reels under flood as pandemic wears on. The Wire Science. https://science.thewire.in/environment/assam-floods-covid-19-pandemic/
22. Health and Family Welfare, Government of India (2021). National Health Mission. Retrieved from https://nhm.assam.gov.in/.
23. Health and Family Welfare, Government of India (2021). Sarathi-’104’. National Health Mission .
24. Health and Family welfare, Government of India (2021). Sanjeevani - Village Health Outreach Programme. National Health Mission .
25. IFRC. (2020). 17.5 million affected by floods and threatened by disease in South Asia - India. ReliefWeb. https://reliefweb.int/report/india/175-million-affected-floods-and-threatened-disease-south-asia
26. India’s Northeast faces ‘twin disasters’: Floods and the pandemic. (2021, April 29). The New Humanitarian. https://www.thenewhumanitarian.org/news/2020/07/01/India-Assam-floods-coronavirus
27. International Committee of the RED Cross. (2020). Supporting communities affected by floods in Assam - India. ReliefWeb. https://reliefweb.int/report/india/supporting-communities-affected-floods-assam
28. International Institute of Population Sciences. District Level Household and Facility Survey. Assam: 2010. Available from: www.mohfw.nic.in
29. Kabra, A. (2021, March 25). Assam assembly election 2021: Women healthcare workers rue meagre salary and lack of facilities, say let down by successive govts-politics news ,Firstpost. Firstpost. https://www.firstpost.com/politics/assam-assembly-election-2021-women-healthcare-workers-rue-meagre-salary-and-lack-of-facilities-say-let-down-by-successive-govts-9459301.html
30. Kalita, P. (2021, January 30). Assam spends more on healthcare than many rich states | Guwahati news - Times of India. The Times of India. https://timesofindia.indiatimes.com/city/guwahati/assam-spends-more-on-healthcare-than-many-rich-states/articleshow/80603895.cms
31. Karmakar, S. (2020, September 23). Over 50 die in Assam due to Japanese encephalitis. Deccan Herald. https://www.deccanherald.com/national/east-and-northeast/over-50-die-in-assam-due-to-japanese-encephalitis-891957.html
32. Kalita, P. (2021, April 7). WHO features Assam’s Covid-19 frontline workers.Times of India .
33. Ministry of Statistics and Program Implementation | Government Of India. https://www.mospi.nic.in/
34. Ministry of Health and Family welfare. District-wise availability of health centres in India as on 31st March, 2017. Goverment of India. Delhi: 2019. Available from: https://data.gov.in/resources/district-wise-availability-health-centres-india-31st-march-2017

35. Mishra, P.K. and Singla, A. (2020) Public Healthcare and Governance: Two Wheels to Ride the Cart against Covid-19 Pandemic. Disaster and Development (NIDM) 9 (1):Pp 1–18, ISSN: 0973-6700.
36. National Informatics Centre. (2021). Covid 19 Dashboard – Government of Assam. https://covid19.assam.gov.in/
37. Northeast, N. T. (2020, April 18). State Govt reviews Assam Cares Migrant Outreach Programme Scheme.
38. Partnership, U. H. (2020, June 7). From governance to community surveillance: Assam's 360 degree COVID-19 response. Retrieved from Universal Health Coverage Partnership.
39. Paul, S. (2020, June 28). How Assam is holding out against Covid-19. Indian Express .
40. Priyankaraj. (2020, June 10). Poor health care infrastructure, lack of doctors has made COVID-19 pandemic so worse in India. Inventiva. https://www.inventiva.co.in/stories/priyankaraj/poor-health-care-infrastructure-lack-of-doctors-has-made-covid-19-pandemic-so-worse-in-india/
41. PRS. (2020, May 6). Assam government's response to COVID-19. PRSIndia. https://www.prsindia.org/theprsblog/assam-government%E2%80%99s-response-covid-19
42. Saha, A. (2020, April 24). 'Assam Cares' initiative to aid stranded residents 'one of the largest', claims HimantaBiswaSarma. Indian Express .
43. The Sentinel of the land, f. i. (2019 , Dec). Seven mobile medical vans launched under Project OIL SPARSHA. .
44. Simonovic, S. P., Kundzewicz, Z. W., & Wright, N. (2021). Floods and the COVID-19 pandemic—A new double hazard problem. Wiley Interdisciplinary Reviews: Water, 8(2), 1–18. https://doi.org/10.1002/wat2.1509
45. Sub-national HDI - Subnational HDI - Global data lab. (2018). Global Data Lab - Innovative Instruments for Turning Data into Knowledge. https://globaldatalab.org/shdi/shdi/
46. Talukdar, S. (2021, May 21). Assam: Rapid rise in COVID-19 cases. Frontline.
47. Times, T. S. (2021, May 17). Assam supplying oxygen to Meghalaya, other NE states: Himanta. Retrieved from The ShillongTimes .
48. UNICEF. (2020). Millions of children affected by devastating flooding in South Asia, with many more at risk as COVID-19 brings further challenges. https://www.unicef.org/press-releases/millions-children-affected-devastating-flooding-south-asia-many-more-risk-covid-19
49. The World Health Organization (WHO). (2020, December 9). From governance to community surveillance: Assam's 360 degree COVID-19 response. WHO | World Health Organization. https://www.who.int/news-room/feature-stories/detail/from-governance-to-community-surveillance-assam-s-360-degree-covid-19-response
50. WHO-India. (2020, June 22). Community Surveillance Programme launched in Assam to contain COVID-19.

Impact and Aftermath of the Deepwater Horizon Oil Spill, 2010

Aastha Agarwal[1], Soham Chakraborty[2]*, Shivangi[3]

Abstract

The 2010 deepwater horizon oil-spill in the Gulf of Mexico is one of the worst ecological disasters in history. The spill of crude oil from the uncapped well for more than two months is believed to have led to death of countless marine organisms including endangered species of birds, turtles, marine mammals, pelagic organisms, corals and many more. Countless other organisms permanently lost their natural habitats. The disaster also led to direct and indirect impacts on human life in terms of deaths, illnesses, loss of livelihood, etc. The effect of some of which persists even after 11 years. This paper looks at the disaster from a development perspective, taking into account all the factors which led to creating the situation which caused the event and all which affected the aftermath. The paper also attempts to start a discussion on industrial ecosystem and offshore drilling and renewable vs. non-renewable energy debate.

Keywords: *Oil-spill, Deepwater Horizon, off-shore drilling, development, environment*

1. Introduction

Off-shore oil drilling has been a steady source of crude oil and natural gas extraction since the late 19thcentury. The 2011 consumption of petroleum and gas amounted to 7362.2 billion tonnes per year (Schröder, 2011). There are1,470 off-shore rigs around the world out of which 213 rigs are in the Gulf of Mexico (Brixey-Williams, 2015). It is now widely acknowledged that off-shore drillings are a threat to the environment. These drillings are major contributors to oil spills witnessed across the world. On 20 April 2010, the Deepwater Horizon explosion, which was responsible for an environmental

[1] **Aastha Agarwal,**Climate Research Analyst, ISS ESG Goregaon, Mumbai
[2] **Soham Chakraborty,** Senior Research Assistant, Public Health Foundation of India, Plot No. 1, A N V Arcade, Amar Co-operative Society, Kavuri Hills, Madhapur, Hyderabad-500033
* Corresponding Author Email: Sohamayan@gmail.com
[3] **Shivangi,** Communication Animator, Centre for Environment Education, Thaltej Tekra, Ahmedabad-380054

disaster and the death of 11 people, is unparalleled in the US history; 4.9 million barrels of crude oil into the Gulf of Mexico was released from the oil spill (Mendelssoh net al., 2012). The effect of this disaster was severe on nature as well as human beings, but its cause was not natural at all. The whole environmental sensitive region of the Gulf of Mexico was contaminated with crude oil affecting deep-ocean communities and over 1,600 kilometres of shoreline. Multiple species of estuarine organism, tidal and pelagic organisms, marine mammals, sea turtles, migratory birds, sea birds were affected. Over 20 million hectares of the Gulf of Mexico was closed for fishing (Barron, 2012). Regulatory and technological failures were widely understood as gaps that led to the disaster. The immediate cause being the Blowout Preventer (BOP) failing to operate properly as it had a faulty design and was not properly checked. The concept of hollow government had influenced the aftermaths of the explosion (Sidney and Shapiro, 2007). This can be seen as one of the best examples of the inefficiency of the industrial ecosystem.

2. The Deepwater Tragedy

The Deepwater Horizon oil well was built in 2010 in the Gulf of Mexico, 50 miles off the Louisiana coast, to drill the first oil well in the newly discovered Macondo Oilfield. It was a semi-submersible rig, sized 400 feet long, 250 feet wide, and stood 14 stories tall built by Hyundai Heavy Industries (Republic of the Marshall Islands, 2011). It was designed to withstand heavy weather and operate in the extreme deep-water environments.

According to reports, on April 20, 2010, the workers at the rig drilled the Macondo Oil well to its final depth at 18,000 ft. Instantly, a dangerous build-up of methane gas rose to the surface from the well. This led to a sudden explosion. Even after several attempts to operate the Blowout Preventer (BOP is a critical safety component designed to shut off the well in the event of any accident or unprecedented event), all efforts failed. At about 10 p.m., a series of explosions ripped through the rig, killing 11 workers and injuring 17 others (Barron M, 2012). Fire raged unabated for almost two days, as emergency teams raced to the site and poured seawater on the blaze. Despite all the efforts, the rig sank to the bottom of the Gulf and plunged to the muddy seafloor 5,000 feet below on April 22, 2010 (Brenner et al., 2010).

Reports have shown that, initially, the only sign of damage was a thin slick of oil spreading across the water. For the first few days, the U.S. Coast Guard reported that the

Deepwater Horizon was not leaking any oil or gas. Soon, thick, orange-brown crude oil began emerging at the ocean's surface (Jernelov A, 2010).

Over the course of 87 days, the ignored and unattended Macondo oil rig, which was located at 5000 feet depth in the Gulf, kept leaking oil which floated on the surface of the water- making the spill the largest in world history (Smithsonian, 2018). The spread of the oil spill kept expanding pushed by winds. After several efforts from the B.P. to clean the mess, they had created, it took 87 days to finally cover the most disastrous well after it had spewed over 205 million gallons (4.9 million barrels) of crude oil which affected over 600 miles of beaches and wetlands spread across five states of the U.S. (Mendelssohn et al., 2012). On August 5, 2010, the well was contained and plugged with cement.

After numerous investigations, it had been confirmed that the possible causes of the failure were: inadequacy of the design of the rig; lack of backup in the BOP, which was supposed to be installed as a safety measure; and the BOP lacked a remote or trigger to control the device in such cases (BOEMRE, 2011 and Deepwater Horizon Joint Investigation Team Releases Final Report, 2011).

According to several reports, during the oil spill, approximately 180-185 million gallons of crude oil was poured into the Gulf of Mexico (Barron M., 2012). During the EV (Exxon Valdez) accident of 1989 total of 11 million gallons of crude oil was released in less than five hours in Prince Williams Sound (a sound of Gulf of Alaska) (Carson, Mitchell, Hahnemann et al., 1992). In other sense, the oil spill of Gulf of Mexico, 2010, recorded 17 times more destructive than EV.

3. Impacts of the Oil Spill

The oil which was spilled from the oil field was crude oil, which constitutes of hydrocarbons. According to studies, when this oil enters the environment through spill or rupture, it undergoes continuous compositional changes associated with weathering. Weathering of crude oil changes its physical and chemical properties making it more viscous. Spilled oil has the potential to cause environmental damage like ingestion, absorption of the marine biota, coating and layering in the water, which prevents permeability, depletion of oxygen by rendering microbial processes of the flora-fauna (USEPA, 1993). According to reports, when the spilled oil came in contact

with the marshes present at the shoreline, the nutrient cycling of the marshes was altered, resulting in eutrophication. The primary marsh types that were affected in the oil spill were the salt marshes, black mangroves and the common reeds of the shoreline. Even after a year of the disaster, there was minimal recovery observed on the shorelines (Shirley et al., 2010).

Studies and reports have shown that the oil spill caused devastation at all micro and macro-level ecosystems while affecting the sensitive biodiversity of the region. One of the major destructions was observed to the benthic fauna present in the Gulf. Due to the layer of oil spread over the surface of water, the permeability of sunlight was hindered, which is the only source for oxygen for the marine life was compromised due to the coating of oil. Experts had mentioned that an oil spill of such magnitude was bound to cause detrimental effects in the marine life for years. Moreover, the clean-up strategies used to contain the oil spread resulted in creating a greater havoc than oil spill alone. Studies have shown that the addition of dispersants to coagulate the surface oil led to the harming of the marsh benthic community. The oil spill affected large epi-fauna such as fiddler crabs, oysters, periwinkles, mussels, etc. Fiddler crabs are most sensitive to oil toxicity, whose numbers saw a decline after the disaster also affected the economy of fisheries (Mendelssohn, I. A, et al., 2012). In addition, the spill overlapped with the spawning periods of the fishes that were of importance to the coastal fishermen for imports and exports. Large number of eggs and larvae were harmed and killed during this time. In addition, zooplanktons, microscopic marine organisms, showed oil contamination and a majority of the corals showed signs of stress response that were exposed to the spilled crude oil. Almost 86% of the coral colonies had showed signs of the impacts out of which, 45% were severely affected resulting in the bleaching of the corals (White H. et al., 2011). The most vulnerable and severely affected coral species was the Lophelia corals that are found in deep-sea ecosystems (Norse and Amos, 2010). The presence of crude oil around the coral communities was proven with the discoloration of the corals and the impacts could be seen by the visible unhealthy colour of the corals (Gulf Oil Spill, 2018). The spill had covered up to 11 km coverage radius spreading across all the corals present within the mentioned diameter (Norse and Amos, 2010).

Studies have also shown that the large amount of methane gas released in the spill did not escape into the atmosphere; rather it got dissolved with the water molecules, hence consuming the already limited oxygen supply present in the ocean. The presence

of methane gas in water led to the slow degradation of the oil which later formed dead-zones that were devoid of oxygen leading to no fishes or mammals to eat them (White et al., 2012). Moreover, the deliberate effort to disperse the spread oil to wider extents in order to minimize the intensity over one area, left the marine fauna with nowhere to escape the breach. Seabirds were distinctively harmed by the crude oil spread. The US Fish and Wildlife Service (FWS) recorded the number of deaths in the surrounding fauna due to the disaster (Jernelov A., 2010). They presented data representing oil slicked birds- pelicans, northern gannets, laughing gulls; and corpses of oil-coated turtles washed off at the shores. Bottlenose dolphins were also amongst the victims of the disaster. Studies have shown dolphins were found to be underweight along with many other health issues like lung diseases or liver infections, anaemic, deceased level of hormones that regulates their immune system and effected their metabolism too (Cleveland et al., 2011). Neo-tropical birds such as mockingbirds, warbles, orioles, flycatchers and swallows that made a stop at the Gulf of Mexico, were possibly impacted due to the smoke that fumed out the burning oil leading to their deaths and migration declination (Cleveland et al., 2011).

The Deepwater Horizon Oil Spill had also altered the ecosystem services that involved humans. Studies and reports have shown that the communities residing along the coast was also impacted heavily due to the disaster. The impact of oil spill on the coastal marshes rendered the ability of the marshes to carry out the ecological services. Coastal marshes are a very important component of the ecosystem, as they act as storm and flood barriers. They bind soil and promote nutrient cycling, producing a rich biodiversity. They form a major part of the food web, which is beneficial to humans in the form of commercial and recreational fisheries. The loss of coastal marshes mostly affected the local community who were dependent on the mangroves that prevailed all over the shorelines of the Mississippi (Mendelssohn, I. A, et al., 2012). The workers involved in the clean-up of the coastline, were found to be impacted with upper respiratory tract illnesses, throat and eye irritation, headaches, dizziness, nausea, and vomiting (Smithsonian, 2018).

The livelihood of people who were depending on the sea for earning lost it forever. High unemployment was recorded in the four affected states viz. Louisiana, Alabama, Mississippi, Florida. In addition to this, workers like oyster harvesters, crabbers, shrimpers, fishermen, charter-boat operators faced economic crisis too (Clifford, 2010).

Even the Gulf coast vacation rentals and other businesses are influenced because of loss of tourist during their peak season. The revenue was found to drop down by 90 percent when compared to 2009 statistics (Butler and Sayre, 2010) it was a complete down free fall of the economy of the area. Without any significant support or compensation by governmental agencies or BP, many fishermen and boaters were forced to sell their boats and work as clean-up workers (Butler and Sayre, 2010).

4. Aftermath of the Spill

4.1 The Clean-up

For many days, local environmental conditions such as water currents, tides, waves, wind speed and direction, water temperature and air temperature added to the spreading of oil over the water surface. The methods adopted by the clean-up workers were the use of floating brooms, skimmers and boats that skim spilled oil from the water surface. The focus was to clean the shorelines first to prevent the oil from reaching the beaches (Butler S., 2011). Further sorbents and dispersants were used which were added to the water to contain oil. Dispersants were sprayed from above onto the water surface to speed up the degradation of spilled oil (Guarino M., 2010). Reports stated that this clean-up technique had more disadvantages than its merits. The sprayed chemical dispersant entered the food chain, which harmed the marine life eventually (Chapman et al., 2007). Many researchers suggested that the technique of dispersant addition to the sea did not result in lessening the amount of damage caused by the oil spill (Chang et al., 2014). In addition, only some large sized wildlife species were rescued and rehabilitated, but many micro-sized, essential species were left out.

4.2 Investigation on British Petroleum (BP)

The Deepwater Horizon disaster was not an isolated disaster or accident in the history of Beyond Petroleum. Reports have shown that BP was involved in a lot of accidents from its past with the first being an accident which took place in 1965 where thirteen people from the crew lost their lives when an oil rig called Sea Gem collapsed whilst being moved (Gribben Roland, 2010). Another disaster under the governance of BP took place in 2005, although this was not an offshore accident. 15 people lost their lives and about

170 people were injured in this disaster, which took place in Texas. Because of these and others, around this time, BP came to be known as environmentally unsustainable. BP has also been accused of having the worst safety records when talking about oil companies in the US (Smithsonian, 2010). In the case of Deepwater Horizon Oil spill, a Congress Investigations team criticized BP for ignoring the preliminary signs of trouble and ignoring a series of equipment failures. It was found that BP had cut down its security costs, adding to the dangers of the disaster (Gribben, Roland, 2010). This lack of preparedness has often been linked with the budget cuts of 2009 as mentioned above.

4.3 Changes in Policy Frameworks

Unsustainable oil exploration and oil spillage can affect the environment; it threatens human life and results in violation of various interrelated national, regional and international codes. This event led to the intervention of the US Environmental Protection Agency (EPA) to take several activities in response to the spill and formulate stringent additions to the pre-existing laws (AED, 2016). The global community, post the incident, had learned that there must be stringent policy changes and there should have been more focus on Environmental Impact Assessment (EIA) (EPA, 2010). The existing relevant policies were made stricter with strict laws holding them together. There had been suggestions to create an Ocean Energy Safety Institute within the energy department and which would have had ties to the Navy. The oil spill commission had also proposed the formation of an independent body to take care of such accidents. This independent body would take care of all the governmental regulations and broader administrative and legal reforms (EPA, 2010).

5. Development and 'The' Disaster

The greed of mankind intertwined with unsustainable methods of development has had a cumulative effect, which led to the conditions being so poor. Each year the demand for natural oil and gas has been rising. In 2011, only a year after the disaster, the petroleum consumed by U.S was 814 billion tonnes and the global total was 4044.9 billion tonnes. The global consumption of natural gas was 3317.3 billion tonnes. Most of this was consumed by the industrial sector and power generation sector across the world (Schröder, 2011). Developed countries like the United States and United Kingdom,

which take pride in their low population density and higher use of renewable resources consumed more than 20% of the total fuel extracted (Schröder, 2011). This staggering amount of increase in oil extraction is bound to lead to mishaps happening all the time. As development progresses, it should be kept in mind that proper governance is maintained. Corporates like BP and the government together should be responsible to tackle safety measures in order to attain development.

When looking at it from a development perspective, the blame has to be unburdened from the shoulders of the corporate in-charge and has to be distributed amongst the entire industrial ecosystem. Here the demand of unsustainable development has to be taken into account. The concept of Hollow Government (Sidney A. Shapiro, 2007) where third parties do the work of governments has to be checked too. Law and policymaking should be strictly controlled by a firm government. BP was blamed and it can be seen how the snowballed effect of irregular governance led to the disaster. Instead of only putting the officers on duty in trial, it also has to be ensured that the bosses get the equal blame and conviction. Tremendous pressures by upper-level employees to ensure higher rates of oil extraction should be taken into account. Along with BP, there were several other oil excavations which were taking place on the Macondo site where the disaster took place. Some scientists have also accredited those to be a driver behind the pressure created in the area.

As far as future development is concerned, the Deepwater horizon disaster has posed serious challenges to the proponents of development. The first and foremost is the identification of early warnings before a disaster. As the systems approach states, ecological, social and built environment has to be in sync to prevent a disaster from happening (Simonovic S., 2015). When any of these three gives a warning, it should be taken into consideration. Flournoy has stated that risk is not uniform in its perception (Flournoy, 2011). In this context, while thinking about development, the amount of risk, which can be allowed, has to be fixated. While thinking about development, it should also be noted that Deepwater horizon could have been avoided if there were adequate resources, proper infrastructure and safety measures. The proponents of development should look at building proper physical infrastructure to withstand all kinds of hazards.

6. Discussion and Recommendations

Instances of anthropogenic disasters, like the Deepwater horizon oil spill, force us to look at the development from a different lens. The lens of those who have suffered and have borne the whole cost of such disaster/accidents whilst losing all sources of livelihoods; their home and forced to live somewhere else leaving their identities behind rather than of those whose greed increase day by day.

This oil spill raises several questions about the prospects of further heavy amounts of drilling. Whether this should be continued or should there be more investments on renewable and sustainable energy is a huge concern. The debate here is that can huge investments in renewable energy instantly bring significant changes. The answer is always a maybe. Bringing such huge amounts of change can even yield catastrophic results. The first reason is that the investments that have to be done will have to be humongous. It is evident that renewable energy generators like solar cells and windmills need a high number of resources to properly function and function efficiently. There will also be an issue of acceptance by communities and industries that will be sceptical towards renewable sources of energy. Therefore, one can rule out the possibility of instant change. Instant change will also put millions of people out of work. Therefore, while debating about more investment, one should also consider the negative impacts of it. The gradual shift to sustainable energy, on the other hand, can prove to be quite important. The gradual change can ensure safe shift towards sustainability. This will also decrease the risk of such disasters to lower amounts. Malfunctions and hazards can stay persistent, especially in high power generation areas like hydropower projects, but these will not have an enormous impact on the environment. Furthermore, these accidents can also be avoided with proper governance structures and safety measures in action. Increasing amounts of disasters like the Deepwater horizon does bring up serious questions on drilling and extraction of oil. However, if the concepts of sustainable development are to be followed, these increased amounts of energy extraction from Earth can be divided into two parts, one for immediate development and one part to develop for the future. For the second part, the energy can be used to bring up more and more harnesses of renewable energy and new ideas on how to make renewable energy more efficient. The investments on sustainable energy thus should gradually build up the potential of sustainable energy rather than pouring itself on existing technologies of renewable energy. Here, governance plays an important role in control and the building

up of potential. If both the things are balanced properly, there can be a steady shift to renewable energy and this will take some heat off the extraction of non-renewable energy. This will release the pressure and might prevent such further catastrophes (Waghorn T., 2018).

7. Conclusion

In the contemporary scenario, the offshore drilling is much more frequent and is done to even greater depth of the seabed. Since the Deepwater horizon oil spill, 2010, the federal government has approved more than 20 ultra-deep water drilling expeditions. According to Eileen P. Angelico, the Bureau of Safety and Environmental Enforcement (BSEE), a lot has been done to make off-shore drilling safer in the Atlantic and the Arctic Ocean but the Environmental activist argues that not enough has changed in the way the federal government sees the drilling (Worland J., 2015). The offshore incidents include fires, oil spills and explosions has remained high over the past few years. There have been approximately 3,200 incidents and 32 deaths in the last five years and in addition to this, many spills also go unreported (BSEE, 2019).

What the authors and scholar and safety professionals have suggested post the disaster is that this disaster should be taken as a lesson to inculcate proper laws in the society that promotes change in terms of how risk should be perceived and how such disasters shall be avoided. Several experts had earlier suggested strict policy changes after major disasters like 9/11 WTC terror attacks and Hurricane Katrina. In this case, policy changes gave several US organisations funding and power to act on the prevention of such disasters. This learning can be applied to developing countries like India where such a major disaster could heavily impact the environment and the economy. Rather than waiting for a disaster to strike, prevention, mitigation and resilience can be focused upon to ensure damages of such major scales be avoided. Focus should also be made upon shifting to renewable energies so that the exploitation of resources at this level can be reduced and has exploited the resources for the sake of development.

Acknowledgement

The research team would like to thank the faculty of Jamsetji Tata School of Disaster Studies, Tata Institute of Social Sciences, for their constant support and encouragement

during the research. Special thanks to Dr. Janki Andharia (Dean, JTSDS, TISS) for her encouragement and guidance during the course of the research.

Conflict of Interest:

The authors declare that they have no conflict of interests.

Funding Sources:

This paper did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

1. Atlantic Ecology Division. (2016, February 21). BP Oil Spill (Deepwater Horizon). Retrieved from US EPA: https://archive.epa.gov/aed/aed_archive_03/web/html/bpspill.html
2. Alexander SK, Webb JW. 1985. Seasonal response of Spartina alterniflora to oil. Proceedings of the 1985 Oil Spill Conference. American Petroleum Institute. Pages 355–357
3. Arata CM, Picou JS, Johnson GD, McNally TS. 2013. Coping with technological disaster: an application of the conservation of resources model to the Exxon Valdez oil spill. J Trauma Stress. 2000;13(1):23–39.
4. Barron, M. G. 2012. Ecological impacts of the Deepwater Horizon oil spill: implications for immunotoxicity. Toxicologic pathology, 40(2), 315-320.
5. Beever, J., & Hess, J. L. 2016. Deepwater Horizon oil spill: An ethics case study in environmental engineering. American Society for Engineering Education.
6. Breeze, R. 2012. Legitimation in corporate discourse: Oil corporations after Deep water Horizon. Discourse & Society, 23(1), 3-18.
7. Brixey-Williams, S. (2015, October 22). Where are the world's oil rigs? Retrieved from World Economic Forum: https://www.weforum.org/agenda/2015/10/where-are-the-worlds-oil-rigs/
8. Butler, D., & Sayre, E. 2010. Economic impact of the deepwater horizon oil spill on South Mississippi: Initial findings on revenue. The University of Southern Mississippi , 1-3. Retrieved on June 28, 2010.
9. BP. 2010a. BP Sustainability Review 2010. [Online] Available: http://www.bp.com/assets/bp_internet/globalbp/STAGING/global_assets/e_s_assets/e_s_assets_2010/downloads_pdfs/bp_sustainability_review_2010.pdf
10. BP. 2010b. BP Establishes $20 Billion Claims Fund for Deepwater Horizon Spill and Outlines Dividend Decisions. [Online] Available: http://www.bp.com/genericarticle.do?categoryId=2012968andcontentId=7062966
11. BP Oil Spill (Deepwater Horizon), Research, US EPA https://archive.epa.gov/aed/aed_archive_03/web/html/bpspill.html
12. Brenner, Noah; Guegel, Anthony; HweeHwee, Tan; Pitt, Anthea (22 April 2010). "Coast Guard confirms Horizon sinks". Upstream Online. NHST Media Group. Retrieved 22 April 2010
13. Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE) / U.S. Coast Guard Joint Investigation Team (14 September 2011). "Deepwater Horizon Joint Investigation Team Releases Final Report" (Press release). U.S. Government. Archived from the original on 24 September 2011. Retrieved 6 October 2011.
14. Burnett, J. J. 1999. A strategic approach to managing crises. Public relations review, 24(4), 475-488.
15. Bureau of Safety and Environmental Enforcement (BSEE), 2019, Offshore Incident Statistics,https://www.bsee.gov/stats-facts/offshore-incident-statistics
16. Butler, J. Steven (3 March 2011). BP Macondo Well Incident. U.S. Gulf of Mexico. Pollution Containment and Remediation Efforts (PDF). Lillehammer Energy Claims Conference. BDO Consulting. Archived from the original (PDF) on 21 August 2014. Retrieved 17 February 2013.
17. Carroll, C. E., McCombs, M. 2003. Agenda-setting effects of business news on the public's images and opinions about major corporations. Corporate Reputation Review, 6(1), 36.

18. Carson, R., Mitchell, R., Hanemann, W., Kopp, R., Presser, S., & Ruud, P. 1992. A contingent valuation study of lost passive use values resulting from the Exxon Valdez oil spill. Fairbanks: Attorney General of the State of Alaska.
19. Chang, S. E., Stone, J., Demes, K., & Piscitelli, M. 2014. Consequences of oil spills: a review and framework for informing planning. Ecology and Society, 19(2).
20. Chapman, H., K. Purnell, R. J. Law, and M. F. Kirby. 2007. The use of chemical dispersants to combat oil spills at sea: a review of practice and research needs in Europe. Marine Pollution Bulletin 54:827-838. http://dx.doi.org/10.1016/j.marpolbul.2007.03.012
21. Cleveland, Cutler J. 2011. Deepwater Horizon Oil Spill. Encyclopedia of Earth .10 Feb 2011. Web. 25 Mar 2011.
22. Clifford, C. (2010). BP's lost-wages list: Shrimpers, crabbers—and real-estate brokers, June 3 2010.
23. De Wolf, D. 2013. Crisis management: Lessons learnt from BP Deepwater Horizon Spill Oil. Business Management and Strategy, 4(1), 69-90.
24. Deepwater Horizon Marine Casualty Investigation Report (PDF) (Report). Office of the Maritime Administrator. 17 August 2011. Retrieved 25 February 2013.
25. Flournoy, A. C. 2011. Three meta-lessons government and industry should learn from the BP Deepwater Horizon disaster and why they will not. Florida: Faculty Publications.
26. Grattan, L. M., Roberts, S., Mahan Jr, W. T., McLaughlin, P. K., Otwell, W. S., & Morris Jr, J. G. 2011. The early psychological impacts of the Deepwater Horizon oil spill on Florida and Alabama communities. Environmental health perspectives, 119(6), 838
27. Goldman, L.; Mitchell, A.; Patlak, M. 2010. Review of the Proposal for the Gulf Long-term Follow-up Study: Highlights from the September 2010 Workshop: Workshop Report. National Academies Press; 2010.
28. Goldstein, B. D., Osofsky, H. J., & Lichtveld, M. Y. 2011. The Gulf oil spill. New England Journal of Medicine, 364(14), 1334-1348.
29. Gulf oil spill: BP has a long record of legal, ethical violations" 8 May 2010 by McClatchy Washington Bureau". Mcclatchydc.com. Archived from the original on 5 June 2010. Retrieved 5 June 2010.
30. Gulf Oil Spill. (2018, April). Retrieved from Smithsonian Ocean: https://ocean.si.edu/conservation/pollution/gulf-oil-spill
31. Gyo Lee, Y., Garza-Gomez, X., & Lee, R. M. 2018. Ultimate Costs of the Disaster: Seven Years After the Deep water Horizon Oil Spill. Journal of Corporate Accounting & Finance, 29(1), 69-79.
32. Gribben, Roland (3 May 2010). "BP chief Tony Hayward fights to limit the damage after Gulf of Mexico rig disaster". The Daily Telegraph. Retrieved 26 April 2013.
33. Hultman, N. (2010, August 24). Beyond Petroleum: The Broader Effects of the Deepwater Horizon Oil Spill. Retrieved from Brookings: https://www.brookings.edu/opinions/beyond-petroleum-the-broader-effects-of-the-deepwater-horizon-oil-spill/
34. Jernelo¨v A. 2010. The Threats from Oil Spills: Now, Then, and in the Future, Springer Publications. DOI 10.1007/s13280-010-0085-5.
35. Levy, J.K., and Gopalakrishnan, C. 2010. Promoting ecological sustainability and community resilience in the US Gulf Coast after the 2010 Deepwater Horizon oil spill. Journal of Natural Resources Policy Research. 2(3), 297-315
36. Mark Guarino (15 May 2010). "In Gulf oil spill, how helpful – or damaging – are dispersants?". The Christian Science Monitor.
37. Mendelssohn, I. A., Andersen, G. L., Baltz, D. M., Caffey, R. H., Carman, K. R., Fleeger, J. W., &Rozas, L. P. 2012. Oil impacts on coastal wetlands: Implications for the Mississippi River Delta ecosystem after the Deep water Horizon oil spill. BioScience, 62(6), 562-574.
38. Norse, E. A., & Amos, J. 2010. Impacts, perception, and policy implications of the Deep water Horizon oil and gas disaster. Environmental Law Institute, Washington, DC, 40, 11058.
39. Passow U, Ziervogel K, Asper V, Diercks A. 2012. Marine snow formation in the aftermath of the Deep water Horizon oil spill in the Gulf of Mexico, Environmental Research Letters , 2012, vol. 7 art.
40. Petrolia, D. R. 2015. What have we learned from the Deep water Horizon disaster? An economist's perspective.
41. Robinson Jr, R. A. 2010. The Gulf of Mexico oil disaster: A case study on the projected economic impact on tourism among the Gulf States of Louisiana, Mississippi, Alabama, and Florida.
42. Schröder, T. (2011). Oil and Gas From The Sea. Hamburg, Germany: maribusgGmbH.
43. Shirley, Thomas C.; John W. Tunnell Jr.; Fabio Moretzsohn; Jorge Brenner (May 2010). "Biodiversity of the Gulf of Mexico: Applications to the Deep Horizon oil spill" (PDF) (Press release). Harte Research Institute for Gulf of Mexico Studies, Texas A&M University. Archived from the original (PDF) on 30 January 2016. Retrieved 14 June 2010
44. Sidney A. Shapiro, R. S. (2007). Capture, Accountability, and Regulatory Metrics. Texas: Texas Law Review
45. Simonovic, S. P. (2015). Systems approach to management of disasters–a missed opportunity?.IDRiM Journal, 5(2), 70-81

46. Terry Waghorn, 2018, Forbes magazine. Trump Wants More Offshore Drilling And Less Regulation — That's A Recipe For Disaster https://www.forbes.com/sites/terrywaghorn/2018/06/06/trump-wants-more-offshore-drilling-and-less-regulation-thats-a-recipe-for-disaster/#4caf795c2c30
47. U.S. Environmental Protection Agency. Understanding Oil Spills and Oil Spill Response. Publication Number 9200.5–105. Washington, D.C.: U.S. Environmental Protection Agency, 1993.
48. United States Environmental Protection Agency, July 15, 2010, http://www.epa.gov/bpspill/.
49. White, H. K., Hsing, P. Y., Cho, W., Shank, T. M., Cordes, E. E., Quattrini, A. M., ... & Brooks, J. M. 2012. Impact of the Deep water Horizon oil spill on a deep-water coral community in the Gulf of Mexico. Proceedings of the National Academy of Sciences, 109(50), 20303-20308.
50. Worland, J., 2015, TIME, Questions Remain Over U.S. Preparedness for the Next Oil Spill, https://time.com/3828675/bp-oil-spill-anniversary/

Design, Analysis and Feasibility Study of Cyclone Shelter Using BIM and ETABS Software

S. S. Khatu[1], P. D. Mahadik[1], S. J. Chikhale[1], Y. R. Kulkarni[1]*

Abstract

India is having long coastline of 7516 km of which 10% hit by the tropical cyclones several times. The east coast of India is particularly prone to the cyclonic situation. Besides this, the storm surges and rarely occurring but devastating natural hazards like Tsunamis are also creating coastal population vulnerable and at risk for these natural events. To mitigate these types of hazards, cyclone shelters are the most important structural mitigation measures. Therefore, we attempted to prepare the Cyclone Shelter model in REVIT software and ETABS software. We studied and prepared a plan as per the government specified norms and Regulations. This plan is used in REVIT for structural design and then subjected to structural analysis to test various loads. We modified the specified design as per the space utility, usage of modern material and convenience of people in distress during disaster event. The structure designed is successfully tested in ETABS for dead load, live load, Earthquake and wind load. We suggest the use of advanced civil software for design, analysis and feasibility check in such structural mitigation measures as a rapid tool.

Keywords: *Cyclone shelter, Disaster, BIM, ETABS*

1. Introduction

Cyclone and storm surges are among the most destructive of all-natural disasters. The region of the world which are vulnerable to such disasters include the island in the South-West Pacific, South-East Asia (e.g., the Philippines, Viet Nam), Countries adjoining the

[1] **S. S. Khatu, P. D. Mahadik, S. J. Chikhale, Y. R. Kulkarni,** Department of Civil Engineering, Gharda Institute of Technology, Ratnagiri, India 415708
* Corresponding Author Email: yrkulkarni@git-india.edu.in

Bay of Bengal (e.g. India, Bangladesh and Myanmar), South-East Africa, the Caribbean and parts of the USA and Latin America around the Gulf of Mexico and Atlantic Ocean. India has a long and tragic history with cyclones. The Indian subcontinent is one of the worst affected regions of the world when it comes to tropical storms. On an average 10% of the coastal area of India is hit over by the tropical cyclone on an year (NDMA report, India). Particularly the East coast of India faces this natural hazard every year. On the other hand, West coast of India, which was considered relatively safe for cyclonic events, is facing increasing numbers of cyclones postulated as result of Climate Change. Cyclone shelters are the first line of defence against calamities such as cyclones surges (Choudhury et al., 1994), (Hoqueet al., 1994). They are the Buildings constructed on elevated ground to withstand wind speed, moderate earthquake and storm surges. These are the mitigation measure for the threats caused by the Cyclone, Floods, Inundation, and Earthquakes etc (Akm Saiful et al., 2011), (Bosuniaet al., 2011). These are the structures proposed worldwide by the specifications given by Disaster Management Authorities for their respective countries. There are different types of design of cyclone shelters designed in different countries (Figure 1). In case of India, Government of India specified the norms for the construction of Cyclone shelters (GOI-UNDP DRMP Report, 2006)

Figure 1: Design of Cyclone Shelter in various Countries

2. Review of Work on Cyclone Shelters

Majority of studies on cyclone shelters are carried out in Bangladesh and Myanmar as they are the most affected countries due to large tropical cyclones. (Mahmood et al.,2014) studied the state of multipurpose shelter in Bangladesh. They have explained overview of cyclones and cyclone shelter management in Bangladesh. Community needs, requirements in designing and finalization of proposed shelter locations are important. (Faruk et al., 2018) carried out analysis of inclusiveness and accessibility of Cyclone Shelters in Bangladesh, they have described widely accepted inclusive design principles and design standards that can make shelters more user friendly, accessible and inclusive. (Okazaki et al., 2018)carried out a case study on use of cyclone shelter in Bangladesh, They have described that these shelters have saved many lives; they could not accommodate all the residents of the cyclone high-risk areas located on islands in coastal deltas.

(Bihari and Mukherjee, 2015) in their work studied the architectural design strategies for Primary School cum Cyclone Shelter in coastal areas, they have explained that primary schools can be converted into cyclone shelters to greatly reduce the devastation caused by cyclones in India and proved that cyclone shelters are an economical and affective way to save many lives. (Danilo and Ray, 2017) in their work studied a shelter for the victims of the typhoon Haiyan in the Philippines the design, they have said the shelter mostly used locally sourced materials, manpower and understanding the needs and requirements of the users (Belinda et al., 2015) study the post-disaster shelter design and CPoDS. They have explained that there are numerous temporary sheltering projects but there is no perfect shelter which is economic and can be mass-produced and implemented rapidly and respond all the needs of a shelter, and the needs of the survivor. (Arunachalam et al., 12) reviewed the cyclone disaster mitigation in Indian scenario and challenges for future. They have explained reliable forecasting, quality construction, effective decision support systems and policy implementations are some of the future challenges for combating the fury of natural disasters. (Coulbourne et al., 2002) in their research paper, reviewed design guidelines for community shelters for extreme wind events. They have explained about minimum loads, design and construction standards for shelters are needed as communities are presently designing and constructing such structures.

3. Methodology

To design the cyclone shelter we have followed the following process (Figure 2):

1. Initially, we started checking the feasibility of various shapes such as Hexagon, circle and other traditional shapes. Hexagon and circle are perfectly aerodynamic but there was no roominess so we skipped these shapes resulting in more empty space outside the rooms also.
2. Therefore, we decided to go with the Sqircle shape as both the aerodynamics and roominess was maintained.
3. We have decided to take average population for the villages located on coast of Ratnagiri district, Maharashtra to decide the area of structure. This is because the frequency of cyclonic events is increasing in recent years and Ratnagiri is one of the mostly affected regions along west coast of Maharashtra.
4. Further, we designed the basic plan in AutoCAD in order to facilitate it in REVIT
5. The actual architectural model is developed in REVITREVIT software (V20). The norms are used as per government specified (GOI-UNDP DRMP Report, 2006).
6. The architectural model along with structural elements then used in ETABS for the various loads like Dead load, Live load, Earthquake and Wind load.

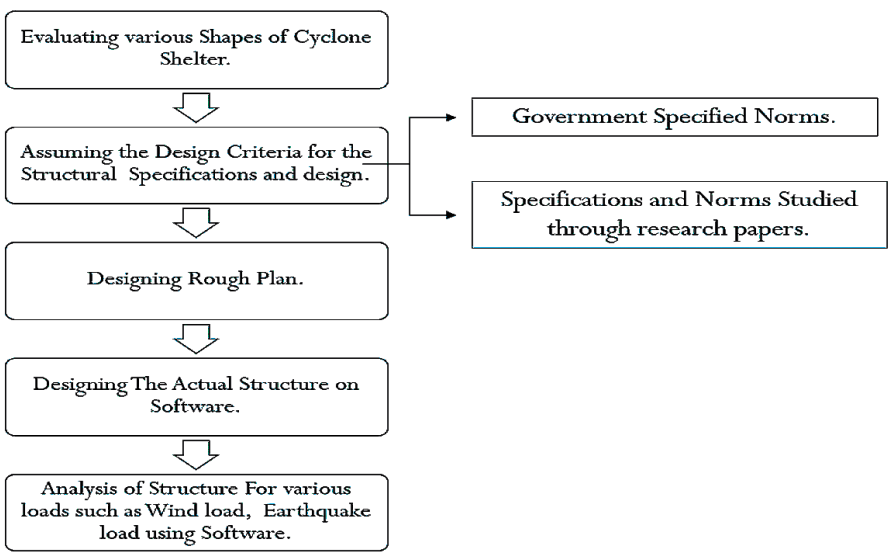


Figure 2: Methodology Adopted for the Present Study

4. Results and Discussion

4.1 Architectural work using REVIT: For the making of structural plan Autodesk AutoCAD is used and For Designing of structure Autodesk REVIT is used.

Step 1: For structural plan in AutoCAD we consider lot of designs like circle, hexagon, rectangle, etc. but those are not economical or aerodynamics. Hence, we finalized design called Squircle which is combination of Square and circle (Figure 3a). Due to its unique shape this plan works as aerodynamic structure. Rounded corners provided in plan are very helpful for diverting high wind flow during cyclone. After finalizing plan we imported same plan in REVIT and created centerline plan version in REVIT (Figure 3b).

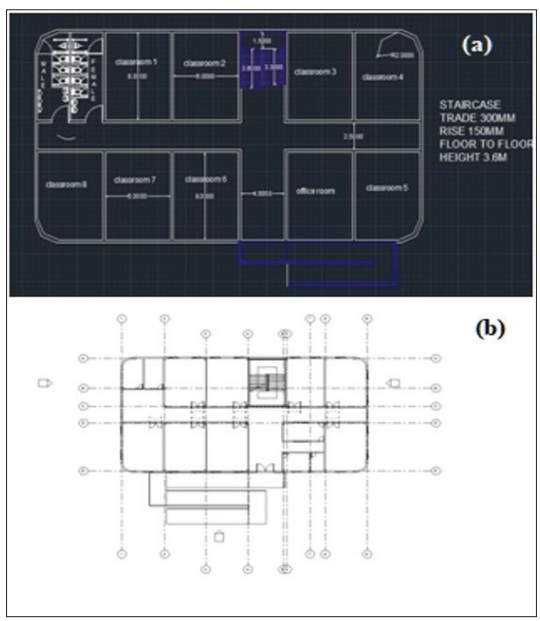


Figure 3: (a) Architectural Plan (b) Centreline Plan

Step 2: After creating centerline plan we are ready to work on building structure. We designed Pile foundation, Plinth, Column, Beam, Slab, Stairs, Ramp, etc (Figure 4). The specifications are used as follow: Foundation size: 2.5x2.5x0.5m, Pile: dia-0.5m, ht-6m, Column size: 300x450mm, Beam size: 300x600mm.

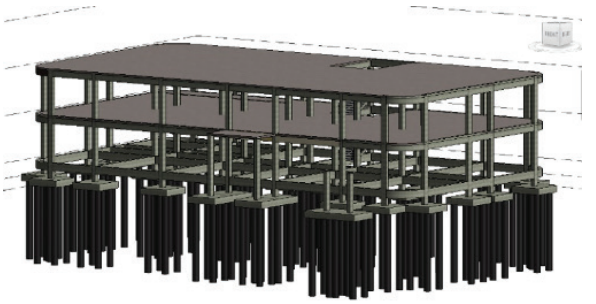


Figure 4: Structural Components

Step 3: After finishing with Structural component, we have to work on Architectural Components such as Walls, Doors, Windows, Floor, etc. (Figure 5). We keep the wall material of AAC Block, door material of Wood and window material as Fiber Reinforced Plastic (FRP) material. FRP has higher resistance than steel and low thickness to withstand the heavy wind forces during the cyclone events.

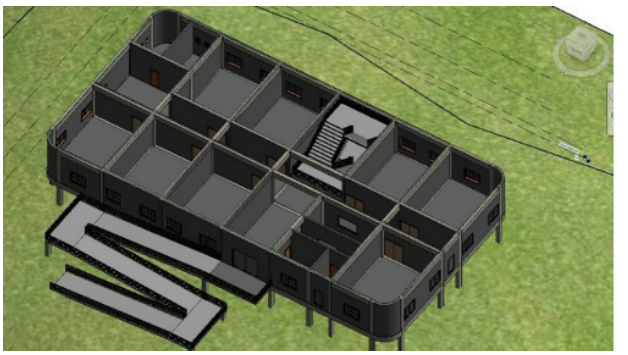


Figure 5: Architectural Components

During designing of architectural components, we took care of economy as well as stability. Also we studied cyclone shelter guidelines and make some changes considering that the structure is different than regular building. The changes made are enlisted follow:

- Provision of Wide Ramp for main entrance.
- Provision of Stairs at back as an emergency exit.

- Provision of Outward opening Doors.
- Provision of windows with FRP
- Provision of separate space in washroom for handicap people.
- While making of this structure we also consider guidelines of school so that we can use this structure as primary school also while there is no cyclone condition.

Step 4: After finishing with architectural components, we started work on Plastering walls, Washroom-component, furniture, Ceiling, Lighting, Paint etc. (Figure 6a). For making model complete outer look is also important. So, after completion of finishing work we started work on outer design, exterior lighting, topography, nature components such as trees, etc. (Figure 6b).

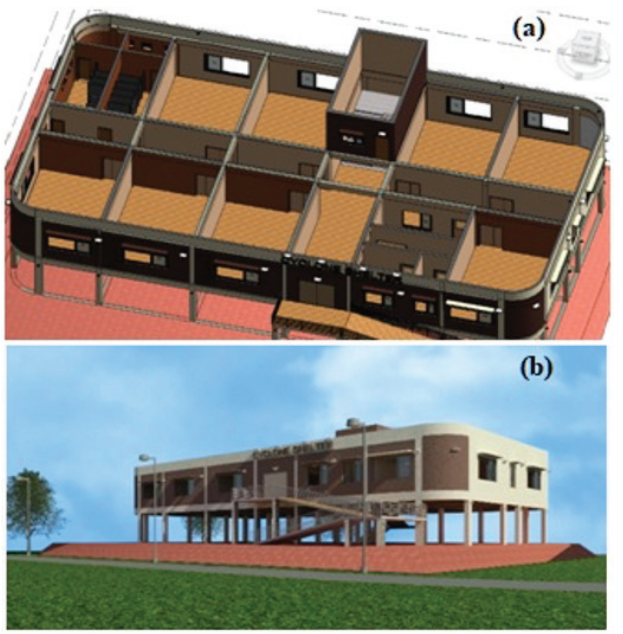


Figure 6: (a) Finishing Work (b) Rendered Model

Step 5: (Providing school components for regular use of structure). After completing cyclone structure, we fill those rooms with school furniture so that we can use this structure as Primary School for regular days (Figure 7) and while cyclone condition this building can work as a Cyclone Shelter.

Figure 7: School Furniture

4.2. Design and analysis work using ETABS: After Completing this work in REVIT our model became ready for analysis study in Etab. Center line diagram is prepared and imported to ETABS model and the following steps by steps procedure are followed.

Step 1: (Defining of property): Select define menu > material properties. Add new material in the defining material property the concrete of M30 and steel of grade FE 500. For our work the size of structural components (beam, columns and slabs) are taken as per the requirement.

Table 1: Beam, Column and Slab Details

Beam No.	Size	Column No.	Size	Slab	
Beam 1	300*400	Column 1	300*450	Material	Concrete
Beam 2	300*450	Column 2	300*500	Type	Membrane
Beam 3	300*500			Thickness	150 mm

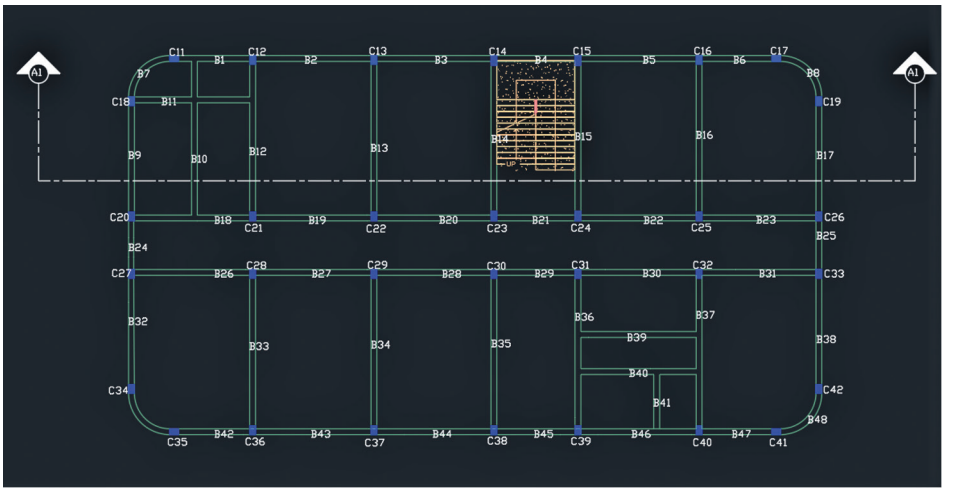


Figure 8: Structural Layout of the Plan

Step 2: (Assigning of property and support): After defining the property we have to draw the structural component and using command menu>draw line for beam and draw column in region for column (Figure 9). By keeping the plan at the base of the structure and selecting all column supports are assigning by Assign menu>joint/frame>restraints, (supports)>fixed.

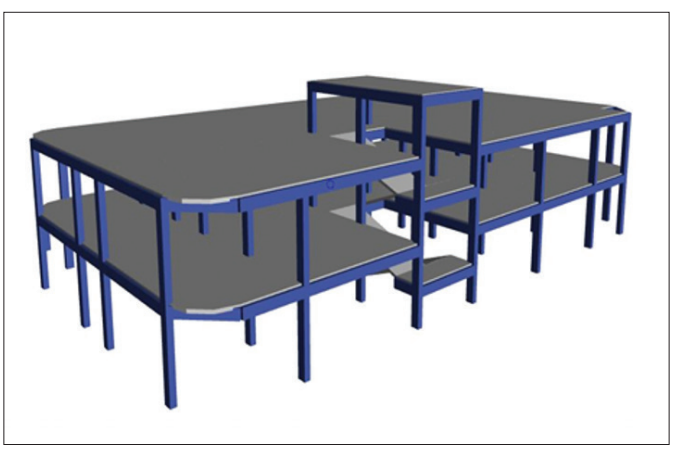


Figure 9: ETABS 3D View Model

Step 3: (Defining of load): The loads in ETABS are defined as using static load cases command in define menu (Figure10).

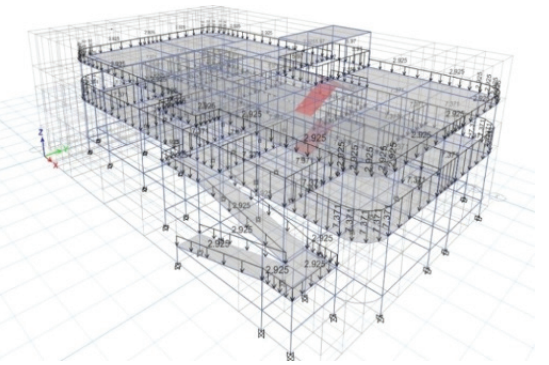


Figure 10: Wall Load Assign

Dead Load: (IS 875 part 1): The dead loads are permanent loads which result from the weight of the structure itself or from other permanent attachment, In dead load case self-weight of structure is automatically taken by ETABS just we have to take self-weight multiplier as 1.

Live Load: (As per IS 875:1987 (part 2)): Live loads are temporary loads; they are applied to the structure on and off over the life of the structure. The imposed loads, specified herein, are minimum loads which should be taken into consideration for the purpose of structural safety of buildings.

Classroom & lecture room = 3 Kilo Newton per square meter (KN/m^2)

corridors and passages = 4 KN/m^2

Toilet and washroom = 2 KN/m^2

On roof -if accessible = 1.50 KN/m^2

-if not accessible = 0.75 KN/m^2

Super Imposed Load: (IS 875 (part 1) This load is mainly caused on structure by the nonstructural elements of building such as tiles stones, partitions, filling material and plastering.

Wind Load: (As per IS 875 (part 3)): Buildings are subject to horizontal loads due to wind pressure acting on the buildings. The wind loads acting on exposed surfaces of a given storey are idealized to be supported by upper and lower floors. Here in software are

(ETABS) we are not defining load pattern as per directly IS 875 (part 3): 2015 because by inputting CPi and CPe values we don't get to know what is wind load before analysis so here we are calculating wind load as per IS 875 (part 3): 2015 and apply the load as per storey height with respect to different condition and parameters.

Earthquake Load: (As per IS 1893:2000): Seismic loading which means application of an earthquake-generated agitation to a structure. It happens at contact surfaces of a structure either with the ground, or with adjacent structures, or with gravity waves from tsunami. These are some important factors are considering while designing the earthquake load in ETABS.

For X direction and Y direction

– Response reduction R = 5

– System = SMRF (Special Moment Resisting Frame)

– Seismic zone factor Z = 0.16

– Silt type = II for Medium Soil as per Table 4 of IS 1893 (Part 1): 2016

– Importance factor = 1.5 as per Cl.7.2.3 and Table 8 of IS 1893 (Part 1): 2016

– Percentage of Imposed Load to be Considered in Seismic Weight = 25% for LL is up to 3 kN/m^2

as per Cl.7.3.1 and Table 10 of IS 1893 (Part 1): 2016

Step 4 (Analysis): After the completion of all the above steps analysis was performed and checked for errors (Figure 11). We used (A11:1.2(DL+SIDL+LL+WLX)) [kN-m] load combination as a sample for deformation.

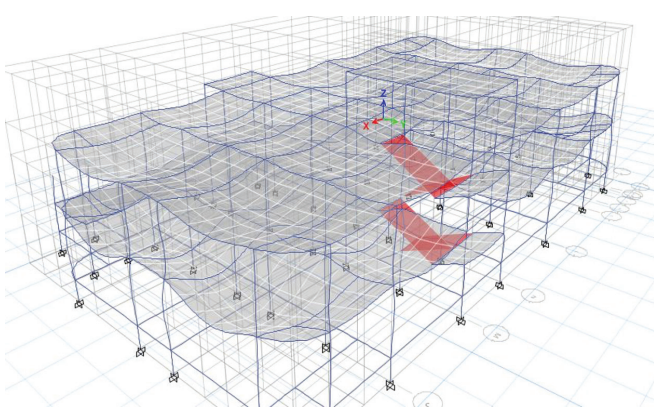


Figure 11: Deformation Views After Analysis

Shear and bending moment diagram are analytical tools used in conjunction with structural analysis to help perform structural design by determining the value of shear forced and bending moment at a given point a structural element such as beam. We have analyses and created shear and bending moment in our model and the results show stability throughout the structure (Figure 12).

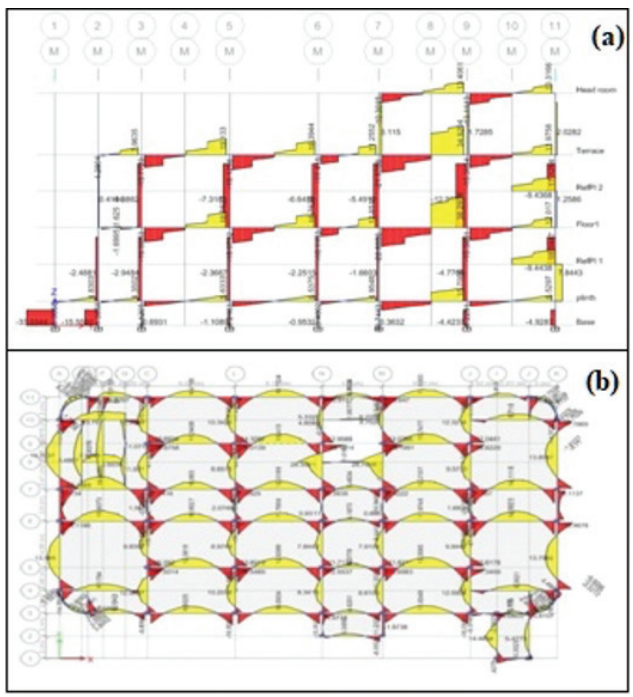


Figure 12: (a) Shear Force Distribution (b) Bending Moment Distribution

Step 5 (Design): After the analysis is over design of the structure elements was done as per IS 456:2000 guidelines. For this go to design menu>concrete design>select design combo after this again go to design menu>concrete frame design>start design/check of structure then ETABS performs the design for every structural element (Figure 13).

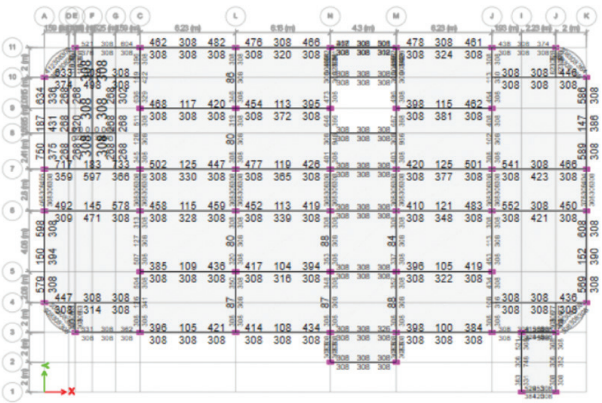


Figure 13: Longitudinal Reinforcement Design

5. Conclusion

Recent trend of increasing cyclonic events along west coast of India suggesting for more disaster resilient infrastructure to be created for this natural hazard. The Nisarg Cyclone in 2020 gave us an example for the need of disaster mitigation structure, particularly in rural population along coast line. The use of software in overall process of the development of disaster resilient structures is necessary for expeditious and accurate development. In this study we attempted to design the Cyclone shelter in REVIT and ETABS with government specified norms and additional changes were made for better stability of structure and ease of movement for distressed people during cyclone event. We made modification to material for the better strength. Structural component like beam, slab, column and footing are designed manually and the results obtained from ETABS software are compared with manual method. The structural analysis by using ETABS software show the structure is withstand to all types of load. Calculation by both manual as well as software analysis gives almost same results. We suggest that use of software for design and feasibility study for structural mitigation measures will be helpful for rapid progress in work and efficiency in the structure for disaster prone regions. This study further demand the use prototype and model based approach with the simulation for further analysis.

Acknowledgment

We thank to our Principal and Head of Department of Civil Engineering, Gharda Institute of Technology (GIT) for the necessary support. We are also thankful to all the faculty of the department of Civil, GIT for their significant inputs time to time during the project evaluation process. We are also thankful for the reviewers for their significant inputs in improvement of manuscript.

References

1. Choudhury, Jamilur R, (1994) "Cyclone shelter and its multipurpose use." Proceedings of the IDNDR Aichi/Nagoya International Conference..
2. Hoque, Abdul, and Abu Mohammad (1994) "Cyclone shelter planning for disaster management and community development in Bangladesh: a case study of Khurushkul union of cox's bazar district.".
3. Islam, Akm Saiful, et al. (2011) "Performance of coastal structures during Cyclone Sidr." Natural Hazards Review 12.3: 111-116.
4. Bosunia, M. Shamim Z., and P. Eng. (2010) "Design Criteria for Shelters in Coastal Areas of Bangladesh Under Multipurpose Cyclone Shelter Program." Wind Storm and Storm Surge Mitigation 4: 94.
5. Guidelines for Design and Construction of Cyclone/Tsunami shelters, GOI-UNDP DRMP Report, 2006
6. Mahmood, Muhammad Nateque, Subas Prasad Dhakal, and Robyn Keast. (2014) "The state of multi-purpose cyclone shelters in Bangladesh." Facilities .
7. Faruk, Mohammad, SyedaAtia Ashraf, and Muhammad Ferdaus. (2018) "An analysis of inclusiveness and accessibility of Cyclone Shelters, Bangladesh." Procedia engineering 212: 1099-1106.
8. Miyaji, Mari, Kenji Okazaki, and ChihoOchiai. (2020) "A study on the use of cyclone shelters in Bangladesh." Japan Architectural Review 3.4: 590-600.
9. Bihari, D. A. and Mukharji Shreya (2015) Architectural Design Strategies for Primary School cum Cyclone Shelter in Coastal India.
10. Ravina, Danilo, and Rowell Ray Shih. (2017) "A shelter for the victims of the Typhoon Haiyan in the Philippines: The design and methodology of construction." Pollack Periodica 12.2: 129-139.
11. Torus, Belinda, and Sinan MertŞener. (2015): "Post-disaster shelter design and CPoDS." A| Z ITU Journal of the Faculty of Architecture 12.1 269-282.
12. Arunachalam, S., SelviRajan, and Prem Krishna. (2015) "Cyclone Disaster Mitigation-Indian Scenario and Challenges for Future." Wind Engineers, JAWE 40.3: 283-289.
13. Coulbourne, William L., E. Scott Tezak, and Therese P. McAllister. (2002) "Design guidelines for community shelters for extreme wind events." Journal of Architectural engineering 8.2: 69-77.

Landslide Study at Tlungvel Quarry Areas, Aizawl District, Mizoram

Lalchhanhima[1], K.S. Rao[1], Laltlankima[1] and Lalbiakmawia[2]*

Abstract

Landslides are the most common hazard in the state of Mizoram. Rapid development and the uncontrolled interaction with the nature are the reason for landslide in Mizoram. Landslide vulnerability of Mizoram is already high due to lithology and structure. The extensive mining activities along the highways for road construction and building materials also cause one of major landslide along the highway of the state. The National Highway 54 passed through the study areas. The National Highway Number 54 is the most important road connecting Aizawl city and Northern, Southern and Eastern part of the State of Mizoram. The improper land use, lack of adequate drainage and toe removal for road widening are the major causative factors for the landslide. The present study deals with geological field investigations as well as recommendations in terms of preventive and remedial measures. On the basis of the studies a set of mitigation strategies have been suggested.

Keywords: *Landslide investigation, Bedding & joint intersection, Shear, Crumpling and mitigation*

1. Introduction

Mizoram state is a rugged region and forms part of the ranges of Patkai-Naga-Lushai-Arakan Yoma Hill. The landslides are the most prominent threat caused by softer lithologies, extreme post-drift kinematic deformation, high seismic degree, complex geomorphic faceting and slope morphometry, high weathering level and heavy rainfall. For different developmental planning, such fragile geological systems are also unmindfully exploited and modified resulting cumulative causes of frequent

[1] **Lalchhanhima, K.S Rao, Laltlankima,** Department of Geology, Mizoram University
[2] **Lalbiakmawia,** Govt. Zirtiri Residential Science College
* Corresponding Author Email: Chhan2007@gmail.com

landslides and land subsidence as well. Although it is impossible to completely eradicate the landslide phenomenon, it can be minimised by properly understanding the controlling parameters and developing protective and predictive land management plans accordingly. In Mizoram, in some areas, mining for building materials also tends to cause landslides. A model study was conducted in Tlungvel quarry, where landslides occur frequently, to understand this phenomenon and mitigate such landslides in the mining areas. Tlungvel quarry is located 60 km from Aizawl on National Highway 54 in the district of Aizawl.

1.1 Geological Setting

The Mizoram perching on the hills of Northeastern corner of India is flanked by Bangladesh on the west and Myanmar on the east and south. It has an area of 21089 sq. Km and has 630 kms long international boundary. North-eastern states are located in active seismic zone i.e., Zone V and Mizoram is one of them.

In addition to the complex lithological setting of the softer Tertiary sandstone and shales and the geological structures related to plate tectonics, the state does not favour for slope stability equilibrium due to high degree of weathering and heavy rainfall. These result that the state experiences landslide and land subsidence. Hence the instabilities of slopes are interrelated and controlled by the combination of complex geological setup, topography, meteorology seismic factor. Anthropogenetic activities like unscientific quarrying and excessive utilisation of explosive for quarrying the building material and road metals.

1.2 Regional Setting

The Aizawl to Lunglei highway was passing through the very steep hilly terrain of the village of Tlungvel, and massive sandstone beds were exposed by this hill. This sandstone bed above the highway has been mined by Border road task force/Public work department for decades for road and building construction, etc. Tlungvel quarry appeared to be the only source of good quality rocks for construction and road materials available in this area. At the same time, the equilibrium of the adjoining structure was deteriorated by the quarrying of rocks on the roadside, resulting in a structural break in the form of a rock slide from the above, endangering human life for rainy reasons. The rocks on the western side of the hill were exposed.

1.3 Study Area

The study area lies under Thingsulthliah Rural development Block in the state of Mizoram between 92° 51.33'E to 92° 52'19" E and 23° 35.81'N to 23° 36'07'N in Aizawl district and falls under Survey of India topographical map No. 84A/14 (Figure 1)

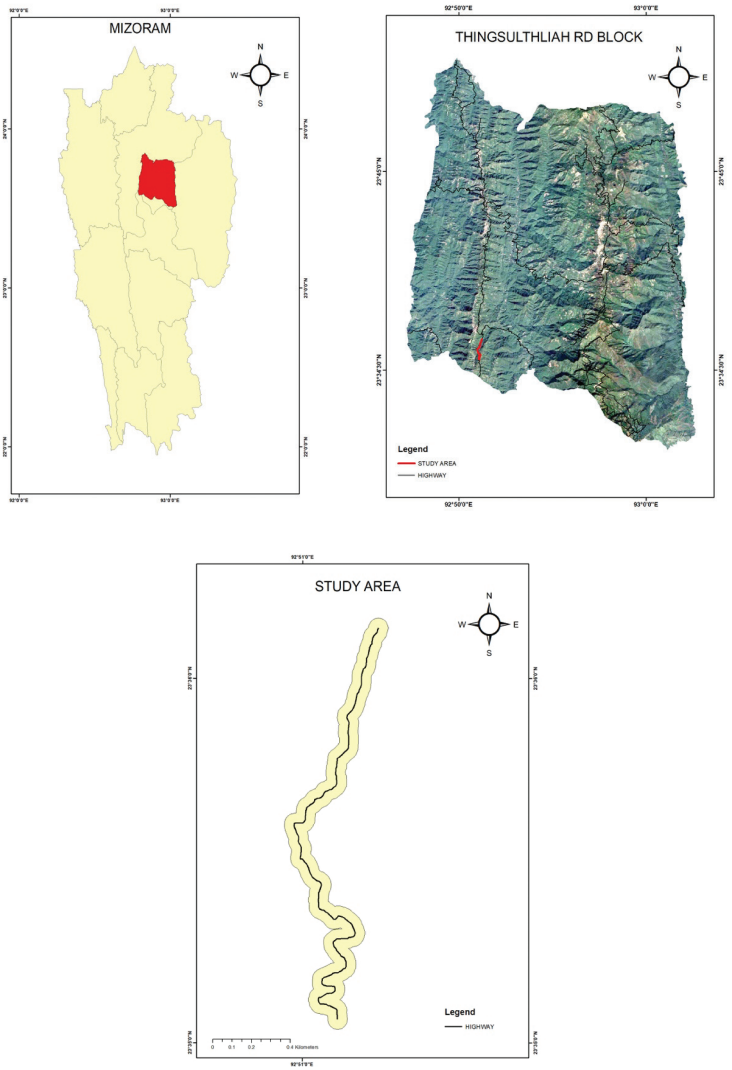


Figure 1: Map of Study Area

2. Materials and Methods

The geological investigation was based on field study and field work, Suunto compass were used for measuring dip and strike amount and direction. GPS map 78sc (Garmin) used for geo-graphical location.

2.1 Lithology :

One of the variables for landslides is lithology (Sharma et al.,2011). Mizoram's geology consisted of large rock flysch facies that comprised monotonous shale and sandstone sequences (La Touche, 1891). The area of study lies over the formation of Bhuban of the Surma Tertiary Age Group (GSI, 2011) and this formation was subdivided into Lower, Middle and Upper formations. Middle Bhuban is exposed, consisting mainly of argillaceous rock, and Upper Bhuban of Arenaceous rock is also exposed within the study area. The area consists of three distinct types of sedimentary rocks: sandstone, shale and silty shale. The main portion of the formation was covered by sandstone, which is highly compact with fine to medium grain having two distinct colors. The weathered sandstone horizons are coloured brownish, while the less weathered sandstones are coloured greyish. Three litho-units were developed purely based on the exposed rock types for the study area. These are called Shale-sandstone, Units of Silty shale and Sandstone-shale. Lithological units containing shale and siltstone are more vulnerable than the strong and compact shale units of sandstone to slide.

2.2 Structure :

In NE-SE, the bed rocks were trending with a dip of 60° to the northwest and south-east. At a daily interval of 2 metres, structures such as parallel cracks were also observed, which were very prominent, and a lot of cracks measuring from a few centimetres to 5 metres were noticed. In most of the exposed formations, shear zones were present.

The slide materials were mostly blocks of sandstone measuring between a few centimetres and 2 to 3 metres in diameter. Also seen as interbedded were shale and silty blocks. Among the rock types in the region, silty shale is the most susceptible unit to landslide.

3. Result and Discussion

The general geological condition providing landslide vulnerability in Tlungvel quarry as mention below:

Due to the presence of shear zones, the major slide of the region was caused by parallel joints and cracks and the resulting intrusion of rain water into the strata. There were amounts of springs (see page) and furthermore the slope angle was as high as 78-85 degrees and the entire formation was also rendered by the excavation of stones along the slope of the road cutting, toe loss which resulted in the area's sudden loss collapse/ rock falls. It was also found that there were no geological features such as faults. The region was located at the western extremity of the anticline of Tlungvel. The anticline axis and the ridges of the elongated hills were crisscrossing Seling and Tlungvel. In the eastern slope, the slide fell as the rock formations dipped westward, i.e., the bed rock dipped oblique to the hill slope. The general strike direction of the rock formation was N50° E dipping 15 towards southerly. No faults were observed for rock exposures in the quarry area, but there were two or more joints set running N 60 W dipping N70° E and N 60° E vertical dip. Mizoram receives heavy rainfall during May to October, under the influence of South West Monsoon. Heavy rainfall triggered the seepage induced through the primary (bedding planes) and secondary (joints and fractures) weakness zones or discontinuities, mostly at the Sandstone shale contacts. Excess rainfall led to the over wetting of the rocks and subsequent reduction of the retaining capacity. The seepage, leads to the reduction of the slope stability. At places the Sandstones are in wet conditions and due to continuous seepage from overlying Shales, blocks of sandstones are detaching.

4. Conclusion

The study revealed the following:

1. The study area falls under Tertiary sediments, most of which are Arenacious and Argillaceous sandstones and lower Bhuban formation shale interbedded.
2. The slide areas of Tlungvel quarry lie at the western limb of the anticline of Tlungvel.
3. The Tlungvel slide is mainly due to unscientific and unregulated excavation of road material boulders and high angle cutting that caused the upper rock to fall.
4. The adverse geological structures such as joint sets which are present in the

formation exacerbated the excessive back break and rock fall. The joint planes acts as a triggering zone where rain water passes through them more during the rainy reason.

5. Primarily from the bottom of the rock formation i.e. toe cutting, the rock excavation and extraction was performed. The rock fall was caused and intensified by this method of extraction and excavation. Along the shale beds, weathering and loosening of rocks are much more faster than that could have added unpredicted instability.
6. The joint space are filled with loose and fractured materials with shale and clay. This filling material decreases the chesion between the bed rock and resulting sliding phenomena, which are supported by heavy rain during monsoon-period .The existing quarry activities in the critical area and future quarry operation must be stopped
7. High angle road cutting should be reduced to less than 45 by stripping benching methods, if so desired for further extraction of road materials.
8. Construction of retaining walls must be adopted in critical areas.
9. Drainage system must be constructed if necessary.
10. Area required soil conservation and prevention of extensive gullies.

Acknowledgements

The authors are thankful to their colleagues of Mizoram University for their cooperation and support during the course of study.

References

1. Selby MJ (1993). Hillslope Materials and Processes 2nd Edn. Oxford University Press, USA, pp. 200-401.
2. Tiwari RP & Shiva Kumar (1996). Geology of the Area Around Bawngkawn, Aizawl District, Mizoram, India. Misc. Publ. No. 3, The Geological & Research Centre, Balaghat, M.P., pp. 1-10.
3. Tiwari RP & Shiva Kumar (1997). South Hlimen landslide in Mizoram – A pointer. ENVIS Bull Himalayan Ecol Develop, 5, 12-13.
4. Ghosh RN & Singh RJ (2001). Geoenvironmental appraisal of Serchhip town, Serchhip district and Champhai town, Champhai district, Mizoram with special emphasis on slope stability studies. Records of the Geological Survey of India (GSI), 135, p. 65.
5. Ganju, J. L. (1975). Geology of Mizoram. Bulletin (Geological, Mining, and Metallurgical Society of India), 48, 17–26.

Understanding the Infodemic and Misinformation During COVID-19 Pandemic

Raju Thapa[1*], Surya Parkash[1], Anil Kathait[1], Harjeet Kaur[1]

Abstract

Infodemics is over flood of information, some accurate while some misinformation, which makes it difficult to identify a solution. Misinformation, disinformation and rumours can be spread easily in infodemics which can impact the effectiveness of public health response. Imfodemic can also result in building mistrust in governments, health agencies and create confusion and distrust among people. The affect of infodemic is amplified multifold in this information age with the availability of social networks. Misinformation can greatly impact people life by altering decision making processes. Every individual has an important role to play in restricting the spread of infodemic.

Keywords: *Information; misinformation; disinformation; COVID-19; pandemic; social media*

1. Introduction

During a disease epidemic, an infodemic is defined as an abundance of information, including incorrect or misleading information, in both digital and physical settings. It creates perplexity and risk-taking behaviours that might be harmful to one's health. It also fosters scepticism of health authorities and hinders public health efforts. When individuals are unclear about what they need to do to safeguard their health and the health of others around them, an infodemic can exacerbate or extend outbreaks. Information can travel more quickly as a result of increasing digitalization, such as the usage of social media and the internet This can help cover knowledge shortages

[1] **Raju Thapa, Surya Parkash, Anil Kathait, Harjeet Kaur,** Geo-meteorological Risks Management Division, National Institute of Disaster Management, Ministry of Home Affairs, Government of India
* Corresponding Author Email: rajuthapa.nidm@gmail.com

more quickly, but it can also amplify negative messages. The systematic application of risk and evidence-based analyses and techniques to manage the infodemic and limit its influence on health behaviour during health emergencies is known as infodemic management.

Misinformation is deceptive information that is intentionally incorrect or erroneous. In the context of the present epidemic, it has the potential to have a significant impact on many parts of life, particularly people's mental health, since searches for COVID-19 updates on the Internet have increased by 50% to 70% across all generations. In a pandemic, misinformation can have a harmful impact on human health. Many fake or misleading tales are made up and distributed without any background or quality checks. Much of this disinformation is based on conspiracy theories, with some of these beliefs being introduced into what appears to be mainstream conversation. For example, 361,000,000 videos were posted to YouTube under the "COVID-19" and "COVID-19" classifications in just 30 days, and about 19,200 articles were produced in Google Scholar since the epidemic began. Around 550 million tweets in March 2020 contained the words coronavirus, corona virus, COVID-19, COVID-19, COVID-19, or pandemic (WHO 2021).

The information crisis is getting worse. The Covid pandemic makes it more difficult for decision-makers and ordinary public health professionals to identify reliable sources in an emergency. Certain news can make people feel emotionally drained, feel anxiety, overwhelmed, depression etc affecting their decision making ability. Due to very high advancement of technology and social media anyone can publish or write anything without any filters which might be misused very extensively.

2. Global Scenario of COVID-19

Globally, as of 10 September 2021, there have been 223,022,538 confirmed cases of COVID-19, including 4,602,882 deaths, reported to WHO (Figure 1). As of 5 September 2021, a total of 5,352,927,296 vaccine doses have been administered (WHO 2021).

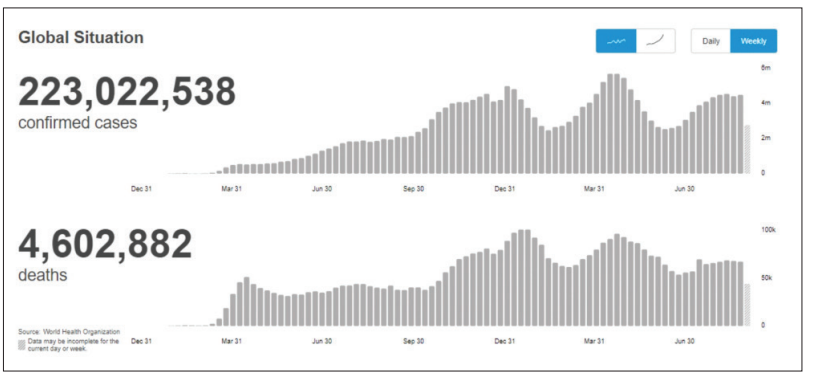


Figure 1: Global Situation of COVID-19 Confirmed and Death Cases by WHO as of 10 September 2021

(Source: WHO, 2021)

In India, from 3 January 2020 to 10 September 2021, there have been 33,174,954 confirmed cases of COVID-19 with 442,009 deaths, reported to WHO (Figure 2). As of 30 August 2021, a total of 651,214,767 vaccine doses have been administered.

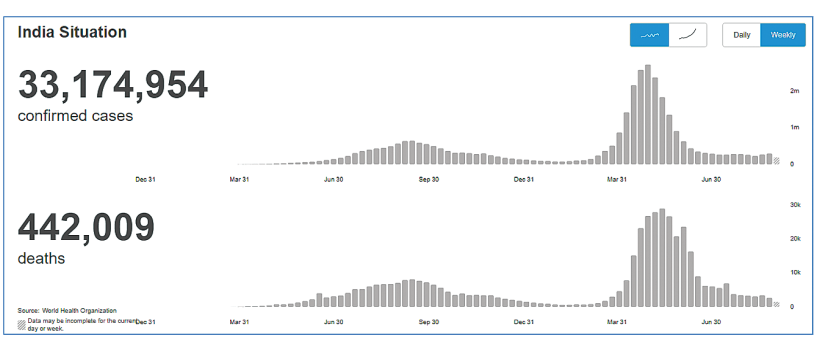


Figure 2: India Situation of COVID-19 Confirmed and Death Cases by WHO as of 10 September 2021

(Source: WHO, 2021)

3. Existing Challenges

India is a developing country and a large section of population resides in rural areas (Pan American Health Organization, 2020). There will be a challenge to include everyone and leaving no one especially those who lack connectivity or knowledge. Management of overloaded information and the vast technological tools can pose a great threat. With the advancement in information and technology, cyber safety poses a huge threat considering crucial issue such as ethical use, privacy, confidentiality of personal data. Technology is improving and advancing day by day which also puts big challenge in getting acquainted with new technological concepts. There is also a need to nurture a judgment skill for selecting tool and develop skills to use them.

4. 5W and 1H for Information Hygiene

Like appropriate behaviors such as masks, hand washing, physical distancing, vaccination can slow down the spread of COVID-19, spread of disinformation and misinformation can be slowdown by practising some information hygiene. To do so, before believing and sharing something we need to follow the 5W and 1H rule as follows (Figure 3):

- What am I sharing?
- Why am I sharing this?
- Where did it come from?
- Whose agenda might I be supporting by sharing it?
- When did the information took place
- How do I know if it's true?

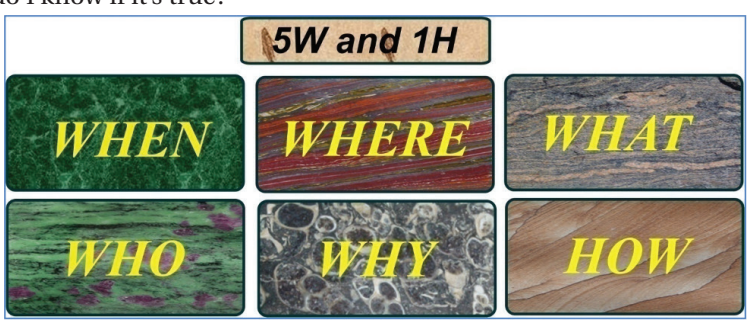


Figure 3: The 5W and 1H for Information Hygiene

5. Navigating the Infodemic

To navigate this wave of information and decide who and what to trust we can follow seven steps i.e., assess the source (WHO, 2021)

a. Assess the source: Assessment of source of information needs to be carried out such as who shared the information with you and where they did get it from. We have to make a habit of verifying the authenticity of images or videos. For example, we can use google's reverse image search tools for verifying image.
b. Go beyond headlines: We have to read between the lines and not judge news by their headlines because sometimes to produce provocative and sensational news, headlines are framed intentionally. We have to access diverse sources to differentiate trustworthy news from misinformation.
c. Identify the author: Before trusting any news of any authors, we need to search the details of the authors to understand their credibility and to know whether they are real or fake.
d. Check the date: We need to check whether the news is relevant to current events and is it up to date
e. Examine the supporting evidence: We need to check for the references or facts that are presented along with the credible stories.
f. Check your biases: We need to evaluate our own biases to understand why we may think or favor and why to a particular headline or story.
g. Turn to fact-checkers: We need to check, refer and consult reliable fact-checking organizations whenever in doubt.

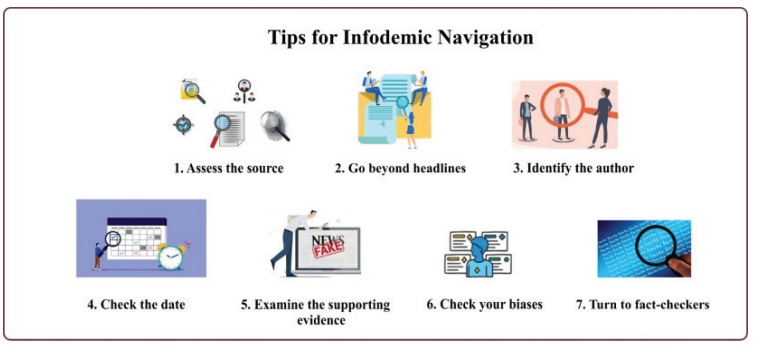


Figure 4: Navigating the Infodemic

(Source: WHO, 2021)

6. Public Participation in the Fight Against the COVID-19 Infodemic

We need to continuously upgrade our skills to cope with the technological advancement. We need to incorporate critical thinking for well-informed, balanced decision-making that distinguishes between content and presentation. We have to build the ability to search for information using multiple sources, including social networks. It is very important to enhance skills in reading, writing, and comprehension in the current digital context, which is dynamic and increasingly hyper connected. Active participation in virtual communities in order to contact other people, discuss issues, share lessons learned, and ask for help needs to be sharpened. People have a very important role to play in the fight against the COVID-19 infodemic. Some of the key actions that can be considered are as follows (Pan American Health Organization, 2020):

- people needs to trust its government, WHO etc for accurate information
- there is a need to identify evidence for all information
- Misinformation and disinformation needs to be avoided
- We have to be open minded and ready for acceptance for upcoming science
- Every information must be determined if the information really adds up
- We must report harmful rumors to the hosting social media platform
- We have to protect privacy
- Do not share any information if you are not sure about source of information and its usefulness
- Confirmed that the information is secure and has been shared before by other people
- In any social conversations, we need to participate responsibly
- Keep yourself updated by learning new skills and information
- The over-abundance of Covid-19 related information has turned up as a big challenge that the world is facing today. Not all information that we come through are true and some are misinformation or disinformation which can be potentially harmful if further disseminated. As said by Mark Twain, "A lie can travel around the world and back again while the truth is lacing up its boots." This holds quite true in case of infodemic regarding Covid-19. Misinformation or disinformation spreads to a wide population very quickly, which make it very difficult for the people to differentiate false and fake news from accurate and trusted sources information. Everyone needs

to do their part to stop the spread of misinformation (Figure 5). If you happen to come through misleading and false information, we must report it to the hosting social media platform.

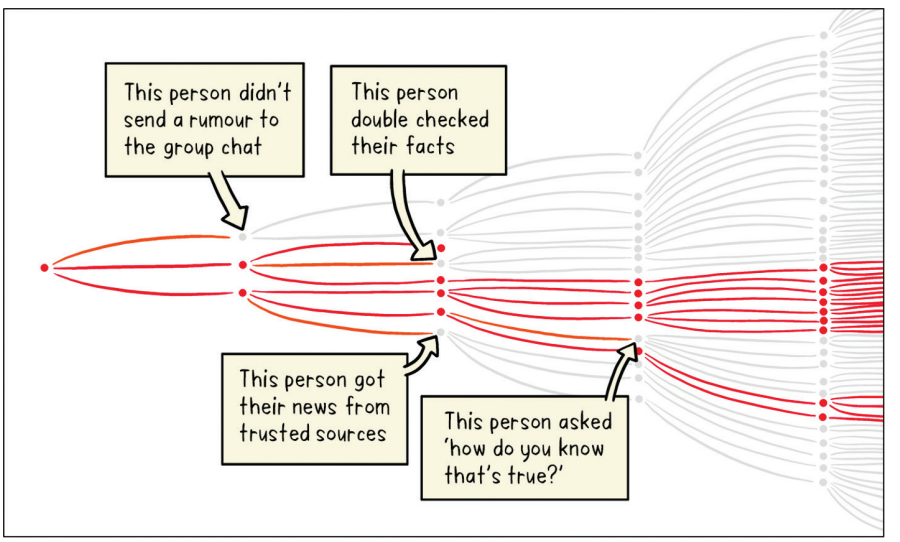


Figure 5: Flattening the Infodemic and Disinformation Curve (WHO 2021)

Conclusion

An infodemic is over load of information which includes accurate information along with misleading or false information in digital and physical environments during a disease outbreak. Overabundance of disinformation or misinformation can create a sense of confusion in people leading to risk-taking behaviours that have a potentiality of causing harm.

Reference

1. WHO (2021) WHO (2021). WHO Coronavirus (COVID-19) Dashboard. https://covid19.who.int/
2. Pan American Health Organization (2020). Pan American Health Organization report on Understanding the infodemic and misinformation in the fight against Covid-19. https://iris.paho.org/bitstream/handle/10665.2/52052/Factsheet-infodemic_eng.pdf?sequence=14

Road Accidents, Economic Burden and Travelling Safety in Punjab

Balveer Singh Sidhu[1]*, Jaswinder Singh Brar[2]

Abstract

Study attempts to capture the nature, incidence and severity of road accidents by using both secondary and primary data for Punjab. The situation of road accidents happens to precarious in the state. Economic burden of road accidents goes much beyond treatment and vehicle damage costs. Majority of road accidents' victims were younger, productive, qualified, working age and skilled personnel. Study calls for comprehensive overhauling of road safety system by factoring modern technology, incentives and good practices.

Keyword: *Accidents, Severity, Victims, Burden, Injured, Treatment.*

1. Introduction

Road accidents, truly speaking, are amongst the most frightening of contemporary hard realities of life. That is why human pain, emotions and suffering associated with accidents will continuously remain its most discussed aspect. By and large road accidents have been viewed and reported by popular media and other concerned quarters in the context of numerically counting of loss of life and property along with some details of happening. But, the economic burden of road accidents upon victim families and hence society at large has received comparatively little academic and policy attention particularly among the developing countries. Most often, it becomes extremely difficult for victim households to recover from the devastating impact of economic injuries triggered by road accidents. The economic burden of road accidents is much deeper, as most of times it impacts lifelong earnings, and goes considerably beyond direct treatment and vehicle damage costs. Road accidents when results in sudden demise

[1] **Balveer Singh Sidhu,** Research Fellow, Department of Economics, Punjabi University Patiala
[2] **Jaswinder Singh Brar,** Professor of Economics, Centre for Research in Economic Change, Punjabi University Patiala
* Corresponding Author Email: sidhubalveer33@gmail.com

of family members belonging to similar age group within the same households create a specific type of mutual look after void which imposes substantial care and nurturing costs in addition to the persistence of traumatic memories. The phenomenal growth of road transport sector in the developing countries in the situation of weak regulatory mechanism has generated a peculiar state of affairs which is culminating into loss of human life on somewhat perpetual basis. A large study (Chen et al., 2019) based on cross-country evidence concludes that the road accidents can cost between 1and 3 percent of income of countries depending upon their intensity. Road injuries are among the ten leading causes of death worldwide and by implication impede economic wellbeing and macro-economic performance. The study further estimated that road injuries will cost the world economy US$1·8 trillion (constant 2010 US $) during 2015-30, which is equivalent to an annual tax of 0·12 per cent on global gross domestic product. The road accident injuries result in higher economic burden through the loss of effective labour supply, rise in mortality, morbidity, increase in out-of-pocket expenses, diversion of savings towards treatment costs, rise in insurance premium, etc. The study further held that the treatment costs accounted for much higher proportion of economic burden in the developed countries than those of developing countries. It is reported that deaths from road traffic accidents have increased to1.35 million during 2016. That's nearly 3700 people dying on the world's roads every day during that year (WHO, 2018). This number is quite high as even during Covid -19 pandemic the number of confirmed deaths at the global level was equivalent to 18,80,463 during 2020, which means there by on an average 5152 deaths occurred per day (Covid-19 Data Explorer: 2021). The road accidents have emerged as some sort of perennial pandemic with huge human toll every year which is actually preventable by appropriate policy interventions. Against the above backdrop, the paper has been divided into sections. The next section second mentions in detail the basic research approach, data collection and methods to measure the economic burden. The third section examines in a comparative framework the situation of road accidents, resultant deaths and injured in the national context. The section fourth, based on primary data, provides the profile of road accident victims in terms of education, gender, age and occupation. Section fifth deals with the economic burden of road accidents and financing practices adopted by victims for treatment. The last section concludes the study with suggestions to contain the problem of road accidents in order to enhance travelling safety.

2. Material and Methods

The study used both the primary and secondary data in order to assess the situation of road traffic accidents in Punjab and the resultant economic burden on the victim households. The problem of road accidents is extremely serious as it is resulting into the loss of precious human life with devastating emotional costs to the near and dear ones. But somehow the emphasis so far remained on counting the mechanical dimensions of road accidents in terms of their number, deaths, injuries and damage to motor vehicles etc. However, during the last decade or so it has gradually been realized that the road accidents put huge economic burden upon the households, society and economy in numerous respects. It results into diversion of plethora of resources from productive uses to meet contingencies of life apart from loss of productive manpower.

The secondary data for the numerous dimensions of road accidents have been taken from the annual publications of the union Ministry of Road Transport and Highways, GoI, New Delhi. The MRTH has been doing a valuable service in collecting, processing and putting in public domain, in an easy to understand format, the vital aspects of road accidents in the country for all the states and union territories. The collection of primary data pertaining to road accidents is a daunting task as households are not ready to share the information as in majority of cases some sort of litigation has been going on. They fear that the information provided to any person may be divulged to other party which may adversely affect the court proceedings including insurance claims. Moreover, society including knowledgeable persons by and large believes that there cannot be any economics of road accidents. So convincing the respondents about the secrecy, academic and economic policy use of data is the pre-requisite for building proper data base. Further, it is extremely difficult to construct any meaningful sampling frame for the road accidents as their incidence involve happening of motor vehicle crash over a large geographical space divided into huge number of population settlements, viz. villages and cities. After trying various permutations and combinations, it was decided to collect data through the process of what is generally called as chain-referral sampling which is helpful in generation of data related to events which occur with infrequent happening. To enhance the representativeness of data base the two-stage stratified sampling process has also been added. Among the three well specified regions of state (i.e., Mazha, Malwa and Doaba) the region of Malwa has been selected which accounted for the highest (i.e., 68.71 per cent) proportionate share of overall road accidents in the

state during 2017. Noticeably this region happens to be the largest region of state in terms of population and area also. All the 14 districts of this region were further clubbed into two categories accounting for districts with accidents higher and lower than that of the average of the region (308 accidents per district). Within this break up, two districts namely Patiala and Mansa were randomly selected respectively representing the higher (16.2 per cent) and lower (3.2 per cent) proportionate share of road accidents. Further, from these two districts, a purposely selected sample size consisting of one hundred road accidents has been selected. The sample has been further divided into two parts as per the proportionate share of road accidents in the selected district in the region. The two districts Patiala and Mansa respectively constituted 16.2 per cent and 3.2 per cent share of road accidents of the region. Thus, out of total sample of 100 road accidents, 84 were selected from Patiala and 16 from Mansa. The data have been collected in case of those road accidents which took place between 2014 and 2018, i.e., the period of five years prior to the survey. The recall period has been fixed to five years in order to avoid the fallacies of long recall period particularly related to monetary details. The overall sample has been sub divided into two equal sub samples consisting of fifty cases of death and injuries each in order to work out and compare their collective and separate economic burden on victim households. Hence, the ultimate sample consisted of 42 case of deaths and 42 cases of injured for Patiala and 8 cases of each deaths and injured for Mansa. The sampled households were selected and data have been collected by using social network of known persons. Every next sampled household was selected among the references provided by the previously surveyed households. The households from the reference based list were sometimes dropped because of non-cooperation by the targeted households. In this way a sample of hundred households was generated as per objectives of the study by upholding the basic contours of the sampling framework. The road accidents impose huge costs on the households involved which ranges from emotional cost to large number of monetary costs in the form of direct treatment and vehicle damage costs. The economic burden also plays its part through the loss of current as well as future income loss besides diversion of family resources to unproductive uses. The present study is confined to measurement of the direct monetary cost in the form of medical treatment and cremation costs. The medical cost has been separately calculated as actually incurred and reported by victim households for different categories of victims in both of death and injury cases. It has been calculated for death

cases for three categories, viz. on the spot, on route to hospital or in hospital, and a few days after the accident. In death cases, families have spent on cremation and its related ceremonies also. Similarly, in case of injuries the medical cost has also been calculated for three categories, viz. permanently disabled, partially cured and fully cured.

3. Road Accidents in Punjab

Accident situation in the state of Punjab is quite serious when viewed in the national context and that of some other parameters. The various annual reports of MRTH entitled Road Accidents in India are sufficient enough to understand the deteriorating situation of road accidents in the state of Punjab. Over the period of eight calendar years from 2011 to 2018, as many as 51,923 road accidents happened in the state of Punjab causing the death of 38,133 persons besides injuring 32,955 persons (Table 1). The number of road accidents in the state declined marginally from its level of 6513 during 2011 to 6323 during 2013 but increased subsequently. During 2018 alone, as many as 6428 road accidents happened in the state resulting in death of 4740 persons besides injuring 3384 ones. Importantly, the state witnessed higher number of road accidents during 2018 as compared to 2017; respectively being 6428 and 6273 means thereby 155 more number of accidents. The average share of state, over the period 2011 to 2018, in the total number of road accidents in the country was equivalent to 1.34 per cent, but its share in accident related deaths was 3.46 per cent which was much higher than the proportionate share (2.30 per cent) of Punjab in the overall population of India.

The dismal situation of accidents in the state further becomes clear when we take into account some other indicators (Table 2). The state has experienced substantially higher level of fatal accidents than the rest of country. For all years reported here, from 2011 to 2018, the Death to Accident Ratio (DAR), also called severity of road accidents, was much higher in case of Punjab than that of national average. For example, during 2018, its level was 0.74 for the state and 0.32 for the country (Figure 1). Similarly, the number of persons killed per lakh of population was higher in the state than that of national average respectively being 16.0 and 11.70 during 2018. Furthermore, in terms of daily average the state has gone through higher number of road accidents. For example, during 2018, in the state, as many as18 accidents had happened which caused the deaths of 13 and injury to 9 persons; implying the direct impact on 22 persons.

Type of collusion wise break up of data (Table 3) brings to fore some other disgusting

features of road accidents. During 2018, in as many as 1498 cases (14.98 per cent) of road accidents, one of the colluding vehicles after hitting the other party run from the spot. The proportionate share of other collusion types was as follows: Hit from Back (12.52 per cent); Hit from Side (11.51 per cent); Head on Collusion (11.09 per cent), Vehicle Overturn (7.37 per cent); Parked Vehicle (4.64 per cent); and Run off Road (2.62 per cent). However, as high as 2546 accidents (30.62 per cent) do not fit into any of above specified neat and fine categories and were of mixed types. Further, comparatively higher proportion (21.54 per cent) of deaths occurred in the hit and run category of collusions. But, maximum (20.64 per cent) of injuries happened in case of head on collusion. Furthermore, as per Table 4, during the period of five years from 2014 to 2018, as many as 23,794 persons died in road accidents in the state, out of which 3033 (14.61 per cent) were females. The proportionate share of females in overall road accidents hovered between 11.46 per cent and 17.50 per cent (Figure 2).

The MRTH (2018) report brings to fore some other worrisome aspects of road accidents in the state. Another indicator, the Death to Injury Ratio (DIR) in the state stood at 1.40 which was actually 4.34 times higher than that of national average 0.32. The report clearly points towards the high severity of road accidents in the state. Here on this score, during 2018, among all the 36 states and union territories, the rank of the state was second from above only next to Mizoram's 84.90. What is more disgusting is that the severity of road accidents (i.e., number of road accident deaths per hundred accidents) increased in the state from its level of 71 during 2017 to 74 during 2018 (MRTH, 2018: 62)? Out of total accidents about 70 per cent proved fatal, 19 per cent caused grievous injury, 9 per cent minor injury and astonishingly non-injury cases were just 2 per cent (MRTH, 2018: 63). According to type of collusion, the head on collusion occurred in 922 cases (14 per cent) leading to death of 691 persons besides grievously injuring 294 persons. In 585 cases, motor vehicles hit the pedestrians resulting in the death of 415 persons along with grievously injuring 187. Over speeding and wrong side driving were reported to be responsible for respectively 52 per cent and 16 per cent accidents. The most revealing findings come in the form of involvement of drivers with valid permanent driving license in 3237 cases (50 per cent). The happening of 631 accidents at traffic light signals is another worrisome point indicating failure of regulation and control mechanism. About half of accidents were caused by two wheelers and four wheelers consisting of cars, jeeps, vans and cabs etc.

Table 1: Number and Share of Punjab in Overall Road Accidents in India

Year	Number of Accidents			Persons Died			Persons Injured			*Population Share of Punjab
	Punjab	India	%	Punjab	India	%	Punjab	India	%	
2011	6513	497686	1.31	4931	142485	3.46	4081	511394	0.80	2.32
2012	6341	490383	1.29	4820	138258	3.49	3997	509667	0.78	2.32
2013	6323	486476	1.30	4588	137572	3.33	4383	494893	0.89	2.31
2014	6391	489400	1.31	4621	139671	3.31	4127	493474	0.84	2.31
2015	6702	501423	1.34	4893	146133	3.35	4414	500279	0.88	2.30
2016	6952	480652	1.45	5077	150785	3.37	4351	494624	0.88	2.29
2017	6273	464910	1.35	4463	147913	3.02	4218	470975	0.90	2.29
2018	6428	467044	1.38	4740	151417	3.13	3384	469418	0.72	2.28
Total	51,923	3,877,974	1.34	38,133	1,154,234	3.46	32,955	3,944,724	0.80	2.30

Note: * shows share of Punjab in overall population in the country
Source: MRTH (2018).

Table 2: Certain Critical Indicators Related to Accidents in Punjab

Year	Deaths to Accident Ratio (DAR)		Persons killed Per Lakh of Population		Per Day in Punjab		
	Punjab	India	Punjab	India	Accidents	Deaths	Injuries
2011	0.76	0.29	17.80	11.80	17.84	13.51	11.18
2012	0.76	0.28	17.20	11.40	17.37	13.21	10.95
2013	0.73	0.28	16.20	11.20	17.32	12.57	12.01
2014	0.72	0.29	16.20	11.30	17.51	12.66	11.31
2015	0.73	0.29	17.00	11.70	18.36	13.41	12.09
2016	0.73	0.31	17.40	11.90	19.05	13.91	11.92
2017	0.71	0.32	15.20	11.50	17.19	12.23	11.56
2018	0.74	0.32	16.00	11.70	17.61	12.99	9.27

Source: Road Accidents in India, MRTH (various issues).

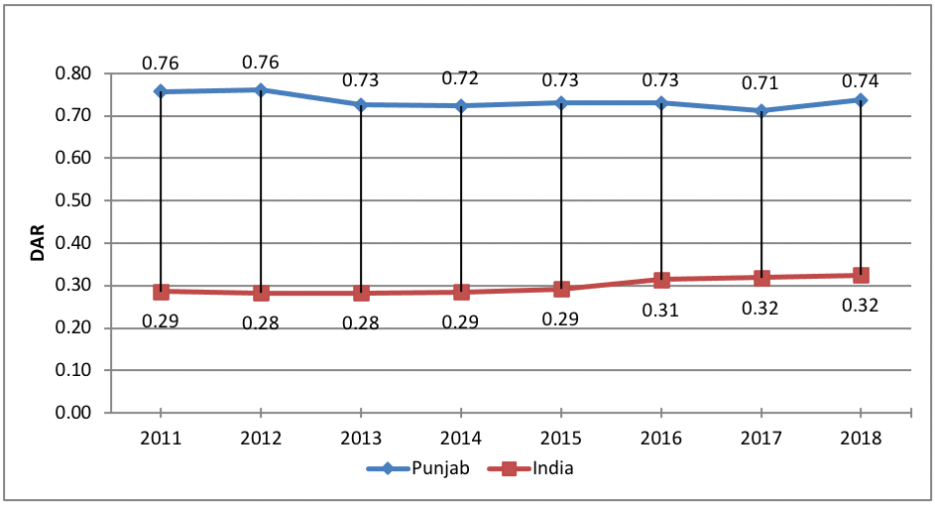


Figure 1: Death to Accidents Ratio (DAR) in Punjab and India: 2011-18

Source: Based on Table 2

Table 3: Road Accidents, Deaths and Injured in Punjab According to Type of Collusion, 2018

Type of Collusion	Accidents		Deaths		Injured	
	Number	Percent	Number	Percent	Number	Percent
Hit and Run	1498	18.02	1186	21.54	715	10.01
Head on Collusion	922	11.09	691	12.55	1475	20.64
Vehicle Overturn	613	7.37	399	7.25	363	5.08
Fixed Object	133	1.60	93	1.69	85	1.19
Run Off Road	218	2.62	147	2.67	141	1.97
Hit from Side	957	11.51	635	11.53	590	8.26
Hit from Back	1041	12.52	706	12.82	661	9.25
Parked Vehicle	386	4.64	301	5.47	167	2.34
Others	2546	30.62	1349	24.50	2948	41.26
Total	8314	100.00	5507	100.00	7145	100.00

Source: MRTH (2018).

Table 4: Sex Wise Break Up of Road Accident Deaths in Punjab

Year	Person Died	Male		Female	
		Died	Per Cent	Died	Per Cent
2014	4621	3956	85.61	665	16.81
2015	4893	4390	89.72	503	11.46
2016	5077	4458	87.81	619	13.89
2017	4463	3923	87.90	540	13.76
2018	4740	4034	85.11	706	17.50
Total	23794	20761	87.25	3033	14.61

Source: Road Accidents in India, MRTH, New Delhi (various issues).

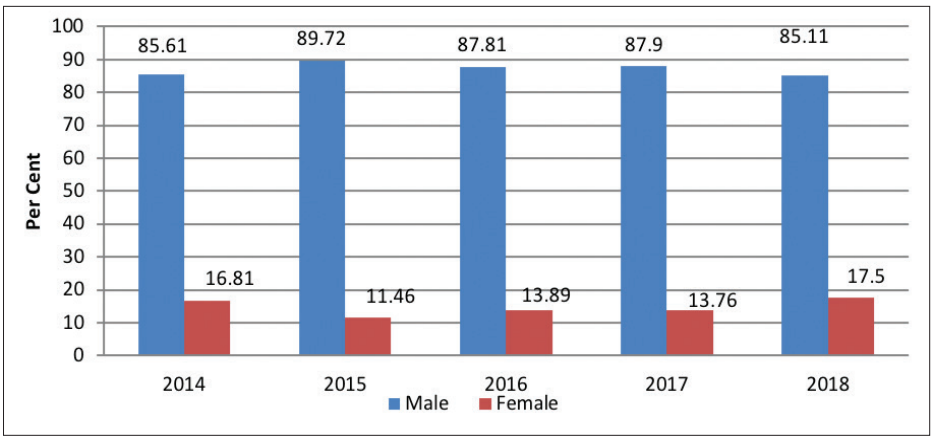


Figure 1: Male and Female Share in Road Accident in Punjab, Per Cent

4. Profile of Road Accident Victims

The gravity of the situation of road accidents in the state becomes clear from the perusal of primary data (Sidhu, 2019). The data, in nutshell, conclusively established that road accidents have disproportionately affected the younger, productive, qualified, working age and skilled populace. For example, in both categories namely injured and died, about a half belonged to 15-40 years of age group (Table 5) with qualification of metric and above (Table 6); doing government and private jobs, involved in daily wage work, pursuing study and farming (Table 7).

Table 5: Age and Sex Specific Profile of Road Accident Victims in the State of Punjab

Age Group (Years)	Persons (Injured)			Persons (Died)		
	Male	Female	Total Person	Male	Female	Total Person
a. under 14	0 (0.0)	0 (0.0)	0 (0.0)	4 (8.5)	0 (0.0)	4 (8.0)
b. 15-40	26 (65.0)	5 (50.0)	31 (62.0)	25 (53.2)	2 (66.7)	27 (54.0)
c. 41-59	12 (30.0)	2 (20.0)	14 (28.0)	12 (25.5)	1 (33.3)	13 (26.0)
d. 60 and above	2 (5.0)	3 (30.0)	5 (10.0)	6 (12.8)	0 (0.0)	6 (12.0)
Total	40 (100.0)	10 (100.0)	50 (100.0)	47 (100.0)	3 (100.0)	50 (100.0)

Note: Figures in brackets show row-wise per cent share.
Source: Field Survey (January - February 2019).

Table 6: Education Profile of Sampled Road Accident Victims in Punjab

Education Level	Persons (Injured)			Persons (Died)		
	Male	Female	Total	Male	Female	Total
1. Illiterate	7 (17.5)	5 (50.0)	12 (24.0)	14 (29.8)	2 (66.7)	16 (32.0)
2. Primary	3 (7.5)	2 (20.0)	5 (10.0)	2 (4.3)	0 (0.0)	2 (4.0)
3. Middle	10 (25.0)	0 (0.0)	10 (20.0)	5 (10.6)	0 (0.0)	5 (10.0)
4. Metric	9 (22.5)	0 (0.0)	9 (18.0)	15 (31.9)	1 (33.3)	16 (32.0)
5. Senior Secondary	7 (17.5)	0 (0.0)	7 (14.0)	5 (10.6)	0 (0.0)	5 (10.0)
6. Graduation	2 (5.0)	2 (20.0)	4 (8.0)	4 (8.5)	0 (0.0)	4 (8.0)
7. PG and above	2 (5.0)	1 (10.0)	3 (6.0)	2 (4.3)	0 (0.0)	2 (4.0)
Total	40 (100.0)	10 (100.0)	50 (100.0)	47 (100.0)	3 (100.0)	50 (100.0)

Source- Field Survey (January - February 2019)

Table 7: Occupational Profile of Sampled Road Accident Victims in the State of Punjab

Occupation of Victim	Persons (Injured)			Persons (Died)		
	Male	Female	Total	Male	Female	Total
(a). Farmers	10 (25.64)	0 (0.00)	10 (20.00)	12 (25.53)	0 (0.00)	12 (24.00)
(b). Agriculture Labour	0 (0.00)	0 (0.00)	0 (0.00)	2 (4.26)	0 (0.00)	2 (4.00)
(c). Non-Agriculture Labour	0 (0.00)	0 (0.00)	0 (0.00)	1 (2.13)	0 (0.00)	1 (2.00)
(d). Business	2 (5.13)	0 (0.00)	2 (4.00)	2 (4.26)	0 (0.00)	2 (4.00)
(e). House Maker	0 (0.00)	6 (54.55)	6 (12.00)	0 (0.00)	2 (66.67)	2 (4.00)
(f). Private Job	11 (28.21)	0 (0.00)	11 (22.00)	11 (23.40)	0 (0.00)	11 (22.00)
(g). Government Job	5 (12.82)	0 (0.00)	5 (10.00)	3 (6.38)	1 (33.33)	4 (8.00)
(h). Students	3 (7.69)	3 (27.27)	6 (12.00)	10 (21.28)	0 (0.00)	10 (20.00)
(i). Daily Wage Worker	8 (20.51)	2 (18.18)	10 (20.00)	6 (12.77)	0 (0.00)	6 (12.00)
Total	39 (100.0)	11 (100.0)	50 (100.0)	47 (100.0)	3 (100.0)	50 (100.0)

Note: Figures in parentheses are percentage share in the total of respective row.
Source- Field Survey (January - February 2019)

5. Economic Burden

Road accidents entail huge economic burden upon the victim households, society in general and overall economic growth and development by impacting the human and material capital accumulation process. The resources at the household level with rise in accidents got diverted to unproductive channels through the treatment and vehicle damage costs along with loss of human capital. The saving and investment circuit specific to household sector experiences distortionary effects constraining its growth capacity, welfare profile and upward mobility of young family members. The economic burden has been assessed and reported as under:

5.1 Death Cases

Structural dynamics of accidents points toward the growing complexity of road accidents in the state when viewed in terms of timing of deaths and associated treatment costs (Table 8). It is important to note that accident impact was so strong that 34 (68 per cent) victims, at the time of accident, died on the spot. And, 10 (20 per cent) victims died after few days of happening of the accident. Noticeably, as many as 6 victims (12 per cent) succumbed to their injuries on route to the hospital or during treatment in hospital. The victim households spent heavily on medical expenses for treating the injured during road accidents. In case of accidents resulting into death, the overall cost goes up because of incurring of cremation cost in addition to the medical cost. Per person cremation cost varied between Rs. 31,971 and Rs. 46,200 according to the timing of death from road accident. Per person total cost (medical cost and cremation cost) on an average was Rs. 1, 14,944. It varied according to timing of death and was as follows: death on spot (Rs. 35,529); death on route to hospital or just after hospitalization (Rs. 1, 01,199) and a few days after accident (Rs. 3, 93,200). Noticeably, the overall cost of 50 death cases was equivalent to Rs. 57.47 lakh to the accident victim households. Of this cost, the highest component Rs. 39.32 lakh (68.42 per cent) was spent in those cases where death occurred a few days after the accident.

Table 8: Treatment and Cremation Costs of Sampled Road Accident in Death Cases (Rupee)

Timing of Death	Per Person (Rupee)			Overall Cost (Rs. Lakh)	Total Cases
	Medical Cost	Cremation Cost			
a. On Spot	3,558	31,971	34 (68.00)	12.08(21.02)	34 (68.00)
b. On Route to Hospital or in Hospital	67,533	33,666	6 (12.00)	6.07 (10.57)	6 (12.00)
c. Few Day after Accident	3,47,000	46,200	10 (20.00)	39.32(68.42)	10 (20.00)
--	79,924*	35,020*	50 (100)	57.47(100)	50 (100)

Note: * Per Person cost, in last row, is weighted average of timing of death wise mentioned three cases.
Source: Field Survey (January - February 2019)

5.2 Injury Cases

The road accidents have been found to be posing huge crippling effect on the persons involved. The data in Table 9 brings to fore the status of the victim of road accident according to type of injuries. It emerged that 14 victims (28 per cent) had suffered injuries on their head. The proportionate share of rest was as follows: on the abdomen part, lower back, lumbar spine and pelvis (4 per cent); on shoulders, upper arm, hip and thighs (8 per cent); on elbow and forearm (2 per cent); on wrist and hand (6 per cent); on knee and lower legs (30 per cent); and on multiple body parts (14 per cent).

Among injured (Table 10), 21 victims (42 per cent) were cured partially and 14 victims (28 per cent) experienced permanent disability after the accident. Just 30 per cent were fully cured after the accidents. In case of injured persons, per person medical cost was found to be the highest in case of persons who suffered permanent disability (Rs. 5,96,785), followed by partially cured (Rs.1,86,429) and lowest for fully cured (Rs.83,667). Per person medical cost on an average was Rs. 2, 70,500 in case of injured persons. The sampled households have spent Rs. 135.25 lakh on the treatment of persons injured in the road accidents. Of this, the highest amount of Rs. 83.55 lakh (61.77 per cent) was spent in case of persons who experienced permanent disability during the various accidents.

Table 9: Distribution of Road Accident Victims by Type of Physical Injury

Site of Injury	Cases	Per Cent
a. Injuries involving multiple body regions	7	14.0
b. Injuries to the knee and lower leg	15	30.0
c. Injuries to wrist and hand	3	6.0
d. Injuries to the hip and thigh	4	8.0
e. Injuries to shoulders and upper arm	4	8.0
f. Injuries to the elbow and forearm	1	2.0
g. Injuries to the abdomen, lower back, lumbar spine and pelvis	2	4.0
h. Injuries to the head	14	28.0
Total	50	100.0

Source- Field Survey (January - February 2019)

Table 10: Treatment Costs of Sampled Road Accidents in Injury Cases, Rupee

Type of Injury	Total Cases	Overall Cost (Rs. Lakh)	Per Person Medical Cost(Rupee)
Permanently Disable	14 (28.00)	83.55 (61.77)	5,96,785
Partially Cured	21(42.00)	39.15 (28.95)	1,86,429
Fully Cured	15 (30.00)	12.55 (9.28)	83,667
Total	50 (100.00)	135.25 (100)	2,70,500

Source- Field Survey (January - February 2019)

5.3 Financing of Treatment

Further, the cost of hospitalization was found to be beyond the manageable capacity of the accident victim households (Table 11). Among injured, in case of 25 persons (50 per cent) the money was arranged by family members from the friends. And in case of 11 persons (22 per cent) the money was arranged from landlords and money lenders which involve interest also. Noticeably, 4 per cent of victim households sold some property to get the injured treated. It is important to note that the handling of treatment becomes much difficult in situation of lack of insurance system in the form of health and life insurance cover. From primary survey, it is to be noticed that among injured persons just 4 per cent were in possession of life insurance policy, 6 per cent that of vehicle insurance and an overwhelming (90 per cent) had no insurance protection. Among death cases, 14 per cent were covered by life insurance policies, 2 per cent with vehicle insurance and 84 per cent were without any insurance cover (Sidhu, 2019). The near absence or weak insurance cover further aggravates the financial balance of the victim households. Thus, the arrangement of funds for treatment of persons involved in road accidents poses big economic burden and results into diversion of resources from their intended use towards the treatment of effected persons. Further, the accidents by their very nature pose sudden financial burden on the households which leads to emergency arrangement of funds on the part of households. The instant arrangement of funds leads to the acceptance of more unfavourable terms and conditions as the borrowing households being placed on the receiving end of transaction. Thus, out-of-pocket expenditure which already is a big issue connected with availing of health services for large majority of households becomes further serious when accident related treatment expenditure too falls upon such households.

Table 11: Arrangement of Fund for Treatment of Road Accidents in Punjab

Sources	Persons (Injured)	Persons (Died)	Total Persons
No Borrowing	0(0.0)	33(66.0)	33(33.0)
Current income/Past Saving	3(6.0)	0(0.0)	3(3.0)
Selling Property	2(4.0)	0(0.0)	2(2.0)
Relative/Friends	25 (50.0)	6(12.0)	31(31.0)
Landlord/Money Lender	11(22.0)	5(10.0)	16(16.0)
Donation	1(2.0)	3(6.0)	4(4.0)
Miscellaneous	8(16.0)	3(6.0)	11(11.0)
Total	50(100)	50(100)	100(100)

Note: Figures in parentheses are percentage share in the total of respective rows.
Source: Field Survey (January - February 2019).

6. Concluding Observations and Suggestions

The road accidents in the state have emerged as a huge public health crisis with prolonged impact on all aspects of normal human activity. Accidents entails enormous economic burden by seriously disrupting the human resource base of victim families by cutting short the existing and potential income flows, diversion of household resources from productive uses towards meeting contingencies, unbalancing the saving and investment profile, loss of bread earners, serious jolt to accumulated human capital, decline in productive workforce, increased litigation costs and resort to treatment oriented borrowings by victim households, etc. The economic burden further goes up in situation of dysfunctional public health system in the state. From survey, it emerged that overwhelmingly higher proportion (86 per cent) of victims was admitted in private hospitals after the accidents than that of the government hospitals (14 per cent). The near exclusive dependence on private health care in situation of emergency results in borrowing from private sources in order to start the very process of treatment. The privatization of health care in situation of poor insurance coverage has brought double whammy in its wake. Overwhelmingly higher proportion of victims (87 per cent) was without insurance policy when the accident occurred. Just 9 per cent victims were covered by life insurance policy and 4 per cent with vehicle insurance (Sidhu, 2019).

The road safety system is just not working keeping in view the incidence, severity,

timing of deaths and types of road accidents. Majority of victims succumbs to injuries because of non-availability of first aid on the spot and associated medical follow up. Readily availability of first aid along with speedily arrangement of shifting the injured to hospitals comprises the integral part of any sound road safety system. The state has to develop and design the road safety system by taking into account all possible dimensions of such happenings. The road safety starts with quality of drivers which, apart from the social and psychological factors, exclusively depends upon the rigour of training which is tested while issuing the driving licenses. The state has definitely compromised on this aspect as large number of accidents was committed by persons with valid driving licenses. The irony of the situation is that large number of public vehicles in the state has also been found to be involved in road accidents which in an ideal situation must be the torch bearers of road safety with highest confidence of passengers. The state has been depending upon physical type of measures, such as stopping and verifying of vehicles at selected traffic inter-section points, for rule enforcing which is rudimentary approach to the growing problem of road accidents. Latest technology needs to be used to fix the traffic rule violators, like reckless driving, drunken driving and over-speeding etc., which is not that costly but is actually foolproof method which also stands legal scrutiny as evidence of violation is generated there and then. There is need to install speed monitoring radars at every 20 Km to check over speeding. Some simple steps like stoppage of unauthorized parking and halting along road sides could reduce fatal accidents to large extent. The system of incentives and disincentives has to make operational as in case of countries with minimalist number of accidents by linking the vehicle insurance, life insurance and credit markets by strictly following the policy of zero tolerance as it involves human life. The situation demands that instead of concentrating upon limited traffic inter-section points by deputing good number of traffic personnel the multiple stretches of roads should be covered under the intensive use of technology. The content of driving license itself has to be upgraded by incorporating more chip based features into it. The best practices existing elsewhere within and outside the country need to be identified and adopted. It is to be noted that within the country Tamil Nadu happens to be the only state which succeeds in reducing the road accidents related deaths to a noticeable extent. The government of India has signed the Brasilia declaration on Road Safety 2015, which, inter-alia, resolved to halve the deaths and injuries from accidents by 2020. Road safety has been

incorporated as a goal to be achieved under SDG Target 11.2 by 2030. This call for comprehensive overhauling of transport system in order to build a system with access to safe, affordable, accessible and sustainable transport systems for all. This further requires improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons (NITI Aayog, 2018). The road safety has to be treated as essential component of public safety as pedestrians, cycle users, street playing children and road side vendors have been succumbing to horrible type of road accidents. The WHO (2018) report appropriately sums up the problem of road accidents by concluding that road traffic crashes are not 'accidents', they are completely preventable. Hence, the state has to do much more in a time bound and comprehensive manner with specific targets and initiatives in order to reduce and ultimately minimize the growing problem of road accidents.

References

1. Chen Simiao, M. Kuhn, K. Prettner, D. E. Bloom (2019): The Global Macroeconomic Burden of Road Injuries: Estimates and Projections for 166 Countries, Lancet Planet Health, Vol. 3, P. e390-98.
2. Covid-19 Data Explorer (2021): Our World in Data Series, Statistics and Research Division, Website URL: our world in data.org/covid-deaths, Date 10August, 2021.
3. MRTH (2018): Road Accidents in India, Ministry of Road Transport and Highways, Government of India, New Delhi
4. NITI Aayog (2018): Sustainable Development Goals, India, Mapping of Central Sector Schemes and Ministries of Government of India, NITI Aayog, New Delhi
5. Sidhu, Balveer Singh (2019): Road Accidents in Punjab: An Analysis, M. Phil. Dissertation, Submitted to Department of Economics, Punjabi University Patiala.
6. WHO (2018): Global Status Report on Road Safety, World Health Organization, Geneva.

Mitigation Measures with Respect to Developmental Activities in Garhwal Himalaya

Ruchi Saraswat[1*], Shilpa Pal[2], Surya Parkash[3]

Abstract

Garhwal Himalaya is one of the most affected landslide areas in the Indian Himalayas due to steep topography, geological causes, often arising from intense precipitation events. The region has seen an increase in the frequency of landslides due to the increase in developmental activities owing to the presence of a large number of pilgrimage sites. This has led to an increased risk of landslide events, thereby making it imperative to examine the impact of such development activities to landslide occurrences in the region. Out of the various natural hazards like landslides, earthquake and flash floods, this paper focuses on the landslides occurrences have been increased due to increase in the anthropogenic activities in these areas. It is the need of hour to plan for hazard assessment for these areas to mitigate the impact of hazards like landslides so that accordingly to the assessment of these hazards developmental activities can be carried in the future. So, zonation of hazard prone areas is a must to find out the degree of influence caused by these hazards. Hazard zonation mapping has been done using 8 Landsat satellite imageries, field data, Google earth, landslide location data, toposheets by survey of India department and preparation of various thematic layers like slope, altitude, structure, geology, drainage, land use and land cover. Landslide hazard zonation has been prepared by integrating all the thematic layers in the GIS domain by weighted overlay technique. Landslide hazard susceptibility map categorises the area into different zones. Landslide hazard zonation map has been validated with the Landslide Inventory map of the study area. Hazard zonation map has also been validated mathematically as well as in the field.

[1] **Ruchi Saraswat,** Department of Civil Engineering, Gautam Buddha University & Department of Civil Engineering, JSSATE, Noida
[2] **Shilpa Pal,** Department of Civil Engineering, Delhi Technological University, Shahbad Daulatpur, Delhi 110042, India
[3] **Surya Parkash,** Geo-meteorological Risks Management Division, National Institute of Disaster Management, Ministry of Home Affairs, Govt. of India, New Delhi
* Corresponding Author Email: rsaraswat@jssaten.ac.in

Keywords: *Mitigation measures, Garhwal Himalaya, Development activities*

1. Introduction

Landslides are one of the most devastating and recurring natural disasters affecting different parts of the world. Most of the landslides are triggered either due to rainfall or earthquake, of which rainfall-induced landslides are the most prominent (Froude and Petley, 2018). The Indian Himalayan region is the most affected rainfall-triggered landslide area, accounting for nearly 15% of the global landslides (Dikshit et al., 2020a). The Uttarakhand region of the Indian Himalayas is highly prone to landslides, leading to enormous amounts of financial losses and casualties. In a recent review article, by (Dikshit et al., 2020a) on landslide studies in Indian Himalayan region, more than half of the studies were dedicated to the region of Uttarakhand. This bias was due to the greater number of casualties in the region, which accounted for over 80% of fatalities during 2007-2015 (Pham et al., 2019). Apart from rainfall being a major influencing factor for landslide incidences, other key parameters include the effect of climate change (Gariano and Guzzetti, 2016) and anthropogenic activities (Dikshit et al., 2020b). The effect of climate change has led to erratic rainfall patterns, whereas the influence of anthropogenic factors is immense as the region has seen a rise in developmental activities over the past 15 years. Therefore, the present study would look towards examining these factors also and understand how these factors affect the occurrences of rainfall-induced landslides in the region.

Further, the landslide studies in the region have looked towards developing thresholds, i.e., the minimum amount of rainfall required for landslide occurrences. As an example, Kanungo and Sharma, (2014) found that a 10-day antecedent rainfall of 55mm and 20-day antecedent rainfall of 185mm are sufficient for landslides occurrences in the Chamoli district (north-eastern part of Uttarakhand). There are multiple studies which have looked towards developing a landslide susceptibility map, either regionally or locally. Landslide susceptibility assessment determines the potential of landslide event considering several predisposing factors and investigating their spatial distribution (Reichenbach et al. 2018). These studies have been conducted using either statistical or data-driven models including machine learning (Dikshit et al., 2020b). For a complete reading of the various studies and their outcomes, readers are referred to Dikshit et al., (2020a). Of the various landslide studies conducted in the

region, one that has been missing, is a comprehensive understanding of the spatial and temporal changes of landslide occurrences in the region.

The present study is focused on the Dunda region which is situated in the northern part of the state. The study area was chosen as the region has been suffering from frequent and recurring landslides every year. The three main objectives of the paper are: i) Examining the decadal variation (2008-2018) of the spatial and temporal changes in landslide occurrences; ii) Analysing the effect of rainfall patterns and various developmental activities, and iii) Possible mitigation measures which could be adopted to prevent landslide casualties.

2. Study Area

The study area (119 km^2) is between Dunda to Bhatwari which is located in the Uttarkashi district situated in the northern Indian state of Uttarakhand. The area is located along the banks of River Bhagirathi with an average elevation of 1680m (Figure 1). The study area is selected as it covers one of the most pilgrimage routes and the frequent landslides in the region causes severe casualties and economic loss.

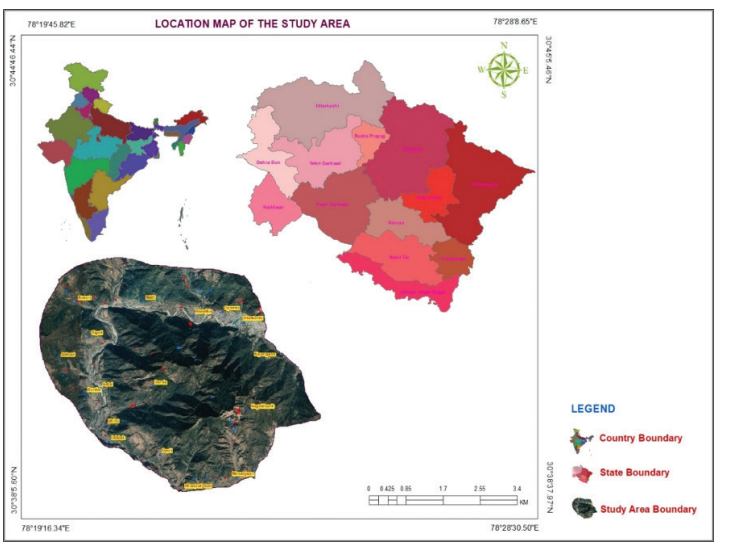


Figure 1: Location of the study area

Geologically, the study area is mainly composed of major rock formations like quartzite, metavolcanics, Pujaragon limestone etc. Dunda quartzite, augen mylonite

and epidiorites are the main rock formations which occurred in the study area. Due to repeated tectonic activities in the rock formations, geology of the area is very much complicated. Dunda formation consists of thick limestone, slate and quartzite. The Garhwal Himalaya forms the most extensive group of rocks in Uttarkashi district. Garhwal group is limited by the main central thrust in the north and main boundary fault in the south. The main rock types are dolomite, limestone, slate, phyllite. These rocks are disrupted by acid and basic igneous rocks. Geology plays an important role in shaping the groundwater scenario of an area. Therefore, it becomes necessary to understand the geology of Uttarkashi district. The geology of the area is highly complex as the rock formations have undergone tectonic activities as shown in Figure 2.

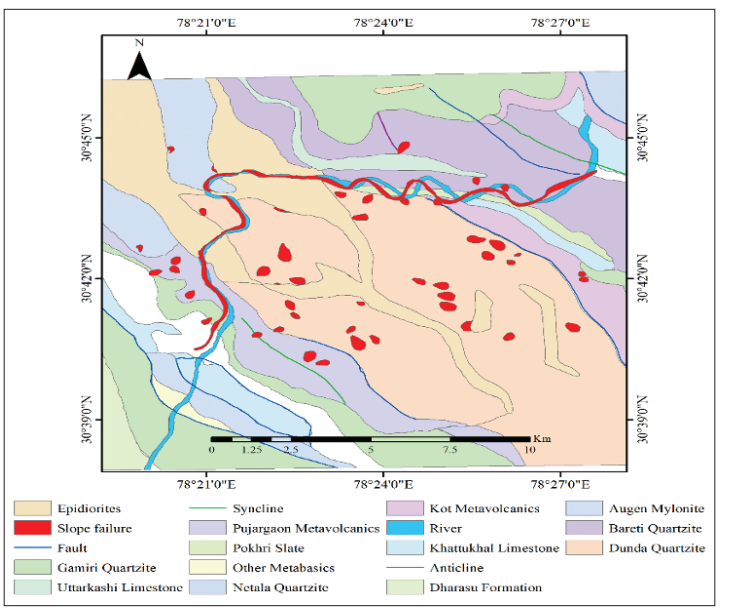


Figure 2: Geology of the study area

The region receives an annual rainfall of more than 1400mm, with more than 75% of the rainfall during the monsoon season (June-September). The contribution of pre-monsoon (March-May) and post-monsoon (October-December) are 14% and 3% respectively. Figure 3 illustrates the monthly and cumulative rainfall for the region from 2013-2017, collected from Indian Meteorological Station, Pune.Whereas Figure 4 shows the damages observed during the field study.

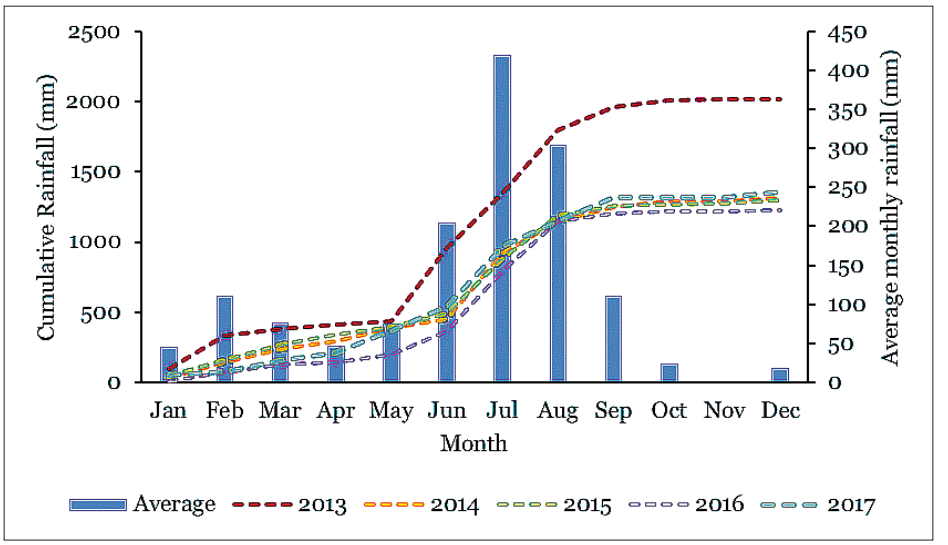


Figure 3: Average monthly and cumulative rainfall in the study region (2013-2017)

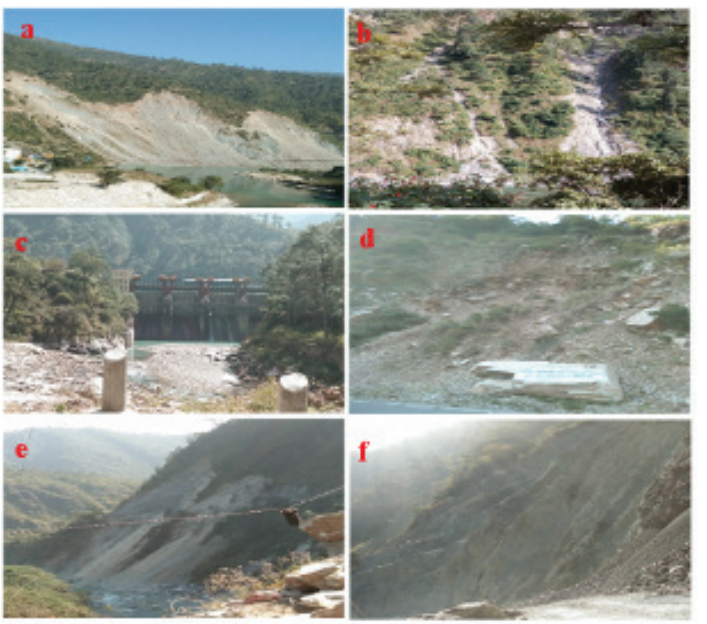


Figure 4: Observed damages during the field study

3. Data Collected

Different types of data have been used in this study, which can be categorized as remote sensing data, google earth, field data, ancillary data and relevant literature. In the present study, the remote sensing data consist of both optical and microwave sensing images. Optical image-based data have been utilised in the preparation of various thematic layers and satellite-based data have been used in finding out the vulnerability studies in the study area.

The use of satellite remote sensing images has increased rapidly for landslide studies as it provides synoptic view of the area and provides continuous data at high spectral resolutions. Table 1 shows the details of the satellite data used in the study.

Table 1: Satellite data used in the study area

S. No.	Name of Thematic Layers	Scale of Map	Data Source
1.	Slope Map	1:25000	Bhuvan
2.	Land use and Land Cover Map	1:25000	Bhuvan
3.	Geological map	1:50000	Parkash 1998
4.	Road map	1:1000	Google Earth
5.	Soil map	1:50000	Open Source World Soil Map
6.	Drainage map	1:50000	H44G06 and H44G05
7.	Structure Map	1:50000	Parkash 1998
8.	Toposheets	1:50000	H44G06 and H44G05
9.	LISS III Satellite image	1:25000	Bhavan / NRSC Open Source
10.	Landslides Inventory Map	1:1000	Google Earth

3.1 Road Infrastructure map

Owing to the cutting of steep slopes on hilly terrain, road construction often leads to slope instability. In addition to this, road building also requires rock blasting, which destabilises rock masses and also disturbs the slopes and makes it more vulnerable to failure due to heavy traffic movement and rock blasting. The road buffer map was then prepared around the main road that was plotted from the satellite images. Developmental activities which affect the landslides are discussed below buildings and roads.

3.2 Building Infrastructure

Man-made structures are also affected by the landslides whether they are near to landslides or not. As the landslides destroy foundations, transportation network, transmission lines, damages of the residential buildings occur. Commercial buildings can also experience the same after effects as residential buildings, but due to disruption to access roads, impacts may be greater in the case of commercial structure due to business interference. Figure 5 represents the building map of the field of study which has been prepared from the building footprint map using the data of high resolution. Satellite images of the study area have been procured. About 7000 numbers of buildings were digitized within the study area. Table 2 indicates number of types of buildings falling in the field of study. Figure 6 indicates different types of buildings in the study area whereas Figure 7 shows the decadal change of buildings in the study area.

Table 2: Types and numbers of buildings in the study area

Building types	No. of Buildings (2018)	No. of Buildings (2008)
Industrial Building	30	1
Government building	30	11
Hydropower plant	1	1
Educational Building	22	22
Religious Building	33	16
Commercial Building	1023	600
Residential Building	1366	900

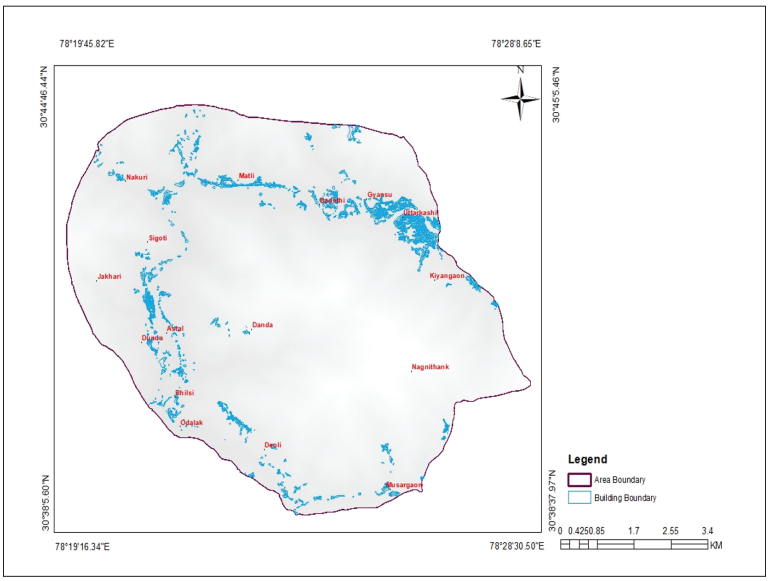


Figure 5: Building Map of the Field of Study

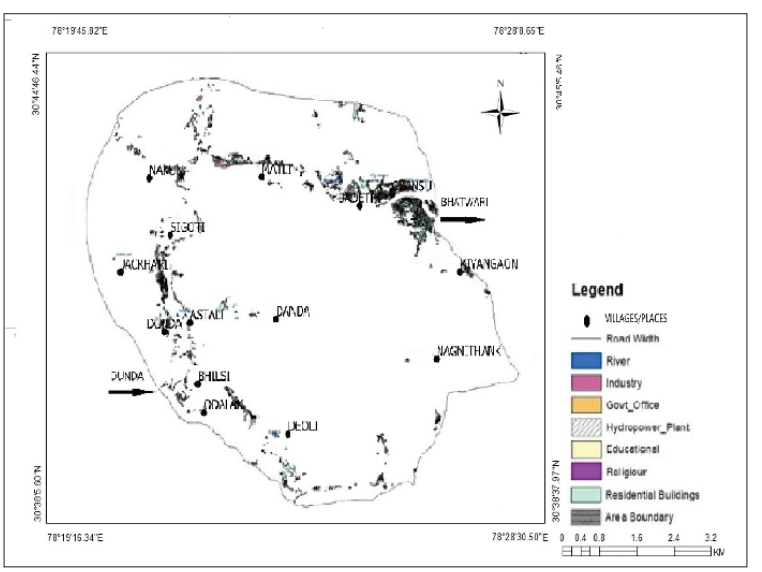


Figure 6: Types of Buildings in the Study Area

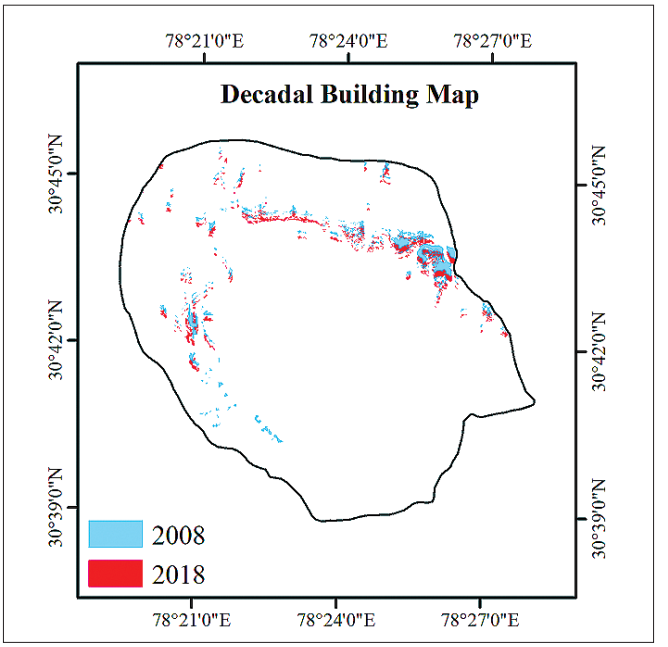


Figure 7: Decadal Change of Buildings in the Study Area

3.3 Road Infrastructure

Landslides have one of the biggest impacts on highways, impacting the highest number of people in any area. Connecting roads whether it may be national highways or state highways are also very vulnerable to the effect of landslides. Figure 8 represents road map of study showing availability regarding different types of roads. Table 3 shows the increase in the length of the roads from 2008 to 2018.

Table 3: Types of roads with their lengths in the field of study

Road Type	Road Length (in km) (2018)	Road Length (in km) (2008)
National Highway	21	17
State Highway	30	29
Other Major Roads	40	38
Village Road	75	70

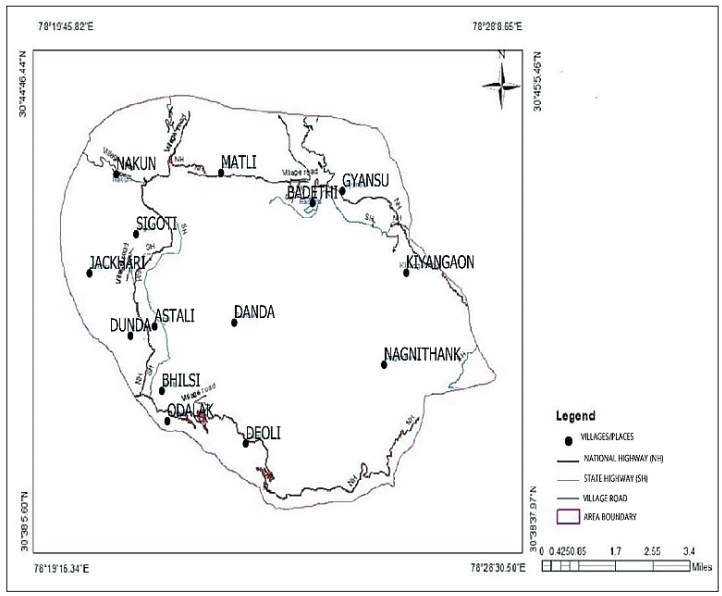


Figure 8: Road Map of the Study Area

In this study, change detection of developmental activities with respect to land use for two (2) periods of ten years (10) was conducted. This was done using satellite images of different dates (2008 and 2018) which were interpreted and analysed to extract the required information for finding out the changes in the study area. The results showed significant increase in built up areas whereas vegetation was annually decreasing. Also, there is no appreciable change in the water bodies. This study can help the urban planners in managing the land use development of the region. Table 4 gives the change detection of developmental activities with respect to land use of 2018 and 2008. Whereas Table 5 gives the change detection with respect to land use and land cover class of 2018 and 2008. Figure 9 shows the change detection map on the basis of number of buildings.

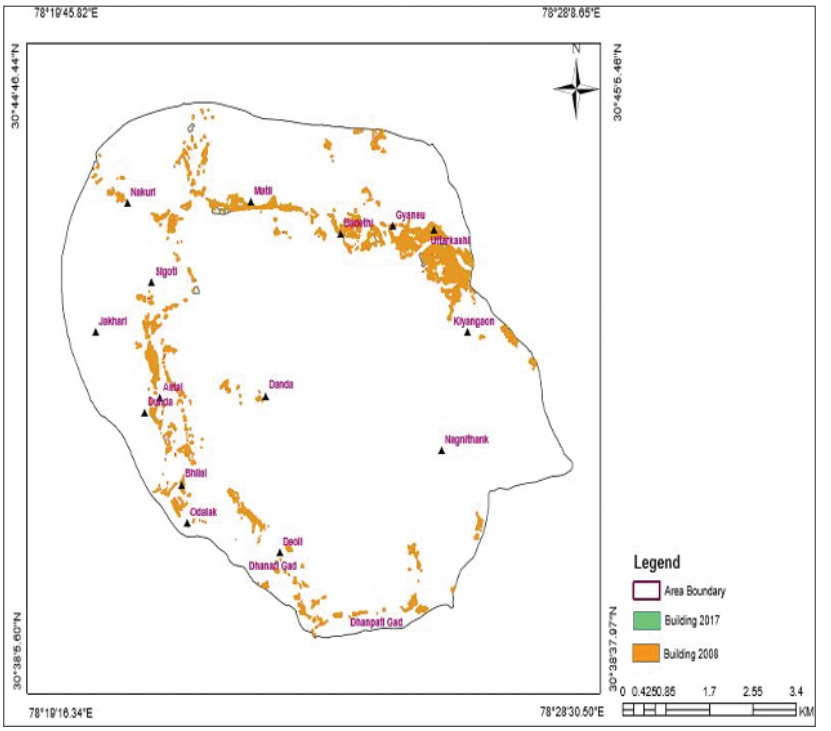


Figure 9: Change detection map on the basis of number of buildings

Table 4: Change detection of developmental activities with respect to land use

Sl. No	Class Name	Land use 2018	Land use 2008	Change Detection
1	Residential Building	3665	2711	954
2	Industrial Building	3	1	2
3	Educational Building	29	22	7
4	Commercial Building	3252	2711	541
5	Government Building	18	11	7
6	Religious Building	33	16	17
7	Hydro Power Plant	1	1	0
8	Major Roads	41	21	20

Table 5: Change detection in land use between 2008 and 2018

Land use	2018	2008	Change Detection
Class Name	**Area in Ha.**	**Area in Ha.**	**Area in Ha.**
River	246.62	227.21	19.41
Waterbody	1.39	1.53	-0.14
Dense Forest	4781.95	4688.37	93.58
Medium Dense Forest	1811.78	2637.91	-826.13
Low Dense Forest	1378.31	1528.7	-150.39
Agriculture Land	1319.97	1080.54	239.43
Open Land	2098.98	1503.84	595.14
Village Settlement	110.72	87.55	23.17
Urban Settlement	141.71	138.02	3.69
Dense Urban Settlement	75.71	73.58	2.13
Industry	8.52	8.41	0.11
Total Area	11975.66	11975.66	

4. Landslide Mitigation and Remedial Measures

Systematic approaches related to the preparation and implementation of principles and interventions are needed for a comprehensive risk management strategy. It includes risk control. Pre-disaster and post-disaster reduction techniques. Pre-disaster methods include hazard identification, risk analysis by tracking current incidents, hazard zoning mapping and the implementation of new techniques to avoid the activation of hazardous processes. The purpose of Comprehensive Hazard Zoning is to avoid settlements, to identify infrastructural components in vulnerable areas and, to some degree, to administer adequate treatment measures needed at vulnerable locations.

Various Mitigation measures which include correction in case of slope geometry, protection of the slope toe by retaining structures, water management of surface and subsurface water which includes pore pressure growth, bolting, nailing, anchoring, micro-piling, geo-textile application and afforestation, are powerful components employed in case of geotechnical packages being used to improve stabilisation.

4.1 Mitigation Methods for Various types of Landslide Hazards

Avoiding construction on steep slopes and current landslides is the best way of dealing with landslides. This is not always realistic, however. Another solution is to control the usage and development of land to ensure that construction does not minimize slope stability. Physical measures should be used in situations in which landslides impact existing structures or cannot be stopped. In some of the cases, monitoring systems are helpful for the residents to evacuate when there are chances of landslide activity. Fig 10 (a) and Fig10 (b) gives the slope stitching techniques for surficial failures. Fig 10 (c) shows the block masonry wall with weep holes whereas Fig 10 (d) shows the remedial measures taken for stabilizing landslide site. Fig 10(e) shows the empty bitumen drums acting as retaining wall whereas Fig 10 (f) shows the random boulder gabion wall as wire crates

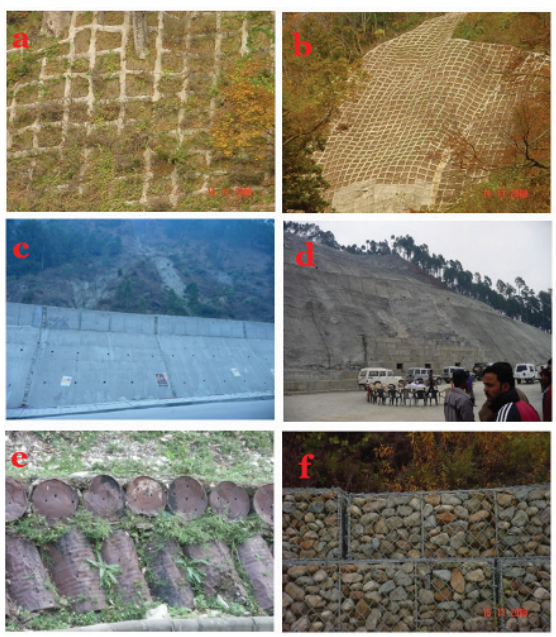


Figure 10: (a, b) Slope stitching technique for preventing surficial failures, (c) Block masonry retaining wall with weep holes, (d) Multiple remedial measures for stabilizing landslide site, (e) Empty bitumen drums filled act as retaining wall, (f) Random Boulder Gabion Wall debris with wire crates (Prakash, 2019)

4.1.1 Mitigation Measures for Buildings:

The following impact-reducing, non-structural mitigation steps are:

- Early warning systems
- Restricting building activities
- Growing resistance by accommodation, evacuation methods, etc.
- Relocation of the building or not using it for essential facilities

Non-structural mitigation measures for reducing the effects, such as the warning system, building restrictions, and structural mitigation measures for the reduction of the impact on operating operations during hazards should be given priority for critical infrastructure.

4.1.2 Mitigation Measures for Roads Planning for Existing Highways

Primary concern for the highway slopes is the stability of the slopes. Scope of planning for existing highways can vary widely, ranging from a road upgrade to local changes to the alignment of a road including widening of roads. The planning of road improvement is usually more limited by existing systems compared to a new highway, services and utilities and the surrounding topography. A significant constraint also is the need to maintain traffic flow during construction. These restrictions should be taken into consideration in choosing suitable route alignment and/or design choices.

If a network has a large number of failures, an inventory may help to determine a target for earthworks that are most likely to fail or pose the greatest risk. Once a database of relevant slope data has been developed and analysed, it is possible to focus on those datasets that are both important to the slope condition and are likely to change during engineering time to update the database. The inventory can provide a tool to:

- layout the location of earthwork.
- Description and classification of slope failure
- Cost of repair calculation

The major drawback of a slope inventory is that the data only provides data on the calculated slopes. If the landscape is large, there is no data about the slopes. The two together form a powerful tool for planning, design and management when used within the context of a terrain classification. A wide variety of hazard management methods are available and these methods may have very different applications:

a) **New Roads construction:** The key task is to determine an alignment that minimizes the hazards that are likely to impact the route. This includes broadly examining a wide area of landscape. This suggests a terrain assessment approach to the evaluation.

b) **Existing Roads:** Specific design details for particular slope hazards may be needed by the engineer for an existing alignment or network. In this case, a numerical method is more likely to be acceptable.

c) **Geomorphological mapping and geotechnical mapping:** It is based on the assumption that there are strong indicators of past instability in the landscape, which can be expected for future operations. It also includes that how the land has been developed in its present state and how it can be used in future.

d) **Techniques for Hazard Reduction on existing roads:** The risk mitigation challenge is to classify areas with a sufficiently high-risk rating to justify investing large amounts of money on engineering work. In economic terms, it is difficult to justify the costs associated with the construction of remedial works over long road distances and may be unaffordable. As part of any developmental activity, a significant study of the alignment of culverts and other conduits close to the road should be done.

Three extensive methods are being used in case of hazard reduction works:

- Path protection: Acquire the presence of debris flows and take steps to safeguard the path. Debris basins, lined debris channels, debris flow shelters, overshooting and obstacles (including ditches, walls and fences) are possible solutions.
- Preventive measures for debris flow: engineering activities are carried out to minimize the chances of a debris flow happening
- Realignment of the Road: Realign the road. In order to improve the road in terms of alignment and junction setting, road re-alignment may be taken as route improvement practises, in particular to minimise accidents and to ensure competition with existing design requirements.

5. Conclusions

1) Landslide Hazard Susceptible zonation map of the study area shows that around 11.2% of the area lies in very low hazard zone,10% of the area falls in low hazard zone,13.3% of the area falls in low moderate zone,21.7% of the area falls in moderate

zone, 35.5% of the area falls in high hazard zone and 9.45% of the area falls in very high hazard zone where the probability of landslides is high due to weathered rock and soil debris covering steep slopes which when disturbed are prone to landslides.

2) Main developmental activities are road construction and urban development in terms of construction of buildings which have been calculated as 7000 buildings. Out of which, maximum are the number of residential and commercial buildings which are 4496 in number.

3) In calculating the building susceptibility with reference to LSZ it has been noticed that 29.63% of buildings are there in the high hazard zone and 32.48% n of buildings are there in the very high hazard zone which again indicates that construction activities are one of the reasons which account for the increase in hazards and accordingly planning should be done to mitigate the hazard to some extent.

4) In finding out the road susceptibility with respect to LSZ, it has been concluded that out of 166km length of the road in the study area,39 km of road is lying in the high and 65km of road is in the very high hazard zone. It also signifies that 23.49% of the roads lies in high hazard zone and 39.16% roads lies in very high hazard zone.

References:

1. Dikshit, A., Sarkar, R., Pradhan, B. et al. (2020a) Rainfall Induced Landslide Studies in Indian Himalayan Region: A Critical Review. Appl. Sci., 10, 2466
2. Dikshit, A., Pradhan, B., Alamri, A.M. (2020b) Pathways and challenges of the application of artificial intelligence to geohazards modelling. Gondwana Research, https://doi.org/10.1016/j.gr.2020.08.007
3. Froude, M.J., Petley, D. (2018) Global fatal landslide occurrence from 2004 to 2016. Nat. Hazards Earth Syst. Sci., 18, 2161–2181.
4. Gariano, S.L., Guzzetti, F. (2016) Landslides in a changing climate. Earth-Sci. Rev., 162, 227–252
5. Kanungo, D.P., Sharma, S. (2014) Rainfall thresholds for prediction of shallow landslides around Chamoli-Joshimath region, Garhwal Himalayas, India. Landslides 11, 629–638
6. Kaur.H., Gupta. S., Parkash. S., and Thapa, R. Application of geospatial technologies for multi-hazard mapping and characterization of associated risk at local scale. ANNALS OF GIS, 2018 VOL. 24, NO. 1, (2018). 33–46c
7. M.S Rawat, B.S Rawat, V. Joshi and M.M Kimothi 'Statistical analysis of Landslides in South district, Sikkim, India using Remote sensing and GIS'. IOSR Journalof Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) ISSN: 2319-2402, ISBN: 2319-2399. Volume 2, Issue 3 (Nov. - Dec. 2012), PP 47-61
8. Pham, B.T., Shirzadi, A., Shahabi, H. et al. (2019) Landslide Susceptibility Assessment by Novel Hybrid Machine Learning Algorithms. Sustainability 2019, 4386.
9. Pradhan, Biswajeet and Ahmed M.Youssef, 'Manifestation of remote sensing data and GIS on landslide hazard analysis using spatial-based statistical models. Arabian journal of Geoscience 3, (2010) 319-326.
10. Pham.T.B., Bui.T.D,Indra.P, M. B Dholakia 'Landslide Susceptibility Assessment at a Part of Uttarakhand Himalaya, India using GIS – based Statistical Approach of Frequency Ratio Method', International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 4 Issue 11 (2015)
11. Reichenbach, P., Rossi, M., Malamud, B.D. et al. (2018) A review of statistically-based landslide susceptibility models. Earth-Sci. Rev., 180, 60–91.
12. Sati.P.V 'Landslide Vulnerability and rehabilitation issues: a study of hydropower projects in Garhwal region, Himalaya',Springer journal of natural hazards 75 (2015)2265-2278

Infra Development Vision for Himalaya in the Aftermath of Rishiganga Tragedy

Aniruddha Uniyal[1*]

Abstract

Rishiganga tragedy of February 7th, 2021 in Uttarakhand has been an astonishing experience for the masses. However, this event might not have been very unusual for the geoscience fraternity which is well versed with the multi hazard proneness of Himalaya. As of now the plausible causes for this event vary from a combination of detached rock mass and slur waves to that of avalanche and debris flow. The question then arises, "Can we really afford to oppose infrastructure development in Himalaya by citing the multi-hazard proneness of this region to earthquakes, landslides and cloud burst induced flash floods?" Are these multi-hazard prone, socio-economically backward but strategically significant hinterlands of Himalaya destined to remain backward for these obvious reasons? Rather than stopping infrastructure and power projects, it is the reduction in vulnerability that is key to disaster mitigation in Himalaya. There is a dire need for taking up some important infrastructure planning initiatives for recalibrating our ongoing and future projects of infra and power sector. An Integrated Centralized Forewarning System can be a potential game changer in enhancing resilience of the vulnerable groups viz. construction workers, local populace and the floating population. Most of the urban agglomerations in hill areas are coming up along the roads. This calls for planning the new alignments on relatively stable upper hill slopes beyond the limit of high floods. Since the urban agglomerations along such roads could fall beyond the maximum water level of high floods. Our strategy for Himalaya should not be centered around the concept of long loops of environmental clearances and termination or non initiation and or delays in infrastructure and power projects. It should in fact be aimed at greater access and connectivity to the Himalayan hinterlands through safer roads, railway, communication

[1] **Aniruddha Uniyal,** Remote Sensing Applications Centre Uttar Pradesh, Lucknow-226 021, India
* Corresponding Author Email: drauniyal8@gmail.com

network, uninterrupted power supply lines with elements of river management and disaster resilience embedded in such projects.

Keywords: *Infrastructure, Flash Floods, Landslides, Action Points, Forewarning System, Disaster Resilience*

1. Introduction

The recent Rishiganga tragedy of February 7th, 2021 in Uttarakhand has been an unfortunate event with element of astonishment. The catchments of Rishiganga and Dhauliganga valleys in the Chamoli district of Uttarakhand were impacted by a catastrophic flood triggered due to a massive rockslide. The huge detached mass of rock and ice caused rapid fluidization, created massive water/slush waves and washed away partially or completely the hydel power projects in its route (Pandey and Chauhan et al., 2021). Damming of Rishiganga River due to the detachment of a sizeable rock mass and overlying hanging glacier in the Raunthi catchment caused devastation in the downstream (Sain, Kumar and Mehta et al., 2021). According to Rana, (Shubhra and Sundriyal et al., 2021) the flash flood was triggered by a combination of avalanche and debris flow. They further argued that obstructing the free flow path of rivers in paraglacial zones is going to have an amplified impact on the life and infrastructures in the Himalaya.

Natural disasters in Himalaya are being attributed to geodynamic complexity, active seismicity, extreme climatic events, fragile rocks, critical hill slopes of this region and the global warming (Valdiya, 1998 & 2001; Bajracharya et al., 2009; Naithani and Nawani, 2009; Uniyal, 2013 & 2016; Verma, Prasad and Uniyal, 2017; Dubey and Shukla et al., 2013; Hoegh-Guldberg, Jacob and Taylor et al., 2018). Earlier Naithani & Nawani (2009) reported high probability of planar and wedge failures in dry slopes and those of subsidence and creeps on wet and dripping zones in the lower catchment of River Dhauli Ganga. This is a possibility which may now be investigated by researchers in the upper catchment of Dhauli Ganga (that covers Rishiganga River as well) along with the other plausible causes. Further, the sequence of events and process mechanism of Rishiganga tragedy was unraveled by (Pandey and Chauhan et al., 2021), through multi-temporal satellite image analysis, aerial survey, seismological data in conjunction with geo-spatial and geo-visualization tools.

Rishiganga disaster in fact raises the second alarm for a number of valleys of Higher Himalayan region. It was Kedarnath tragedy during the summers of 2013 that had raised the first alarm (Dobhal et al., 2013; Uniyal, 2013). For quite some time, we have become habituated to look deep into the causes for such disasters only after they happen. We need to accept this harsh reality with utmost respect for the scientists, engineers and researchers who are tirelessly working in the Himalayan hinterlands. The bits and pieces of information on earlier disasters and sequence of events as recreated by Himalayan researchers are still not being put together to create an integrated disaster forewarning mechanism.

2. Himalayan Hinterlands: Beautiful but Treacherous

Himalaya is too beautiful to look at and equally adventurous but at the same time the lofty mountains, narrow valleys, critical hill slopes, hostile weather and high altitude make it one of the toughest places to work. Labourers, engineers and geologists staying in tin shades in the narrow treacherous Himalayan valleys by the side of a torrent deserve a thumbs-up. Since, they have their lives at stake while working on a hill road or tunnel of a dam. In the post disaster scenario of Rishiganga Tragedy (also referred to as Joshimath tragedy due to the proximity of the disaster site to Joshimath town of Chamoli district of Uttarakhand), our instantaneous reaction will be to comment on the negative aspects of construction of dams and hill roads in fragile Himalaya. Over the past couple of decades or so, particularly after Okhimath and Malpa tragedy of Uttarakhand Himalaya in August 1998, there have been number of deliberations. The recommendations of most of these deliberations call for avoidance of rigorous construction of hill roads and other infra and hydropower projects in this region.

After Kedarnath tragedy of 2013, the causative factors were elaborated in detail by a number of researchers with many of them calling for strict adherence to the norms of environmental conservation. Further, a new debate was initiated on whether or not shall there be new mega-infrastructure and hydropower projects in Himalaya.

It is easy to blame planners for the ill-conceived construction of roads, dams, tunnels, powerhouses and buildings in eco-sensitive and fragile terrain of Himalaya. However, it is quite difficult to provide an alternate model of development for eco-sensitive and strategically significant hinterlands of Himalaya nestling in the natural beauty.

When we advocate ban on construction of infra and hydropower projects in Himalaya, we must not ignore two important challenges, the first being the well known challenge of economic and social development in these hinterlands. The other one is the strategic challenge that calls for development of roads, communication and power infrastructure at a rapid pace. This is a well known fact that during past six decades or so, it is not only the economic development of Himalaya where we have been lagging behind but even the strategic initiative in terms of border infrastructure development has been lost. Much of this can be attributed to the sluggish pace of our infra development projects, which have otherwise been entangled in the long loops of planning. Long wait for environmental clearances, slow pace of construction owing to economic constrains and also the ill planned rehabilitation has delayed the projects. However, during past decade or so the infrastructure development in this region has picked up pace.

Rehabilitation of the populace affected due to the construction of infra and hydroelectric projects in Himalayan region has been an important and sensitive issue. Long duration of time ranging from few years to many decades in the rehabilitation of the affected community has taken toll of many developmental projects and also caused great inconvenience to the former. Loosing ancestral villages and beautiful crop fields with step cultivation and fruit trees has certainly been a trauma for the generation of locals who lost them to infra and hydropower projects. As a consequence, the picture of inclusive socio-economic development as painted by many could not become a reality in Himalayan region. To add worst to it, has been the frequent occurrence of landslides, extreme rainfall induced flash floods, glacial lake outburst floods (GLOFs), landslide lake outburst floods (LLOFs) and avalanches in this region (Allen et al., 2016; Uniyal, 2016). The question then arises, "Had the phenomena of global warming, climate change and increase in the frequency of disasters would not been there in Himalaya, if roads, bridges, dams and tunnels were not constructed ? The answer to this with a plausible logic could be that the instances of natural disasters could have been far less in such a scenario. The big question that haunts us is how do we move ahead with our infrastructure planning in the immediate aftermath of Rishiganga tragedy with scary memories of Kedarnath tragedy still afresh in our minds?

The dual challenge of economic development and strengthening strategic infrastructure in Himalaya certainly calls for unimpeded infra development in this

region. But environmental degradation and increase in the frequency of disasters become the major impediments in it. What do we do then and what is the future course of action ? We have no option but to continue with the present pace of infra development in Himalayan region, otherwise, in the coming decades, we may find it difficult to stop the migration of local populace. Consequently, many of the Himalayan valleys might be abandoned in the coming decades. During 20th century the lack of development, slow pace of rural to urban transformation and fewer employment opportunities have been the main reasons for the population migration from this region. In recent years catastrophobia has become a major reason for migration from some of the Himalayan valleys. Large scale migration from Mandakini valley (also referred to as Kedar Valley) in the aftermath of Kedarnath tragedy of 2013 is a noteworthy example. This calls for a multifaceted approach wherein the development initiative goes hand in hand with the disaster containment. Such an approach shall be aimed at the unimpeded infra development in Himalaya with elements of disaster resilience imbedded in the planning stage itself. Roads in and around towns and villages, expansion of railways and construction of new dams with elements of disaster resilience are need of the hour. Furthermore, the infrastructure and power sector projects don't always invite greater disasters, contrarily in some cases they even enhance resilience to the impact of disasters. Since the dams have the capacity to impound the large amount of flood waters of their upper catchment areas. A modelling framework was proposed by Boulange, Hanasaki, and Yamazaki et al. (2021) for the first global assessment of the role of dams in reducing future flood risk. Their modelling framework quantifies changes in the frequency of historical 100-year return period floods when dams are considered and estimates the global population at a reduced risk of flood exposure. A series of small dams could structurally mitigate floods to a great extent in Himalaya, particularly in the downstream populated areas having infrastructure and business activity.

3. Some Action Points for Developing Disaster Resilience

Need for incorporating the component of disaster risk assessment in our developmental planning has been advocated by some workers in the aftermath of Rishiganga tragedy (Rana, Shubhra and Sundriyal et al., 2021). There seems to be a dire need for taking up some important R&D and infrastructure planning initiatives for recalibrating our

ongoing and future infra and hydroelectric projects. Some of the urgently required initiatives aimed at timely forewarning and mitigation of disasters and selection of safer sites for new constructions are elaborated below:

i. Near real to real time monitoring of emerging GLOF/LLOF and or slope instability scenarios in Himalayan valleys through conjunctive use of geospatial technologies such as series of high resolution earth observation satellites with high temporal resolution, aerial LiDAR, UAVs/Drones, GPS surveys and GIS based Decision Support System.

ii. Creation of digital terrain and flood forecast models showing simulation of cloudburst and landslide induced flash floods, GLOFs and LLOFs for hazardous valleys. This should be coupled with the demarcation of the extent of lower, middle and upper hill slopes of Himalayan valleys prone to GLOF, LLOF and or flood hazard.

iii. Installation of automated weather monitoring stations, sensors and instruments to monitor incessant rains, slope failures and avalanches in all the risk prone Himalayan valleys.

iv. Use of the new innovative ways such as sensor fusion and machine learning for automatic creation and time to time upgradation of multi-risk models. Such risk models should be area specific, workable and actionable and not just the demonstrative one meant for visualization only.

v. Establishment of an 'Integrated Centralized Disaster Forewarning System (ICDFS)' for Himalaya should be the first step forward towards developing effective resilience. This ICDFC shall be connected to the field data collection sites through wide area network (WAN). Further, it should have a robust system for real time data reception from field sensors, instruments, UAVs and earth observation satellites. Equipped with data storage, analysis and transmission facilities the proposed ICDFS will gather the bits and pieces of information from vulnerable areas and process them to infer the incubating disaster. Finally, it will disseminate the warning among the vulnerable community and the first responders in real time.

vi. The above proposed Integrated Centralized Disaster Forewarning System (ICDFS) will have to be strengthened through conglomeration of smart technologies for

mass data collection from a number of hazardous areas. Further, it should have interconnected intelligent systems and also the capability of data sinking and real time processing of huge volumes of data. Cutting edge techniques such as cloud computing and data mining should also employed for real time processing of data and dissemination of warnings.

vii. Since the available time for evacuation from the probable disaster site/sites in the event of a flash flood or debris flow would be a few minutes or even less. Hence, there must be forewarning systems and SOPs in place for the construction workers and the local and floating populace for the safe evacuation within a very short span of time.

viii. Action on point number 'v' above should be supplemented by real time crowd sourcing involving shepherds and local villagers of Himalayan valleys for getting information from them about the signs of an impending disaster. In order to make them an integral part of disaster resilience framework the shepherds and local villagers of risk prone Himalayan valleys can be provided mobile phones. Further, their capacity building sessions shall also be organized, so that they can inculcate their interest in reading the signs of an incubating disaster.

ix. A system of cash rewards for locals and shepherds can also be put into place for timely forewarning about the signs of large scale slope instability or natural damming of rivers in Himalayan hinterlands. The signs of large scale slope instability can vary from emergence of large cracks, sudden widening of existing cracks in the upper reaches of hill slope to subsidence of road, foot/mule track and tilting of trees and poles etc.

x. There is also a need for integration of traditional and also the earlier systems of disaster forewarning practices with the modern technical know-how. This can help in adopting a holistic and community friendly approach towards disaster management in Himalaya. The age old traditional practices of hill drainage (danada cool in local parlance) system for mitigation of landslides and the early warning communication some 125 years ago in 1894 have been researched by some workers (Rautela, 2015; Demri, 2013). The age old whistle blowing practices for forewarning of flood disasters were also prevalent in some areas of Uttarakhand Himalaya.

xi. A well defined mechanism for the disposal of slope cut debris with dedicated sites for dumping of muck or its optimal utilization as the construction material for the existing project and also the afforestation measures should be in place for slope stabilization and amelioration of the local environment.

xii. More and more use of cut and fill method for road construction, gradual replacement of diesel driven shovels by electric shovels are some eco-friendly measures that can be adopted in the construction of new infrastructure and hydel projects, so as to mitigate to some extent the risk of frequent slope failures in new and/or recently widened route corridors.

xiii. Faster mechanization of construction activity in Himalayan valleys will enhance the resilience of construction workers and engineers of infra and hydroelectric projects in this region. Innovative ways such as introduction of robotic arms and remote controlled shovels can help reduce the risk posed to human lives involved in the construction activity in the areas of flood and/or landslide risk.

xiv. According to the BMTPC (2005), a major part of this region falls in the Earthquake Very High Damage Risk Zone V. Hence, there is a dire need for planning the new settlements and infrastructure with earthquake resistant design as a precondition.

xv. In order to enhance the resilience of the new infrastructure to multi-hazards, a long term action plan should be in place. Any such plan shall include gradual shifting of business and housing facilities to the upper hill slopes, which are beyond the limit of high floods and at the same time don't fall in the critical zones of landslide hazard. However, there can be exceptions in case of strategic infrastructure projects and or the tunnels of hydroelectric projects. Because there might not be any scope for taking the alignments of such projects to upper hill slopes.

xvi. Strict adherence to landuse regulations should be ensured and new provisions for tax incentives and other financial incentives are required for encouraging planned shifting of the existing commercial areas falling in the unsafe zones. This will encourage new business opportunities along the landslide and flood safe segments of hill roads and drastically reduce the number of elements at risk.

xvii. The paucity of funds for a robust infrastructure of disaster forewarning can be dealt with by modifying the clauses of the competitive bids of major infra and hydroelectric projects. It can be made mandatory for the bidders to contribute

for disaster forewarning infrastructure including installation of sensors and instruments in and around the area of the project, if they get the contract.

All the above suggested measures from point 'i' to 'xvii' might not prevent Himalayan hazards, but could certainly enhance the resilience which in turn can drastically reduce the fatalities during such events.

4. Some Noteworthy Examples of Mountain Infrastructure Development in the Alps

Switzerland is the best example which has developed connectivity to the snowy mountains of Jungfrau, rocky ridge of Gornergrat and the summit of Brienzer Rothorn and ameliorated their environment as well. Had Switzerland not developed railway infrastructure on its beautiful snow clad mountains just out of the fear of environmental degradation and onslaught of disasters, it would not have emerged as a leading tourist destination in the world. India too can offer tourist facilities in Himalaya matching those with Switzerland by developing mountain infrastructure. This in turn will greatly contribute to the economic and social development of Himalayan hinterlands and will also give us a great strategic strength on our northern frontiers in terms of border infrastructure. However, developing an infrastructure in Himalaya similar to Alps is constrained by geodynamic complexity, active seismicity, extreme climatic events and fragile hill slopes. Further, the high vulnerability of many settlements and above all the huge economic cost of projects are some of the major hindrances in creation and sustainable management of infrastructure such as mountain railways in Himalaya.

5. Conclusion

How long would we continue to oppose infrastructure development in Himalaya by citing earthquake high damage risk zones V and IV, high to severe landslide and flood hazard zones and occurrences of extreme climatic events in this region? Are these multi-hazard prone, strategically significant Himalayan hinterlands nestling in the natural beauty destined to remain backward for these obvious reasons? Can we every time impede infrastructure development in this region by citing the Gauna Lake Outburst of 1894 and Madhyamaheshwar Lake formation in 1998? However, we can certainly

avoid constructing roads on every bits and pieces of Himalayan mountains, so as to avoid the immediate surge in floating population during pilgrimage season. But to out rightly reject the idea of connectivity crisscross, combo of rail road network and series of small and medium dams in this region is not only a development blunder but it will also amount to strategic hara-kiri in the long run.

Rather than initiating a debate on stopping infrastructure and hydroelectric projects, it is the reduction in vulnerability that is key to disaster mitigation in Himalaya. As discussed above an Integrated Centralized Disaster Forewarning System (ICDFS) can be a crucial component for enhancing resilience of the vulnerable population including those of construction workers and the local populace.

Our strategy for Himalaya should not be centered around the concept of long loops of environmental clearances and termination or non-initiation and or delays in infrastructure projects. It should in fact be aimed at greater access and connectivity to the Himalayan hinterlands through safer roads, railways, communication network, uninterrupted power supply lines with elements of river management and disaster resilience embedded in these projects.

(The views expressed in this article are those of the author and do not reflect the views of any organization and or institution)

References

1. Allen, S.K., Linsbauer, A., Randhawa, S.S., Huggel, C., Rana, P. and Kumari A. (2016). Glacial lake outburst flood risk in Himachal Pradesh, India: an integrative and anticipatory approach considering current and future threats. Natural Hazards, v. 84(3), pp. 1741–1763.
2. Bajracharya, S.R. and Mool, P. (2009).Glaciers, glacial lakes and glacial lake outburst floods in the Mount Everest region, Nepal. Ann. Glaciol., v. 50(53), pp. 81–86.
3. BMTPC (2005).Vulnerability Atlas of India, Building Materials and Technology Promotion Council, New Delhi.
4. Boulange, J., Hanasaki, N., Yamazaki, D. et al. (2021). Role of dams in reducing global flood exposure under climate change. Nat. Commun. 12, 417 https://doi.org/10.1038/s41467-020-20704-0
5. Dimri, V. P. (2013). Uttarakhand had early warning communication in 1894. Current Science, v. 105, pp, 152.
6. Dobhal, D.P., Gupta, A.K., Mehta, M. and Khandelwal, D.D. (2013). Kedarnath disaster: facts and plausible causes. Current Science, v.105(2), pp. 171–174.
7. Dubey, C.S., Shukla, D.P., Ningreichon, A.S. and Usham, A.L. (2013). Orographic control of the Kedarnath disaster. Current Science, v.105(5), pp.1474–1476.
8. Hoegh-Guldberg, O., Jacob, D., Taylor, M., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., Djalante, R., Ebi, K.L., Engelbrecht, F., Guiot, J., Hijioka, Y., Mehrotra, S., Payne, A., Seneviratne, S.I., Thomas, A., Warren, R., and Zhou, G.(2018). Impacts of 1.5ºC Global Warming on Natural and Human Systems. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor and T. Waterfield (eds.)]. In Press.

9. Naithani., A.K and Nawani, P.C. (2009).Landslide hazard zonation mapping of Tapovan – Helong hydropower project area, Garhwal Himalaya, India, using univariate statistical analysis. Journal of Nepal Geological Society, v. 39, pp. 59-76.
10. Pandey, P., Chauhan, P., Bhatt, C.M., Thakur, P., Kannaujia, S., Dhote P.R., Roy, A., Kumar, S., Chopra S., Bharadwaj, A. and Agarwal S.P. (2021). Cause and Process Mechanism of Rockslide Triggered Flood Event in Rishiganga and Dhauliganga River Valleys, Chamoli, Uttarakhand, India Using Satellite Remote Sensing and in situ Observations. J. Indian Soc. Remote Sens. 49, 1011–1024 (2021). https://doi.org/10.1007/s12524-021-01360-3
11. Rana, N., Shubhra, S., Sundriyal, Y., Kaushik, S., Pradhan, S., Tiwari, G., Khan, F., Sati, S.P. and Juyal, N. (2021). A preliminary assessment of the 7th February 2021 flash flood in lower Dhauli Ganga valley, Central Himalaya, India. J. Earth Syst. Sci. 130:78. https://doi.org/10.1007/s12040-021-01608-z
12. Rautela, P. (2015).Traditional practices of the people of Uttarakhand Himalaya in India and relevance of these in disaster risk reduction in present times. International Journal of Disaster Risk Reduction 13, 281-290.
13. Sain, K., Kumar, A., Mehta, M., Verma, A., Tiwari, S.K., Garg, P.K., Kumar, V., Rai, S.K, Srivastava, P. & Sen, K.(2021). A Perspective on Rishiganga-Dhauliganga flash flood in the Nanda Devi Biosphere Reserve, Garhwal Himalaya, India. J. Geol. Soc. India 97, 335–338 (2021). https://doi.org/10.1007 /s125 94 -021-1691-5.
14. Uniyal, A. (2013). Lessons from Kedarnath Tragedy of Uttarakhand Himalaya, India. Current Science, v. 105(5), pp. 1472–1474.
15. Uniyal, A. (2016). A Kedarnath-like Disaster Incubating at Yamunotri – Janki Chatti area of Uttarakhand Himalaya, India. IJARSGIS, v. 3(2), pp. 13-23.
16. Valdiya, K.S. (1998). Catastrophic landslides in Uttaranchal, Central Himalaya. Jour. Geol. Soc. India, 52, 483 - 486.
17. Valdiya, K.S. (2001). HIMALAYA: Emergence and Evolution, Universities Press (India) Limited, pp139.
18. Verma, V.K., Prasad C. & Uniyal, A. (2017). Aspects of Earth Environment. Lambart Academic Publishing, Germany, pp 161

Management of COVID-19 Pandemic by Kerala Police – An Analysis of Disaster Management Mechanism through the Lens of Community Resilience Approach

Prayaga M.A.[1]

Abstract

The year 2020 can be earmarked for the excellence as well as trendsetter in the professional front of Kerala police team. Dangerous floods from 2018 and the recent pandemic days vividly altered the entire gamut of policing throughout the state. While we calculate the proximity of the force among public, they are into the shoes of first-hand responders. This so-called response notion within the common man is the reason for the upsurging dependency on police for all daily measures taken by the legislation. Usually in the process of disaster management, each step is carried out by different stakeholders but in the recent instances starting from flood till the latest days there exist no step where the act and presence of Kerala police was lagging. Thus, an inclusive involvement by encouraging more community systems within a fit adaptable environment turned to be the most exciting contribution of the force, however, certain lacunae need to be filled in along with the change in tone of complex nature of the ongoing pandemic situation. This paper sheds light upon the collaboration of the force through this changing perspective which they collectively applied in the recent Covid days. It further elaborates the change of approach connivance by the team into a more holistic to sturdy community resilience method. The paper concludes by going through certain analysis for improving the effect of these implementation procedures.

Keywords: *Police, Disaster Management, Vulnerability, COVID-19, Community, Resilience.*

[1] **Prayaga M.A.,** (ICSSR Doctoral Fellow 2019) Research Scholar in Public Administration, Department of Political Science, University College, University of Kerala, Thiruvananthapuram, Kerala.

1. Introduction

Police force in Kerala intervene the very life of common man. They act as the coercive arm of the state thereby extending duty to maintain law and order making their presence in different gamut of life of the people. Prevention of activities having criminal flavors and offenders with the same tone do add to the rising influence of the force within. They thereby contribute an imperative role in imparting security as well as dignity to all its citizens. Adding to their box of duties, police also deliver a set of activities that include social, economic, and political situations essential to preserve integrity of our land and contribute towards its upliftment and development. Undoubtedly, the character of force in our country is exceptionally remarkable with view of the changing politics, democratic polity, multi-cultural, multi ethnic and large size diverse population of India (Sen, 2019).

Kerala police through their ubiquitous perceptible presence and action do affect every single Keralite and everything in the land of God's own country. By a near monopoly and ambiguity of other legal forces policy actions of COVID-19 management period during these days they alone provided for the whole handed security of Keralites and extended their full involvement in the law enforcement during this pandemic situation. This adaptable intervention at various situations of fancy vagueness in pandemic management steps due to the novelty of such occurrence, helped the policy institutions to get along with the puzzled daily execution of different decisions. For instance, project like "Project Eye", "Kasaragod Initiative" by the police itself can be taken as good examples of their adaptable involvement along with other policy- stakeholders in the initial stage of this COVID-19 management phase (Anand, 2020). Though police personnel turned hectic and overburdened during the extraordinary days they prudently determined the special decentralized manner accordingly the democratic decisions of the state machinery were implemented timely.

More than any stakeholders entrusted with the task of ensuring democratic decisions, it was policing which assured equality and dignity to the numerable minorities and weaker sections of the society due to the proximity in their relation with the common man. They formed the 'backbone' to the entire pandemic management mechanism with necessary resources in all means. Such holistic intervention among public from a closer government agency is quite necessary to get the community 'back-on-track' during such a crisis situation.

Clearly, the role of police in the state of Kerala was reassuring during the time of this pandemic hit period. It is high time that the degree of these reassurance in police system needs to be well stated and analyzed during any such complex situations for a more community-oriented action which is comparatively reliable and sustainable in its goal-achievement. The study well contains a triangular method which surrounds a clear analysis, verification and suggestions for further inclusiveness of police involvement in a more democratic- ecologically focused manner within the present institutional framework (Ghosh, 2020).

2. Study Area

The study is focused on the Kerala police force and the role they played in managing Covid-19 days. The area selected for the study involve two districts Thiruvananthapuram and Kasaragod. These regions were selected due to the initiation of more community-oriented programs by police during this pandemic hit days.

Main objectives of this study can be pointed out as: -

- To analyze the managing mechanism during COVID-19 Days by Kerala Police – a Mechanism for Disaster Management from a Group Resilience Lens approach.
- Identify the effect of various measures taken by state enforcement agencies which included various strategies for facilitating a balanced community resilience environment.
- To access the out-turn and recommend measures needed for improving the force involvement through studying the level of interference in different phases of managing this pandemic situation.

In General, this analysis can help to improve the understanding of the role of police in carrying out such situations and thereby would help to make action-contingency plans for dealing with such an extreme situation in a more environmental-development approach.

3. Methodology

The methodology used in the study is empirical and content analysis. Empirical study was carried out in analyzing the programs initiated by police force and in getting an

effective analysis these data were used. Random sampling was used in taking the survey report from the population in the area of study. It involved interaction in a form of surveys, interviews, news and other means of communication with the participant in a bid to collect the necessary information. Primary data collection was carried out using this method. Secondary data and analysis were carried out using content analyses from different articles on media. The study is carried out by analyzing the police working method from March 2020 to March 2021.

4. Analysis

It was on Jan 30, 2020 the first case of Covid-19 got reported in India which was based in the state of Kerala. Government machinery got into the track of imposing regulations by taking assistance from different agencies in governance system. It was a great challenge for the entire system of administration to cope up with novel situations each day with regard to this new pandemic outburst. It was after three months when the whole situation started to turn darker the police got entrusted to carry on with framing more functional regulations and restrictions so as to contain the further spread of this dreadful virus (Anand, 2020).

On 23rd, March, Top officer from the list Vijay Sakhare IPS was deputed by Chief Minister of Kerala Pinarayi Vijayan to the worst hit Covid region of the then period, north district of Kasaragod. This region was emerging as one of the worst hit COVID-19 hotspot. A new move steered up by Kerala Police in a people friendly regard paved the way for new form of discussion on "Kasaragod Initiative of the Kerala Police" – as a model to be pursued by other badly Corona hit regions of the nation (Kumar, 2020). This need to be regarded as the initial step towards a community-oriented resilience method that got implemented by the force.

Primarily police are an agency conceived with the maintenance of law and preservation of order. However, COVID-19 management by the police opened a new addition in the approach towards the force. One of the major roles played by the force in pandemic management can be connected with implementation of mechanism to contain COVID-19 spread.

The most wondering and appreciable part is that police without any prior training or any SoP to counter such dangerous situations did rise to the occasion in an evolving

nature. The involvement of police in COVID-19 management need to be analysed in three phases (Ghosh, 2020). Phase 1 was with outstanding action and result starting from March 2020 to August 2020. Phase II from September 2020 to November 2020 and Phase III from December 2020 to March 2021. Phase II witnessed many pitfalls that got risen as a result of too much work division upon force. From the study researcher got the report as when the I phase period was a tremendous success which even became a trend setter in the whole management of COVID-19 situation in avery constructive manner as laid down by police. Furthermore, most of the government machinery began to follow those initiations as developed by police to handle the situation. Mainly because of the over burdening of the function and lack of a well-knit SoP system the regular functioning of the force got into a new state of confusion. Overburdening of the duties without proper synergy among other departments is further aggravating the unbalanced situational rise.

At the time of this model's inception the community orientation was not directly included. This particular method of allowing members from the area to get on work with these public officials and providing assistance to quickly rebuild and overcome the disasters effect started after the success of this Kasaragod model. Following this in Nemom a region under Thiruvananthapuram Corporation started with the volunteer involvement in managing the conflicts and tensions of these crisis period. If we take an account of these different phases of police action it is quite evident that when this sort of community orientation was facilitated the COVID-19 management was more democratic and people-centred. The result of a collective effort under the supervision of police turned to be very effective in reducing the pandemic spread among the locals (Anand, 2020).

4.1 Novel Strategies by Kerala Police in COVID-19 Management

Kerala police showcased its best side in managing this pandemic situation which can be an added advantage in its community policing status. The Pandemic situation provided an opportunity for the force to explore the level of their creativity in facing challenges at any range. This is clearer when we analyse the strategies which Kerala police involved while dealing with this crisis situation. The given picture clearly depicts those different steps carried out by the police personnel during these situations (Figure 1).

Figure 1: Different steps carried out by the police personnel during Covid-19 situation

(Source: Survey Report)

i) Lockdown strategies

This model became a turning point in the entire history of pandemic management worldwide with the experimentation of 'triple-lock down' concept. This was a crucial step taken by police unlike in any part of the world (Varma, 2010). They adopted a new resilience strategy which can be named as 'containment strategy'. It was based on three phases of locks which were named as Lock 1, Lock 2 and Lock 3 that were implemented to ensure that the public do not get mix up. This strategy had reduced further infectious spread of COVID-19 in Northern regions of the district. Inspector General of Police imposed three locks in the district which was clearly in line with the central governments lock down measures also in tune with states. This great initiative paved the ground for chances to arrest the further spread of the deadly virus in the particular region. The three-pronged strategy is highly appreciable which need to be put forth as directly from the police force for the National Disaster Management authority to formulate new model of disaster management accordingly with this strategy (Ghosh, 2020).

Lock 1 strategy included fundamental policing strategies that included road block and mobile patrolling. This step assured in controlling the movement of people thereby curtailing the public commuting from their homes. Lock 2 strategy

involved implementation of a Geographical Information System thereby mapping all the COVID-19 assured cases, list of home quarantined people, every expatriate from foreign places and primary, secondary contacts who mingled with already positive tested persons. As a result of enforcement of this strategy in early itself police could identify the core Corona 19 hit seven areas of the region and located the nearby five police stations (Ghosh, 2020). This step further helped the police team to strategically isolate the areas with high positive cases by cordoning them off. Thus, all roads were completely blocked and movement in and out got halted for the lock down period in adherence with central and state measures. A third lock was then declared by police by announcing the seven places as Covid Containment Zone. Police strategically implemented their master plan even before State Disaster Management Authority and the force was successful in isolating the worst affected area of the state from rest of the districts which in turn reduced the out flow of dangerous spread of COVID-19 in entire Kerala.

ii) Reverse Quarantine Strategy

The much-applauded strategy of reverse quarantine opted by state of Kerala allowed the pandemic days to march into flatten COVID-19 curve. In adopting this methodology in dealing with COVID-19 situation state policemen extended a whistling role. Police got into the strategy by collecting and properly analyzing the list of people who came to the state from abroad by connecting their route maps of stay in this state. They were able to quote down the days of their stay at home, list of met friends, list of family kith and kin they mingled with those days and prepared detailed list of primary and secondary contacts. A third lock of the mechanism went through these positive tested NRIs after identifying their contact list from the already prepared route map by police (Anand, 2020). Men in uniform adopted two strategies for ensuring their complete lock down, it was fostered either through locked down in isolation with help of technology or by adopting traditional methods of Kerala policing. This was further carried out by deploying police to their house fronts. They were given in charge of 10 to 12 houses of these charted persons.

iii) Police Surveillance Strategy

Another worthy step by Kerala police is in its use of modern gadget of drone to watch an eye on those heads who purposefully flout the period of lockdown. This idea got

initiated with the new project launch of the team, Project Eagle Eye when around 350 drones were tracked into the air of state to lock down these law breakers. This was another major helpful step by police in the state where modern technology was used as a tool to accolade with manual mode of surveillance, where the latter event was not possible due to strict rule of social distancing throughout the State.

Further a new gadget took hold of the scene was the drone. In most instances it was the drone surveillance that helped Kerala police to curtail the inappropriate behaving of people during lock down. Here too all, houses where primary and secondary contacts got resided were brought under the surveillance contact of police drone. Safety applications concerning COVID-19 got installed in the phones of all these primary and secondary contact list of positive tested people.

This really equipped the well-established information technology facility of Kerala police. If at all any quarantined person tried to leave the locked down premises police used to get an alert. In such cases they rush to the locked down areas and do shift such people to government quarantine facilities and never went for traditional initiation of stringent legal actions against them. Here we could notice the change in behavioural pattern employed by the entire police team during such a serious pandemic situation (Ghosh, 2020).

A large number home quarantined people had to face the consequences of the negligence during lock down. District police were successful in launching and continuing with the service of home delivery especially in COVID-19 containment zones thereby able to deliver essential commodities at the doorsteps of those people. This step further ensured the safety and strength of quarantined society of Kerala.

iv) Community Police Strategy

In some districts of the state, for instance 'Kasaragod', police were able to launch a 'Kasaragod Suraksha App' which aimed to provide telemedicine to this isolated section and ensured the availability of doctor online for various other ailments. Throughout the state of Kerala, the entire police team wore the dress of Covid Warriors Day and night seamlessly and their support in of containing the further spread of Corona 19 (Varma, 2020). Thus, the police adapted to new defined role of 'community police' by transforming into the front line Covid Warriors along with the Health & Sanitation workers.

v) Awareness Campaign Strategy

An educative awareness class got carried out by community policing team of Kerala on the relevance and need of staying safe their homes by paying a visit to these quarantines people and to their relatives. Though the mass awareness campaign got initiated by Kerala government during 15th March, 2020 under the tag 'Break the Chain', this decision was properly enforced during the community by the police during the lockdown days from 24th March 2020. Throughout the study the well framed and proper application of a community-oriented disaster management mechanism got build through this awareness campaign strategy by the force. To ensure whether people stay at homes, a check point at each main junction got started. This got wide reach when regional volunteer groups also got into action.

The M-Beat initiation arranged for the interaction of police with public was another step which marked an evidence for a community oriented pandemic situation management mechanism. Also, along with this movement different sorts of public encouragement to wide use of electronic technology like WhatsApp, mail, to submit grievances by public during these days. POLAPP, the police application for ensuring public participation in managing the effects of the crisis situation was a great success too in determining a foolproof community resilience mechanism (Anand, 2020).

A novel initiative of home delivery system in 'Covid Containment Zone' of Kasaragod district got started in the name, 'Amritham'. Social media platform of WhatsApp was used very effectively and the phone number coordination were directly controlled from police corona control room in order to ensure safety of public details. A similar program got introduced in Wayanad district also but with different name, 'Safalyam'. Senior citizen helping programs were included through a plan named, 'Prashanthi', particularly aiming those aged people who are staying alone at home. This was a 24x7 service using a toll-free number of police. Another one striking initiation that got applause was the 'Bask in the Mask' campaign, through which masks got distributed to the public by police force. This policy was to create more awareness among public to make a habit of wearing mask regularly and properly.

vi) Collaborative Strategy

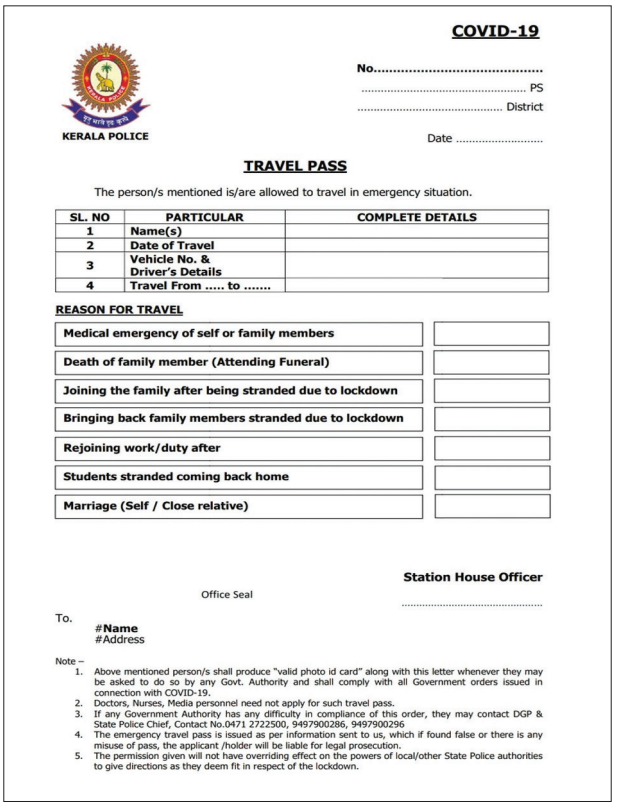
Police, people, government all are functioning within the society. No single entity can exist without getting interacted with other stakeholders of this society. This sort of interaction was continuing pre-pandemic days in a name's sake manner. However, pandemic hit days gave us a different experience where all the stakeholders need to interact if they want to sustain. Among all the stakeholders it was police force which had to maintain a close collaborative tone throughout due to its primary respondent label during any crisis situation.

Police need to maintain timely, proper relation and coordination with district administration, health department, labor department, railways, NGOs, fire department and other regional offices. This falls an additional duty upon the force. Moreover, state police force acted as a bridge between community and other government agencies in ensuring the availability of basic essentials, food kits, ration, medicines and other personal assistance (Anand, 2020).

An E-pass system got initiated by Kerala police particularly for making the movement of people under regulated control. In order to receive the pass, public need to initiate the application through proper channel of Kerala police website under strict procedures. Once they submit the form for pass, the same will be assessed and after stringent verification strategy police will issue the pass for the concerned situation. This is also known as 'Pass B-Safe' (Figure 2).

If the government official need to travel for their work-related duties are to carry with them the identity cards issued by the concerned department always. Nevertheless, public were allowed to interstate under special cases only if they carry the acquired travel pass obtained digitally from the police covid assistance portal named, 'COVID-19 e-Jagratha'.

Usually, the travel which are of least urgency were prohibited under strict regulations and normally cases were registered. Below given is a figure showing the list of cases registered under this particular situation of charge due to curfew violation.



COVID-19

KERALA POLICE

No.....
..... PS
..... District

Date .....

TRAVEL PASS

The person/s mentioned is/are allowed to travel in emergency situation.

SL. NO	PARTICULAR	COMPLETE DETAILS
1	Name(s)	
2	Date of Travel	
3	Vehicle No. & Driver's Details	
4	Travel From ..... to	

REASON FOR TRAVEL

Medical emergency of self or family members	
Death of family member (Attending Funeral)	
Joining the family after being stranded due to lockdown	
Bringing back family members stranded due to lockdown	
Rejoining work/duty after	
Students stranded coming back home	
Marriage (Self / Close relative)	

Station House Officer

Office Seal

.....

To.

#**Name**
#Address

Note –

1. Above mentioned person/s shall produce "valid photo id card" along with this letter whenever they may be asked to do so by any Govt. Authority and shall comply with all Government orders issued in connection with COVID-19.
2. Doctors, Nurses, Media personnel need not apply for such travel pass.
3. If any Government Authority has any difficulty in compliance of this order, they may contact DGP & State Police Chief, Contact No.0471 2722500, 9497900286, 9497900296
4. The emergency travel pass is issued as per information sent to us, which if found false or there is any misuse of pass, the applicant /holder will be liable for legal prosecution.
5. The permission given will not have overriding effect on the powers of local/other State Police authorities to give directions as they deem fit in respect of the lockdown.

Figure 2: Travel Pass B Safe

(Source: E-Jagratha portal, Government of Kerala)

5. Discussion

Reverse quarantine, the practice of detaching the most vulnerable groups from common man was another successful step in the pandemic season adopted policies by state. This particular step of quarantine was enforced through a well-established local body administration. Police were included right from step 1 of the new policy till the last ongoing step. The involvement of police personnel during and post this step need to be regarded most appreciable in making the whole process more people friendly (Anand, 2020).

Therefore, the big lesson learnt from Kerala successful model of COVID-19 during the given period battling is that among all the stakeholders involved police played a noteworthy role by ensuring their full spirited role and presence throughout the effective implementation of this decision. This is by standing close to the community and by providing spaces for the community to participate in these situations (Ghosh, 2020). Reverse quarantine got enforced by proving medicines, food, counselling sessions and it further ensured the availability of any other assistance to those population who went for this type of quarantine.

How Kerala was able to flatten the curve is directly related to the various measures adopted by the law enforcing agencies of the state, which included different strategies like social distancing, self-isolation, and reverse quarantine. This was the scientific world-renowned methodology adopted by Kerala society to slacken unroll of corona virus by joining full hands and moods with the most important agencies of disaster management, the police (Anand, 2020).

Local self-government department were given complete in charge of successful implementation of reverse quarantine by the State. The department gave the role to police in collecting the first-hand list of primary groups and there by police played another auxiliary role with local self-government in imparting service during these lock down days. The primary list prepared by the team with the help of police included elderly people, palliative care required ones, cancer patients; cardiac ailment people, heart surgery done people, persons with respiratory problems, chronic disease people and the set also included the immune compromised people.

When compared with the survey of surveillance post drone deployment, the area coverage of regular police surveillance got improved to more inaccessible and unfamiliar terrain got involved by the new police aid. The idea got mooted as part of 'Break the Chain' campaign of the State government.

The initiated the idea of Operation Eagle eye with help of drone operators' association. During the period of those pandemic management, it helped police team enormously in locating rule offenders as well as illicit liquor brewing were also detected using this gadget In total illegal and unwanted gathering of people during the lock down were seriously brought under strict surveillance thereby reducing the cause for further spread of the malady. Beside all these initiatives Kerala police social networking platforms are very well used in offering different services to people of the state (Anand, 2020).

5.1 Challenges Faced by Police in Different Phases of COVID-19 Management

5.1.1 Phase-I Challenges

- Enforcing lock down norms
- Quarantine enforcement
- Border management
- Management of passengers at railway station/ airport
- Containment zone regulations
- Contact tracing
- Guest worker issues
- Awareness Campaigning
- Mask, Social distancing and Sanitisation rule enforcement
- Social media campaigning and problems
- False/fake news alert
- Distribution of food, medicines and essential commodities

The entire force was trained along with the deployment procedures in order to carry out with these challenges. They went through these challenges in a very packed and mobilised manner during the period.

5.1.2 Phase-II Challenges

- Change of guidelines, rules and regulations continuously
- Comprehension of those changed regulations and order in stipulated time
- Spread of Covid-19 among personnel in an unprecedented rate (Rise in death case)
- Patrolling got into different forms like foot, motorcycle and also Janamaithri Beat got deployed into various spots
- Zone classification duty (Red, Orange & Green) depending on the severity of Covid-19 spread turn to be more tedious with change in regulations weekly.
- Social distancing & quarantine protocol observance turned to be primary and most challenging duty for the force.
- Due to illicit liquor production special drive got formed in lieu with special teams with excise departments.
- Crime rate increase- domestic violence, POSCO cases

5.1.3 Phase-III Challenges

- Exam conduction challenges
- Back to normal life in the early days of 2021- public transport and control
- Bus bays, train stations patrolling
- Unlocking process management was another area where police had to keep an extra eye.

6. Conclusion

Human history is entangled in the skirmish against an unseen enemy, proliferating at a rapid rate throughout the world. The times are truly challenging in all respect. Specifically, in the case of India, it has also emerged as a COVID-19 hotspot over a span of month or two. The police took the best measures to stop spreading, with the help and support of the government.

Thus, police by joining hands with all stake holders were able to render a whole hearted supportive system in tackling the menace. Without taking unnecessary leaves and off duties period the able officials placed their thwart in giving out their full chord support in making the COVID-19 curve flattened for the state of Kerala. Kerala police holds an ever shining applaud able place especially in formulating well-structured disaster management techniques and methodologies coming out of the shell of traditional Laissez-faire system. The proactive, adaptable, trained, focused, sharpened work force was truly used by the entire team in reaching this conclusion. Hereafter the science of disaster management will never stand aloof from the law-and-order deployable work force.

It is extremely commendable how Kerala police implemented the measures to contain the pandemic in a best possible way. They've flattened the COVID curve spread in earlier stages, using the initiatives like "Kasaragod" and "Eagle eye". These initiatives demonstrate outstanding results, and has helped helps track, deter and inspire future innovations. The incident such as "Lock 1, 2, 3 demonstrate very successful implementation process. Kerala Police and Government have been cooperative in implementing and improving people's health conditions. They've been laid substantial effort towards effective implementation of the preventive measures. Many methods will be effective in preventing the Population's onset of broad transmission. Such

interventions also have an extraordinarily high degree of public awareness and acceptance. Kerala police are the best example to other nations. With the efforts of the aforementioned initiatives, the government is ready to fight pandemics. Nevertheless, every day is overwhelming in the current scenario as the number of positive cases in the country is rising daily. It's a tough, but initiatives should be enforced more effectively and reliably.

Acknowledgements

I would express sincere gratitude to the editorial board NIDM for the opportunity to publish this paper. I am thankful to ICSSR, Govt of India for the financial support through the Doctoral Fellowship on my research topic. I am also thankful to Dr. P.G. Balachandran Pillai, my PhD supervisor and reviewers whose comments and suggestions helped to improve the quality of this paper.

References

1. Anand, Shilpa. (2020, April 13). Kerala Police's Project Eye uses closes to 350 drones to track those flouting the rules of Covid-19 Lockdown. The Hindu.https://www.thehindu.com/society/kerala-polices-project-eagle-eye-uses-close-to-350-drones-to-track-those-flouting-the-rules-of-lockdown/article31331170.ece
2. El Alaoui, Aicha& .P, Maneesh. (2020). How Countries of South Mitigate COVID-19: Models of Morocco and Kerala, India. SSRN Electronic Journal. 10.2139/ssrn.3567898.
3. Ghosh, A. (2020, April 21). Explained: How Kerala's Kasargod Has fought corona virus. The Indian Express.https://indianexpress.com/article/explained/kerala-coronavirus-cases-kasaragod-model-6371484/
4. Kumar, D. (2020, April 14). Kerala opts for Reverse qurantine to flatten Covid-19 curve. TheNew Indian Express. https://www.newindianexpress.com/states/kerala/2020/apr/14/kerala-opts-for-reverse-quarantine-to-flatten-covid-19-curve-2129719.html
5. S.V.R.K.Prabhakar and Parwey, Shahid.(2019).Participatory Information Managemnt for Sustainable Disaster Risk Reduction. Switzerland :Springer.pp. 563-577.
6. Sanderson,D.(2019). Coordination in urban humanitarian response.Progress in Disaster Science, vol. 1, pp. 1 – 4. Retrieved from http://dx.doi.org/10.1016/j.pdisas.2019.100004
7. Sen, Dhrubajyoti.(2019).Flood Hazards in India and Management Strategies. Switzerland :Springer.pp. 126-146.
8. Singh,Ajay. (2018). Managing Risks of Disasters for Sustainable Development. Geographia IAS Institute. Retrieved from https://www.geographiaias.com/blog/2018/05/23/managing-risks-ofdisasters-for-sustainable-development/.
9. Varma, Vishnu. (2020, April 16). Eagle in the sky: Drone operators and Kerala Police are a winning combination to enforce lockdown. The Indian Express.https://indianexpress.com/article/india/kerala/coronavirus-lockdown-kerala-drones-police-6365496/
10. Beck, Ulrich.(1992). Risk Society: Towards a new Modernity. London: Sage Publications.
11. Becker, Per.(2014). Sustainability Science: Managing Risk and Resilence for Sustainable Development. Amsterdam: Elsevier
12. Chakrabarti, P.G. (2017). Managing Risks of Disasters for Sustainable Development. Yojana. January.p.11.
13. Delaney, P.C and Shrader, E. (2000). Gender and Post Disaster Reconstruction: The Case of Hurricane Mitch in Honduras and Nicaragua. Washington DC: The World Bank.
14. Denney, David. (2005). Risk and Society. London: Sage Publication.
15. Deolankar, Vivel. (2010). Disaster Management Strategies – A Global Perspective. New Delhi: Commonwealth Publishers Pvt. Ltd.

16. Douglas, Mary.(1992). Cultural Anthropology, Cultural Theory of Risk. London: Routledge.
17. Douglas, Mary.(1992). Risk and Blame Essays in Cultural Theory. London: Routledge.
18. Garlak, Teresa. (2000). Dealing with Disasters. Oxfam: Oxford Publisher.
19. Giddens, Anthony.(1999). Runaway World. London: Profile Books.
20. Hood, Christopher and Jones, David. (2004). Accident and Design- Contemporary Debates in Risk Management. London: UCK Press, Taylor and Francis Group.
21. Jha, Madan. (2019).Natural and Anthropogenic Disasters, Vulnerability, Preparedness and Mitigation. Switzerland: Springer.pp.1-16.
22. Jha, Madan.(2019).Sustainable Management of Disasters; Challenges and Prospects . Switzerland: Springer.pp. 598-609.
23. Krishnaswami, P,B; Kumar,S& Dave, M .(2001). Gender Issues for Livelihood Options for Disaster Risk Reduction. Ahmedabad; Disaster Mitigation Institution.
24. Kumar, Santhosh . (2017). " Managing Disaster Risks". Yojana. January.p.15.
25. Lalit, Rahul,(2019). Kerala Floods- Need for Disaster and Fraud Crisis Management Process, PWC, Retrieved from https://www.pwc.in/consulting/forensic-services/blogs/kerala-floods-need-for-disaster-
26. Levitt, M. (1997). Disaster Planning and Recovery. New York: John Valley and Sons, pp.50- 180.
27. Lyons, M; Schilderman T; Sanderson,D.(2011). Harnessing time: Reflections on constraints to development. Environmental Hazards, vol. 10, pp. 213 – 217. Retrieved from http://dx.doi.org/10.1080/17477891.2011.597498
28. Narayan, B. (2000). Disaster Management. New Delhi: APH Publishing Corporation.
29. Palanithurai, G. (2009). Panchayats in Disaster Preparedness and Management. New Delhi: Concept Publishing Company, pp.60-120.
30. Parasuram, S; Unnikrishnan P.V. (2000). Indian Disasters Report- Towards a Policy Initiative. New Delhi: Oxford University Press
31. Patel ,R; Sanderson ,D; Sitko P and De Boer, J. (2020). Investigating urban vulnerability and resilience: a call for applied integrated research to reshape the political economy of decision-making, Environment and Urbanization. Retrieved from http://dx.doi.org/10.1177/0956247820909275
32. Poljansek,K; Marin Ferrer,M; De Groeve; T,Clerk .(2017). Science for Disaster Risk Management: Knowing Better and Losing Less. Luxembourg: Publications Office of the European Union.
33. S.V.R.K.Prabhakar and Parwey,Shahid.(2019).Participatory Information Managemnt for Sustainable Disaster Risk Reduction. Switzerland :Springer.pp. 563-577.
34. Sanderson,D.(2019). Coordination in urban humanitarian response. Progress in Disaster Science, vol. 1, pp. 1 – 4. Retrieved from http://dx.doi.org/10.1016/j.pdisas.2019.100004
35. Sen, Dhrubajyoti.(2019).Flood Hazards in India and Management Strategies. Switzerland :Springer.pp. 126-146.

Coping with Disaster: Lesson Learnt from Super-Cyclone Amphan in India

Debabrata Mondal[1*] and Sarthak Chowdhury[2]

Abstract

With the double burden of Super-cyclone and COVID-19, India is grapple with the situation. Cyclonic Storm 'Amphan' wreaked havoc on the eastern part of India especially West Bengal and Orissa on 20th May 2020 and destroyed natural resources, infrastructures and lives. Among all calamities, the devastation caused by cyclones tends to be the most sudden and severe. An attempt was therefore made in the study to assess damages, impact, preparedness measures taken by the people, the role played by government organization and suggestions given by the respondents to minimize the effect of disaster and thereby find out the alternative livelihood opportunity who losses their job to sustain their life. This paper aims to find out knowledge about the source of information of disasters, precautionary measures for safeguard of lives both human and domestic animals, assets, and crop etc. management approach after disasters for dwellings, household articles, crops, animals and public infrastructure were selected as variables for assessing knowledge level. A total of 200 respondents were selected. Data were collected from July-August, 2020 through the mail, social media and telephone conversation using a structured schedule developed by the investigators. Data were processed into frequency, percentage, mean scores and rank position. The findings of this study indicated that the main occupation of the respondents was cultivation (33%) followed by service. News media played important role in forecasted warning system. The role performed by the government is a moderate amount. The majority of the respondents' taken preparedness measures for the preservation of safe drinking water and almost all the respondents demanded government support in terms of the warning systems, relief materials and shifting important documents/ infrastructure to a safer place. Respondents suggested that concrete/ permanent coastal embankments should be built and monitored regularly.

[1] **Debabrata Mondal,** Research Scholar, Department of Agricultural Extension, Institute of Agriculture, Visva Bharati, Sriniketan, West Bengal, India.
[2] **Sarthak Chowdhury,** Prof., Department of Agricultural Extension, Institute of Agriculture, Visva Bharati, Sriniketan, West Bengal, India.
* Corresponding Author Email: mondal.debabrata@gmail.com

Keywords: *Coastal Areas, Amphan, COVID-19, Cyclone, Disaster, Suggestion*

1. Introduction

India is prone to different kinds of disasters. Floods, cyclones and earthquakes are the most common and widespread of all natural disasters and can occur almost anywhere in the State. Local self-governments are the grass root level extension functionaries' who deal with the villagers. Local self-government has a pivotal role to play in disaster management. The major tasks entitled by the local self-government in managing natural calamities are implementing relief, rehabilitation and reconstruction activities (Mondal et al., 2014). Villagers of the disaster prone areas have great role towards precautionary measures to manage disasters. Making people conscious, common settlement and cooking, safe storage of essential commodities, regular liaison with government machineries etc are precautionary measures to be taken up by the villagers. All the developmental departments of the government had also equal responsibilities for different management approaches to keep the disaster affected areas in normal condition as early as possible. This paper examined impact of Amphan and measures taken by the people themselves and government functionaries to cope with the disaster. The central and state governments strengthened their efforts to minimize the loss of economy as well as to generate alternate livelihood strategies. Both government and non-government organizations have distributed reliefs after the disaster. Human beings were mostly affected due to disruptions of electricity, drinking water, telecommunication and uprooting of trees on the road.

2. Cyclone Amphan

2.1 Background

On 18 May, at 12:10 P.M. Amphan reached its peak intensity with 3-minute and 1-minute with a sustained wind speeds of 150 metre per hour and 160 metre per hour respectively, and a 920 mbar barometric pressure (27.17 in Hg) (https://en.wikipedia.org/wiki/Cyclone Amphan).

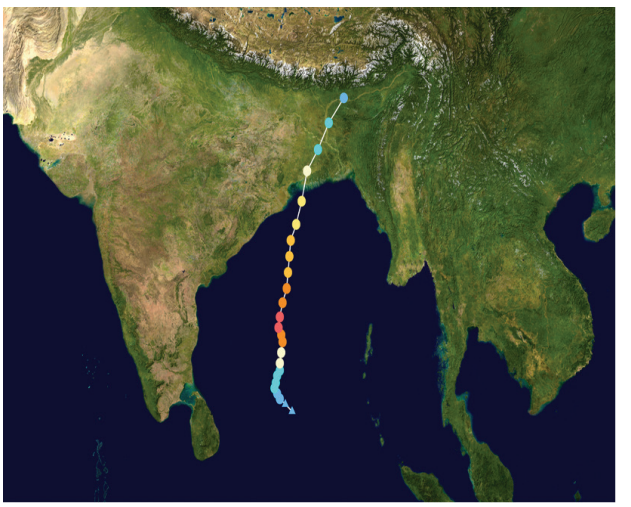


Figure 1: Map Plotting the Track and the Intensity of the Storm

(Source: Wikipedia)

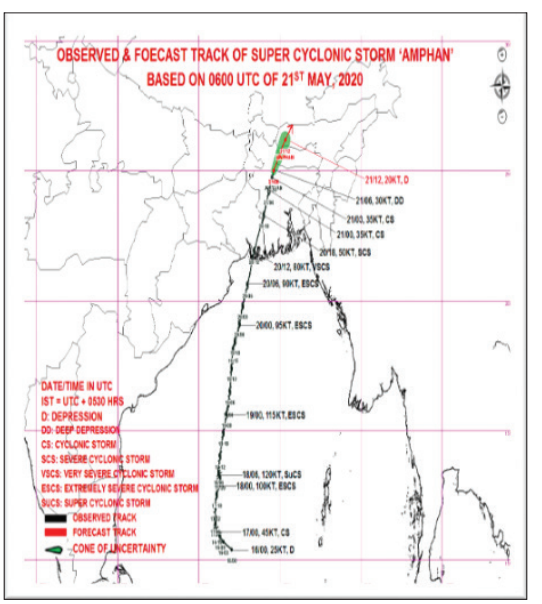


Figure 2: Track on Cyclone Amphan

(Source: Indian Meteorological Department)

The Amphan started with dry air, weaken the eastern coastline of India (Figure 1 and 2). Just After one day on 20 May 2020 the Amphan made landfall in the state of West Bengal, India between 10:00 and 11:00 A.M. with wind speeds spiralling of 165-185 kilometres per hour has smashed away state by the COVID-19. The neighbouring country Bangladesh and state Odisha were also severely affected by the Amphan.

2.2 Impact:

The West Bengal government reported that 86 people died due to electrocution or the collapse of homes and financial losses to around 1,00,000 cores (U$15.38 billion) in West Bengal (The Times of India) and it directly hits the 70 percent of the state's population (Sabarwal and Harshit, 2020). The greatest tidal surge were expected in the Coastal areas like North and South 24 Parganas, where flooding could extend upto 15 km (9.3 metre) inland (Nag Choudhary and Paul, 2020). Embankments in the coastal region were swept away by the storm surge and flooding, resulting inundation in the coastal areas (Figure 3) (The Indian Express). Bridges linking coastal islands (Sundarbans) to the Indian mainland were washed away (The New York Times).

The Government of West Bengal estimated that cyclone impacted around 22,000,00 hectare of area effecting millions of lives of people. In the North and South 24 Parganas, where more than 10,00,000 habitats have collapsed (Figure 4) and the reaction is 'we don't have one drop of water and we don't have electricity, how we can survive' (Majumdar and Dasgupta, 2020).

Figure 3: Water Breaches an Island in North 24 Parganas. Photo by Sudhansu Maity.

Figure 4: Houses Destroyed in Patharpratima, South 24 Parganas. Photo by Prasenjit Mandal

The cyclone destroyed the standing rabi crops such as paddy, mangoes, lychee, sesame, vegetables, gram and betel. It was time to harvest paddy. Due to lockdown, most of the farmers were facing shortage of labour and lack of transportation. It seems that they are facing survival challenge for the loss of income. The cyclone followed by heavy rainfall uprooted about 5000 trees as well as disruption of power supply in electrical, cable, and traffic across the state and after the cyclone, the snapped of electrical wires and damage to water pipes led to power outages and water shortages across the state (Singh, 2020).

2.3 Relief and Rehabilitation

According to Government of West Bengal, over 3,00,000 people were evacuated by using HAM radio volunteer (Figure 5) to around 100 shelters which were school, office building, and an average rate of 3,000 people per shelters in West Bengal, including 2,00,000 from district North 24 Parganas (Figure 6) and more than 40,000 from South 24 Parganas district (Freedman, Andrew; Slater, Nag, Loiwal). The National Disaster Response Force reported that over 5,00,000 people evacuated from States of Orissa and West Bengal (Misra and Sekhar, 2020). In comparison with Cyclone Bulbul which occurred in 2019, an estimated 1.8 lakh people were evacuated to cyclone shelters (The New India Express, "Cyclone Amphan").

Figure 5: HAM Radio Volunteers Urging people to shift to Cyclone Shelters. Photo by: Ambarish Nag Biswas

Figure 6: Residents Affected Cyclone Ampan Shifted to Shelters in West Bengal

(Source: ANI News)

To maintain social distancing norms, shelters could fill one-third of their capacity (Nandi and Thakur, 2020). COVID-19 and Social distancing norms reduced 50,000 to 20,000 capacities in shelters in West Bengal (Brackett 2020). In West Bengal, schools and government institutions/organizations were used for cyclone shelters accompanying more than 2,000 shelters (Free press Journal, 2020).

The government of West Bengal has released a fund of Rs. 1,444 crore just after the cyclone Amphan for rehabilitation. Chief Minister of West Bengal, Mamata Banerjee said that the state government has transferred cash to almost five lakh affected people for repairing their homes, other than crop failure assistance to 2.33 million farmers apart from 0.2 million betel farmers (Press Trust of India, 2020). Banerjee also added Prime Minister Narendra Modi had announced an immediate relief package of Rs. 1,000 crore for the cyclone-hit state of West Bengal (Press Trust of India, 2020).

The national and state disaster relief forces working together by clearing out trees and helped the people during relief work. During COVID-19, protests against the disruption of power supply and drinking water abated with time, health officials cautioned that the social distancing norms could adobe the state in the weeks to come (Majumdar and Gupta, 2020).

Government, non-government organizations and international agencies helped the affected areas. The local self-government provided relief materials, compensation to victims, arranging health facilities during and after the disaster. Affected people demanded more support from government organizations. The roles performed by the local self-government in respect of disaster management were not remarkable. (Mondal et al, 2018).

Raghavulu and Bose (1992) pointed that‘ politics pursued by the states and centre concerning natural hazards as well as the biological disasters such as the set procedures, damage assessment, accounting procedures, providing assistance, role of different agencies in providing relief materials etc.

Therefore, this study describes the damages caused by the cyclone, how it affected the population in various districts of West Bengal, and how prepared the authorities were in responding to the disaster. We found that the participants were most adversely affected in this disaster due to disruption of services like electricity, phone and internet (as opposed to uprooting of trees and water-logging).

Therefore, the study is relevant to the strategy and the implication is worth of the following points.

i. It can serve as a source of information for related research in future.
ii. The results can serve as a reference/guidance for the disaster management authorities in West Bengal.

iii. It can also be used as reference material in academic affairs as well for disaster affected people for management of the disasters.
iv. The district administrators, planners and executors can refer the recommendations for prevention and mitigation of the disasters.
v. The findings can serve as a guideline for the National Disaster Management Agency, Ministry of Home affairs, Govt. of India while developing National Disaster Management frame work.
vi. The opinion/perception of the affected people and the official of institutions (i.e. PRI) is a definitive indicator of the ground situation or facts essential for management of natural disaster in the study areas. The information can effectively utilized for precaution, management and mitigation of disasters in those areas and other similarly located areas or for other type of disasters.

3. Materials and Methods

3.1 Study Area

An ex-post-facto research design was conducted to find out the aftermath of cyclone Amphan and adaptation measures in West Bengal, India (Figure 7). The study also concentrated on the perception of people about the role of government functionaries after the disaster. 200 respondents were selected for the study from four districts-Hooghly, Howrah, North 24 Parganas and South 24 Parganas districts (Figure 7) purposively where a random sampling technique was followed to the selection of villagers. Both purposive and random sampling techniques were followed for this study. The districts (Figure 8) were selected purposively.

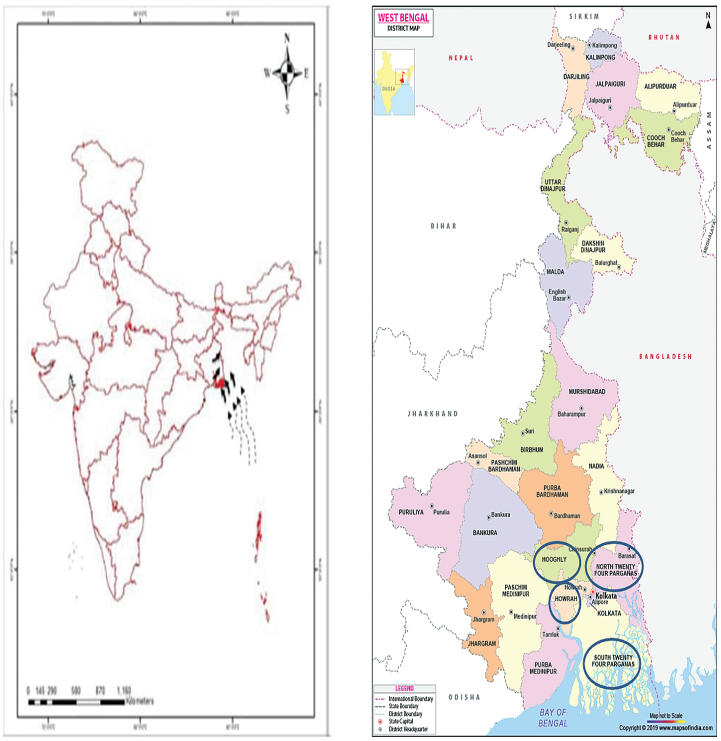


Figure 7: Map of West Bengal, Circle Representing the Study Area

Both dependent and independent variables (Table 1) were selected for the study and the data were collected from June 2020 to August 2020 through mail, social media and telephone conversation using a structured schedule developed by the investigator. Apart from primary level data collection, the researcher collected resources from secondary sources such as articles, journals, the internet, media and other pertinent documents that were also used for conducting this study.

Measures relating to this study were collected from respondents. More than one hundred measures were collected. These were then grouped into four components in disaster management based on prima facie emphasis on each measure. The measures were then scrutinized and edited as per the objective of the study. After pretesting the measures twice with the respondent, a total of 40 measures were retained.

The scale consists of a set of items (measures) to which the subject is asked to react. On the other hand, a 3 point scale was used. These are: 'Always', 'Sometimes' and 'Never'

with scores 3, 2, 1 respectively. Data were processed into frequency, percentage, score value and rank position. Measures that seem to be either definitely favourable (strongly agree) or definitely unfavourable (strongly disagree) to the attitude under study are used. The respondents indicate their agreement or disagreement with each item.

Table 1: Variable and their Empirical Measurement

Sl. No.	Variables Independent Variables	Measurement
1.	Age	Chronological (number of years) age of the respondents
2.	Educational level	Structured schedule developed for the study
3.	Occupation	Structured schedule developed for the study
4.	Type of house	SES scale (rural) of Trivedi 1963
5.	Annual income	Structured schedule developed for the study
6.	Social participation	Structured schedule developed for the study
7.	Mass media exposure	Structured schedule developed for the study

B. Dependent variable

1. Measures taken by individual and different organizations in disaster management Structured schedule developed for the study

4. Results and Discussion:

Table: 2 Distribution of the respondents according to age

(n=200)

Sl. No.	Category	Number	Percentage
1.	Young (up to 35 yrs)	40	20.00
2.	Middle age (36 – 50yrs)	100	50.00
3.	Old (above 50 yrs)	60	30.00

Table-2 showed that 50 percent of the respondents belonged to the middle age group followed by old age (30.00%) and young (20.00%).

Table 3: Distribution of respondents according to their occupation

(n=200)

Sl. No.	Occupation	Number	Percentage
1.	Agriculture	66	33.00
2.	Farming+Business	27	13.50
3.	Student	36	18.00
4.	Service	41	20.50
5.	Daily Wagers	30	15.00

It is noted from the table 3 that the main occupation of the respondents was cultivation (33%) followed by service (20.50%). Rests of the people were engaged in small business (13.50%) and daily wages (15.00 %). Before the disaster, the maximum number of respondents was largely dependent on agriculture for their livelihood. After the catastrophic majority shifted their occupation agriculture to daily wages as most of the agriculture land was inundated with saline water which caused huge damage to crops. For this, a major portion of the workforce migrates to nearby districts even to outside states for gainful employment. But due to restrictions in transportation people are not able to migrate for searching jobs. However, some government scheme such as Mahatma Gandhi National Rural Employment Programme which is typically known as "100 days work" has helped to generate additional employment to the job seekers at grass-root level.

Table 4: Sources of Information Utilized by the Respondents in the Time of Disaster

(n=200)

Sl. No.	Source of information	Extent of Utilization of Information Sources			Mean Score	Rank
		Always (3)	Sometimes (2)	Never (1)		
		No.	No.	No.		
1.	Social media (Facebook/ Whatsapp/Twitter)	110	52	38	2.36	II
2.	News Media (Newspaper/TV/Radio)	122	51	27	2.47	I

3.	Government Official (SMS/Phone/e-mail)	57	68	75	1.91	IV
4.	Friends and Relatives	92	63	45	2.23	III
(Maximum obtainable score-3)						

From table-4, News and Social media play an important role in the forecasting of weather conditions. It is observed from the table that the means score was highest in electronic media and followed by print media. The least score was obtained in case of government officials. It means that respondents got information about the intensity, impact of the disaster from news media and government officials did not forecast information about the disaster.

Here, score value 3, 2, and 1 were used as sources of information used. As for example, 110 respondents always used social media as a source of information at the time of disaster.

Table 5: Distribution of the Respondents According to the of Mass MediaExposure

(n=200)

Sl. No.	Medium	Frequency	Percentage	Listening/Reading/Viewing		
				Regular (2)	Occasional (1)	Never (0)
1.	Radio	102	52.00	64	38	00
2.	Television	148	74.00	98	50	00
3.	Newspaper	160	80.00	100	60	00
4.	Magazines/ Journals	00	00.00	00	00	00
5.	Internet	138	69.00	112	26	00
6.	Mobile	175	87.50	162	13	00
1.	Kisan Call Centre	00	00.00	00	00	00

As observed from the table-5, 52.00 percent of the respondents had radio, 74.00 percent T.V., However; it is noted that the person listening radio on regular interval was 64 and occasionally was 38 whereas regular and occasionally TV viewing was 98 and 50 respectively. But 80 percent of the respondents were subscribing for newspaper and 87.50 percent had mobile set The respondents used to get first hand information from mobile

but detail information can be only obtained from newspaper. None of the respondents subscribed magazine or farm related journals in the study areas. Similarly, mobile phone are very much essential at the time of disasters for exchange of information mainly for intimating about the weather condition and preparedness related information and damages, rescue operation, relief measures etc. after occurrence of disaster.

Table 6: Preparedness Measures taken by the Respondent as Pre-disaster Management

(n=200)

Sl. No.	Precautionary Measures	Extent of Measures Taken					
		Always		Sometimes		Never	
		Number	%	Number	%	Number	%
1.	Shifted to cyclone shelter	69	34.50	60	30.00	71	35.50
2.	Storing of essential relief commodities	85	42.50	57	28.50	58	29.00
3.	Shifted livestock to a safer places	78	39.00	53	26.50	69	39.50
4.	Collect medicine from Govt./local administration	44	22.00	65	32.50	91	45.50
5.	Storing safe drinking water	93	46.50	84	42.00	23	11.50
6.	Collection of materials for cooking food	55	27.50	67	33.50	78	39.00
7.	Collection and storing of cattle feed	56	28.00	55	27.50	89	44.50
8.	Helped from administration/official	78	39.00	54	27.00	68	34.00
9.	Demanding government services for all support	114	57.00	86	43.00	00	00.00
10.	Keeping communication materials with self	92	46.00	75	37.50	33	16.50

The scale for administration was provided with three response categories: 'Always', 'Sometimes' and 'Never', with scores 3, 2, 1, respectively. The scale consists of set of items (measures) to which the subject is asked to react. Measures that seem to be either definitely favourable (Always) or definitely unfavourable (Never) to the attitude under study were used. The respondents indicate their agreement or disagreement with each

item. The individual's total score indicates his or her position on a scale of favourable–unfavourable attitude towards the object.

Table-6 showed that the preparedness measure taken by the individual respondents. The majority of the respondents' taken preparedness measures for the preservation of safe drinking water (46.50%) and almost all the respondents demanded government support in terms of the warning systems, relief materials and shifting important documents/infrastructure to a safer place. About 46% of respondents reported that they always keeping communication materials with themselves for getting information and connected with the government officials about further sensitization of disaster and during emergencies. In fact, some respondents from coastal areas i.e. North and South 24 Parganas of West Bengal commented that the Government of West Bengal warned us through SMS that those who were staying at mud houses, find someplace safe and stay there for the next few days.

Table 7: Management Support by Government Officials as Perceived by the Respondents

(n=200)

Sl. No.	Measures	Extent of Measures					Mean Score	Rank
		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree		
1.	Repairing of damaged houses	72	83	00	24	21	3.80	III
2.	Temporary shed for rehabilitation in the village	52	47	22	t38	41	3.15	IX
3.	Arrange relief and rehabilitation programme for the victims	65	75	26	13	21	3.75	IV
4.	Rescued vulnerable group	51	76	32	24	17	3.60	V
5.	Provide compensation for houses/ crops/animals loss/damages	64	54	30	36	16	3.57	VI

6.	Immediate repairing of transport/roads	77	73	12	14	24	3.82	II
7.	Arrange long term programme for food, shelter and livelihood support for fully and partially damaged persons	53	65	36	25	21	3.52	VII
8.	Restoration of electricity and telephones connectivity	87	75	08	12	18	4.00	I
9.	Arrange training and education facilities	00	00	39	75	86	1.76	X
10.	Supervise and monitor long term reconstruction	35	47	65	39	14	3.25	VIII

(Maximum obtainable score-5)

Mixed responses were observed from the respondents on scale points towards various management support provided by the government functionaries (Table-7) after occurrence of disasters. Maximum people reported that disruption of electricity due to uprooting of trees was prevalent in all localities. The disruption of drinking water supply is closely correlated with electricity service which is disrupted after the disaster, rendered electric water pumps inoperable. Governments restore the electricity and telephone cable as early as possible. Poor responses were obtained from the respondents on arrange training and education facilities after the disasters. The respondents expressed favourable attitude towards the assistance provided by the government authorities after the Amphan. A cursory look into the table-6 reveals that a significant number of respondents have no viewpoints towards the measures as because these respondents belongs to city/town and are service holders therefore the effect on Amphan on these respondent were comparatively less.

Table 8: Suggestions to Protect the Areas from Disaster given by the Respondents

(n=200)

Sl. No.	Suggestions Given by Respondents	Always	Sometimes	Never
1.	Arrangement of disaster shelters permanently	77	67	56
2.	More financial support from the government	82	65	53
3.	Repair/maintenance of concrete river embankment	112	57	31
4.	Planting trees besides the river to protect from wind	81	85	34
5.	Early warning system forecasted in advance	68	77	55
6.	Local government must be taken more initiative in future	93	68	39
7.	Need more relief materials from government	87	75	38
8.	Training and orientation for capacity building	110	80	10
9.	Repair of roads, local institutions as early	108	76	16
10.	Alternative sources of drinking water	112	78	10
11.	Arranged underground cable for power distribution	145	55	00

Table 8 showed suggestions given by the respondents. One of the important suggestions is the arrangement for permanent disaster shelters in near future for the coastal people. Though few temporary cyclone shelters are available at present these are not sufficient to protect the majority of people. The maximum number of respondents suggested that repair and maintenance of the damaged embankments should be given priority to protect the affected areas. The important measure as suggested by respondents is to provide an early warning system well in advance, before 3-4 days of occurrence of cyclonic storms. The other significant suggestion given by the respondents is that local governments must take more initiative and play proactive role in disaster management. While distributing relief materials and financial support by the local institutions there were some biases in selecting the victims. People in the coastal areas reported that the financial support provided by the government is too meagre to mitigate the suffering. The government provides only Rs.20, 000 for the victims whose houses were

fully damaged and Rs. 28,000 for part of their wages for 100 days of work under the Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGS). They suggested more financial support from the government. The maximum number of respondents suggested (1) planting trees beside the river to protect from strong wind and (2) providing training for capacity building; in the two districts - North and South 24 Parganas. Some of the respondents suggested that they need more relief materials from the government. This suggestion, therefore, bears significant importance. A glance at the table suggests that the majority of the respondent were in favor of permanent solutions rather than taken and temporary measures.

5. Conclusion

In this paper, we analysed the responses of 200 participants to get insights about the damages, impact by the super-cyclone Amphan as well as opinion of the respondents towards preparedness measures, role of government agencies and suggestions to combat the disaster in near future. Amphan landfalls during the COVID-19 pandemic, when West Bengal and the whole of India was under strict lockdown protocols. It is concluded from this study that the villagers got information about the disaster from news and social media. Most of the respondents were farmers and they lost their land totally by the inundation of flood. People prepared themselves in arranging many facilities prior to the disaster such as storing food and drinking water, keeping important documents to the safer places, storing medicine etc. Government functionaries extended help on many occasions but people demanded more support from the government departments. The official did not forecast the weather in advance. People in the coastal areas helped themselves prior to the disaster. Therefore, they suggested that repair and maintenance of coastal embankments should be given top priority as it serves to protect coastal communities and other productive resources (e.g. agricultural land) from tidal surges. It is therefore suggested that the central government and district administration should take appropriate steps for mitigation of the disasters in disaster-affected areas and more particularly in the vulnerable areas of flood and cyclones.

References

1. "72 killed in Amphan's march through Bengal, PM Modi to visit today". The Times of India. Bennett, Coleman & Company. Times News Network. 22 May 2020. Retrieved 21 May 2020.

2. "After Cyclone Hits India and Bangladesh, the Waiting Begins". The New York Times. 21 May 2020. Retrieved 22 May 2020.
3. "Cyclone Amphan: Wind velocity in Kolkata clocks 112 kmph as cyclone crosses WB; 2 people dead in state". TimesNowNews.com. Bennett, Coleman & Company. Times Now Digital. 20 May 2020. Retrieved 22 May 2020.
4. "Cyclone Amphan: Low pressure over Bay of Bengal, likely to intensify into cyclonic storm by May 16". The Indian Express. The Indian Express Ltd. Express Web Desk. 14 May 2020.
5. "Mamata pegs cyclone Amphan damage at 1 lakh crore, toll rises to 86". The Hindu. THG Publishing. 23 May 2020. Retrieved 23 May 2020.
6. "Over 1 lakh evacuated in Odisha as cyclone Amphan hurtles towards Bengal coast". The Free Press Journal. Bhubaneswar, India: Free Press Journal. Asian News International. 20 May 2020. Retrieved 20 May 2020.
7. "West Bengal govt releases Rs 1,444 crore for cyclone Amphan relief" Deccan Herald. Kolkata, India: The Printers. Press Trust of India. Retrieved 02 June 2020.
8. Brackett, Ron (18 May 2020). "India, Bangladesh Tell Millions to Evacuate as Tropical Cyclone Amphan Approaches". The Weather Channel. TWC Product and Technology. Retrieved 20 May 2020.
9. Cyclone Amphan: Protests erupt as Bengal reels under storm aftermath; Army deployed for restoration work". The Indian Express. The Indian Express. 23 May 2020. Retrieved 25 May 2020.
10. Freedman, Andrew; Slater, Joanna (19 May 2020). "Cyclone Amphan poses extreme storm surge danger for eastern India, Bangladesh". The Washington Post. Washington, D.C.: The Washington Post. Retrieved 19 May 2020.
11. https://en.wikipedia.org/wiki/Cyclone Amphan.
12. Majumdar, Boria. and Das Gupta, Sunipa. (2020) Let Bengal be heard: dealing with Covid and cyclone Amphan together, South Asian History and Culture, 11:3, 317-322, DOI: 10.1080/19472498.2020.1780063.
13. Mishra, Himanshu Sekhar. (20 May 2020). Bhasin, Swati (ed.). "Cyclone Amphan To Hit Bengal Between 4 And 6 PM, Heavy Rain Along Coast: 10 Points". NDTV. New Delhi, India: NDTV Convergence. Retrieved 20 May 2020.
14. Mondal D, Chowdhury S, Basu D (2014). The role of gram panchayats in disaster management: a study in Aila affected areas in West Bengal. Indian Res J Ext Educ 14(3):51–54.
15. Mondal, D., Chowdhury, S. and Basu, D. (2018). Role of Panchayat (Local self government) in Managing disaster in terms of Reconstruction, Crop Protection, Livestock management and Health and sanitation measures. Natural Hazards, 94 (1): 371-383.
16. Nag choudhary, Subrata., and Paul, Ruma. (20 May 2020). "Cyclone kills 14 in India, Bangladesh leaving trail of destruction". Reuters. Retrieved 20 May 2020.
17. Nandi, Jayashree; Thakur, Joydeep (18 May 2020). "Cyclone Amphan likely to intensify, hit Bengal soon". Hindustan Times. Bhubaneswar, India: HT Media. Retrieved 18 May 2020.
18. Raghavulu, C. V., and B. P. C.Bose . "Centre-State Relations in Disaster Mitigation and Preparedness." The Indian Journal of Political Science 53, no. 3 (1992): 314–331.
19. Sabarwal, Harshit. (22 May 2020). "West Bengal suffered losses of Rs 1 lakh crore due to Cyclone Amphan, says CM Mamata Banerjee". Hindustan Times. Retrieved 22 May 2020.
20. Singh, Gurvinder. (2020). West Bengal faces the brunt of Cyclone Amphan. MONGABAY news and inspirations from nature's frontline in India.
21. Thakur, Joydeep; Mohanty, Debabrata (20 May 2020). "As cyclone Amphan nears, 4.2 million evacuated in coastal regions of India, Bangladesh". Hindustan Times. Retrieved 20 May 2020.
22. The New India Express. "Cyclone 'Amphan': West Bengal Government Mounts One of Its Biggest Evacuation Exercises," June 3, 2020.

Funding

No funding was received for this work. This is a research work done by the authors.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property.

We confirm that the manuscript has been read and approved by all authors.

Efficacy of Social Media in Disaster Mitigation with Special Reference to Kerala Floods 2018

Mr. Christo Ninan[1], Dr. Sudharsan. S[1]

Abstract

The research attempts to explicate the utility of innovation, social media during disaster mitigation. To explain it in a clear-cut view, the researcher attempts to elucidate the pivotal role placed by social media in disaster mitigation in Kerala Floods. For the study, the researcher has used a quantitative method with 190 samples collected via Google Forms. The sampling technique used for the study is the convenient sampling technique. The challenges faced by social media due to fake news in imparting its aid in its fullness, the new techniques which are utilized in disaster mitigation, and the correlation of social media and social work fall under the purview of the study for its detailed and constructive analysis. This study found out that social media has been extensively utilized by people regardless of their age or context to both receive and provide help to people in their distress. It has also revealed that the connectedness which was made into its almost complete effect through social media, helped and played a vital role in keeping the mental equilibrium of the people affected by the disaster. Along with this, this study also proposes suggestions regarding more constructive and fruitful use of social media, one of which is to utilize these media for rehabilitation and awareness along with rescuing them at the time of distress.

Keywords: *Disaster, Disaster Management, Social Media, Efficacy.*

1. Introduction

Right from the genesis of human beings, he presented himself as a social animal.

[1] **Mr. Christo Ninan, Dr. Sudharsan. S,** Department of Social Work, Madras Christian College, Affiliated to University of Madras.

The word Society traces its etymology from the Latin word Socius, which means Companionship. Human beings through developing their societal structure, also develop a collective consciousness, which is a cradle of shared or common knowledge within a society. Thus, a society not only shares its land and resources among people but also shares the intellectual arena among them. The concepts of society prioritize the value of companionship and interdependence within a group of people.

This companionship has manifested itself in a variety of forms over the ages. Man has never been the lone survivor of this world, but has received and contributed to the survival of the entire flora and fauna. In the beginning, this companionship was characterized by physical presence and work done by fellow beings within society. In an Agrarian society, the contribution was in the form of manual labor. And this had undergone a considerable and significant change by the advent of technology, boosted by the new developments and its new inventions. The togetherness of the past enabled them to survive difficult times, including natural calamities and disasters. Technology was the later addition to the life of human beings. But even before that man lived in coalition and interdependence. Technology and its inventions played a huge role in both transforming and developing former modes of communication and companionship.

2. Review of Literature

Communication forms the rubric of any society. Effective and enhanced communication and communicative mediums transforms a society into a more effective and productive entity. It forms and transforms social structures and relationships. Communication and technological development have gone hand in hand in the entire history, and the emergence of mobile and internet services have propelled communication to an exceptionally high level (Harankhedkar, 2011). Technology and advancements in technology plays a crucial role in the development and evolution of communicative mediums. Such a revolutionary innovation is the Social Media platforms of the present ages. Social Media are collaborating online mediated innovative methods that allow the creation or propagation of information, views, career interests, and other forms of expression via the virtual world. The diversity of separate and built-in social media services presently available provide challenges of definition; somehow, there are some common features (Jan H. Kietzmann, Kristopher Hermkens, Ian P. McCarthy, 2011). As social media and its enhanced tools made communication and transference of

information very easy, it is used and employed effectively in different arenas of social life and organizations. The observations that "Social media also transcended the limitations of geography and made available innumerable and equal opportunities for everyone irrespective of their living situations. Therefore, according to Lenhart et al., (2010), about 57% of online network users are 18-29 years old and have a profile on various social media websites. In a study that undertook by Pempek, Yermolayeva, and Calvert (2009), the amount of time spent daily on social network sites varied greatly. This new habit of social media has penetrated itself very deeply into the societal life of modern people. The approach of web-based media is changing how individuals associate with one another also, the way wherein data is shared and disseminated" are interesting observations that need to be qualified as there are numerous reports that social media may spread fake news and are 'vulnerable to manipulation and misrepresentations.

3. Objectives of the Study

- To study, the efficacy of social media in disaster mitigation with special reference to Kerala floods 2018
- To explore the scope of media in Kerala floods 2018
- To understand the innovative methods used in social media for the rescue and mitigating
- To find the effect of fake news in creating panic
- To examine the challenges faced in accessing social media during Kerala floods 2018
- To understand the psychosocial wellness in community togetherness

4. Research Methodology

The research method used for this is Quantitative Method. In this research design, the general technique used to investigate the characters of the social media when used in disaster mitigation by analyzing the responses through the collection of opinions from the respondents, interpretation, analysis, and discussion of data. The field of study was among the people affected/worked during the Kerala floods in 2018 where they used social media platforms for disaster mitigation, awareness, etc. The criteria of the respondents are they have to be either affected, involved in rescue, or both. The

research design used for this study was the descriptive design. In this particular study, the researcher also defines the involvement of media in various phases such as recovery, preparedness, etc.

The universe is the people who worked in the disaster mitigation in the Kerala flood with the help of any mode of social media without prior knowledge about how to handle the situation of the management before it happened. The universe of the study is comparably vast and the respondents were chosen according to their availability and willingness to participate. For the sampling, the researcher used, convenient sampling. In this research, the researcher adopted the plan to collect research data from a conveniently available pool of respondents who were readily approachable to be a part of the sample. The tool used in this research is Google forms. In this the respondents have to fill the Google forms according to their choice. The response collected by the researcher through the google forms are properly managed, arranged and updated to get the genuiness of the data and removed all the issues like multiple entries, fake entries etc. And it was also collected in spreadsheets for the future reference and clarifications.

5. Analysis and Interpretation of Data

Data analysis is a process used to transform the obtained data in the form of tables and figures. The interpretation should be in a way to solve the research problem. The researcher has analyzed the collected data using different statistical tools. Analyzed data were presented in the form of tables and figures. The analysis was done with the help of SPSS version 25.

5.1 Age of the Respondents

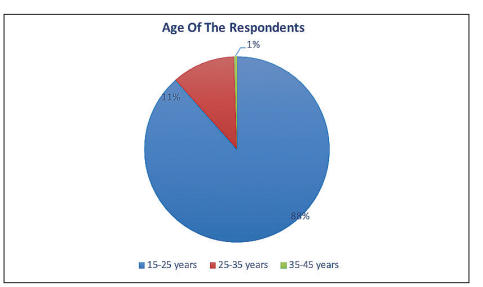


Figure 1: Age of the Respondents

The Figure 1 shows the Age of the respondents, high majority belong to the age groups between 15-25 years that is a high majority as compared to the other age groups (Figure 1). Both the other mentioned age groups are in a considerable proportion (11%) are from 25-35 years and 35-45 years (1%).

5.2 Gender of the Respondents

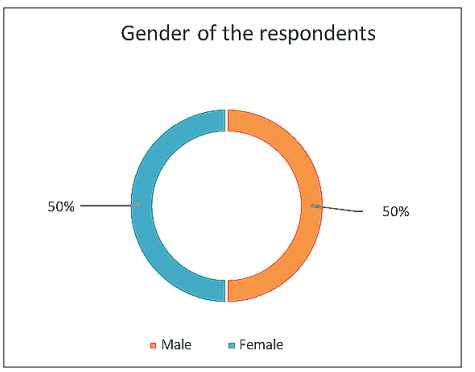


Figure 2: Gender of the Respondents

The Figure 2 shows the distribution of respondents based on gender. The analysis revealed that half of the respondents are in the Male category and the other half is from the Female category.

5.3 Social Media Usage During Kerala Floods of 2018

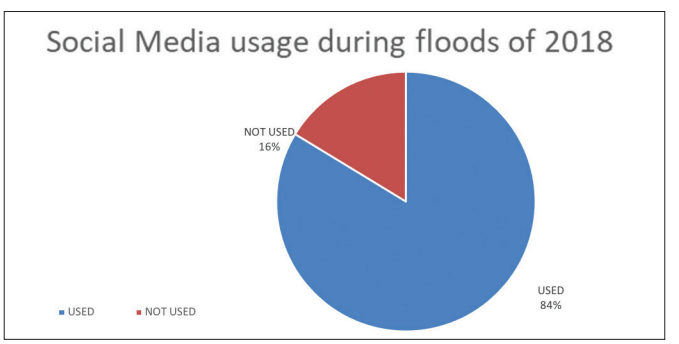


Figure 3: Social Media Usage During Kerala Floods of 2018

The figure 3, shows the distribution of respondents based on whether they used their social media accounts during the Kerala Floods 2018 to help others. The analysis revealed that a vast majority of the respondents have used their social media accounts during the Kerala Floods 2018 to help others and a considerable proportion of respondents did not use their social media accounts during the flood.

5.4 Purpose of Social Media During Disaster Mitigation in Kerala Floods of 2018

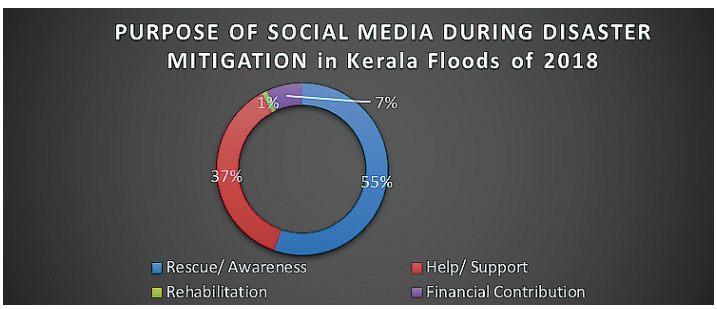


Figure 4: Purpose of Social Media during Disaster Mitigation in Kerala Floods of 2018

The figure 4 shows the distribution of respondents based on their opinion on the purpose of social media during disaster mitigation in Kerala Floods of 2018. The analysis revealed that less than two-thirds of the respondents think that the purpose of social media is rescue/awareness and more than one-third think that the purpose is help/support while a considerable proportion thinks that the purpose of social media is rehabilitation and financial contribution.

5.5 Helpfulness of Social Media During Kerala Floods of 2018

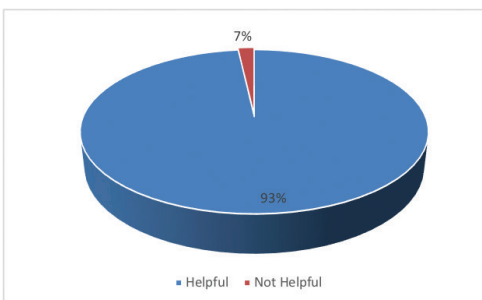


Figure 5: Helpfulness of Social Media During Kerala Floods of 2018

The Figure 5 shows that revealed that the absolute majority of respondents agreed that social media was helpful and a considerable proportion of the respondents said it was not helpful during the Kerala floods of 2018.

5.6 Effective Usage for Maximum Productivity

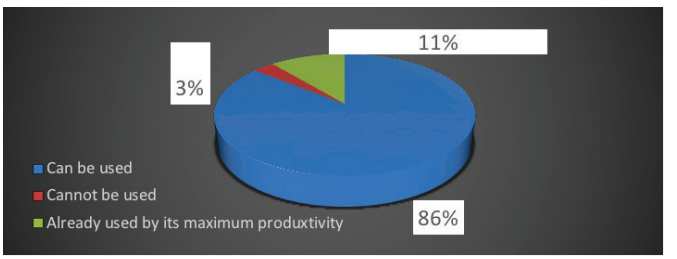


Figure 6: Effective Usage for Maximum Productivity

The figure 6 was analyzed to know whether social media was used in its maximum productivity during the Kerala floods of 2018, a high majority of respondents suggested that social media can be used more productively, a considerable number of respondents suggested that social media cannot be used more productively, a considerable number of respondents suggested that social media was already being used at its maximum productivity.

6. Discussions of Main Findings

6.1 Demographics

The respondents who participated in the study can be divided into two categories according to their gender — Male and Female. The respondents who participated in this research consist of 50% of male and 50% of female. And the age of the respondents was categorized into 4 categories in this study that is 15-25 years, 26-35 years, 36-45 years and 46-55 years and most of the participants are from the first category that is from 15-25 years. According to United Nations, the people who belong to age 15-24 are categorized as youth. And this study shows that the involvement of youth in disaster mitigation during Kerala floods was inevitable.

Respondents are mainly characterized and included in the research based on some

features such as they should be either affected, involved in rescue, or both. It is found that a total of 82.6% of the total respondents were participants to the rescue process of the Kerala floods of 2018 online. Out of which a considerable proportion of 16.3% was affected and involved in rescue at the same time. A study conducted by the University of British Columbia's Sauder School of Business in 2013 found that people wish to 'like' a cause than opting for acting upon the cause. Similarly, the studies also revealed that, people are more inclined to provide online and financial support, if needed, over their physical and personal help (Riley, 2013)

6.2 The Scope of Social Media in Kerala Floods 2018

In all the respondents, it is found that 83.7% of the total respondents have effectively used social media accounts during the Kerala floods of 2018 for disaster mitigation including for awareness, rescue, sharing information, etc. As per the studies held on the role of social media and the impact of social media during the floods by Rekha Rani and Yadukrishnan, (Rekha Rani Varghese, Yadukrishnan T A, 2019) exposed the fact that at an average rate people spend more than 3 hours in social media during the time of the flood. It also provides the fact that they depended on social media for information regarding their beloved ones.

The mental health perspective in disaster mitigation is one of the key factorsthat has to be checked but it's very pathetic that after the due analysis it is found that social media has been effectively used by, a total of 92.1% of total respondents for help and rescue. On the contrary, it is also revealed from the study that these social media platforms have not been utilized (only 1.1%) for rehabilitation, where rehab is considered to be a major duty of social work. According to Suresh Bada Math, Maria Christine Nirmala, Sydney, and Naveen, they talked about the mental health perspective in Disaster Management. The mental health perspective principle has made a change in the overall view from relief-centered post-disaster management to holistic development, multi-dimensional combined public method of health promotion, disaster prevention, readiness, and mitigation. But the rehabilitation program in the post-disaster situation was not done at its maximum effectiveness.

Studies undertook on the challenges or issues that might reduce the effective use of social media lead to some of the findings which include network issue, power failure, etc. It is also revealed that a total of 25.8% of total respondents were vulnerable due to either the lack of awareness and knowledge or lack of gadgets. So, it's a crucial drawback when

taking into consideration the technological advancement and developments that we claim to have on these pages. According to the study by Harankhedkar about the impact of technology on communication, communication and technological development have gone hand in hand in the entire history, and the emergence of mobile and internet services have propelled communication to an exceptionally high level (Harankhedkar, 2011) but in this present world, we have to rectify that the involvement and accessibility of technology have not reached to all the phases of the society.

6.3 The Innovative Methods used in Social Media for the Rescue and Mitigating

Social media being an innovative addition to the disaster mitigation process worldwide this study has also substantiated and found that 61.6% of the total respondents consider or think of social media as a tool that can be used in disaster mitigation. This was not a recent discovery though; it has been effectively used in the past in the field of disaster mitigation. Thus, this study also emphasizes the effective utilization of social media during desperate and tiring times. Studies regarding the innovative methods and utilization of social media lead to the finding that 58.9% of the total respondents were using social media groups for other helping programs apart from the Kerala flood 2018. This data effectively demonstrates the in-depth utility of social media irrespective of the situation, that is whether it is an emergency or a normal day. The Nepal earthquake, Odisha cyclone of 2013 also proves that social media has something to do with the disaster and before Kerala floods itself people started using social media as a tool.

Social media, in the beginning, was criticized severally for altering the lifestyle and dimensions of human life. Kaplan and Haenlein in 2010, explained how the propagation of data made quickly through social media, the revolutionary brainchild of technology, has made the transportation and propagation of information easy and quick. This ability of social media had a very huge impact on the people affected by disaster, to be specific 96.3% of total respondents of this study found that the information and warnings received through social media as helpful.

Even when networking, technologies provide highly developed technological assistance with the prospect of helping people in disaster, such as location technology, mark safe option, Google maps, and various other web portals to seek help. It is found that the majority of the respondents were either unaware or lacked the knowledge of its effectiveness.

According to Junco et al (2010), "social media is a collection or amalgamation of internet websites, services, and practices that support collaboration, community building, participation and sharing". Even though these types of technologies are available around us and it is known that social media through its technological advancement provides innumerable scope and possibility, people are either ignorant or unaware of them. This study also substantiates such a sad state among the society. It is found that 24.7% of the total population was either disinterested or unaware to provide awareness during the Kerala floods of 2018, while 61.1% found it difficult to donate via social media. Along with this, it is also found that 89.5% and 70.5% of the total respondents are unaware and thereby not using social media for review meetings and networking, respectively. The reasons of which have to be dealt with seriously.

Even though in the previous experience about the usage of social media in effective disaster mitigation like 2013 Odisha cyclone, it is also found that respondents of this study consider and suggest the efficient utilization of social media in the future. While 11.1% of total respondents think that it has been utilized to its maximum productivity a vast majority that is 85.8% of them believe that it can be used further. To note that a considerable proportion that is 3.2% consider that it cannot be used anymore.

6.4 The Effect of Fake News in Creating a Panic

The accumulation of too much information regarding the same event led to the emergence of fake news and manipulated information regarding the same. This is one of the major challenges faced by online social media platforms and that they are vulnerable to manipulation and misrepresentations. This also proposes social media as a great threat to the safety and composure of a society.

The application and development of electronic wave has found extensive use in creating and transferring documents in the entire globe (Burg, 2013) When the propagation and transferring of data across the world becomes easier, one of the threats born along with that is the propagation of fake news through the social media. Apart from the numerous challenges faced by social media, fake news emerges as a crucial threat to social media and its smooth conduct in society. This has effectively been reflected in the times of disaster, it is found that 88.9% of the total respondents of this study have responded affirmatively to the fact that, fake news had a huge impact on disaster mitigation.

In the study that was meant to delineate the means through which fake news propagates in society, it is found that 83.7% of the total respondents opine that fake news is spread through social media, while 42.1% consider it to be the aftermath of rumors that propagated. Social media along with its wide spectrum of possibilities and advancements, it has been curtailed from its utilization to its maximum productivity due to the propagation of fake news. Through this study, it is found that a total of 76.4% of the total respondents believe that fake news has reduced the efficiency, effectiveness, and credibility of social media.

Even when the contributors are in the high majority, they are made to leave due to the propagation of fake news and its effect. Fake news mainly manipulates the truth and thereby reduces the effectiveness of the aid. Through this study, it is found that a total of 75.8% of the total respondents think that fake news manipulates the aid which is provided during a disaster.

Another important finding from the perspective of disaster management is that disaster mitigation is made either impossible or hard by the involvement of fake news. Fake news or false information could increase the panic among the people who are already disrupted by a disaster. A total of 93.1% of the respondents supports this argument. It not only makes mitigation a harder process but at the same time it also reduces the morale of both the affected and the people who work hard in the field for rescue.

6.5 Challenges Faced in Accessing Social Media During Kerala Floods 2018

The number of people using social media is increasing from day to day at an alarming rate. The increasing number of participants and aspirants in social media platforms like Facebook, Instagram, and Twitter helps the news reach as many people as possible. The reach and influence that social media has, in this modern world, marks it as the most reliable and effective medium in propagating news and information. This opportunity has been effectively utilized by many organizations in extending their helping hands to the needful in society. Further, technology has improved storage and retrieval of communication when the essentiality arises, primarily verbal communication whose storage modeled real challenges in pre-technology times (Harankhedkar, 2011). This ability of social media, to record and form the archives of memories also makes it important and crucial in the field of communication.

Challenges faced by the social media during the Kerala Floods 2018, 51.1% of the

total respondents consider rumors as the main challenge faced by the social media. While another 58.9%, 65.3%, and 65.8% consider Unclear data, Network issues, and Power failures as the difficulties faced by social media in its mitigation process during Kerala Floods 2018. Respondents have also provided their response on whether such challenges affected the efficiency of disaster mitigation. It is found that 84.7% of the total respondents believe and consider that the above-mentioned challenges had adversely affected the efficiency of disaster mitigation during Kerala Floods 2018. About the Kerala Floods of 2018, it is found that a total of 76.3% of the total respondents, either agree or strongly agree to the fact that inadequate resources reduced the scope and accessibility of social media.

The application and development of electronic wave has found extensive use in creating and transferring documents in the entire globe (Burg, 2013). So likewise, technology has influenced the communicative aspects of society. If we are to examine the major developments that marked the revolutionary change in communication, it is the development of social media platforms. Social media was initially utilized for friendly communication and entertainment. Later on, it transformed itself to become the carrier of information to all parts of the world within no time. So, it is also found that the general attitude towards social media as something that can be only used for entertainment also affected the effective use of social media in disaster mitigation during Kerala Floods 2018. This finding was acknowledged affirmatively by a total of 75.2% of the total respondents. They either agreed or strongly agreed to the fact that the general attitude of the people towards social media was a hindrance in the effective action via social media.

A study in the U.S shows that almost 80% of the people in almost all countries have an active Facebook account. This shows the seriousness of the issue at hand. There is an ever-growing influence of this virtual platform-induced passivity in human beings, who are expected to be active participants within a society. In one of the data evaluated, the researcher analyzed and found that a considerable number of respondents strongly agreed that the activities online makes people more passive, less than two-third of respondents agreed that the activities online makes people more passive, less than one-third of respondents disagreed that the activities through online make people more passive, a considerable number of respondents strongly disagreed that the activities through online make people more passive.

6.6 The Psychosocial Wellness in Community Togetherness

According to Suresh Bada Math, Maria Christine Nirmala, Sydneyand Naveen, they talked about the mental health perspective in Disaster Management. The occurrence of mental health problems in catastrophe affected population is two to three times more as compared with the general population. In one of the data, the respondents responded their view about the crisis and the ability to overcome and do daily activities, .the researcher analyzed and found that a considerable amount of the respondents strongly agreed that crisis never affected the ability to overcome and to do daily activities, less than two-third of the respondents agreed that crisis never affected the ability to overcome and to do daily activities, one-third of the respondents disagreed that crisis never affected the ability to overcome and to do daily activities, a considerable amount of the respondents strongly disagreed that crisis never affected the ability to overcome and to do daily activities.

In the same study mentioned above, the authors opine as epidemiological studies have documented that elevated rate of mental health disorders, such as anxiety disorders, posttraumatic stress disorder are very much common and a chance of occurring is very much also. In this table the researcher analyzed and found that a considerable amount of the respondents strongly agreed that an individual can manage his/her stress on their own in the crisis, one-third of the respondents agreed that an individual can manage his/her stress by their own in the crisis, half of the respondents disagreed that an individual can manage his/her stress by their own in the crisis, a considerable amount of the respondents strongly disagreed that an individual can manage his/her stress by their own in the crisis. The researcher also studied response about a change of level of stress after and before the crisis, and found that less than one-fourth of respondents strongly agreed that there was a change in the level of stress before and after the crisis, three fourth of respondents agreed that there was a change on the level of stress before and after the crisis, a considerable number of respondents disagreed that there was a change on the level of stress before and after the crisis.

In this research, the researcher discussed the involvement of social media or being connected can reduce issues such as fear, and sleeplessness. The data was analyzed and found that less than half of respondents strongly agreed to the fact that involvement of emotional support can reduce the effect of sleeplessness, anxiety, fear, etc., less than half of respondents agreed to the fact that involvement of emotional support

can reduce the effect of sleeplessness, anxiety, fear, etc., a considerable number of respondents disagreed to the fact that involvement of emotional support can reduce the effect of sleeplessness, anxiety, fear, etc., a considerable number of respondents strongly disagreed to the fact that involvement of emotional support can reduce the effect of sleeplessness, anxiety, fear, etc.

As per one of the studies conducted by the Space and Naval Warfare System Center Atlantic (2013), the innovation of social media in Emergency management is very much noted in the last decades. Through the use of web-based social media, members of the community who observes events can provide public care organizations with appropriate, geographic-based data. This data can be used by decision-makers in preparation response plans, organizing resources on the ground, and, in turn, inform efficient and precise data to the community. Less than two-third of the respondents strongly agreed that the effectiveness of collective working through online media can increase the efficiency of mitigation, half of the respondents agreed that the effectiveness of collective working through online media can increase the efficiency of mitigation, a considerable amount of the respondents disagreed that effectiveness of collective working through online media can increase the efficiency of mitigation, a considerable amount of the respondents strongly disagreed that effectiveness of collective working through online media can increase the efficiency of mitigation

Social media can deliver public safety organizations better capabilities to, engage in ongoing collaborative communications with community members and better prepare them for emergencies and also gather, analyse, and act on actual emergency information provided straight by social media users within the public. This helps the individuals to shape a positive association within the individuals and community thus develop a feeling of togetherness and oneness

In this research, the researcher analyzed and found that less than half of respondents strongly agreed that Kerala floods stood as a reason in building positive relationship among the people, less than two-third of respondents agreed that Kerala floods stood as a reason in building positive relationship among the people, a considerable amount of respondents disagreed that Kerala floods stood as a reason in building positive relationship among the people, a considerable amount of respondents strongly disagreed that Kerala floods stood as a reason in building positive relationship among the people.

7. Suggestions & Conclusions

7.1 For Government

Even though most of the people in society are using at least one of the social media platforms, they are unaware of its utility when it comes to emergencies like disasters and calamities. So governmental organizations and the disaster management sector, Government of India could conduct programs and awareness drives to make people aware of the effective and constructive use of social media during such tiring times.

One of the best ways to reduce the overcrowding and propagation of fake news is by providing proper clarification and details to the concerned authority and thereby ensuring the reduction of propagation of unclarified or vague data. Indian Government authorities, organizations and respective institutions like NIDM can ensure this by making them easier to access and making them available for the people during emergency calamitous situations like a disaster or natural calamity.

Another major concern regarding the efficiency of disaster mitigation is the lack of availability of qualified gadgets and resources. Indian Governmental organizations and institutions could provide the people in the vulnerable areas with quality resources and measures to ensure the efficient conduct of disaster mitigation.

Most of the time disaster mitigation and management efforts end up in vain mainly because of the inadequate resources that are provided among the people and with the people who wish to help. A similar challenge is also faced by online media and specifically social media. Resources such as Gadgets, Power Connection, and Data availability are to be made more accessible and acquirable to the common people with the help of Governmental organization's or NGO's. Such a state of adequate resources and measures will improve the efficiency of the effort that is invested by the people within a society to help others during disasters.

It proves costly when it comes to disaster mitigation during disasters like Kerala Floods 2018. Misinformation could divert the resources and thereby increase the vulnerability and destruction of the disaster. Therefore, the Information Technology Department of India and the concerned departments could ensure and execute plans to monitor and censor the propagation of such fake news through social media. Since social media has in-depth roots in society, it has greater effects on the people.

7.2 For Social Workers

Social media has been utilized in multiple ways during pre-disaster and post-disaster situations. It is analyzed from the studies that the opportunities that are provided by the social media platforms are less utilized in the field of Rehabilitation. Rehabilitation is one of the significant processes by which people are retrieved back to their normal state of affairs from suddenly disrupted emergencies.

One of the key factors social workers have to keep in mind is that, as we are living in a world of digital resilience the involvement of different media in our day-to-day life has an impact on every phase of life. The usage of social media for awareness, help is common but the social workers have to make the stages for review meetings and resource networking. The connecting of resources from the donor to the receiver should be and could be done properly with the help of social media.

As is already mentioned, fake news proposes a great threat to the effectiveness of the utilization of social media in all kinds of disaster mitigation. Social workers and social work departments in institutions could increase their area of work towards making people aware of the danger of fake news and the existence of fake news in social media

Another help that social workers can provide concerning social media is that they can inform and make the public aware of the positive impact social media has on modern society. Since social media has developed into a whole new level and as it has a huge impact on the day-to-day life of the people in the society, social workers, as caretakers of the society, could empower the people with the new knowledge and skillsets about the positive use and thereby positive impact of these social media platforms.

Social media has its roots running very deep in modern society. Every person acquires or gets hold of majority of their needs through online platforms. So as social workers who wish to extend their hands to help the people in the society, they should now join their hands both on online and offline platforms to impart a holistic impact of the work rendered to the society. Social workers can start to interact and converse with people via online and social media platforms especially during times of disasters where staying connected to the outer world could prove significant in the face of isolation.

Another threat faced by the developing social media sector and its effectiveness is the propagation and existing misconceptions within the minds of the people. General attitudes or misconceptions about using social media could diminish the social being in human beings and it increases passivity etc. This could be effectively reduced through

the intervention of social workers. Social workers could ensure that people are aware of the usefulness of social media regardless of the limits of the physical structures. They can conduct seminars and activity drives that demonstrate the constructive utilization of such social media platforms and online platforms in general.

Along with this notion of social workers, it is also worth noting that they play a vital role in keeping a safe and healthy mental atmosphere among the people of the society. Their conversation with the people and their support in the face of havoc and pain prove very helpful and make people capable of overcoming the difficult situations they are in. So social workers could also extend their domain of influence and service into the mental spheres of the people.

Another important help that can be effectively implemented in the society by the social workers is that they can ensure collective activity within a society. Social workers could ensure that activities are performed, especially during times of disasters, collectively. This has to be emphasized by the social workers because it can increase and help in developing the level of integrity and togetherness among the people within a society. This also has to be done on both online and offline platforms whereby it can have a significant contribution in helping people to cope up with the changing atmospheres.

8. Conclusion

The concept of being connected has undergone a considerable change along with the means that kept people connected. The emotional and psychological benefit of being connected has also undergone a considerable change. Similarly, another aspect that characterizes human beings is their ability to adapt and overcome the struggles they face in their life. These struggles might be natural and some might be artificial.

Physical and virtual worlds came into existence and people joined their hands both online and offline to efficiently carry out disaster mitigation. One such event was the Great Floods that happened in Kerala during the year 2018. It affected the land and its people very badly, resulting in the casualty of numerous people. People were taken by surprise by this disaster. So they were clueless as to what is to be done to save themselves and others. This is where social media emerged with its opportunities to connect them with the entire world and thereby making them feel that they are not

alone and that numerous hands and hearts werecoming up with help. This study which attempts to understand the efficacy of social media in disaster mitigation has found out that people have utilized the opportunities provided by social media to keep them virtually connected with the world and also to avail help. People all around the place have utilized social media for rescue and support, social media platforms were widely and effectively utilized for providing instructions and warnings and also for directing the resources in the right path and to the right place. Several challenges were faced during the proper functioning of social media in such a situation.

This study also led to the revelation as to how deep the roots of social media have penetrated our society. This also demonstrates another evolution of human society that attempts to blend the physical and the virtual world. Thus, social media emerges as a crucial element in effective social work as well. Social workers, who attempt and toil to bring in a constructive change along with providing a healthy and wealthy living atmosphere in the society, should able to utilize this medium for effective interaction with society. Taking this into account, social workers could interact with all groups within society through social media. Thereby impart an effective and constructive influence on society. The mental atmosphere and the attitude of people towards social media and their perspectives on helping people can be constructively transformed by the efforts of social workers.

Reference

1. Abhimanyu Shankhdhar, JIMS / Social media and business.
2. About disaster management. (n.d.). Retrieved from International Federation of Red Cross and Red Crescent Societies: https://www.google.com/search?sxsrf=ALeKk03jS3PGsOU-S8MOLOsQ43lLrhe3nA%3A1615784998699&ei=JuxOYJ-YKvnA3LUPqoO24AY&q=ifrc&oq=ifrc&gs_
3. Burg, N. (2013). How Technology has Changed Workplace Communication, http://www.forbes.com/sites/unify/2013/12/10/how-technology-has-changed-workplace-communication/
4. Carr, C. (2019, October 04). The data behind the average article lifespan. Retrieved March 18, 2021, from https://blog.parse.ly/post/1768/data-on-article-lifespans/
5. Carter, n. (2008). Disaster management, a disaster manager's handbook [pdf]. Philippians: Asian development bank.
6. Dave, D. R. (n.d.). Role of Media in Disaster Management. Retrieved from Odisha State Open University, Sambalpur, Odisha: https://www.osou.ac.in/Search.php?cx=000358487220416256137%3Aklgukv03bxe&cof=FORID%3A9&ie=UTF-8&q=role+of+media+in+disaster+dr+r+k+dave&srchbtn=GO
7. Dhanashree Giri, Aman Vats. (2017). Social Media and Disaster Management in India: Scope and Limitations. Emirates International Research Conference (pp. 349-356). Dubai, UAE: Springer, Cham.
8. DimiterVelev and PlamenaZlateva. (2012). Use of Social Media in Natural Disaster Management. ICITE, (p. Volume 39). Hong Kong.
9. Disaster noun - DEFINITION, PICTURES, pronunciation and usage notes: Oxford ADVANCED American dictionary at oxfordlearnersdictionaries.com. (n.d.). Retrieved March 18, 2021, from https://www.oxfordlearnersdictionaries.com/definition/american_english/disaster
10. Disaster. (2021). Retrieved March 18, 2021, from https://www.merriam-webster.com/dictionary/disaster

11. DOLLARHIDE, M. E. (2020, September 6). Social Media Definition. Retrieved from Investopedia: https://www.investopedia.com/terms/s/social-media.asp#:~:text=Social%20media%20is%20computer%2Dbased,quick%20electronic%20communication%20of%20content.
12. Framework & Guidelines of using Social Media. (n.d.). Retrieved from Department of Electronics and Information Technology, Government of India: https://www.meity.gov.in/writereaddata/files/Approved%20Social%20Media%20Framework%20and%20Guidelines%20_2_.pdf
13. Harankhedkar, H. (2011). Impact of Technology on Communication, http://www.buzzle.com/articles/impact-of-technology-on-communication.html
14. Jan H. Kietzmann, Kristopher Hermkens, Ian P. McCarthy, (2011). Social Media? Get Serious! Understanding the Functional Building Blocks of Social Media. Business Horizons, pp.241-251.
15. Libretexts. (2020, December 16). 1.2F: Durkheim and social integration. Retrieved March 18, 2021, from https://socialsci.libretexts.org/Bookshelves/Sociology/Book%3A_Sociology_(Boundless)/01%3A_Sociology/1.02%3A_The_History_of_Sociology/1.2F%3A_Durkheim_and_Social_Integration#:~:text=Society%20is%20a%20social%20product,social%20beings%2C%20not%20just%20animals
16. M.D., S. J. (2014, September 11). The Role of Social Media in Disaster Psychiatry. Retrieved from Psychology Today: https://www.psychologytoday.com/us/blog/the-aftermath-trauma/201409/the-role-social-media-in-disaster-psychiatry
17. Mahmoudi Sidi Ahmed et al., "Detection of Abnormal Motions in Multimedia", Chania ICMI-MIAUCE'08 workshop, Crete, Greece, 2008.
18. Reporter, S. (2020). Role of media in disaster management highlighted. KALABURAGI: THE HINDU.
19. Rekha Rani Varghese, Yadukrishnan T A. (2019). Role of social media during Kerala floods 2018. DigitalCommons@ University of Nebraska - Lincol
20. Riley, A. (2013, November 08). Slacktivism: 'liking' on Facebook may mean less giving. Retrieved March 18, 2021, from https://news.ubc.ca/2013/11/08/slacktivism-liking-on-facebook-may-mean-less-giving/
21. Role of social media in Natural Disasters. (n.d.). Retrieved from Aniruddha's Academy of Disaster Management: https://www.aniruddhasadm.com/index.php/component/k2/item/305-role-of-social-media-in-natural-disasters
22. S. Willium, "Network Security and Communication", IEEE Transaction, Vol.31, Issue.4, pp.123-141, 2012.
23. Saleem, V. (2015, June 07). How people turn to social media during natural disasters. Retrieved from Down To Earth: https://www.downtoearth.org.in/blog/how-people-turn-to-social-media-during-natural-disasters-49587
24. Social work Action. (n.d.). Retrieved March 18, 2021, from https://www.ifsw.org/what-is-social-work/global-definition-of-social-work/
25. Society. (n.d.). Retrieved March 18, 2021, from https://dictionary.cambridge.org/dictionary/english/society
26. Space and Naval Warfare Systems Center Atlantic. (2013, September). Innovative Uses of Social Media in Emergency Management. Retrieved from Homeland Security Digital Library: https://www.hsdl.org/c
27. Suresh Bada Math, Maria Christine Nirmala, Sydney Moirangthem, and Naveen C. Kumar. (2015). Disaster Management: Mental Health Perspective. Indian Journal of Psychological Medicine, 261-271.
28. What is a disaster? (n.d.). Retrieved from IFRC: https://www.ifrc.org/en/what-we-do/disaster-management/about-disasters/what-is-a-disaster/

Depreciation of Capital Due to Natural Disaster and Adjusted Net Domestic Product

Amarendra Das[1], Dasarathi Padhan[1], Chinmayee Sahoo[1]

Abstract

The conventional measures of national income accounting do not account for the depreciation of physical capital caused by natural disasters. To our knowledge, systematic studies on the economic accounting of loss due to natural disasters in the Indian context, are limited. This paper tries to account for the economic loss due to natural disasters, as the depreciation of capital and provide the adjusted estimate of NDP. We have estimated the Natural Disaster adjusted NDP by deducting the financial losses due to natural disasters from the conventional NDP. Systematic data on economic loss due to natural disasters are limited for all Indian states. Therefore, this paper provides a methodological framework for accounting for the depreciation of the capital due to natural disasters for all Indian states and provides an approximate estimate of adjusted NDP for all Indian states. Due to availability of systematic data on the economic loss due to natural disasters, time series estimates of adjusted NDP are provided for Odisha state which experiences maximum climatic natural disasters. Calculation of adjusted NDP will be very much useful for fiscal transfer from Union to States and other economic policy making.

Keywords: *Adjusted NDP, Natural Disaster, Consumption of Fixed Capital, Depreciation*

1. Introduction

In the last two decades, attempts are being made to compute better metrics to measure the national income that accounts for the environmental resources and costs. The conventional measures of national income accounting do not take into consideration

[1] **Amarendra Das, Dasarathi Padhan, Chinmayee Sahoo,** School of Humanities and Social Sciences, National Institute of Science Education and Research Bhubaneswar, Jatnai, Khordha-752050, Odisha, India Homi Bhabha National Institute, Anushakti Nagar, Mumbai.

the benefits of environmental/natural resources and the cost of their degradations. Therefore, economists have been trying to include the depletion of natural resources as the depreciation of natural capital and measure a modified Net Domestic Product. This adjusted NDP is Gross Domestic Product less the depreciation of physical capital and natural capital. However, this measure also does not account for the depreciation of physical capital caused by natural disasters. Some national and sub-national economies face natural disasters more frequently than others. Capital accumulation through continuous investment and physical capital and human capital are prerequisites for improving the living standard. Therefore, frequent occurrence of natural disasters may deplete the physical capital base (such as public infrastructure, private enterprises etc.) and reduce the fiscal space to invest in human capital (health and education). As a result of this, the capability of individuals and states to improve the living standard may decline or at least not improve. Therefore, NDP calculation should also take into account the depreciation of physical capital caused by natural disasters.

Attempts have been made in other country contexts to measure the full economic cost of disaster (Rasmussen, 2004; Gaddis et al.,2007; Noy 2009; Raddatz, 2009; Shabnam, 2014), and link the effects of disasters on economic growth (Hallegatte and Dumas 2009). Similarly, studies (Raddatz, 2009) have attempted to differentiate the macro economic effects of climatic and other disasters. Other studies have compared the costs of disasters across geographical areas and income levels and to answer structural and policy related aspects of costs due to disasters (Noy, 2008). In Indian context,Das (2012) has attempted to understand the role of natural ecosystems and socio-economic factors in the vulnerability of coastal villages to cyclone and storm surge.

Nevertheless, in Indian context, very few studies have accounted for the depreciation of the physical capital due to natural disasters. In this paper we have computed the Natural Disaster Adjusted NDP by substracting the monetary value of the losses due to natural disasters from the conventional NDP. Data on the full cost of damage and losses due to all types of natural disasters are not available. In this context, we have provided a framework for estimating the Natural Disaster Adjusted NDP and provided estimates for Indian states with the existing data sets. Such estimates will have significant implications for the fiscal transfer to states based on the formula that uses percapita income.

1.1 UN Framework for National Income Accounting

United Nations System of National Accounts (UNSNA, hereafter) provides a systematic and uniform method of calculation of the economic activities which help us in comparing economies throughout the world. GDP has been used as one of the welfare measurements. But how far GDP reflects welfare is a matter of question. What are the components that enter into the measurement of GDP should also be discussed. It has been found that the contributions of environment to the economic growth and human welfare have been ignored in national account system. Environmental costs resulting from human activities and natural disasters have not been accounted for. National Accounts of a country which are measures of economic activities should incorporate the environmental benefits and cost. The System of National Accounts of United Nations prevalent and followed across the economies does not integrate the environmental aspects of an economy. To consider the value of environment and environmental costs in accounting system of the economy, United Nations developed a framework for all countries called Integrated Environmental and Economic Accounting (SEEA) in 1993. The conventional framework for estimation of national accounts may lead to overestimation or underestimation of GDP. In National Account system of India, environmental goods and services like productivity of land, biodiversity are not included. GDP is not adjusted by environmental costs like depletion of natural resources, pollution, deforestation, etc.

1.2 Need for Changes in National Account System

The impact of natural disasters has not been included in National Account System of India due to non-availability of complete data. Natural Disasters have bearings on economy. Disasters affect economic system in many ways. They have impacts on production system, consumption pattern, employment, saving, distribution, etc. One of the limitations of conventional GDP measurement is non-inclusion of costs inflicted by natural disasters (NSO, 2013).

Government has to bear huge amount of costs in terms of compensation, rebuilding of damaged infrastructure, etc. Economic damage from natural disasters is enormous. This amount can be used for the increase of welfare of the people if natural disasters are prevented to occur. Natural calamities impose a fiscal burden on the economy. But the accounting system in India completely ignores this huge cost in the process

of calculating Net Domestic Product. The method followed by Central Statistical Organisation, India is as follows:

1.3 Income Accounting in India

1.3.1 The Production Identities

Gross Value Added (GVA) at factor cost= Output – Intermediate consumption

Gross Domestic Product (GDP) at factor cost= Sum of GVA at factor cost

GDP at Market Prices	=	GDP at factor cost
	+	(taxes – subsidies) on production and export/import
	=	final consumption expenditures
	+	Changes in inventories
	+	Gross fixed capital formation
	+	Acquisition less disposals of valuables
	+	Exports of goods and services
	-	Imports of goods and services
	=	Compensation of employees
	+	Operating surplus/ mixed income
		Consumption of fixed capital (CFC)
	+	(taxes – subsidies) on production and export/import

Net Domestic Product at factor cost/ market price = GDP at factor cost/market price – CFC

1.3.2 Saving and Investment Identities

Net Saving + net capital transfers receivable = Gross fixed capital formation – CFC
+ Changes in Inventories
+ Acquisitions less disposals of valuables and Non-produced non-financial assets
+net lending / net borrowing

Net lending (+)/borrowing (-) = net acquisitions of financial assets less net incurrence of financial liabilities

1.3.3 Capital Formation and Consumption of Capital

Gross Capital Formation (GCF) refers to the aggregate of gross additions to fixed assets (fixed capital formation), increase in stocks of inventories or change in stocks (CIS) and valuables. Gross Fixed Capital Formation (GFCF) comprises two main components, (i) construction, and (ii) machinery and equipment. Only new 'Construction' forms part of GFCF from construction. All repairing and maintenance works won't be accounted in GFCF. Natural Calamities such as floods and cyclones cause damages to infrastructure. Public buildings, roads, canals, etc. get destroyed when a severe cyclone or flood or earthquake occurs. Government spends a huge amount of money in repairing those damaged infrastructures resulting in an extra fiscal burden on economy. But this spending does not appear in our national accounts.

Consumption of Fixed Capital is defined as the decline, during the course of the accounting period, in the current value of the stock of fixed assets owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage. It excludes the value of fixed assets destroyed by acts of war or exceptional events such as major natural disasters which occur very infrequently. But the question arises, what if the natural calamities occur frequently in a country and the costs are enormous. What could be the possible economic implications of the damages of the physical capital on capital stock and income generation? Can we ignore the huge costs borne due to calamities in our national accounts?

We can see in the above method followed by CSO, India only the consumption of fixed capital has been taken into account. Depletion of natural capital is being ignored in the measurement process. Observing this limitation in the methodology, United Nations has developed a new framework named System of Environmental and Economic Accounting which attempts to take environmental costs and benefits into consideration. In this new method, emphasis has been given to depreciation of natural capital.

2. Literature on Natural Disaster, Economic Growth and Capital

Macroeconomic consequences of disasters depend upon the economic structure and stage of development. Studies show that developed countries such as the USA suffered less human deaths as compared to the developing countries like India and Bangladesh

even though the former faced more frequent disasters. (Guha-Sapir et al., 2004). The availability of good-quality, trustworthy data is necessary for effective management of natural disaster risk (Benson and Clay, 2004). Hallegatte, Hourcade, and Dumas (2007) find that production losses due to extreme events depend on strong non linearity in the characteristics of the distribution and on the capacity to conduct reconstruction after disaster. Noy (2008) find no correlation between disaster population variables and GDP growth. Rather they find negative relation between property damage and GDP growth. Property cost has short term impact. Human cost impact is long term in nature. Large disasters have more adverse effects. Small economies are more vulnerable because they are less diversified. Hallegatte and Dumas (2009) found that disasters influence short term growth rate and long term production level. They argue that disasters can't influence the long-term growth rate.

Das (2016) argue that disasters can lead to increase in productivity. It is argued that because of the occurrence of calamities old infrastructures are replaced by new ones and related innovations lead to increase in productivity. On the other hand, huge damages due to natural calamities can lead to economic backwardness.

Jonkman, Bockarjova, Kok and Bernardini (2008) estimated the total economic damage to Netherlands due to flooding at 24 billion euro which is 6.5% of GDP of the year 2000. 70% of the total damages were the direct physical damages to residential property. Cuaresma (2009) founda negative long run effect of geological natural disaster risk on secondary school enrolment rates. Raddatz (2009) found that a climatic disaster reduces per capita GDP by 0.6 percent. Geological disasters do not have significant impact on output of the economy. Hallegate and Przyluski (2010) points out that there are large uncertainties on indirect disaster costs because of insufficient data and inadequate methodologies.

Das (2012) appraised the probability of expected human fatality (death risk) due to severe cyclone and storm surge for the villages associated with one of the most cyclones prone districts of India. Shabnam (2014) found that the total number of affected people in floods significantly affects the GDP per capita growth rate whereas the death toll in floods has no substantial effect on annual GDP per capita growth. Floods naturally create havoc in people's livelihoods rather than claiming a high human death toll.

Parida (2019) found that economic development reduces the fatalities and damage due to floods in India. He also observed that along with economic development better

political coordination between the national and sub-national government is essential to mitigate the impact of floods. However, with district-level analysis conducted for Odisha state, Parida et al (2020) found that economic development (proxied by per capita income) is not adequate to minimize fatalities from natural disasters. They also argue that better disaster adaptation measures such as better medical facilities, adequate road infrastructure, higher primary enrolment, village electrification, forest cover, and financial accessibility help in mitigating disaster fatalities to some extent.

Most of the works on natural disasters have dealt with the impacts of disasters on economic growth, human capital, fiscal burden, etc. We did not find any work which deals with the relation between the impacts of natural disasters and national account of the economy. The central question that arises here is, what would be the change in national accounts if economic losses due to natural disasters are incorporated in the measurement of Net Domestic Product (NDP) and Net State Domestic Product (NSDP). In this context our paper attempts to fulfil the following objectives:

3. Objectives

The objectives of our research paper are two fold:

1. To account for the economic loss due to natural disasters for Indian states
2. To provide a framework for estimating Natural Disaster Adjusted Net Domestic Product and compute the same for Indian States.

4. Methodology and Data

The paper provides a conceptual framework for incorporating the depreciation of physical capital due to natural disaster in the Net Domestic Product calculation. Further secondary data have been compiled to assess the economic cost of natural disaster. Data have been collected from several sources namely Central Water Commission, Reports of Finance Commission of India, Reports of Odisha state Disaster Management Authority and Special Relief Commissioner and National Institute of Disaster Management. We have calculated the Disaster Adjusted NDP by subtracting estimated financial loss due to natural disaster from the Net Domestic Product.

5. Framework for Natural Disaster Adjusted NSDP

In conventional method of calculation of National Accounts, the depreciation of physical capital is deducted from GDP to arrive at NDP. But this depreciation of capital does not consider the destruction of physical capital due to natural disasters. Natural disasters like flood, earthquake, cyclone, etc. cause heavy damage to the physical infrastructures of an economy. Industries, school buildings, hospitals, residential houses and other constructions get devastated by natural disasters. Hence, productive capital base of the economy dwindles. Reduction in the capital base of a country or a state reduces the production capability of both state and individual. Reduction in welfare of the people follows. In post-disaster period state has to spend a lot of resources for rebuilding the destroyed or damaged capital base. These expenditures incurred on repairing the damaged and destroyed capital base could have been used to create new physical capital or invested in the formation of human capital or invested in other poverty alleviating schemes. Therefore, the investment for reconstruction is not contributing to the increase in capital base (physical and human capital) of the economy which was there in pre-disaster period. Rather state has to spend a lot of resources forthe maintenance of the capital base existed before occurrence of the disaster. Hence these expenditures should be treated as the depreciation to the existed physical capital rather than entering them in the capital account.

Economists use Domar (1946) equation to forecast the growth rate if the rate of investment is known. The same equation is also used in computing the required investment for achieving a certain level of growth. The equation is written as G = I/k where G refers to growth rate of national output i.e., GDP or at state level Gross State Domestic Product (GSDP); I is level of investment or in case of S=I this is also rate of saving and k is capital output ratio. Therefore, Growth rate of a state depends positively on the rate of productive investment.

When net investment declines, level of national income decreases. Given this relationship between investment and national income, when there is occurrence of natural disaster the real investment which would help in increasing the level of capital stock does not grow resulting in a reduction of national income.

All investments can be classified into two categories: investment for new productive capital I_p and investment for reconstruction I_r.

Total Investment I= I_p + I_r

I_p increases the Gross capital formation of an economy in increasing production and capital in the absence of disasters whereas Investment for reconstruction helps in bringing back the capital to the previous level (Hallegatte and Dumas, 2009).
Usually, the Gross Capital Formation is calculated using the perpetual inventory method given as follows

$$K_{t-1}=K_{t-2}+I_{t-1}$$
$$K_t=K_{(t-1)}+I_t$$
$$K_{t+1}=K_t+I_{t+1}$$
$$K_n=K_{n-1}+I_n$$

If $I= I_p+ I_r$, then capital accumulation in time period n will depend upon only $I_p$not I_r. In this case, a state having higher expenditure on I_r will have lower capital formation and hence lower growth rates.

Effect of destruction of capital or infrastructure due to natural disaster may vary across economies and households. Possibility of the destruction of infrastructure in terms of money value could be high in case of developed countries as compared to underdeveloped ones. Reconstruction cost will also vary accordingly. Recovering capacity of the economies also depends upon the state of the economy. This logic can be applied to household level as well. Economic condition of households determines the amount cost borne and the capacity to bounce back to normal standard of life. Reconstruction investment plays a pivotal role in state economy and household economy at a disaster period.

In this context, we have computed the Adjusted NSDP by deducting the depreciation of the physical capital due to the natural disaster.

6. Analysis

Between 1891 and 2002 a total number of 356 major tropical cyclones have hit the Indian coast (See table 1). Out of these, east coast has faced maximum number of (308) cyclones and west coast only 48 cyclones. In the east coast, maximum number of cyclones have been faced by Odisha, followed by its neighbouring states namely Andhra Pradesh and West Bengal. Table 1 presents the major tropical cyclones in the Indian Coast between 1891 and 2001.

Table 1: Major Tropical Cyclones in the Indian Coast between 1891 and 2002

West Coast		East Coast	
Kerala	3	West Bengal	69
Karnataka	2	Odisha	98
Maharashtra	13	Andhra Pradesh	79
Goa	2	Tamil Nadu	54
Gujarat	28	Puduchery	8
Total	48	Total	308

(Source: NCRMP 2019)

6.1 Cost of Natural Disasters

Natural disasters cause loss of life, loss of individual property such as crop loss, damage of house, assets, livestock, loss of livelihood; damage of public property such as roads, bridges, disruption of power supply and collapse of power supply systems, school and college buildings, fear of outbreak of epidemics and so on. For this reason government needs to prepare for mitigating the disasters through pre disaster evacuation, information and communication for awareness generation; post disaster relief, reconstruction of private and public properties and so on. It is therefore important to calculate the full cost of natural disaster to know the economic implications. The government of India has enlisted the following 12 disasters for estimation of economic loss. Table 2 describes the list of 12 natural disasters for allocating disaster relief funds.

Table 2: List of Disasters recognized by National Disaster Response Force

Sl. No.	List of Disasters
1	Flood
2	Drought
3	Fire
4	Hailstorn
5	Cyclone
6	Earthquake
7	Tsunami

8	Landslide
9	Avalanche
10	Cloud Burst
11	Pest Attack
12	Cold Wave/Frost

Systematic data are not available in public domain for researchers to carryout in-depth analysis on the full cost of natural disaster. Informations are available for specific disasters and for a few states only. Very recently some data have been generated by the Forecast Monitoring Directorate, Central Water Commission, Government of India (2018) on the economic damage caused by the floods in all states of India. Table 3 presents the total cost of floods in India from 1953 to 2016.

Table 3: Statement Showing Damage Due to Floods / Heavy Rains During 1953 to 2016, All India

			Damage to Crops		Damage to Houses					
Year	Area affected in Million Hectares	Population affected in Million	Area affected in Million Hectares	Value in Rs. Crore	Nos	Value in Crores	Cattle Lost in Nos	Human Loss in Numbers	Damage to Public Utilities in Rs. Crore	Total Damages, Crops, houses and Public Utilities in Rs. Crores
1	2	3	4	5	6	7	8	9	10	11
1953	2.29	24.28	0.93	42.08	264924	7.42	47034	37	2.9	52.4
1954	7.49	12.92	2.61	40.52	199984	6.561	22552	279	10.15	57.231
1955	9.44	25.27	5.31	77.8	1666789	20.945	72010	865	3.98	102.725
1956	9.24	14.57	1.11	44.44	725776	8.047	16108	462	1.14	53.627
1957	4.86	6.76	0.45	14.12	318149	4.979	7433	352	4.27	23.369
1958	6.26	10.98	1.4	38.28	382251	3.896	18439	389	1.79	43.966
1959	5.77	14.52	1.54	56.76	648821	9.418	72691	619	20.02	86.198
1960	7.53	8.35	2.27	42.55	609884	14.309	13908	510	6.31	63.169
1961	6.56	9.26	1.97	24.04	533465	0.889	15916	1374	6.44	31.369
1962	6.12	15.46	3.39	83.18	513785	10.655	37633	348	1.05	94.885
1963	3.49	10.93	2.05	30.17	420554	3.701	4572	432	2.74	36.611
1964	4.9	13.78	2.49	56.87	255558	4.588	4956	690	5.149	66.607
1965	1.46	3.61	0.27	5.87	112957	0.195	7286	79	1.07	7.135
1966	4.74	14.4	2.16	80.15	217269	2.544	9071	180	5.736	88.43
1967	7.12	20.46	3.27	133.31	567995	14.264	5827	355	7.857	155.431
1968	7.15	21.17	2.62	144.61	682704	41.112	130305	3497	25.373	211.095
1969	6.2	33.22	2.91	281.9	1268660	54.423	270328	1408	68.112	404.435
1970	8.46	31.83	4.91	162.78	1434030	48.606	19198	1076	76.441	287.827
1971	13.25	59.74	6.24	423.13	2428031	80.241	12866	994	129.113	632.484

1972	4.1	26.69	2.45	98.56	897301	12.46	58231	544	47.174	158.194
1973	11.79	64.08	3.73	428.03	869797	52.482	261016	1349	88.489	569.001
1974	6.7	29.45	3.33	411.64	746709	72.434	16846	387	84.942	569.016
1975	6.17	31.36	3.85	271.49	803705	34.097	17345	686	166.05	471.637
1976	11.91	50.46	6.04	595.03	1745501	92.16	80062	1373	201.495	888.685
1977	11.46	49.43	6.84	720.61	1661625	152.29	556326	11316	328.948	1201.848
1978	17.5	70.45	9.96	911.09	3507542	167.574	239174	3396	376.1	1454.764
1979	3.99	19.52	2.17	169.97	1328712	210.606	618248	3637	233.627	614.203
1980	11.46	54.12	5.55	366.37	2533142	170.851	59173	1913	303.283	840.504
1981	6.12	32.49	3.27	524.56	912557	159.63	82248	1376	512.314	1196.504
1982	8.87	56.01	5	589.4	2397365	383.869	246750	1573	671.607	1644.876
1983	9.02	61.03	3.29	1285.85	2393722	332.327	153095	2378	873.429	2491.606
1984	10.71	54.55	5.19	906.09	1763603	181.308	141314	1661	818.164	1905.562
1985	8.38	59.59	4.65	1425.37	2449878	583.855	43008	1804	2050.043	4059.268
1986	8.81	55.5	4.58	1231.58	2049277	534.41	60450	1200	1982.535	3748.525
1987	8.89	48.34	4.94	1154.64	2919380	464.49	128638	1835	950.59	2569.72
1988	16.29	59.55	10.15	2510.9	2276533	741.6	150996	4252	1377.8	4630.3
1989	8.06	34.15	3.01	956.74	782340	149.82	75176	1718	1298.77	2405.33
1990	9.303	40.259	3.179	695.61	1019930	213.733	134154	1855	455.266	1708.92
1991	6.357	33.889	2.698	579.015	1134410	180.421	41090	1187	728.893	1488.329
1992	2.645	19.256	1.748	1027.578	687489	306.284	78669	1533	2010.67	3344.532
1993	11.439	30.409	3.206	1308.627	1926049	528.324	211193	2864	1445.534	3282.485
1994	4.805	27.548	3.963	888.622	914664	165.206	52315	2078	740.762	1794.59
1995	5.245	35.932	3.245	1714.787	2001898	1307.894	62438	1814	679.627	3702.308
1996	8.049	44.729	3.827	1124.491	726799	176.589	73208	1803	861.393	3005.743
1997	4.569	29.663	2.258	692.743	505128	152.504	27754	1402	1985.934	2831.181
1998	10.845	47.435	7.495	2594.167	1932874	1108.783	107098	2889	5157.771	8860.721
1999	7.765	27.993	1.753	1850.873	1613260	1299.057	91289	745	462.83	3612.76
2000	5.382	45.013	3.58	4246.622	2628855	680.943	123252	2606	3936.979	8864.544
2001	6.175	26.463	3.964	688.481	716187	816.474	32704	1444	5604.461	7109.416
2002	7.09	26.323	2.194	913.092	762492	599.368	21533	1001	1062.083	2574.543
2003	6.12	43.201	4.268	7307.23	775379	756.481	15161	2166	3262.154	11325.87
2004	5.314	43.725	2.888	778.694	1664388	879.601	134106	1813	1656.09	3314.385
2005	12.562	22.925	12.299	2370.923	715749	380.531	119674	1455	4688.219	7439.672
2006	1.096	25.224	1.822	2850.668	1497428	3636.848	266945	1431	13303.93	19790.92
2007	7.145	41.402	8.795	3121.532	3280233	2113.108	89337	3389	8049.037	13283.68
2008	3.427	29.91	3.186	3401.563	1566809	1141.891	101780	2876	5046.481	9589.935
2009	3.844	29.537	3.592	4232.609	1235628	10809.8	63383	1513	17509.35	32551.76
2010	2.624	18.297	4.994	5887.38	293830	875.952	39706	1582	12757.25	19520.59
2011	1.895	15.973	2.718	1393.847	1152518	410.475	35982	1761	6053.57	7857.892
2012	2.141	14.689	1.95	1534.108	174526	240.572	31558	933	9169.968	10944.65
2013	7.546	25.927	7.484	6378.078	699525	2032.83	163958	2180	38937.84	47348.75
2014	12.775	26.505	8.007	7255.151	311325	581.978	60196	1968	7710.948	15548.08
2015	4.478	33.203	3.374	17043.95	3959191	8046.969	45597	1420	32200.18	57291.1
2016	7.065	26.555	6.658	4052.723	278240	114.676	22367	1420	1507.926	5675.325
TOTAL	460.26	2040.266	251.047	102273.6	79465079	44390.34	6022676	105472	199730.2	347581.2
AVG	7.192	31.879	3.923	1598.026	1241642	693.599	94104	1648	3120.784	5430.956
MAX	17.5	70.45	12.299	17043.95	3959191	10809.8	618248	11316	38937.84	57291.1
(YEAR)	1978	1978	2005	2015	2015	2009	1979	1977	2013	2015

(Source: Flood Forecast Monitoring Directorate, Central Water Commission, Government of India (2018) State Wise Flood Damage Statistics)

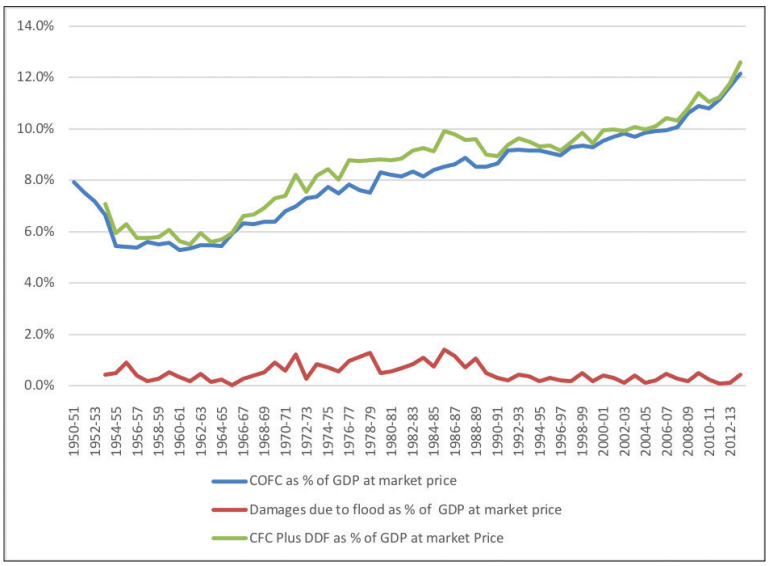


Figure 1: Consumption of Fixed Capital and Damage Due to Floods as Percentage of GDP at Market Price from 1950-51 to 2013-14

Figure 1 presents the Consumption of Fixed Capital (CFC) as percentage of GDP and aggregate economic loss due to floods in India. The objective behind plotting this figure is to see the trends of both indicators. For this purpose, we have used the CFC and GDP at market price in 2004-05 constant prices. The economic losses due to floods are given in constant prices. We used the GDP deflator to bring it to 2004-05 constant prices and then calculated the economic losses due to floods as a percentage of GDP. Between 1950-51 and 2012-13, the rate of CFC as a percentage of GDP varied between eight percent to a little above 12 per cent. The economic loss due to floods as a per cent of GDP varied from 0.4% to 1.4% during 1953-2013. If we consider all the economic loss due to floods as depreciation of capital, the total consumption of capital for the country would increase by 0.4% to 1.4%. We have shown this in figure 1.

Table 4 presents the state wise per capita average annual loss due to floods and heavy rains. We do not find any consistent trend in this table, except, that smaller states have recorded maximum per capita loss due to floods and heavy rainfalls. However, the loss due to floods and rains do not capture all losses due to many other natural disasters such as cyclones, earthquakes, landslides etc. It should be noted that weather related

natural calamities such as cyclones and floods cause maximum damage compared to other disasters. Our objective is to assess the full economic cost of all disasters. But due to lack of systematic data in public domain we are not able to do so rather we rely upon indirect data sources to provide an indicative measurement.

Table 4: State Wise Average of Per Capita Annual Loss due to Floods/Heavy Rains

States	1997-98 to 2001-02	2002-03 to 2006-07	2007-08 to 2011-12	2012-13 to 2016-17
Andaman and Nicobar Islands	0.0	0.0	0.0	2.3
Andhra Pradesh	161.8	736.4	1243.2	193.6
Arunachal Pradesh	17.4	12744.7	5832.4	7937.7
Assam	71.4	86.8	4.7	203.2
Bihar	45.9	114.3	55.7	16.7
Chandigarh	NA	1.4	0.0	0.0
Chhattisgarh	110.7	15.6	15.5	0.0
Delhi	13.5	0.0	0.0	0.0
Goa	5.2	0.5	3.8	0.8
Gujarat	5.1	88.7	39.7	0.5
Haryana	102.1	0.1	10.0	80.6
Himachal Pradesh	971.6	533.5	1565.7	1171.9
Jammu and Kashmir	22.1	0.0	0.0	1300.9
Jharkhand	0.0	0.0	0.1	0.3
Karnataka	4.1	183.3	887.1	164.1
Kerala	89.8	1.3	49.9	70.2
Madhya Pradesh	1.5	19.0	0.2	20.1
Maharashtra	0.4	3.1	0.0	0.0

Manipur	52.5	65.9	86.3	300.9
Meghalaya	7.3	171.5	0.0	1012.1
Mizoram	NA	0.0	0.0	4.0
Nagaland	NA	0.0	0.0	64.3
Odisha	115.1	199.3	331.0	14.8
Puducherry	0.0	0.0	0.0	473.5
Punjab	2.3	0.4	25.4	42.7
Rajasthan	95.5	15.5	0.0	87.0
Sikkim	0.4	0.1	0.0	1.0
Tamil Nadu	3.1	2.2	0.5	0.2
Telangana	NA	NA	NA	NA
Tripura	72.9	23.2	14.6	210.5
Uttar Pradesh	47.9	7.8	22.9	2.3
Uttarakhand	0.0	0.0	0.0	7719.2
West Bengal	236.8	33.0	31.4	561.6

Source: Flood Forecast Monitoring Directorate, Central Water Commission, Government of India (2018) State Wise Flood Damage Statistics

6.2 Inferences from SDRF Estimates

Starting from 1999-2000, the Union government has been providing financial assistances to the states for mitigating the losses of natural disasters. As per the National Disaster Management Policy, the primary responsibility for disaster management rests with the States. The concerned State Governments undertake relief activities according to the magnitude of the ground situation, in the wake of notified natural disasters from the State Disaster Response Fund (SDRF) already placed at their disposal in accordance with Government of India approved items and norms without any discrimination. For calamity of a severe nature, additional assistance is supplemented by Government of India from the National Disaster Response Fund (NDRF) by following the laid down procedure.

The corpus of SDRF is contributed by the Government of India and the State Government in the ratio 75:25 for General Category States and 90:10 for Special Category States. NDRF is fully funded by the Government of India. Under the prevailing guidelines, the first charge of relief expenditure is always on the SDRF. Allocation of

SDRF for each State Government is done by the Finance Commission (set-up under the Article 280 of constitution from time-to-time), for the Award period. In addition, 10% of the annual fund allocation of the SDRF may be used for localized State specific natural disaster. No calamity-wise allocation is made under the SDRF to State.

The allocation to the SDRF by Finance Commission is done after a thorough assessment of the cost of disaster across states and consultation with the state governments. Therefore, analysis of allocation of SDRF to various states will provide an indicative scenario of the cost of disasters across states. Figure 2 presents the state wise SDRF allocation recommended by the Finance Commission XIV. Maharashtra state receives the maximum SDRF allocation followed by Rajasthan, Madhya Pradesh, Odisha and Gujarat. However, we cannot compare the cost of disaster with the total sum of allocation because of the wide variation in the size of the states in terms of geography and population. Therefore, we should compare the per capita SDRF allocation.

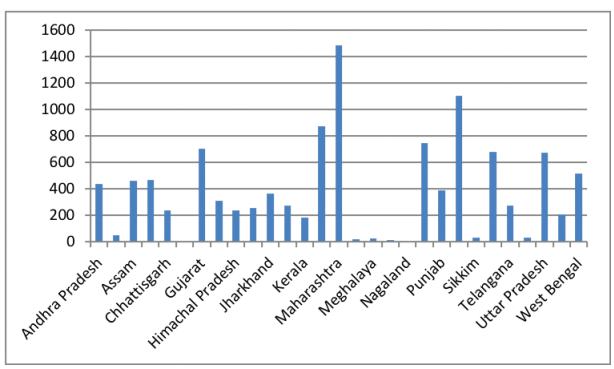


Figure 2 State Wise SDRF Allocation Recommended by FC XIV (Rs. Crore) for the year 2015-16

Figure 3 presents the per capita SDRF allocation to all states of India. Sikkim received the maximum per-capita SDRF allocation from the fourteenth Finance Commission followed by Arunachal Pradesh, Himachal Pradesh and Uttarakhand. Among the major states Odisha has received the maximum per capita SDRF allocation in 2015-16. The all India average per capita SDRF allocation made is 91 rupees.

The financial assistance received by the state from the Union Government, however, falls short of the expenditure incurred by the states. Table 5 presents the relief expenditure of states as percentage of receipts for the period 2002-09. For most of the

states and for most of the years, the relief expenditure far exceeds the receipt. The relief expenditure of states ranges from 22% of the receipts (West Bengal) to 540% for Bihar in some years. This implies that for maximum number of states, the relief expenditure incurred falls short of the receipt of assistance from the Union Government. The relief expenditure, however, does not reflect the actual cost of the disaster. Most of the states submit a memorandum to the Union Government and Finance Commission of India with the estimated economic loss due to different natural disasters and demand financial assistance from the same. In response to such demands the Union Government releases money to the states. However, the financial assistance provided by the Union government is far less than the demand placed by the states (NIDM, 2009).

Table 5: Relief Expenditure as Percentage of Receipts

		2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	Average
1	Andhra Pradesh	256	34	237	120	145	116	144	150.3
2	Arunachal Pradesh	101	100	101	100	98	100	99	99.9
3	Bihar	89	113	37	5	21	540	40	120.7
4	Chhattisgarh	111	123	70	42	62	166	76	92.9
5	Gujrat	213	137	91	69	160	146	130	135.1
6	Haryana	93	9	21	72	80	115	57	63.9
7	Himachal	100	100	100	100	100	100	100	100.0
8	Karnataka	69	90	156	80	192	105	102	113.4
9	Kerala	60	100	57	119	96	133	76	91.6
10	Madhya Pradesh	129	189	133	66	71	192	99	125.6
11	Maharashtra	100	188	74	107	245	96	129	134.1
12	Manipur	61	15	114		253	0	95	89.7
13	Meghalaya	74	58	26	116	23	41	57	56.4
14	Mizoram	100	100	100	100	100	100	100	100.0
15	Orissa	152	130	148	79	111	136	117	124.7
16	Rajasthan	94	87	40	88	121	72	87	84.1
17	Sikkim	113	73	98	79	163	100	102	104.0
18	Tamil	190	224	206	224	163	284	210	214.4
19	Tripura	70	58	125	38	21	193	51	79.4
20	Uttarakhand	387	-	100	-	100	-	114	175.3

21	Uttar Pradesh	123	47	77	23	15	187	65	76.7
22	West Bengal	22	43	39	49	124	241	65	83.3

(Source: Statement 25 furnished by the States to the Thirteenth Finance Commission as cited in NIDM (2009) "FINANCING DISASTER MANAGEMENT IN INDIA: *A Study for the Thirteenth Finance Commission*". National Institute of Disaster Management. August 2009)

In absence of the latest data, we have used the data available in a research report submitted by the National Institute of Disaster Management, (NIDM, 2009) to the 13th Finance Commission of India. In this report NIDM had compiled the data provided by the state governments in their memorandum to the 13th Finance Commission on the demand for financial assistance for natural disasters during 2000-01 to 2008-09. The disasters included, flood, cyclone, hailstorm, and drought. We took the GSDP and NSDP data for all major states from the RBI's Hand Book of Statistics on Indian States. We used the GSDP and NSDP data in 2004-05 constant price for the period 2000-09. The economic losses due to natural disasters were obtained from the NIDM (2009) report. We used GDP deflator to convert the economic loss due to disasters into 2004-05 constant prices. Using 2001 census data and the economic loss due to disaster we calculated average per capita cost of disaster for the period 2000-09. Similarly, we have also calculated the average per capita NSDP for the period 2000-09 and per capita disaster cost adjusted NSDP (Per capita NSDP minus per capita economic cost due to natural disaster). At the end we have also estimated per capita disaster cost as a percentage of per capita NSDP (Table 6). Arunachal Pradesh witnesses the maximum per capita cost of disaster as percentage of per capita NSDP (6.8%) followed by Jammu and Kashmir (3.5%), Bihar (3.1%) and Himachal Pradesh (2.7%). 14 states have reported more than 1% of per capita NSDP as cost of disaster.

Table 6: Per Capita NSDP, Cost of Disaster and NSDP adjusted for the Cost of Disaster

State	Per Capita Cost of Disaster	Per Capita NSDP	Percapita Disaster Cost adjusted NSDP	Per Capita Disaster Cost as % of Per Capita NSDP
Andhra Pradesh	156.3	16433.1	16276.8	1.0%
Arunachal Pradesh	1951.2	28678.7	26727.4	6.8%
Assam	205.3	17684.8	17479.5	1.2%
Bihar	267.7	8717.9	8450.1	3.1%

Chhattisgarh	161.9	20308.2	20146.3	0.8%
Gujarat	501.0	35542.1	35041.1	1.4%
Haryana	109.3	42162.5	42053.2	0.3%
Himachal Pradesh	960.1	35514.7	34554.6	2.7%
Jammu and Kashmir	808.8	23296.8	22488.0	3.5%
Jharkhand	139.9	18372.2	18232.4	0.8%
Karnataka	358.1	30119.2	29761.1	1.2%
Kerala	292.3	33989.3	33697.0	0.9%
Madhya Pradesh	123.1	17229.1	17106.0	0.7%
Maharashtra	226.2	41261.6	41035.5	0.5%
Manipur	198.3	19785.4	19587.2	1.0%
Meghalaya	101.8	25921.9	25820.0	0.4%
Mizoram	626.5	28185.9	27559.4	2.2%
Nagaland	16.4	28429.9	28413.4	0.1%
Odisha	214.8	18536.5	18321.7	1.2%
Punjab	202.5	36952.2	36749.7	0.5%
Rajasthan	371.4	20684.0	20312.7	1.8%
Sikkim	447.4	28597.9	28150.6	1.6%
Tamil Nadu	427.8	33723.0	33295.2	1.3%
Tripura	26.2	25984.6	25958.4	0.1%
Uttar Pradesh	128.4	14392.7	14264.3	0.9%
Uttarakhand	156.7	28453.3	28296.7	0.6%
West Bengal	0.0	24248.9	24248.9	0.0%

(Source: Calculated from the Demand submitted by states to the Finance Commission and compiled by National Institute of Disaster Management in NIDM (2009) "FINANCING DISASTER MANAGEMENT IN INDIA: A Study for the Thirteenth Finance Commission". National Institute of Disaster Management. August 2009)

Note: All Per Capita estimates are the average estimates of the specific indicator in 2004-05 constant price for the period 2000-01 to 2008-09

The money spent on the mitigation of disasters could have been invested in either new productive investment. Therefore, the part of expenditure incurred on disaster mitigation should be considered as leakages from productive expenditure of the government. Figure 4 shows the SDRF allocation as a percentage of the total expenditure of the states for the year 2015-16. At all India level the total SDRF allocation amounts

to 0.5% of the total expenditure (TE). For Assam this amounts to 1.2% of State Total Expenditures (STE), followed by Odisha (1% of STE), Arunachal Pradesh (0.9% of STE), Uttarakhand (0.8% of STE).

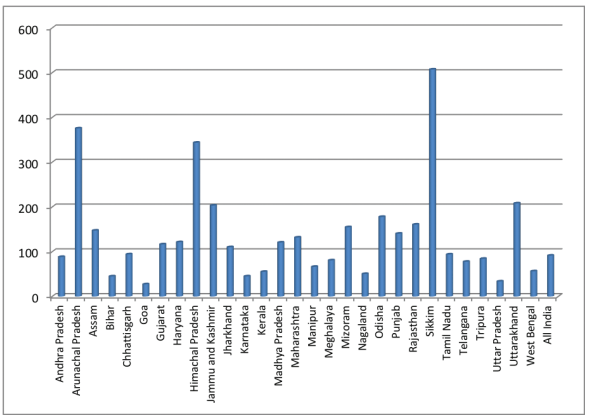


Figure 3: State Wise Per Capita SDRF for the year 2015-16

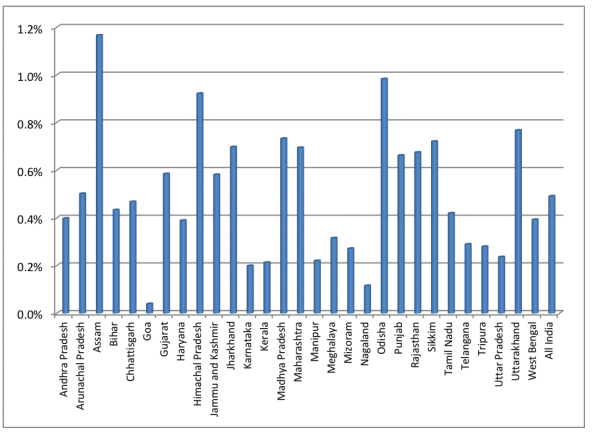


Figure 4: SDRF as a Percentage of Total Expenditure of the State for the Year 2015-16

6.3 Case Study of Odisha

Odisha faces maximum number of tropical cyclones every year. After the devastation made by 1999 super cyclone, the state government has been maintaining systematic data to quantify the total economic loss due to cyclones only. The financial losses due

to disasters are much higher than the relief expenditure incurred by the state. Therefore, the state wise SDRF allocation will be a gross underestimation of the actual financial losses accrued to the state and individuals. Figure 5 shows the financial loss due to natural disaster and relief expenditure incurred by Odisha. Barring a few years, the relief expenditure has always remained much below the financial loss. Relief expenditure as a percentage of the total financial loss has ranged from the lowest three percent to highest 374%. Between 1994-95 and 2013-14, only in three years the relief expenditure has exceeded the assessed financial loss. In rest 15 years for which data are available total relief expenditure has remained far below the assessed financial losses. This clearly shows that use of SDRF allocation to quantify the financial losses due to disasters is a gross underestimation. However, due to unavailability of systematic data we are using this data for getting only indicative scenario.

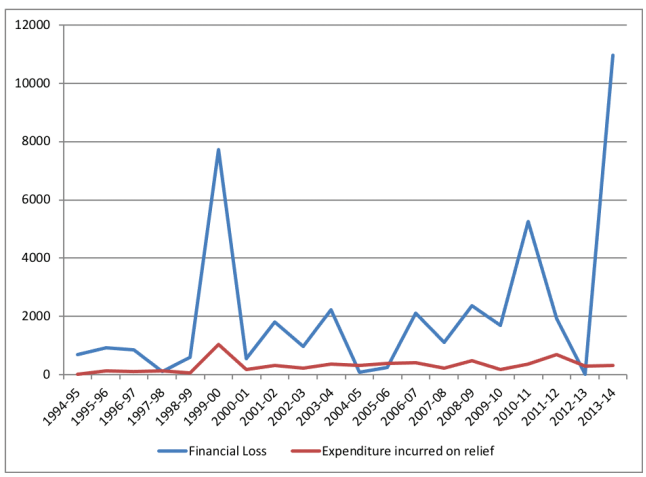


Figure 5: Financial Loss Due to Natural Calamities and Relief Expenditure of Odisha (Rs. Crore in Base Year 2004-05)

Since our primary objective is to compute the Net Domestic Product adjusted for the depreciation caused due to natural disasters it is important to compute the economic loss due to natural disaster as a percentage of GSDP. Figure 6 presents the economic loss as a percentage of GSDP. During the major cyclones the economic loss shoots up to a very high level. In 1999 the economic cost of super cyclone was as high as 13% of GSDP and in 2013 the economic cost of Phailin was eight percentage of GSDP. In most

other years the cost of natural disasters in Odisha has been estimated between one to four percentage of GSDP. Thus, for Odisha, the depreciation due to natural disaster has widely varied from as low as one percent to 13% of GSDP. This has huge negative implications for the welfare of the state. Out of one rupee earned by the state one to 13 paisa is spent every year just to remain at the same level.

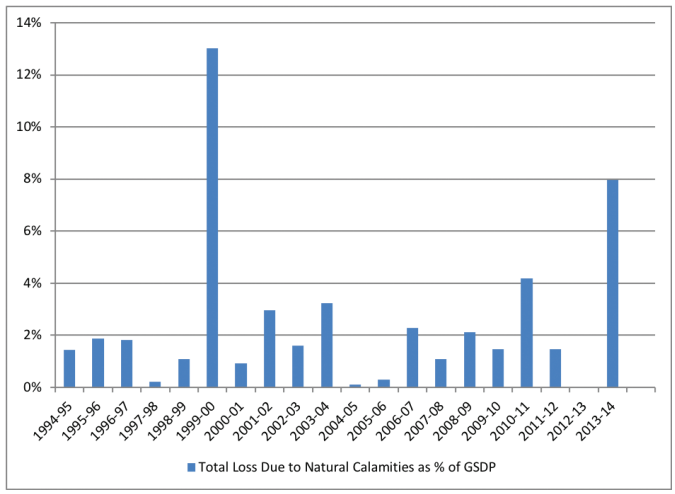


Figure 6: Total Economic Loss Due to Natural Calamities as % of GSDP in Odisha

In order to know the implications of natural disaster on the investment we had discussed in earlier section that a large amount of money is spent for repairing and reconstruction of the same physical capital. Therefore, the amount of productive investment declines signifincatly in the states that face natural disasters. Figure 7 shows the financial losses due to natural disaster and relief expenditure as a percentage of the total expenditure of the state. The total economic losses as a percentage of Total Expenditure (TE) of Odisha varies widely from a low of one percent to the highest level of 44 percent during the period 1994-95 and 2013-14. During this period, in maximum years the economic loss due to natural disaster as a percentage of TE has remained around 10 percent. In spite of this high level of economic losses, the expenditure of the state on relief has remained very low. The total expenditure of Odisha on relief as a percentage of total expenditure of the state has mostly remained between one to two percent. Only during super cyclone of 1999 this share had reached five percent. This has dampening effect on the capability

of the state and individuals. When the economic losses due to natural disaster is very high but the state fails to adequately compensate the losses, it may have wide ranging effects on the economy. In case of damage of public utilities, like roads, electricity, cold storage, drinking water, industries, without adequate expenditure on the repairing and reconstruction, this will not only affect the quality of life but also discourage the private investment. This may also ruin the Micro, Small and Medium scale industries. There are evidences that after 1999 super cyclone the MSME sector was worst hit. The film theatres in rural parts of Odisha were completely destroyed during this cyclone and they could never come back to operation. As a result of which the Odia film industry has been suffering from low level of equilibrium trap. In the extremely sever cyclone Fani, in May 2019 Raghurajpur village, which is famous for Patachitra arts has been completely devastated. Hundreds of households in this village who depended upon the art have lost their income source. Without adequate relief to these households, it may not be possible to restart their business.

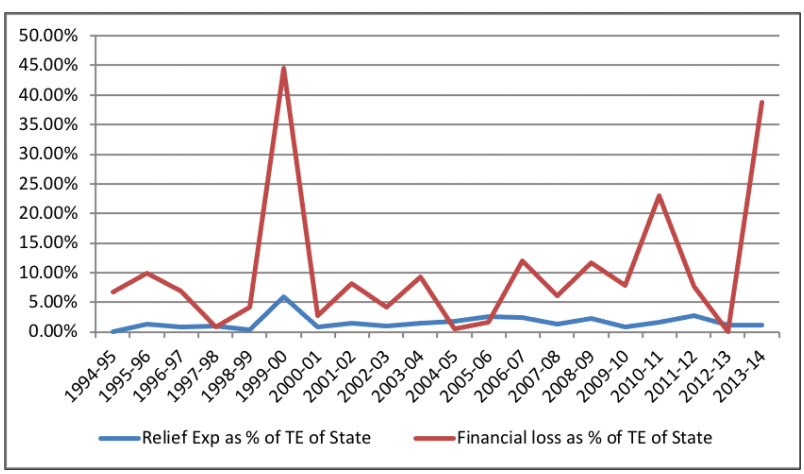


Figure 7: Financial Loss Due to Natural Disaster and Relief Expenditure of State as Percentage of Total Expenditure

6.4 Natural Disaster Adjusted NSDP for Odisha

Table 7 presents the Natural Calamity Adjusted NDP for Odisha for the period 1994-95 to 2013-14.

Table7: Net Domestic Product Adjusted for the Depreciation due to Natural Disaster

Year	GSDP At Current Prices	GSDP At 2004-05 prices	NSDP At Current Prices	NSDP At 2004-05 prices	Financial Loss Due to Natural Disaster (Current Price)	Financial Loss due to Natural Disaster (in 2004-05 price)	Disaster adjusted NSDP (current price)	Disaster adjusted NSDP 2004-05 price	Percapita Disaster adjusted NSDP in current Prices	Percapita Disaster adjusted NSDP in 2004-05 Prices
	Rupees Lakh								Rupees	
1994-95	2637803	4728488	2227992	4009160	37653	67496.23	2190339	3941664	6521.88	11737.02
1995-96	3200294	4923531	2712473	4164616	59772	91956.96	2652701	4072659	7777.74	11941.37
1996-97	3162811	4684672	2633170	3913538	57700	85463.71	2575470	3828074	7439.32	11058.12
1997-98	3830064	5311965	3214665	4464813	8092	11222.9	3206573	4453590	9130.96	12682.04
1998-99	4255150	5462975	3582055	4592379	46410	59583.49	3535645	4532796	9929.66	12730.66
1999-00	4789168	5932446	4314452	5372881	624396	773452.8	3690056	4599428	10207.81	12722.49
2000-01	4841484	5830376	4325303	5223400	44523	53617	4280780	5169783	11688.43	14116.60
2001-02	5170371	6110766	4590332	5448028	153088	180931.9	4437244	5267096	11967.12	14205.02
2002-03	5480111	6105838	4873028	5432171	87140	97089.77	4785888	5335081	12761.65	14226.11
2003-04	6610014	6889860	5855462	6078415	214183	223250.8	5641279	5855164	14876.20	15440.29
2004-05	7772943	7772943	6798702	6798702	8120	8120	6790582	6790582	17628.92	17628.92
2005-06	8509649	8214472	7354959	7100497	25218	24343.25	7329741	7076154	18781.38	18131.62
2006-07	10183947	9270083	8792126	7984484	232243	211402.5	8559883	7773081	21649.62	19659.33
2007-08	12927445	10284562	11110925	8669191	140023	111396.7	10970902	8557794	27385.48	21361.93
2008-09	14849071	11081178	12751620	9320665	315781	235652.8	12435839	9085012	30638.02	22382.43
2009-10	16294643	11585113	13583679	9395723	239116	170005.9	13344563	9225717	32447.59	22432.63
2010-11	19752990	12513105	16476038	9987972	827776	524378.7	15648262	9463593	37550.59	22709.65
2011-12(3rd)	22058927	13011301	18352151	10362763	326538	192606.1	18025613	10170157	42689.67	24085.86
2012-13(2nd)	25122046	13501017	21062228	10766375	-	-	-	-	-	-
2013-14(1st)	27297992	13746828	22787686	10808072	2176600	1096101	20611086	9711971	47538.70	22400.86
2014-15	31081024	14857608	26022195	11656558						

(Source: Own estimation using the GSDP and NSDP data from Economic Survey of Odisha and financial loss due to natural disaster from the Special Relief Commission, Government of Odisha.)

7. Conclusion

The frequency of natural disasters and the extent of damages are showing an increasing trend in recent years. Per-capita GDP or NDP numbers are used to assess the level of wellbeing and backwardness of states. These are also used for fiscal transfer in India. Per-capita NDP calculation accounts for the depreciation of physical capital due to wearing and tearing effect. However, the conventional measures of Consumption of Fixed Capital do not include the damage of capital due to natural disaster. However, when the damage to physical capital due to natural disaster is substantial, it has significant implications for welfare of the people and economic growth of the state. If a state suffers massive damage to physical infrastructure due to natural disaster on regular interval, it will definitely reduce its capability to achieve fast economic growth and reduce poverty. Therefore, the damage to physical infrastructures caused by natural disasters should be accounted for in the NDP calculations. In this paper we have provided a framework for this purpose and provided the natural disaster adjusted NDP estimates for the state Odisha. We observed that the cost of disasters as percent of the per capita NSDP varied from less than one percent to about seven percent. This implies that the people living in the disaster-prone states lose seven percent of the income due to natural disaster. Due to unavailability of the appropriate data this is again gross underestimation of the damage. If we take into consideration all other natural disasters and the expenditure for preparedness, cost of damage and losses and recovery needs the value would be much higher. From the case study of Odisha, we observed that cost of only cyclones goes up as high as 13 percent of GSDP in some years. For assessing the fiscal implications of natural disasters, we have estimated the financial losses due to natural disaster as a percent of total expenditure of Odisha. The financial loss goes up to as high as 44 percent of the total expenditure of the state. Nevertheless, due to limited fiscal space of the Odisha the state is able to provide a very small fraction of the total loss as the relief/compensation. Finally, we have calculated the Natural Disaster adjusted NSDP for Odisha.

References

1. Benson, C. and Clay, E.J. (2004). Understanding the Economic and Financial Impacts of Natural Disasters. Disaster Risk Management Series. Retrieved from https://doi.org/10.1596/0-8213-5685-2
2. Cuaresma, J.C.(2009). Natural Disasters and Human Capital Accumulation. Policy Research Working Paper 4862. Retrieved from https://doi.org/10.1596/1813-9450-4862
3. Central Statistical Office, India (2012). National Accounts Statistics: Sources and Methods 2012.Retrieved from http://mospi.nic.in/sites/default/files/publication_reports/sources_method_2012%20(1).pdf

4. Das, S. (2012). The role of natural ecosystems and socio-economic factors in the vulnerability of coastal villages to cyclone and storm surge. Nat Hazards, 64, 531-546.https://doi.org/10.1007/s11069-012-0255-9.
5. Das, S. (2016). Economics of Natural Disasters in Odisha. In P.B. Nayak, S.C.Panda& P.K Pattanaik (Ed.), The Economy of Odisha: A Profile (pp. 266-300). New Delhi: Oxford University Press. DOI: 10.1093/acprof:oso/9780199464784.001.0001
6. Domar, E.D. (1946) Capital Expansion, Rate of Growth, and Employment. Econometrica, 14, 137-147.
7. https://doi.org/10.2307/1905364.
8. Guha-Sapir, D., Hargitt, D., and Hoyois, P. (2004). Thirty Years of Natural Disasters 1974-2003: The numbers.Belgium: Presses universitaires de Louvain.
9. Hallegatte, S., Hourcade, J.C., & Dumas, P. (2007). Why economic dynamics matter in assessing climate change damages: Illustration on extreme events. Ecological Economics, 62, 330-340.https://doi.org/10.1016/j.ecolecon.2006.06.006
10. Hallagatte, S., and Dumas, P. (2009). Can natural disasters have positive consequences? Investigating the role of embodied technical change. Ecological Economics, 68, 777-786.https://doi.org/10.1016/j.ecolecon.2008.06.011
11. Hallegatte, S., & Przyluski, V. (2010). The Economics of Natural Disasters.The World Bank , 5507.
12. Jonkman, S.N., Bockarjova, M., Kok,M., and Bernardini, P. (2008). Integrated hydrodynamic and economic modelling of flood damage in the Netherlands. Ecological Economics, 66, 77-90.https://doi.org/10.1016/j.ecolecon.2007.12.022
13. Kadekodi, G.K.(2001). Environment and Development. In R.N. Bhattacharya (Ed.), Environmental Economics: An Indian Perspective (pp. 162-217). New Delhi: Oxford University Press.
14. National Statistical Organisation (2013). Green National Accounts in India: A Framework. Retrieved from http://www.mospi.gov.in/sites/default/files/publication_reports/Green_National_Accouts_in_India_1may13.pdf"
15. NCRMP (2019). Cyclones and their Impact in India. National Cyclone Risk Mitigation Project, Govt. of India. https://ncrmp.gov.in/cyclones-their-impact-in-india
16. NIDM (2009). Financing Disaster Management in India: A Study for the Thirteenth Finance Commission. National Institute of Disaster Management. August 2009.
17. Noy, I. (2008). The macroeconomic consequences of disasters. Journal of Development Economics, 88, 221-231. https://doi.org/10.1016/j.jdeveco.2008.02.005
18. Parida, Y. (2019). Economic impact of floods in the Indian states. Environment and Development Economics,25(3), 267-290. doi:10.1017/S1355770X19000317.
19. Parida, Y., Agarwal,G. P., Roy, C. J. et al. (2020). Do economic development and disaster adaptation measures reduce the impact of natural disasters? A district-level analysis, Odisha, India. Environ Dev Sustain. https://doi.org/10.1007/s10668-020-00728-8.
20. Patnaik , S. (2011). State's first cinema in ruins - Sri Sitaram Vilas Talkies fails to rise after super-cyclone blow. The Telegraph, February 19, 2011.https://www.telegraphindia.com/odisha/state-s-first-cinema-in-ruins-sri-sitaram-vilas-talkies-fails-to-rise-after-super-cyclone-blow/cid/431548
21. PTI (2019).After the storm: Odisha village picks up pieces after Cyclone Fani. The Economic Times, May 14, 2019. https://economictimes.indiatimes.com/news/politics-and-nation/after-the-storm-odisha-village-picks-up-pieces-after-cyclone-fani/articleshow/69322984.cms
22. Raddatz, C. (2009). The Wrath of God: Macroeconomic Costs of Natural Disasters. Policy Research Working Paper 5039, World Bank.http://documents.worldbank.org/curated/en/955981468150888752/The-wrath-of-God-macroeconomic-costs-of-natural-disasters
23. Rasmussen, N. T. (2004). Macroeconomic Implications of Natural Disasters in the Caribbean.IMF Working Paper, 04, 224.https://www.imf.org/external/pubs/ft/wp/2004/wp04224.pdf
24. Shabnam, N. (2014). Natural Disasters and Economic Growth: A Review. Int J Disaster Risk Sci, 05, 157-163.https://doi.org/10.1007/s13753-014-0022-5

Manuscript Submission Guidelines: Notes for Authors

1. Manuscript may be submitted in English only. Contributions are considered for publication only on the understanding that they are not published already elsewhere, that they are the original work of the authors(s), and that the authors assign copyright to the National Institute of Disaster Management, New Delhi.

2. Papers should normally be submitted as e-mail attachments to the Editor with copy to editor (ddjournal.nidm@gmail.com). The subject of the e-mail should be typed CONTRIBUTION FOR DISASTER AND DEVELOPMENT.

3. Papers can also be sent in hard copies by registered post but these must always be accompanied by a CD with manuscript in MS Word format. CD should be labeled with the name of the article and the author.

4. Title of the paper in bold, 14 point size (Times New Roman). Title of the paper should be followed by the name(s) of Authors, Affiliation(s), abstract, introduction, methodology, analysis, results, discussion, conclusion, acknowledgments and references.

5. Length of the paper should be maximum of 8000 words or 16, A4 pages including tables and illustrations (1.5 spaced with 1 inch margins and justified).

6. An abstract of upto 200 words with 4-5 key words, 12 point size italics. Figures, maps and diagrams should be of good resolution (150 dpi or more), numbered consecutively

7. Referencing and index citations should be as per American Psychological Association (APA) guidelines.
   a. Journal Articles: Scruton, R. (1996). The eclipse of listening. The New Criterion, 15(30), 5-13.
   b. Article in a Magazine: Henry, W.A., III. (1990, April 9). Making the grade in today's schools. Time,135, 28-31.
   c. Book (Single and multiple Author(s))
      i. McKibben, B. (1992). The age of missing information. New York: Random House.
      ii. Larson, G. W., Ellis, D. C., & Rivers, P. C. (1984). Essentials of chemical dependency counseling. New York: Columbia University Press.
   d. Article or Chapter in an Edited Book
      Barlow, D. H., Chorpita, B. F., & Turovsky, J. (1996). Fear, panic, anxiety, and disorders of Emotion. In R.Dienstbier (Ed.), Nebraska Symposium on Motivation: Vol. 43. Perspectives on anxiety, panic, and fear (pp. 251-328). Lincoln: University of Nebraska Press.
   e. Conference Proceedings
      Schnase, J. L., & Cunnius, E. L. (Eds.). (1995). Proceedings from CSCL '95: The First International Conference on Computer Support for Collaborative Learning. Mahwah, NJ: Erlbaum.
   f. Individual document/report/web page authored by an organization and available on organization Web site, no publication date:
   Accreditation Commission for Programs in Hospitality Administration. (n.d.). Handbook of accreditation. Retrieved from http://www.acpha cahm.org/forms/acpha/acphahandbook04.pdf

8. Authors receive proofs of their articles, soft copy of the published version and a soft copy of the journal.

9. Authors are responsible for obtaining copyright permission for reproducing any illustrations, tables, figures or lengthy quotations published elsewhere.

Design & Print : kam@kamstudio.net

Resilient India - Disaster free India

National Institute of Disaster Management (NIDM)
(Ministry of Home Affairs, Government of India)

Plot No. 15, Block B, Pocket 3, Sector 29, Rohini, New Delhi 110042
Website : www.nidm.gov.in