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LANDSCAPE

A Forum for Young Geographers

Issues, challenges, mitigations, and way forward

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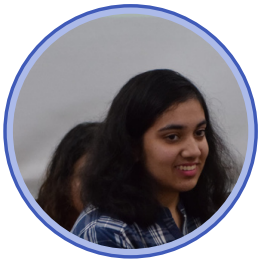

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Prof. Arun Kumar Attree
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It gives me an immense pleasure to know that Department of Geography, Shaheed Bhagat Singh College is bringing its 17th Annual Magazine, Landscape on the theme "**Geo – Environmental Hazards and Disasters".**

Understanding environmental calamities is important for making smart decisions about human life, cities and the environment. The college magazine talks about these issues, helps students discuss them, and gets them ready to solve big problems like climate change. It's a place where students can work together from different fields to protect the environment in a better way.

This Magazine is a testament to the dedication and hardwork of the Geography Department. I would like to appreciate; Prof. Vishwa Raj Sharma, Teacher in charge; Dr. Gourav Nain, Staff Advisor; Dr. Suraj Kumar Mallick, Convenor of the Magazine and Dr. Rahul Kumar, Co – Convenor of Magazine for their belief in the magazine and it's spirit. I would also like to congratulate the Heads and editorial team for the hard work they have put into this magazine. Last but not the least, the students are praiseworthy who made significant contributions through sending their articulate view based on respective theme in the success of this Landscape Magazine.

Best Wishes!

Prof. Vishwa Raj Sharma
Teacher-in-Charge
Department of Geography
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University of Delhi

The Landscape, the annual magazine of the Department of Geography, Shaheed Bhagat Singh College, University of Delhi, is a forum for young geographers. It aims to raise awareness about the pressing issue of geo-environmental hazards and disasters.

These events, such as landslides, floods, earthquakes, and volcanic eruptions, can have devastating effects on communities and the environment. It is crucial for readers to understand the causes and potential impacts of these hazards, as well as the steps that can be taken to mitigate their effects. For example, proactive land-use planning and infrastructure design can help reduce the risk of landslides and floods.

Additionally, early warning systems and emergency preparedness plans can save lives in the event of an earthquake or volcanic eruption. By providing readers with accurate and up-to-date information on geo-environmental hazards and disasters, the Landscape magazine can empower individuals and communities to take action to protect themselves and their environment.

I wish great success to the annual magazine, Landscape.

Dr. Gourav Nain
Staff Advisor
Department of Geography
Shaheed Bhagat Singh College
University Of Delhi

I am delightful to have an opportunity to address each and every one through Department Magazine. With this message, I hope all you feel well and have positive thoughts.

It's grateful to announce the release of 17th Volume a yearly magazine, "Landscape," by Department of Geography, Shaheed Bhagat Singh College, for the year 2024. The theme of a magazine is "Geo-Environmental Hazards and Disasters." These days, it is crucial for everyone in the world—students, teachers, scholars, leaders, and others to understand this subject. A nation's desire for growth is frequently set back several decades by disasters, which destroys the hard-earned rewards of laborious developmental efforts and impede progress.

Natural hazards are harmful and are seen in the form of damages brought to both land and man-made structures. Disaster damage varies according to the economic development of the region affected; in developing nations, the number of casualties from natural disasters is rising, whereas in developed nations, the financial losses are usually larger. The word disaster can also be applied to personal disasters since they can lead sufferers to experience both financial and emotional hardship.

I hereby thank the magazine committee for selecting such a timely theme and thank to all of the contributors for their diligent work on this publication. Landscape is a lovely fabric that unites a variety of viewpoints, concepts, and perceptions since we received a wide range of thoughts and ideas on our theme from the collection of essays and articles from students and from various departments across the universities.

I wish all the magazine's readers a pleasant read.

Dr. Ashwani Kumar Agnihotri
Co- Staff Advisor
Department of Geography
Shaheed Bhagat Singh College
University of Delhi

Dear Readers,

With great pleasure and enthusiasm, I welcome you to the 17th volume of our Annual Magazine, "Landscape," proudly presented by the Department of Geography at Shaheed Bhagat Singh College. I am delighted to unveil this year's theme, which promises to be both enlightening and thought-provoking – "GEO-ENVIRONMENTAL HAZARDS AND DISASTERS."

In a world where our environment faces unprecedented challenges, it becomes imperative to explore and understand the intricate relationship between geography and environmental hazards. The 17th volume of "Landscape" delves deep into the complex web of geo-environmental hazards and disasters that shape our planet. Through the lens of geography, we aim to unravel the interconnectedness of natural processes and human activities that contribute to environmental vulnerabilities. Our contributors have passionately explored various facets of geo-environmental hazards. This volume provides a comprehensive overview of the challenges our world confronts. Each article, research paper, and creative piece within these pages seeks to highlight the urgent issues that need our attention and action.

As we navigate through the diverse landscapes of knowledge presented in this magazine, I encourage you to engage critically with the content and reflect on the role each of us plays in safeguarding our environment. May this volume inspire discussions, spark curiosity, and foster a deeper appreciation for the complex interplay between nature and humanity. Together, let us embark on a journey of exploration and discovery as we navigate the intricate terrain of "GEO-ENVIRONMENTAL HAZARDS AND DISASTERS."

Happy reading!

Dr. Rahul Kumar
Landscape Magazine Co-Advisor
Department of Geography
Shaheed Bhagat Singh College
University Of Delhi

It gives us immense joy and satisfaction to present 2023-24 issue of our annual magazine "Landscape". The theme of this year's magazine is Geo-Environmental Hazards and Disasters. The magazine highlighted on issues, challenges, mitigation and way forward related to Geo-Environmental Hazards and Disasters. I congratulate the editorial team of Landscape and the contributors for their honest efforts in bringing out the Landscape magazine.

The Earth is a very dynamic place. Sometimes conditions change across its diverse landscape, leading to situations where natural hazards can become disasters that threaten society. One only has to consider the number of earthquakes, volcanoes, tsunamis, cyclones, and droughts that occur to know that we live on a dynamic Earth. Most students are fascinated with natural hazards such as extreme weather and climate events, as well as with events caused by natural disasters that have an immediate and grave impact on humans and their way of life. Unfortunately, the increasing frequency and intensity of natural disasters have been tied to climate change. While we may not be able to stop natural disasters from occurring, we can educate students about the link between climate change and natural disasters and the necessity of mitigating and adapting to climate change. The study of natural disasters also broadens our student's perspective of other nations and cultures by learning how individuals from different places on Earth respond to such events. We got a wide range of viewpoints on our topic from students across the University of Delhi and from various departments, making the landscape a beautiful thread that connects a variety of perspectives, understandings and interpretations. We hope you enjoy reading the magazine.

Dr. Suraj Kumar Mallick
Landscape Magazine Advisor
Department of Geography
Shaheed Bhagat Singh College
University Of Delhi

I am extremely delighted to have an opportunity to publish 17th volume of our Departmental Magazine "Landscape" 2023-24. First of all, I would like to congratulate the editorial team of the Landscape Magazine. Without their positive attitude and continuous hard-works, this magazine could not achieve this much height. I would also like to thank the contributors for their sincere and significant effort in bringing out the magazine on theme " **Geo-environmental Hazards and Disasters**".

Geo-environmental hazards are quickly becoming the biggest threat to life and infrastructures today as industries advance, communities expand, and the rate of global warming quickness. Geo-hazards and disasters can occasionally be caused by the thoughtless placement of projects or construction where environmental factors weren't taken into account. India is one of the major countries in the world that frequently has been facing different sort natural and human-induced hazards and disaster in the forms of floods, landslides, glacier lake outbrust, cyclonic stroms, severe drought as well as extreme heat effects. Therefore, it is high time to keep our focus on this aspect, so that we can prepare and get alert about the upcoming environmental events and calamities. Nevertheless, geo-hazards and disasters related management are essential for global well-being and development, especially in changing climates. Geological hazards cause economic setbacks and impact citizens' security as well as human livelihood. In a better understanding of Geo-environment related hazards and disasters, their prerequisites, causes, and repercussions, mitigation, and prevention of human activities like drilling through over-pressured situations, which could result in severe danger, that need to be checked.

We have fortunate enough to get a wide range of viewpoints and thoughts on this selected topic through different research articles and concept notes in a quick interval. Hopefully, readers and students in different level would relish reading the magazine.

Harsh
President & Magazine Coordinator
Geography association

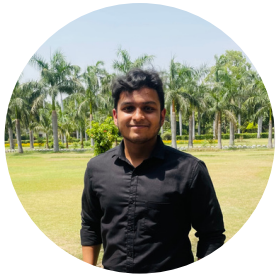
As we embark on this enlightening journey through the pages of our magazine, dedicated to the profound exploration of geo-environmental hazards and disasters, I extend my sincerest best wishes to each of you. With every issue, we endeavour to illuminate the intricate dynamics of our planet's geological and environmental systems, shedding light on the myriad challenges we face and the innovative solutions that hold the promise of a more resilient future.

In a world increasingly shaped by the consequences of human activity and natural phenomena, we must deepen our understanding of geo-environmental hazards. Through the lens of science, research, and expert analysis, we aim to empower you, our cherished readers, with knowledge that transcends boundaries and inspires action.

May the articles, insights, and perspectives shared within these pages serve as a beacon of enlightenment, guiding us towards a future where communities are fortified against the forces of nature, where sustainability is paramount, and where collective stewardship of our planet is embraced as a sacred duty.

Together, let us embark on this voyage of discovery, armed with curiosity, compassion, and a steadfast commitment to preserving the precious balance of our environment. Here's to a magazine that not only informs but also ignites the passion for positive change.

Happy reading!!



Ayush Pandey
Vice President
Geography association

Dear Readers,

As we delve into the latest issue of our magazine, themed around Geo-Environmental Hazards and Disaster, I extend my warmest greetings and best wishes to each of you.

In this edition, we embark on a journey to explore the intricate relationship between the environment and the various hazards and disasters that can shape our world. From natural phenomena like earthquakes and hurricanes to human-induced challenges such as pollution and climate change, our planet faces a multitude of threats that demand our attention and action.

Through insightful articles, captivating stories, and thought-provoking analyses, we aim to shed light on the complexities of geo-environmental hazards and disasters. By understanding the underlying processes, vulnerabilities, and impacts associated with these events, we can better equip ourselves to mitigate risks, build resilience, and foster sustainable solutions.

I encourage you to immerse yourselves in the diverse perspectives presented in this issue, as we strive to deepen our understanding of the challenges facing our planet and the imperative to protect and preserve our environment for future generations.

Wishing you an enlightening and engaging reading experience!

Aaryan Singh
Vice-*President*
Geography association

It is with great pleasure and anticipation that we present to you the annual magazine of the Geography Department, focusing on the critical theme of "Geo-Environmental Hazards and Disaster." In a world constantly grappling with the repercussions of environmental change and natural calamities, understanding the intricate dynamics of our planet's geography is more crucial than ever.

This year's magazine delves deep into the myriad facets of geo-environmental hazards, ranging from the subtle shifts in climate patterns to the catastrophic impact of natural disasters. Through insightful articles, captivating visuals, and thought-provoking analyses, we aim to shed light on the challenges posed by these phenomena and explore innovative solutions to mitigate their effects.

As stewards of the Earth, it is incumbent upon us to not only comprehend the complexities of our environment but also to actively engage in endeavors aimed at preserving and safeguarding it for future generations. This magazine serves as a testament to our unwavering commitment to fostering awareness, fostering dialogue, and fostering action in the realm of geo-environmental sustainability.

We extend our heartfelt gratitude to all the contributors, researchers, and editors whose dedication and passion have brought this publication to fruition. May this magazine inspire you to delve deeper into the fascinating world of geography and galvanize you to join us in our quest for a more resilient and harmonious coexistence with the environment.

Happy reading!

PREFACE

It is matter of immense pleasure and pride to announce the release of 17th Edition of Landscape, the Annual Magazine Department of Geography, Shaheed Bhagat Singh College, University of Delhi. Welcome to join us to dive into the narratives, case studies and stories of excruciating harmonious relationship between people and the environment, focusing on how natural disasters impact society. This year we are focusing on the Theme 'Geo – Environmental Hazards and Disasters' .

We live on a dynamic planet where gentle breezes and explosive volcanoes constantly reshape the land, influencing civilizations and leaving their mark on humanity.Disasters disproportionately hurt those already struggling, widening existing social and economic gaps. Studying these effects is crucial for creating fair plans to prepare for, respond to, and recover from disasters. It has a huge impact on the Socio-Economic fabric of the society across the world.

They can disrupt livelihoods, social support systems, and deepen poverty cycles, particularly for marginalized communities lacking access to resources and infrastructure.

Hazards and Disasters are essential topics of study in today's world due to their profound impacts on human well-being, the environment, and socio-economic development. By understanding these phenomena, we can work towards building more resilient, sustainable, and safer communities for current and future generations.
By analyzing disasters through a social and economic lens, policymakers and aid organizations can identify weaknesses, promote fairness, and build resilience strategies that are more inclusive. Additionally, recognizing the economic cost of inaction highlights the importance of proactive measures to reduce risks, ultimately saving lives and protecting livelihoods.

The magazine will definitely enhance the perspicacity towards the necessity for efficient strategies in handling disasters to create resilient societies.

Thank You!

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The Department of Geography
Shaheed Bhagat Singh College
University of Delhi

Events organized by Department of Geography

VASUNDHARA'23

The Department of Geography organized its Annual Festival, VASUNDHARA 2023 on 1st and 2nd of April, 2023 on the theme "Geographical Indications and Intangible Cultural Heritage." Prof. Anindita Datta, Head at the Department of Geography, Delhi School of Economics, University of Delhi was the keynote speaker at the inaugural ceremony of the fest.

On the 1st day, Verbatim: The debate competition, Impasto: The poster making competition and Mudra: The dance competition were organized. Participants from various educational institutions turned up in these competitions making them successful.

On 2nd Day, Rangmanch: Theatre competition along with Tarang: The instrumental competition were organized. In the list of events, there was an online photography competition named picturesque as well.

GRANDIOSE - Farewell'23

On May 1, 2023, The Geography Association, Shaheed Bhagat Singh College bid a heartfelt farewell 'GRANDIOSE' to the 3rd year students of Batch 2020-2023. As the seniors arrived, they were greeted with a shower of flowers by their juniors, setting a warm welcome.

Anchors started the program by welcoming all the faculty members and students. With smiles and blessings, the teachers expressed their happiness for the day and welcomed their beloved students. The program was filled with fun, emotions and laughter. Throughout the event, engaging games were played, and the juniors showcased their talent by giving beautiful performances, adding to the memorable day. Further, the seniors were given titles like the Ms. and Mr. Geographer, adding a touch of honor and recognition. Proceeding the program, the seniors were presented with thoughtful gifts by their juniors as a token of love and affection to them. During the program, beautiful smiles were captured by the lenses of the cameras, to cherish the day forever. Students also expressed their gratitude to the teachers for their support and guidance and the teachers too were beaming with pride and happiness.

As the event drew to a close, heartfelt expressions of gratitude were extended, accompanied by best wishes for their future to the seniors by the teachers and all the juniors. The day ended with everyone saying good luck and letting balloons fly into the sky to mark the start of something new.

ORIENTATION CEREMONY

The Geography Department at Shaheed Bhagat Singh College organized the orientation ceremony with the 1st year students along with their parents on 16th August , 2023. At the orientation ceremony, the students received an overview of the department. All the teachers of the department were present there to talk about the various activities and opportunities offered by the Department. On this day, the newly joined students and their parents were given confirmation by the teachers that the students will be getting the best education and exposure in the Department and will look after the interest of the students. The Staff Advisor apprised the students about various activities of the Department and facilities available at the College. Faculties also guided them with the support they offer to students throughout their academic journey within the college.

RUBARU'23: The cultural fiesta

On the 21st of October 2023, The "Rubaru'23 event: The Cultural Fiesta," bestowed upon the novice students of the Department of Geography an occasion etched in memory, marking their commencement of the academic voyage. The title "Rubaru'23 event: The Cultural Fiesta", contains two elements which means - "Rubaru" signifies a face-to-face interaction, as this the event brings people together in an engaging way. "The cultural fiesta" signifies a celebration that showcases various aspects of culture, which can include music, dance, art, and other creative expressions. Thus, "Rubaru'23: The Cultural Fiesta" represents an event that brings people together in a face-to-face manner and serves as a lively celebration of culture, likely featuring a diverse range of cultural performances, activities, and interactions. This title suggests an event that is both engaging and culturally enriching.

During the event , a talent hunt was organized where beginners could present their talent. The students felt motivated and enthusiastic after attending the cultural fiesta.

FIELD VISIT: Yamuna flood banks

Report: Impact Assessment of 2023 Delhi Floods

On 21st February 2024, final year students from Shaheed Bhagat Singh's Geography Department conducted a field trip to Yamuna Bank, Delhi, to evaluate the aftermath of the 2023 floods. Through on-site observations and surveys among affected individuals, the students assessed the physical damage, government aid effectiveness, assistance during the flood, and the lasting impact on people's lives.

Findings revealed significant infrastructure damage, mixed opinions on government aid, challenges during the flood, and profound socio-economic repercussions. Recommendations include strengthening early warning systems, improving coordination for relief efforts, implementing long-term resilience strategies, and conducting periodic assessments. This report serves as a foundation for further research and policy advocacy to enhance disaster resilience in flood-prone areas.

URBAN FLOOD MANAGEMENT IN DIBRUGARH CITY OF ASSAM

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1. ABSTRACT

Urban Flooding in Dibrugarh is a frequent occurrence that impacts infrastructure, ecosystems, and the people of the city. Floods are natural disasters, that may cause extensive destruction and disruption leading to the urgent need for efficient flood control methods. The study area, Dibrugarh, Assam, is a location prone to urban flooding due to factors such as land use changes, urbanization, and the consequences of climate change. The study emphasizes the disastrous impact of urban flooding on people's lives, property, and the economy, stressing the need for enhanced urban planning, better drainage systems, and measures to mitigate the effects of intense rainfall. The research delves into the hydrological analysis of floods in Dibrugarh, focusing on the relationship between heavy rainfall events and subsequent flooding. It also examines the duration and intensity of flooding, highlighting the historical flood events that have occurred in the city.There are major challenges posed by urban flooding, including inadequate drainage infrastructure, excessive rainfall, and unplanned urban growth.

KEYWORDS- Urban Flooding, Dibrugarh, Rainfall, Monsoon Season, Brahmaputra, Drainage Systems, Urban Growth, Disaster Management, River Discharge

2. INTRODUCTION

Floods are a form of natural disaster that takes place when water overflows onto normally dry land, frequently resulting in extensive destruction and disruption. Flooding is a widespread occurrence that affects many parts of the world and poses serious problems for infrastructure, ecosystems, and people.

The National Weather Service defines floods as, “An overflow of water onto normally dry land. The inundation of a normally dry area is caused by rising water in an existing waterway, such as a river, stream, or drainage ditch. Ponding of water at or near the point where the rain fell. Flooding is a longer-term event than flash flooding: it may last days or weeks”

Numerous aspects can trigger floods such as heavy or prolonged rainfall that can saturate the soil, overload drainage systems, and cause rivers and streams to overflow, storm surges, tropical cyclones, or the collapse of dams and levees. Snowmelt in mountainous areas can contribute to higher river discharge during warmer seasons, which may cause flooding downstream. Urban areas are more likely to experience localized flooding due to human activities that alter natural drainage patterns, such as urbanization and changes in land use.

India has a very vast geographical area and almost 40 million hectares of it is flood-prone. As stated by the National Disaster Management Authority (Govt. Of India), every year approximately 75 lakh

hectares of land is impacted by floods, and 1600 lives are lost. The frequency of major floods is likely to be more than once every five years.

Urban areas are densely populated, and the risk of loss of lives and infrastructural damage is much higher in terms of urban flooding. Developed catchments result from urbanization, flood peaks, and flood volumes can increase. As a result of the faster flow times, flooding takes place very rapidly. Not only does it cause suffering to the people, but it also has an effect in the form of secondary infections that cause loss of livelihood and, in severe situations, even death. An increase in urban floods will have a devastating impact on the national and local economies.

3. STUDY AREA

3.1 LOCATION

Dibrugarh is a city located in the eastern region of Assam and functions as the Dibrugarh district's administrative center. The region falls between 93.46-96.10 degree east latitude and 26.50-27.90 degree north latitude. The area is roughly 439 kilometers east of Guwahati, which is the largest city in Assam. Dibrugarh is situated at 104 m above the mean sea level.

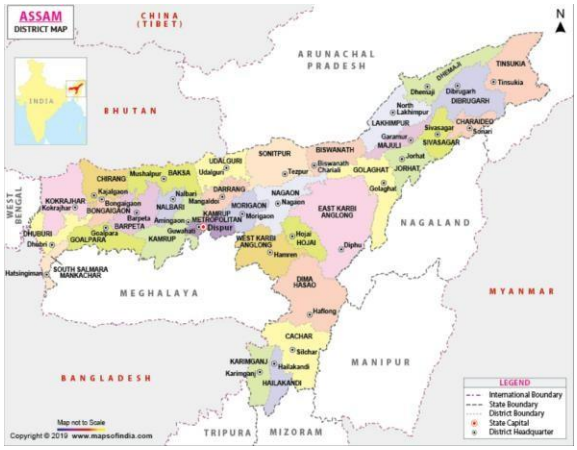

Figure 1 Map showing the location of Dibrugarh in Assam (Source: Maps of India*)*

3.2 GEOLOGY AND CLIMATE

One of the most important geographic features of the city is located near the banks of the Brahmaputra, one of the main rivers in the Indian subcontinent. Thus, the city is surrounded by expansive fertile plains. Overall, this area has a humid subtropical climate and distinct seasons. Dibrugarh experiences warm summers and abundant rainfall in the monsoon season; from June to September. The average annual temperature is 23.90C and the average annual rainfall is around 2400 mm. The Brahmaputra River also influences the weather patterns and climate of the region.

3.3 ECONOMY

Dibrugarh is essential to Assam's economic structure. With many tea estates and oil refineries nearby, it is a significant hub for the tea and oil industries. Widely known as the "Tea City of India," Dibrugarh is home to some of the world's best tea estates. Due to its location on the banks of the Brahmaputra, this area has developed as an important center of trade. The river promotes trade by facilitating the flow of goods and has significantly increased commercial activity. The city's

markets and business districts also function as crucial hubs for trade, catering to the needs of both the local and regional populations. Dibrugarh is very well-connected by road and is an important railway junction. Furthermore, the city has a domestic airport; Dibrugarh Airport which provides air connectivity. Over time, Dibrugarh has also seen advancements in its infrastructure, including healthcare facilities, educational institutions, and transportation networks.

3.4 AREA AND POPULATION

Table 1 Area and Population of Dibrugarh

Particulars	**Figures**
Land Area	15.5 sq. km
Population	146,122
- Male population	75,429
- Female Population	70,692
Number of Wards	22

(Source: Census of India & Town & Country Planning, Dibrugarh)

4. METHODS AND MATERIALS

4.1 METHODS OF DATA COLLECTION

Secondary data is information collected, processed, and analyzed for purposes other than those originally intended by the original researcher or for other purposes. This kind of data is pre-existing data used to achieve a different analytical or research goal.

The secondary data for this report has been taken from various sources such as the Census of India 2011, reports by the Government of Assam, National Disaster Management Authority, reports by various authorized newspapers, etc.

4.2 MATERIALS

4.2.1 SUSCEPTIBILITY OF DIBRUGARH TO FLOODS

Table 2 River Danger Level and its Highest Water Level

River	**Location of Gauge**	**Name of District**	**Danger Level in M**	**H.F.L in M**
Brahmaputra	Dibrugarh	Dibrugarh	105.70	106.48

(Source: Water Resources - Govt of Assam)

Dibrugarh is located on the southern bank of the Brahmaputra, one of the world's biggest and most active rivers. Seasonal variations in water levels are common in the Brahmaputra, with increased discharge and a higher risk of flooding resulting from monsoon rains.

4.2.2 RAINFALL

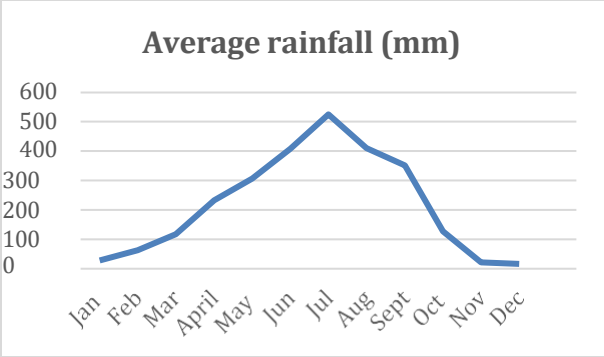

Figure 2 Average Rainfall in MM

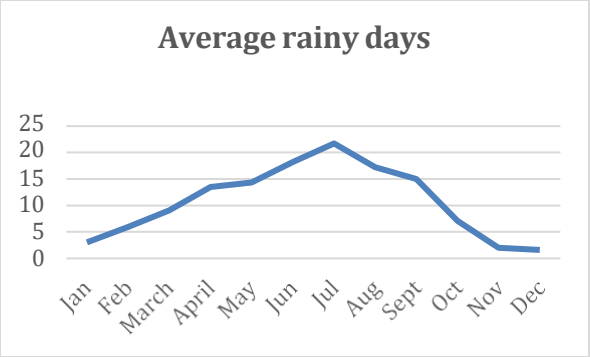

Figure 3 Average Rainy Days

Table 3 Seasonality of Rainfall

Months	Average rainfall (mm)	Average rainy days
January	27.8	3.0
February	63. 0	5.9
March	117. 5	9.1
April	232. 9	13.5
May	307. 2	14.3
June	408. 5	18.2
July	525. 0	21.7
August	410. 5	17.2
September	351. 5	15.0
October	127. 5	7.1
November	21. 5	2.0
December	16. 4	1.6
YEAR	**260.9**	**128. 5**

(Source: Indian Metrological Department)

Heavy monsoon rains usually fall on the area between June and September. During the period the average rainfall can also exceed 350 mm, Flooding in low-lying areas can occur from the Brahmaputra, swelling as a result of heavy and prolonged rainfall. This is due to the fact that the Brahmaputra River has a high discharge volume, and when coupled with heavy monsoon rainfall, the river can overflow its banks.

4.2.3 HISTORY OF FLOODING : Floods appear to be a regular phenomenon in the city of Dibrugarh. They have severely impacted numerous lives and livelihoods of the local population. Here is a timeline of recent floods and their consequences.

- **2016, July –** NH 37 affected by flood, roads damaged
- **2019, July –** Road damage, congestion due to traffic
- **2019, August -** Road damage, congestion due to traffic
- **2019, September –** Traffic, road damage and unhygienic conditions created by floods
- **2020, June –** Drain water entered houses, traffic

(Source: Suntoo Das, Uttam Mili, Prasanna Bora: An overview of Urban Flooding in Dibrugarh Town, Assam)

4.2.4 VULNERABLE AND FLOOD-PRONE AREAS

Table 4 Vulnerable Areas in Dibrugarh

Area	**Ward Number**
Northern part of N.H.37	Parts of ward no. 10,11,16
New market	11
Area bounded by B.C. Das Road, Mancota road, K.P. road	Northern part of ward no. 14
Both sides of Durgabari Road excluding Kabarsthan area	19
Area north-east of N.H. 37	Part of ward no. 19
Area bounded by R.K. Bordoloi path, Rotary Road, Railway track, and Overbridge.	Western part of ward no. 15

(Source: City Disaster Management Plan- Dibrugarh 2022)

Like many other cities along riverbanks, Dibrugarh has areas that are especially vulnerable to the effects of flooding. Due to a variety of factors, these areas frequently face a higher risk and may suffer more severe consequences. Rainwater received by the city during the monsoon season doesn't drain away easily from many areas due to inadequate stormwater drainage systems. Many low-lying areas of the city frequently experience waterlogging. Road damage and traffic are frequent occurrences in the event of flooding in Dibrugarh. Road foundations can also be weakened over time by constant exposure to water.

5. RESULTS AND DISCUSSIONS

5.1 HYDROLOGICAL ANALYSIS OF FLOODS IN DIBRUGARH

After evaluating the past rainfall patterns in the Dibrugarh area, there is a strong emphasis on the precipitation contribution of the monsoon season. There is a clear increase in rainfall from June to September and these four to five months account for most of the rainfall received by this region. Very notable variations in average rainfall, intensity, and distribution were found in the data collected over several years. In particular, this analysis looks at the relationship between heavy rainfall events and subsequent flooding.

The Brahmaputra River has varying discharge levels all year long. Studying the river discharge clearly showed monsoon season peak times. This gives us information about the dynamics of flooding in Dibrugarh. When there is a sudden rise in water levels and intense downpours, it leads to the river overflowing its banks. This gives a temporal perspective to the multiple flooding events.

5.2 DURATION AND INTENSITY OF FLOODING

This study examined official reports and historical documents to create a timeline of the major flood events that occurred in Dibrugarh. Besides this, it is also very important to focus on the severity of the event which can be done by studying the duration of the flooding.

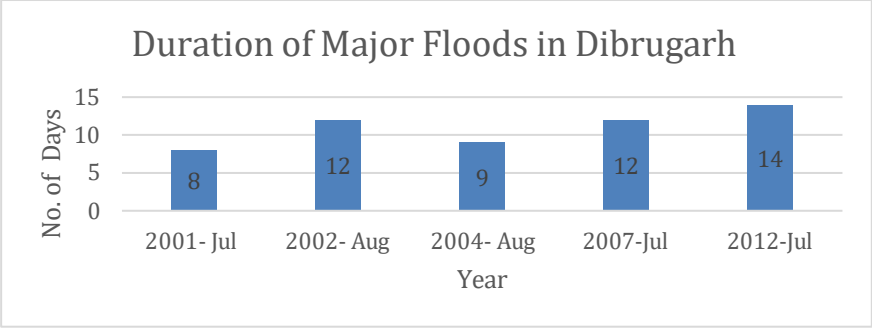

Figure 4 Duration of Floods (Source: Dibrugarh Municipal Board)

The duration of a flood event is a critical parameter that provides valuable insights into the nature of the flooding. Knowing the length of a flood event facilitates evaluating its influence on the impacted region, organizing response and reconstruction plans, and executing efficient mitigating activities. Floodwaters have the potential to cause structural damage and road surface erosion, particularly during periods of heavy and prolonged rainfall. This is especially true for roads in low-lying areas or those that are close to bodies of water. Roads that follow riverbanks are vulnerable to damage. Areas around National Highway 37 are particularly vulnerable. Road collapse or washouts may result from these structures being undermined by rising water levels. Road closures, traffic diversions, and reduced accessibility are all factors that when coupled together cause major inconvenience to the residents.

5.3 ISSUES AND CHALLENGES

Urban flooding in Dibrugarh is most prominent during June to September, which is the monsoon season. Inadequate drainage infrastructure and excessive rainfall and the two biggest factors that contribute to the recurrent flooding event in the city. Moreover, unplanned urban growth also adds to the problem. Because of the poorly designed drainage system, the drains clog and cause rainwater to overflow.

The topography of Dibrugarh is mostly flat with mild slopes, making effective drainage difficult. The inadequate urban drainage system is ultimately a result of unplanned urbanization.
Overflowing rivers, dam failures, snowmelt, and the wider effects of climate change primarily cause urban flooding. The year-round high and heavy precipitation which comes to an average of 260.9mm a year has led to a swift escalation of urban flooding in Dibrugarh. The city's problems are made worse by deforestation, inappropriate land use, a decrease in pervious surfaces, and an increase in its urban footprint. Massive rainfall, the efficiency of drainage systems, and the general layout of the infrastructure all have a big impact on how well-equipped the city is to handle flooding and heavy rains.

6. CONCLUSION

An extensive examination of the elements causing urban flooding in Dibrugarh, Assam, can be seen in this research report. The relationship between the city's susceptibility to flooding and heavy precipitation, insufficient drainage infrastructure, and unplanned urban growth has been extensively highlighted. To determine the extent and duration of flooding, historical flood events and hydrological analysis of the study area are analyzed. There are major difficulties brought about by land use changes, urbanization, and the broader consequences of climate change on urban flooding.

Urban flooding is disastrous for people's lives, property, and the economy. There is a requirement for efficient flood control methods, such as enhanced urban planning, better drainage systems, and steps to mitigate the effects of intense rainfall. There is an urgent need to address these issues to prevent further devastation and understand the importance of climate resilience and sustainable urban development.

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FOREST FIRE IN NER OF INDIA

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1. ABSTRACT

The issue of forest fires has reached critical levels worldwide, and India is no exception. Considering this, a comprehensive review of the current state of forest fires in India has been conducted. India's forest cover can be broadly divided into four clusters: North Himalayan, North-Eastern, Southern, and Central. Interestingly, while the North-Eastern cluster covers the largest area (55%) of all clusters in India, it has only accounted for a small fraction (16%) of the burnt forest area. The occurrence of fires in the North-East region of India is typically limited to a smaller area that experiences frequent burns, while Central and Southern India tend to have larger, more widespread fires. To understand the consequences of these forest fires on India's biodiversity, forest species, climate patterns, and soil quality, this paper presents a comprehensive analysis.

KEYWORDS: Forest fire, FSI, cluster, land cover, shifting cultivation, vulnerability class.

2. INTRODUCTION

Forests are fundamental to our existence, serving as a vital source of biodiversity and supplying us with invaluable resources, such as carbon storage, flood and landslide protection, clean water, medicinal plants, and crops. They play a critical role in the balance of our ecosystem. The forest cover in India has 4 clusters: North Himalayan, North-Eastern, Southern, and Central. A thorough review reveals that the North-Eastern cluster covers the largest portion (55%) of the country's forest area, its burnt forest area is a mere 16%.

Forests encounter a myriad of challenges that can be detrimental to their well-being and productivity, ultimately resulting in a decline in their capacity to provide goods and services. A common example is forest fires, which can occur in any type of ecosystem. A forest fire, usually known as a wildfire, is an uncontrolled fire occurring in forests, grasslands, or other wildlands. The driving force behind it is weather conditions such as wind, dryness, and high temperatures, often causing extensive damage to vegetation, wildlife habitats, and sometimes human structures. Forest fires can occur naturally through lightning strikes or human activities such as campfires, arson, or accidental ignition.Throughout history, fire has served as a valuable tool in farming techniques such as crop rotation, ploughing, and grazing land creation for domesticated animals. However, due to changes in society, these traditional practices have been neglected. In recent years, the prevalence of forest fires has become a growing concern as they devastate entire ecosystems, communities, and economies (jhariya & Raj, 2014). This can be attributed to the significant reliance placed on forests by human populations for various purposes, causing their fragmentation and ultimately exacerbating the occurrence of fires.

The north-eastern region (NER) of India is a geographically diverse area categorized as the Eastern Himalayas, Northeast hills, and the Brahmaputra and Barak Valley plains.

Shockingly, almost half of all forest fires in India take place in the north-east region, as reported by (Bahuguna and Upadhyay in 2002). These fires are predominantly linked to the traditional practice of burning jhum or shifting cultivation, accounting for 95% of all forest fires.

2.1 TYPES OF FOREST FIRES

There are three distinct classifications for forest fires:

1. CROWN FIRE: which ravages trees up to their very tops, racing through the canopy and jumping from treetop to treetop. These fiery infernos are known as the most perilous and fierce forest fires, as they are incredibly challenging to contain. Only strong winds, steep terrain, and a significant amount of fuel can sustain these blazing monsters.

2. SURFACE FIRE: only consume the top layer of the forest floor, consisting of items such as dried leaves, twigs, and grasses. In comparison to crown fires, surface fires are much more manageable and cause minimal damage to the surrounding ecosystem. They typically arise from dry grass or fallen leaves, which act as prime fuel for the flames.

3. GROUND FIRE: These types of fires are known as underground or subsurface fires. They typically occur in deep layers of humus, peat, and other decaying plant matter that have dried out and can catch fire. Although these fires move at a slow pace, they can prove to be quite challenging to fully extinguish or contain. These ground fires can smolder for weeks or even months, patiently waiting for the right conditions to transform into a surface or crown fire. Due to their nature, these fires are often difficult to detect and can wreak havoc on the vegetative cover of the soil over an extended period.

2.2 TRENDS OF FOREST FIRE IN NER

According to the World Bank's 2018 report, a staggering 40% of all forest fire detections in India between 2003 and 2016 were concentrated in just 20 districts. Interestingly, these districts predominantly belong to the North Eastern regions.

Table 1: 20 districts responsible for a significant portion of forest fires

DISTRICT/STATES	CLUSTER	SHARE OF FIRE DETECTION (2003-16)
Lunglei, Mizoram	North east	3.82
Karbi Anglong, Assam	North east	3.48
Dima Hasao, Assam	North east	3.3
Churachandpur, Manipur	North east	3.15
Mamit, Mizoram	North east	2.56
Lawngtlai, Mizoram	North east	2.42
Tamenglong, Manipur	North east	2.32
Aizwal, Mizoram	North east	1.91
Gadchiroi, Maharashtra	Central	1.78
Dhalai, Tripura	North east	1.77
Champhai, Mizoram	North east	1.69
W.Khasi Hills, Meghalaya	North east	1.48

Narayanpur, Chhattisgarh	Central	1.45
Ribhoi, Meghalaya	North east	1.37
Kandhamal, Odisha	Central	1.35
E. Garo Hills, Meghalaya	North east	1.33
Ukhrul, Manipur	North east	1.32
Chandel, Manipur	North east	1.32
Bijapur, Chhattisgarh	Central	1.31
North Tripura, Tripura	North east	1.61
Top 20 total		40.28

Source: (World Bank,2018)

The frequency and severity of forest fires have risen dramatically across the globe, and India is not immune to this trend. Thus, it is crucial to examine and understand the current state of forest fires in India particularly the NER (north east region)

3. STUDY AREA

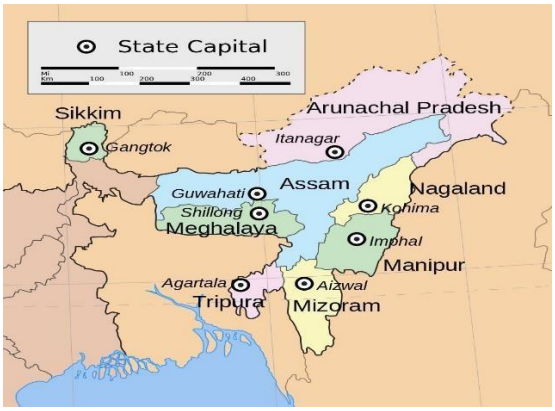


Fig: Map showing the states of NER and their position

Source: Indian govt. website

3.1 LOCATION

The enchanting North Eastern Region of India is home to eight states that are a treasure of culture and natural beauty: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura. Nestled in the far east of the country, this region shares borders with four other nations. Namely: Bhutan, China, Myanmar, and Bangladesh.

The Northeast region of India is located between approximately 22°N to 29°N latitude and 89°E to 97°E longitude. It encompasses an area of around 262,230 square kilometers.'=

3.2 CLIMATE

The climate here is predominantly humid subtropical, offering diverse experiences across its varying landscapes. When summer arrives, the air becomes hot and thick, with temperatures typically peaking at 25°C to 35°C.

The monsoon season, which spans from June to September, supplies a substantial amount of rainfall to the region. Heavy rain is very common, especially during the monsoon, resulting in the lush greenery and diverse flora and fauna found in this region.

Winters in this area are generally mild, with temperatures averaging between 10°C to 25°C in the lowlands, but dropping below freezing in the higher regions.

3.3 TOPOGRAPHY

This region has diverse terrain, featuring a picturesque mix of hills, mountains, valleys, and plains. As a part of the Eastern Himalayas, this region is blessed with stunning mountain ranges, including the Patkai, Naga, and Mizo hills. The Brahmaputra and Barak River valleys add to the region's charm, providing fertile plains that support thriving agriculture.

As far as altitude goes, the North Eastern Region sees a dramatic range, with elevations reaching as high as 7,000 meters in the Himalayas and going down to sea level in areas like Assam and Tripura. Thus North Eastern Region of India possesses a mesmerizing combination of geographical, climatic, and topographical elements, making it a truly exceptional and environmentally diverse area within the country.

4. MATERIALS AND METHODS

Different data used for forest fire assessment are as follows:

MATERIALS:

4.1 FOREST FIRE ASSESSMENT IN NER

An Analysis of Data from FSI: To gain insight into the frequency of forest fires in NER, this study collected data from the Forest Survey of India for the years 2001-2014. By analyzing this information, we aimed to paint a clearer picture of the forest fire situation in NER.

4.2 PAST DOCUMENTS OF FIRE ASSESSMENTS IN NER

An engrossing study on forest fire data from the past, this analysis relies on several types of input information: - Fire location data: This includes the fire points from the years 2001 to 2013, sourced from the Forest Survey of India (FSI), for comprehensive analysis.

Eg. FOREST FIRE BREAKOUT IN NER IN 2014

Let's take a look at the different types of spatial data included in this analysis:

1. We have administrative boundaries, which outline the different jurisdictions and divisions within a certain area.
2. We have a Land Use and Land Cover (LULC) map sourced from the reliable and comprehensive Natural Resources Database (NRDB). This map provides valuable information on how the land is being utilized and what type of vegetation is present.
3. We have data on the aspect, slope, and elevation of the land, obtained from the high-resolution ASTER 30m DEM.

Combining these different layers of data will give us a more complete picture of the land and its characteristics

4.3 VULNERABILITY ZONES AND MAPPING

This study incorporates a forest fire vulnerability zonation approach. With data collected from as early as 2001 to the present year of 2014, a fire vulnerability map is skilfully created for every state within NER India. Through analysis of month-wise forest fire incidences, we have determined the peak month and season for fires.

4.4 FIRE ALERTS

Every day during the forest fire season from February to April of 2014, state forest departments receive essential information in the form of a map and accompanying table. This information outlines the locations of potential forest fires and provides specific details for each point. To create these daily alerts,

Three categories of input data are utilized:

1. Fire location data (MODIS FIRMS)
2. Spatial data
3. Non-spatial data.

4.5 CONNECTION BETWEEN FOREST FIRE AND SHIFTING CULTIVATION

To better understand the link between forest fire incidences and shifting cultivation, a detailed case study was conducted in the state of Mizoram. This study utilized various sources of data such as fire location data from the Forest Survey of India (FSI), spatial data showing administrative boundaries, and imagery from the Advanced Wide Field Sensor (AWiFS).

METHODS:

SECONDARY DATA: Secondary data is information gathered from sources that already exist. This data is not firsthand, meaning it was not collected originally, but instead was acquired from published or non-published sources such as articles, reports, magazines, and books.

5. RESULTS

5.1 FIRE SCENARIO IN NER IN 2001-2014

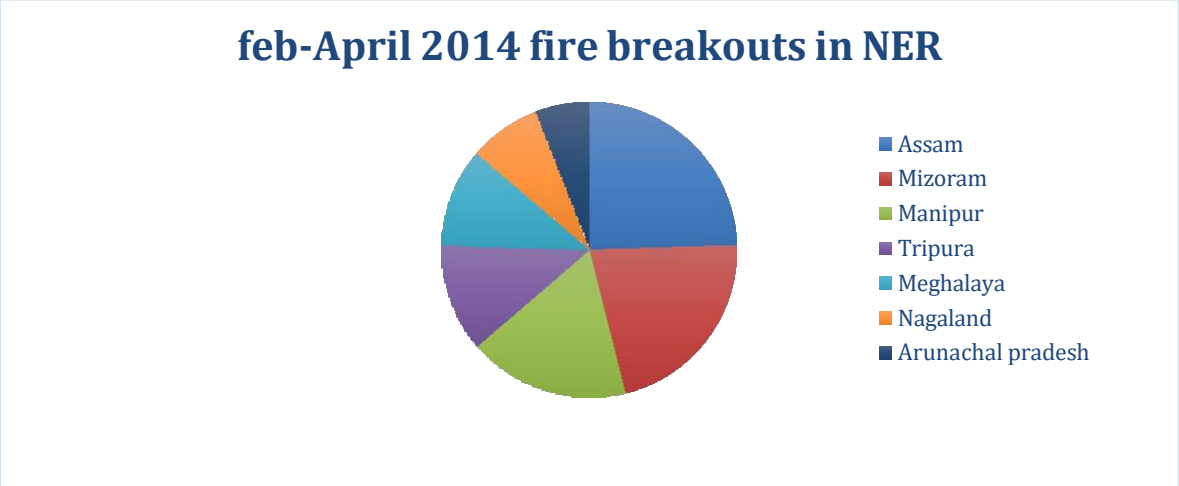
Table 2: Overall year-wise fire incidents (in %) in NER:

YEAR	FIRE INCIDENTS (%)
2001	1.5
2002	N/A
2003	N/A
2004	9
2005	7.2
2006	11.7
2007	9.8
2008	N/A
2009	N/A
2010	N/A
2011	4.9
2012	6.4
2013	5.4
2014	2.6

Source: FSI report

5.2 FIRE SCENARIO INCIDENTS IN NER IN 2014

Amid the 2014 forest fire season in NER India, an alarming 10,084 fire incidents were documented (FSI, 2014), sparking concern and urgency.



Source: FSI

The PIE CHART says the following:

Assam stands out with the highest rate (25%) of fire incidents among the seven states, followed by Mizoram (22%), Manipur (18%), Tripura (12%), Meghalaya (11%), Nagaland (8%), and Arunachal Pradesh (6%).

Table 3: Overall Month Wise Fire Breakouts In Ner In 2014

MONTH	PERCENTAGE
February	3
March	54
April	43

Source: FSI

The data says:

Forest fires are most prevalent in April, particularly in Arunachal Pradesh, Assam, and Tripura.

In February, however, the number of fires drops significantly in all states except for Tripura, where no fires are reported at all.

In contrast, Manipur, Meghalaya, Mizoram, and Nagaland experienced the highest level of fires in March.

5.3 MAPPING THE ZONE OF VULNERABILITY TO FOREST FIRES.

The five classifications of fire vulnerability zones, including very high, high, moderate, low, and very low, were determined.

We will look for it with each state in NER separately.

1. **Arunachal Pradesh**

Table 4: classifications of fire vulnerability in ARUNACHAL PRADESH

Fire vulnerability class	Area in %
Very low	9
Low	23
Moderate	51
High	16.7
Very high	0.4

Source: nesac govt

The table says:

Arunachal Pradesh has the highest percentage (51%) of its total area in the moderate vulnerability zone, followed by 17% and 9% being in the very high and high vulnerability zones respectively.

Comparatively, a smaller amount of land, 23%, and 9% fall within the low and very low vulnerability zones respectively.

2. **Assam**

Table 5: classifications of fire vulnerability in ASSAM

Fire vulnerability class	Area in%
Very low	12.4
Low	56.4
Moderate	21
High	10.1
Very high	0.03

Source: nesac govt

In Assam, the vulnerability to fire is varied across regions, with 0.03% and 10% being classified as highly and very highly vulnerable, respectively. In contrast, 12% and 56% of the area have low and very low fire potential, according to Table 3.2. Additionally, about 21% of the area has moderate vulnerability to fire.

3. **Manipur**

Table 6: classifications of fire vulnerability in MANIPUR

Fire vulnerability class	Area in %
Very low	6.9
Low	20
Moderate	39
High	33.4
Very high	0.8

Source: nesac govt

Among Manipur's forest area, a mere 0.8% is classified as being under a severe state of vulnerability. However, a much larger portion, 33%, is in high vulnerability zones, with an additional 39% in moderate vulnerability and 20% in low vulnerability zones. This highlights significant levels of varied vulnerability within the state's forested regions.

4. **Meghalaya**

Table 7: classifications of fire vulnerability in MEGHALAYA

Fire vulnerability class	Area in %
Very low	1.8
Low	21.9
Moderate	39.6
High	36.4
Very high	0.3

Source: nesac govt

In Meghalaya, roughly one-third of the terrain falls within the category of high vulnerability, while a further 40 percent is considered to be of moderate vulnerability.

5. **Mizoram**

Table 8: classifications of fire vulnerability in MIZORAM

Fire vulnerability class	Area in %
Very low	1.5
Low	12.5
Moderate	48.4
High	37.2
Very high	0.4

Source: nesac govt

According to Table, a significant 37% of the population in Mizoram falls in the highly vulnerable zone, with a further 48% categorized as moderately vulnerable, leaving only 12.5% in the low vulnerability category.

6. **Nagaland**

Table 9: classifications of fire vulnerability in NAGALAND

Fire vulnerability class	Area in %
Very low	1.6
Low	17.8
Moderate	35.7
High	43
Very high	1.7

Source: nesac govt

According to Table, the state of Nagaland has a concerning level of vulnerability in its forest areas. Roughly 43% of the region is categorized as high vulnerability, with an additional 36% classified as moderate vulnerability. On the brighter side, 18% falls under the low vulnerability category.

7. **Tripura**

Table 10: classifications of fire vulnerability in TRIPURA

Fire vulnerability class	Area in %
Very low	1.3
Low	22.2
Moderate	22.9
High	52.7
Very high	0.9

Source: nesac govt

In Tripura, over half, or 53%, of the region falls into the high vulnerability zone, while 23% is considered moderate and 22% falls into the low vulnerability zone.

5.4 DAILY ALERTS ABOUT POTENTIAL FIRE HAZARDS

Fire hazard alerts are for every state based on actual fire occurrences. These alerts, totaling 392 in number, were distributed to the appropriate forest departments in the 8 states of the North Eastern Region.For instance, in Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Tripura, and Sikkim, 98%, 57%, 58%, 75%, 97%,100% show low level of hazard and only 2%, 43%, 42%, 20% and 3% showed moderate level of hazard, respectively. (SOURCE: FSI)

A small percentage, 5%, of fire alerts in Nagaland indicated a high level of hazard, while even fewer, 0.3%, reached the severe level. In contrast, the majority of fire hazard alerts in Assam and Mizoram, 68% and 92% respectively, were classified as moderate.

Table 11: level of fire hazards in NER states separately

Region	Low	Moderate	High	Severe
Arunachal Pradesh	98	2	0	0
Manipur	57	43	0	0
Meghalaya	58	42	0	0
Nagaland	75	20	5	0
Tripura	97	3	0	0
Sikkim	100	0	0	0
Assam	26	68	0	0
Mizoram	7	92	0	0

Source: FSI

5.4.1 BURNT AREA ASSESSMENT

To identify the extent of burned areas, a DNBR (Differenced Normalized Burn Ratio) image is utilized.

A STUDY WAS DONE IN WHICH:

The collection of pre-fire images occurred on November 15th, 24th, and December 17th of 2013, as well as January 11th and 27th of 2014. Post-fire images were collected on April 1st and 24th of 2014. To separate burned pixels from the surrounding unburned ones, a threshold method was employed. Additionally, a majority filter was iteratively applied to remove small patches with an area of less than 1 hectare, preventing overestimation of burnt areas due to irrelevant pixels.

The compiled results, demonstrate the correlation between vulnerability index and forest fire occurrences in the Northeast region.

5.5 SHIFTING CULTIVATION TAKING THE EXAMPLE OF A STATE

Efforts were made to analyze the correlation between shifting cultivation and forest fires.

Data in the form of shapefiles were collected for three consecutive years (2005-06, 2008-09, and 2011-12) to determine the extent of current and abandoned shifting agriculture areas. (By FSI)

As depicted the number of forest fires showed a moderate level of correlation with current shifting cultivation, but a significant correlation with abandoned shifting cultivation. This suggests that abandoned shifting patches are often used for repeated shifting cultivation, or that shifting cultivation may contribute to forest fires.

6. CONCLUSION

The investigation deals with the vulnerability of Northeast India's forests to fires, shedding light on the significant influence of various factors such as vegetation type, topography, and human activities. The study also highlights the heightened risk for open forests. Topography, including slope and aspect, as well as the proximity to roads and settlements, are found to be key factors in fire vulnerability. Notably, the frequency of fires is the highest near roads and settlements.

The examination of fire incidents over a period reveals an inconsistent trend, with high points in specific years. This research emphasizes the importance of implementing efforts toward prevention and exploring alternative economic ventures to safeguard forest resources and promote biodiversity. Furthermore, the study proposes that integrating fire hazard warnings with an analysis of past data can serve as a valuable tool in devising strategies for forest management that can ultimately minimize future losses.

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CYCLONE FORMATION IN INDIA AND ITS MITIGATION POLICIES

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ABSTRACT

The nomenclature of cyclones varies in different regions of the world – They are termed typhoons, hurricanes, tornadoes, and willy-willies, and in India, it's simply called tropical cyclones. A tropical cyclone is a speedy rotating storm system featuring a low-pressure center, strong winds, and a spiral arrangement of thunderstorms that produce heavy rain. The coastal population of the Indian subcontinent such as people residing in the states of Orissa, Andhra Pradesh, etc. experience a manifold of coastal hazards, of which cyclone is the most catastrophic. India is highly vulnerable to natural hazards, particularly cyclones, floods, earthquakes, drought, and landslides. A vast coastline of about 7,516 km of flat coastal terrain, shallow continental shelf, high population density, geographical location, and physiological features of its coastal areas make India, in the North Indian Ocean Basin, extremely sensitive to cyclones. Climate change is a ponderable and Herculean task for developing nations like India, threatening to enhance risks already elevated by high levels of social vulnerability and climate variability. As climate change and precedented variability have become Indispensably pronounced, hazard events are set to resonate and proliferate. In this paper, we will discuss cyclones and their process of formation in the Bay of Bengal and the Arabian Sea. This will mainly illustrate the major lethal cyclones and the significant union government's and state government's role in its mitigation.

KEYWORDS: Cyclone in Indian context, Cyclogenesis, Mechanism, Mitigation

1. INTRODUCTION:

The India Meteorological Department (IMD) defines a cyclone as "an intense vortex or a whirl in the atmosphere with very strong winds circulating it in an anti-clockwise direction in the Northern Hemisphere and clockwise direction in the Southern Hemisphere." Cyclone word was coined by Henry Peddington which originates from the Greek word Cyclos meaning coil of snakes. It is named so as Paddington observed the tropical storms of the Bay of Bengal and Arabian Sea inter-tangling like serpents of the sea. Cyclones are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation. Cyclones are eventually associated with violent weather and agitated storms, with distinguished air circulations being anticlockwise direction and clockwise direction in the Northern and Southern Hemisphere respectively.

2. STUDY AREA:

Cyclone

Studying the definition of cyclones and its broader classification

In the context of India

Underscoring Tropical cyclones and their mechanism of occurrence in North Indian Oceans

- **Arabian Sea - With** the rising global temperature occurrence of Tropical Cyclones has become frequent in the Western part of India i.e. Arabian Sea. The coastal population from Gujarat to Thiruvananthapuram is highly vulnerable to this Tropical cyclone. In this report, we have tried to explain the broad process of Cyclone formation in the Arabian Sea.
- **Bay of Bengal –** It is surrounded by Bangladesh in the North, Myanmar and Andaman and Nicobar Islands in the East, India in the West, and Sri Lanka and Open India Ocean in the South. Major rivers drain into the Bay of Bengal like Ganga, Brahmaputra, etc. Tropical Cyclone occurrence is prevalent

in the Bay of Bengal and it's a major threat to the coastal population of Andhra Pradesh, Orissa, Tamil Nadu, etc. In this paper, we have illustrated the cyclogenesis in the Bay of Bengal region and highlighted some mitigation steps undertaken by the government.

Mitigation

Illustrating the major steps taken by the government towards dwindling the effect of cyclones.

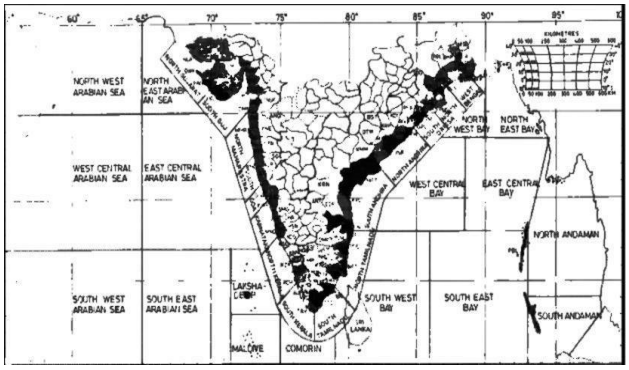

Fig. (1) Cyclone Hazard Prone Districts of India
(Source- National Disaster Management Authority, IMD)

3. CLASSIFICATION

Cyclones are majorly divided into two. On the one hand, it is an extratropical cyclone also inferred as a temperate cyclone, and on the other hand Tropical cyclone. The phrase Tropical cyclones is upheld to specify the weather conditions in which wind speed intensifies and exceeds the Gale force featured by a minimum wind speed of 34 knots or 63 kph under the modus operandi of World Meteorological Organizations (WMO). Tropical cyclones are the progeny of ocean and atmosphere, upheld by the heat from the sea and driven by easterly trades and temperate westerlies, high planetary winds, and their fierce energy.

In India, cyclones are classified by:

- Strength of associated winds,
- Storm surges
- Exceptional rainfall occurrences.

4. CYCLOGENESIS

The developmental stages of the cyclone are divided into three:

Formation and Initial Development Stage

Cyclone's initial development and formation are aided by a multitude of enticing circumstances. These are:

- Warming up of seawater above 26° Celsius to a depth of 60 m in addition to mass and turbulent transfer of water vapor to above surface through evaporation.
- Due to convection with condensation of the air above the ocean surface, there is a formation of massive vertical cumulus clouds, resulting in Climatic instability.

Mature Tropical Cyclones

When the Tropical Storm intensifies, the air above the ocean surface is forced upward through violent thunderstorms and spreads horizontally outward at the Tropopause level. Consequently, a positive regular pressure is built at a high level which catalyzes the downward motion of air mass due to convection. This prevailing situation of air subsidence warms up the layer below by exerting pressure and compression, resulting in the formation of an eye. Generally, the 'Eye' of the storms has three basic shapes: (i) circular; (ii) concentric; and (iii) elliptical. The main physical feature of a mature tropical cyclone in the Indian Ocean is a concentric pattern of highly turbulent giant cumulus thundercloud bands.

Modification and Decay

The intensity of tropical cyclones begins to dwindle which is characterized by central low pressure, internal warm, and extremely high velocity. This is due to the cut off of warm moist air which aids the process. This mainly happens due to its passage over cold water or after its landfall. The weakening of a cyclone does not mean that the danger to life and property is over.

5. INDIAN CONTEXT

Ocean kisses India's vast exaggerated 8041 km coastline, making it susceptible to 10 percent of the world's tropical cyclones. Of these, the majority of them are progeny of the Bay of Bengal which strikes the Eastern coast of India. On average, five to six tropical cyclones form every year, of which two or three could be severe. Meteorologically Bay of Bengal is four times more vulnerable to cyclones than the Arabian Sea i.e. approximate ratio is 4:1 respectively. Cyclones occur frequently on both coasts (the West coast – Arabian Sea; and the East coast – Bay of Bengal). According to statistical analysis of the frequency of cyclones on the East and West coasts of India between 1891 and 1990 shows that nearly 262 cyclones occurred among which 92 of these were severe in a 50 km wide strip above the East coast. On the contrary, less severe cyclonic activity has been recorded on the West Coast, where 33 cyclones occurred in the same period, out of which 19 were severe.

The occurrence of Tropical cyclones is observable in the months of May-June and October-November. Intensified and accentuated cyclones in the North Indian Ocean are bi-modal, with their primary peak in November and secondary peak in May. The disastrous capability is particularly high during landfall in the North Indian Ocean (Bay of Bengal and the Arabian Sea) due to the reinforcement of destructive wind, storm surges, and torrential rainfall. Of these, storm surges cause the most damage as sea water inundates low-lying areas of coastal regions and causes heavy floods, sweeps away beaches vehemently blows away vegetation, and reduces soil fertility. Tropical cyclones, accompanied by destructive winds, torrential rainfall, and storm surges, disrupt normal life with the succession of floods due to the exceptional level of rainfall and storm surge inundation into inland areas. Cyclones are characterized by their devastating potential to damage structures, namely houses, lifeline infrastructure-power and communication towers, hospitals, food storage facilities, roads, bridges and culverts, etc.

6. MECHANISM OF CYCLONE FORMATION IN NORTHERN INDIAN OCEAN

ARABIAN SEA

The mechanism of cyclone formation in the Arabian Sea bears resemblance to that of other Tropical regions but stands out with some unique features. Here are the processes involved:

Heating of the sea surface due to intense insolation during pre-monsoon and post-monsoon periods specifically leads to a rise in temperatures above 26° Celsius to 28° Celsius.

- Further, the warm water vapor rises aloft creating a low-pressure area above the sea surface. Coriolis effect due to earth's rotation further forces the water vapour into spiral geometry giving rise to cyclonic circulation.
- The cyclonic circulation is fuelled by the inflow of moist air from the Indian Ocean and the Arabian Peninsula, as well as the outflow of dry air from the continental interior.
- The latent heat produced during the condensation of water vapor in clouds enhances and intensifies the Cyclone. The stronger the cyclone, the higher the wind speed and the lower the central pressure.

- The cyclone moves along the steering currents of the upper Troposphere, which are influenced by the seasonal monsoon winds and the subtropical jet stream.
- The cyclone dwindles when it is affected by some climatic features such as land, cold water, and unfavorable shear, which disrupts its structure and energy supply

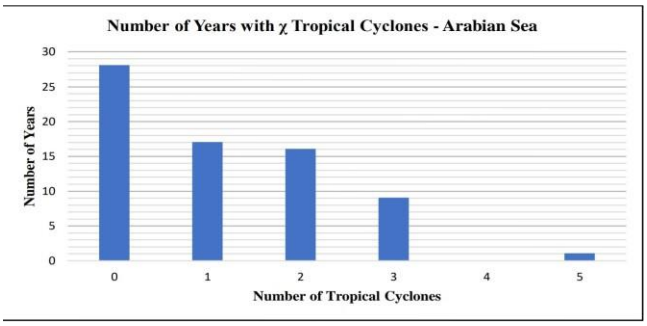

Fig.(2) shows the Arabian Sea Histogram. A Histogram of the Arabian Sea exhibiting an abnormal distribution using the entire study period of 1950 to 2020

(Source- The Meyer Thesis, Texas State University)

The Arabian Sea has experienced an increase in the frequency and intensity of cyclones in recent years, due to the rapid warming of the sea and the atmosphere, which creates more favorable conditions for cyclogenesis and further development. This creates a dilemmatic position for the coastal regions of India, Pakistan, Oman, and Yemen, which are under the vulnerable zone of the impacts of strong winds, heavy rainfall, storm surges, and flooding. Therefore, it is important to observe and predict the cyclonic activity in the Arabian Sea, and cognizant implement effective disaster management strategies to mitigate the life and property as well as risks.

BAY OF BENGAL

The mechanism of cyclone formation in the Bay of Bengal is quite similar to that of cyclones in the Arabian Sea, but with some differences. Here are the main influential factors that lead to the formation and movement of cyclones in the Bay of Bengal:

- The unique funnel mechanism is due to its strategic geographic location viz. Semi semi-enclosed basin roughly in triangular shape, causes massive storm surges when a cyclone approaches the coast. The Bay of Bengal being shallow allows further surge and inundation of the low-lying coastal areas.
- The cyclone development is fed by the influx of large amounts of moisture from the Indian Ocean, the Arabian Sea, and the Bay of Bengal itself. The moisture is enhanced by the seasonal monsoon winds, which bring moist air from the southwest in summer and from the northeast in winter.
- The Bay of Bengal is influenced by the upper-level subtropical jet stream, which drives the cyclones towards the north or northeast. The jet stream also creates wind shear, which can weaken or squander cyclones.
- ▪ The Bay of Bengal is influenced by the El Niño-Southern Oscillation (ENSO) phenomenon, which

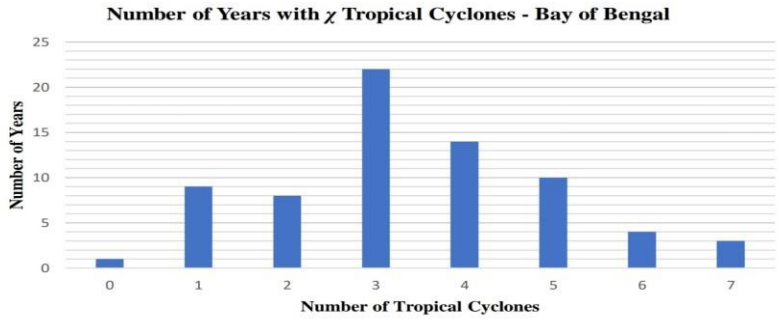

Fig.(3) the Bay of Bengal exhibiting an abnormal distribution using the entire study period of 1950 to 2020.

(Source- The Meyer Thesis, Texas State University)

The Bay of Bengal Is one of the most active regions for cyclone formation in the world, especially during the pre-monsoon (April-May) and post-monsoon (October-December) seasons. Most of the cyclones that originate in the Bay of Bengal are very intense and destructive, causing heavy rainfall, strong winds, storm surges, and inundation in the coastal regions of India, Bangladesh, Myanmar, and Sri Lanka. Therefore, it is important to monitor and predict the unforeseen cyclone activity in the Bay of Bengal, and to implement effective disaster management and mitigation strategies to reduce the risks and losses.

7. MAJOR/MINOR CYCLONES IN INDIA

According to the data from the India Meteorological Department (IMD), it has been seen that there is a surge in cyclone formation in the Arabian Sea and the Bay of Bengal has increased by 32% in the last five years in comparison to previous decades, the last ten years have also seen an 11% rise in these extreme occurrences.

Here Is a list of some of the notable cyclones that hit India in the last five years:

- Cyclone Biparjoy (2023): An extremely violent cyclonic storm landed in Gujarat on June 15, 2023, with a maximum strength of 195 km/hr after originating in the east-central Arabian Sea.
- Cyclone Mandous (2022): A severe cyclonic storm hit the Andaman and Nicobar Islands and the coast of Chennai on December 14, 2022.
- Cyclone Sitrang (2022): A weak tropical cyclone that struck the eastern and northeastern states of Assam, Odisha, West Bengal Andaman, and Nicobar Islands from October 22-25, 2022.
- Cyclone Amphan (2020): In May 2020, the Bay of Bengal witnessed the first supercyclone after the 1999 Odisha super cyclone. The cyclone made landfall near the Sundarbans in West Bengal and was recorded as the costliest tropical cyclone in the North Indian Ocean. The economic losses in India were reported to be approximately USD 14 billion, and it caused 129 casualties across India and Bangladesh.
- Cyclone Fani (2019): An extremely severe cyclonic storm struck the eastern coast of India near Puri in Odisha on May 3, 2019, claiming 64 lives and causing substantial damage to infrastructure.

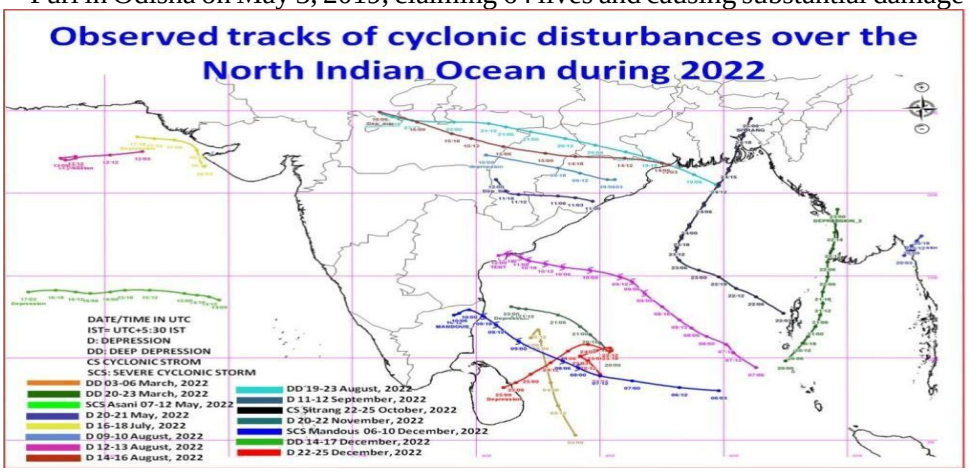

Fig.(5) Shows Cyclonic disturbance over the North Indian Ocean during 2022
(Source- Indian Meteorological Department)

8. RECOVER AND REBUILD (POST-CYCLONE)

"After 'All Clear' is issued for back movement by 'State' give attention to the following:

- Whether 'roads' for reaching home is recommended by authorities
- Whether power lines are safe
- Whether transport arrangement is approved by authorities
- Pure drinking water is available

- Sewage lines are working
- Any epidemic spread in the area
- Safety of neighbour(s) assured"

9. GOVERNMENT INITIATIVES FOR CYCLONE PREPAREDNESS

- National Cyclone Risk Mitigation Project: under NDMA it aims to protect vulnerable local communities from the impact of cyclones and other hydro-meteorological calamities.
- ICZM aims to improve the livelihood of coastal communities and conserve the coastal ecosystem. The ICZM plan involves the identification of infrastructure requirements and livelihood improvement means in coastal districts. Conservation of mangroves is among the components. The national component of the project includes mapping the country's coastline and demarcation of the hazard line.
- Coastal Regulation Zones (CRZ): In 1991, the coastal areas of seas, bays, creeks, rivers, and backwaters that are affected by tides up to 500 meters from the high tide line (HTL), as well as the land between the low tide line (LTL) and the high tide line, were designated as the coastal regulation zone (CRZ).
- Orissa Government: The World Bank has invested over USD 350 million in projects like the Odisha Disaster Recovery Project and the National Cyclone Risk Mitigation Program, aimed at reducing the impact of cyclones in Orissa. The government has taken various steps such as establishing the Early Warning Dissemination System (EWDS)-Last Mile Connectivity, building Cyclone Risk Mitigation Infrastructure like Multipurpose Cyclone Shelters (MCS), Approach Roads, Saline Embankments, providing Shelter level equipment, and conducting Shelter level capacity building activities (Technical assistance for capacity building on hazard risk management by NDMA and National Institute of Disaster Management (NIDM) and the shelter level capacity building activities were carried out by OSDMA) to ensure the safety of the people during such disasters.

CONCLUSION

It is crucial to take steps before a disaster strikes to prepare for its impact. Effective risk preparedness requires the involvement of various stakeholders, including the community, government, NGOs, and the private sector. Although progress has been made, India still faces challenges in managing cyclones, such as the lack of coordination between stakeholders, inadequate early warning techniques, and poor building practices. To enhance cyclone management in India, there is a need to harmonize national and local disaster institutions, implement risk-proof measures, promote people-centric disaster management, involve the private sector, strengthen research and training, and raise awareness at all levels. By emulating successful models like Odisha's, we can minimize the impact of future cyclones.

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UNDERSTANDING COASTAL FLOODING IN KERALA, INDIA

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1. ABSTRACT

Coastal Flooding in Kerala presents a challenge to the lives and environment exacerbated by a combination of factors, including heavy monsoon rains, river swelling, storm surges, and tide rise. This disaster poses a threat to life and property in the region. This research endeavors to analyze the factors leading to coastal flooding disasters in Kerala, focusing on the years 2018 to 2021. The study highlights the critical role of heavy monsoon rainfall in triggering flooding events through data showing the same. By prioritizing sustainable development and investing in infrastructure, Kerala can mitigate the adverse effects of coastal flooding.

KEYWORDS- Kerala, Coastal Flooding, Monsoon rains, River swelling, Storm surges, Tide rise, Sustainable Development.

2. INTRODUCTION

Coastal flooding can be defined as **a sudden and abrupt inundation of a coastal environment caused by a short-term increase in water level due to a storm surge and extreme tides.**

With the growing climate change issues coastal flooding poses a threat to the coastal areas worldwide. It is an issue that continues to threaten coastal communities around the world. With rising sea levels, increasingly intense storms in the changing climate, and human activity altering coastal landscapes, the risk of flooding has become more pronounced. The effects of coastal flooding can be devastating, resulting in displacement of populations, destruction of infrastructure, and economic losses. Furthermore, the environmental impacts cannot be overlooked, as flooding can lead to the contamination of water sources, erosion of coastal habitats, and disruption of delicate ecosystems.

Driven by rising sea levels, tidal swings, and storm surges, coastal floods are a growing threat to buildings, energy and transport infrastructure, water supplies, and human lives.

- **European Environment Agency**

Coastal Flooding is primarily caused by a combination of natural factors and human activities. One of the main natural causes is the sea level rise due to climate change. This rise in sea levels results in flooding along the coastlines. Climate change has also resulted in the rise of Global temperatures that have been linked to more frequent and intense extreme weather events including heavy rainfall and flooding. According to Global Climate Change **(**NASA/GISS), **"Earth was about 2.45 degrees Fahrenheit (or about 1.36 degrees Celsius) warmer in 2023 than in the late 19th-century (1850-1900) preindustrial average."**

On the other hand, according to a study (R. Rudianto, Very Darmawan, A. Isdianto, G. Bintoro) on "*Restoration of coastal ecosystems as an approach to the integrated mangrove ecosystem management and mitigation and adaptation to climate changes in the north coast of East Java"* Human activities such as coastal development and the destruction of natural protective barriers like wetlands have also played a significant role in increasing the vulnerability of coastal areas to flooding. The construction of buildings and infrastructure in vulnerable coastal zones reduces the capacity of the land to absorb and channel floodwaters, leading to more severe flooding events. Furthermore, the removal of natural coastal barriers reduces the protection they provide against storm surges. Overall, the causes of coastal flooding are complex and interconnected, involving both natural phenomena and human activities.

3. STUDY AREA

3.1 LOCATION

Kerala, a state in India is found on the Malabar coast in the south of the country. The State has a latitudinal extent of 8° 18' N and 12° 48' N and longitudinal extent of 74° 52' E and 77° 24' E with a geographical area of 38,863 km sq. In terms of population, Kerala is the 13th largest state in India which stretches from north to south along a coastline of 580 km (about 360.4 mi) with an approximate breadth of 35 to 120 km. Its capital is Thiruvananthapuram, and the state is divided into 14 districts. The state embraces the Arabian Sea in the west and the Indian Ocean in the south and is renowned for its beautiful coastline that stretches along these bodies of water.

3.2 CLIMATE

The climate of Kerala is tropical, offering a pleasant climate throughout the year. The state experiences a warm and humid climate, particularly in April and May, and has a cold climate in December and January. The summer season in Kerala runs from April to June and reaches a maximum temperature of 33 degrees Celsius. The summer season is followed by the Southern West Monsoon which begins in June and continues until September and brings heavy rainfall to the state making Kerala one of the wettest regions in India, receiving substantial precipitation due to its proximity to the Arabian Sea and the influence of the southwest monsoon winds. The winter season in Kerala is from November through January or February and there is a slight chill in the air due to cold winds.

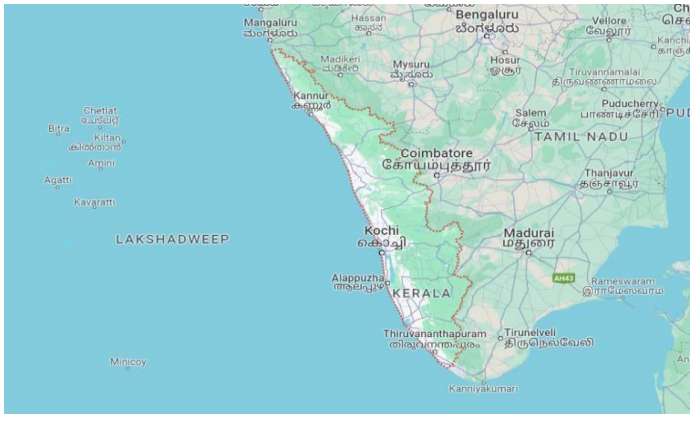

Figure 1 - Map showing the location of Kerala
SOURCE- Google Maps, 17-02-2024

3.3 TOPOGRAPHY

Kerala is characterized by a predominantly low-lying coastal terrain inclusive of coastal plains, hills, western ghats backwaters, and rivers. 44 major rivers are flowing in the state. Out of the total rivers flowing 41 flow to the west and the other 3 to the east. They flow from the western ghats and rush towards the Arabian Sea to drain excess water from the mountains and surrounding areas towards the coast. During heavy rainfall, the rivers swell up leading to inland flooding.

4. MATERIALS AND METHODS

Kerala has experienced coastal floods for many years. In **2018**, the state witnessed devastating floods due to heavy monsoon rains, which caused significant damage to life, property, infrastructure, and agriculture. Coastal areas were also affected during these times.

In subsequent years, such as **2019, 2020, and 2021** Kerala continued to face flooding.

Table 1- Affected years and reasons of flooding in Kerala

AFFECTED YEARS	**CAUSES**
2018	Heavy rain Discharges Landslide
2019	Heavy rain Discharges Landslide
2020	Heavy rain Climate Change Inadequate drainage Deforestation and slope alteration
2021	Heavy monsoon rainfall Cyclonic disturbances and low-pressure systems Storm surges and high tides Poor drainage infrastructure

During the monsoon season in India, Kerala receives its highest rainfall but in 2018 the state experienced its highest level of monsoon rainfall in decades. According to the Indian Meteorological Department, there was 2346.3 mm of precipitation, instead of the average of 1649.55 mm.

Table 2- Months actual rainfall, normal rainfall, and percentage departure from normal (2018)

PERIOD	**NORMAL RAINFALL**	**ACTUAL RAINFALL**	**DEPARTURE FROM NORMAL**
	(mm)	(mm)	(%)
June 2018	649.8	749.6	15
July 2018	726.1	857.4	18
1-19 August 2018	287.6	758.6	164
Total	1649.5	2346.6	42

Source: Report on Kerala floods of August 2018 by Central Water Commission, Hydrological Studies Organisation.

In August 2020, Kerala witnessed a series of low-pressure systems at the time of the southwest monsoon season. These low-pressure systems, combined with strong winds over the Arabian Sea, led to intense rainfall and cloudbursts in various parts of the state. The heavy rainfall saturated the

soil, weakened bedrock, and overwhelmed rivers and drainage systems, contributing to widespread flooding and landslides in Kerala during that period. The combination of multiple low-pressure systems and intense rainfall events exacerbated the flooding situation in the state. This resulted in significant destruction in the state.

Table 3- Data showing the destruction caused

NUMBER OF AFFECTED	DURING MONSOON SEASON (1 JUNE 2020 TO 18 AUGUST 2020)
Total dead/ Missing/ Injured	104/12/40
Property Damage Cost (Estimated)	₹19,000 crore
Districts	All 14 districts in Kerala
Houses Damaged	220 fully destroyed, 5,190 in parts
Villages	All 1,670 villages in Kerala

Source: Ministry of Home Affairs Disaster Management Division Situation Report

4.1 METHODS OF DATA COLLECTION

Secondary data refers to information that has previously been gathered through primary sources and is readily accessible for researchers to utilize in their investigations. This data has been collected beforehand and is available for subsequent analysis and interpretation.

The data for this research has been collected by using existing reports, government-published articles, and reports by the Ministry of Home Affairs Disaster Management Division.

5. RESULTS

The research on "Understanding Coastal Flooding in Kerala" found that the primary cause of coastal flooding mainly in the years 2018, 2019, 2020, and 2021 was the heavy monsoon rains, which further resulted in an increased volume of water flowing into rivers and water bodies.

By analyzing the data of rainfall in the year 2018 it is shown that there was an increase of 42% in the rainfall compared to the average. There was 2346.3 mm of precipitation, instead of the average of 1649.55 mm in the year 2018.It is also found that the other causes of coastal flooding in the above-mentioned years were River swelling due to the excessive rainfall leading to swelling in the rivers beyond their normal levels. Additionally, Storm surges and Tide rise are the other reasons exacerbating the flooding situation in Kerala.These factors significantly contribute to widespread massive destruction in the coastal regions, as in the year 2020, all 14 districts of Kerala were affected. Also, the property damage resulted in approximately around ₹19,000 crore.

6. CONCLUSION

Coastal Flooding in Kerala is a multifaceted issue exacerbated by heavy monsoon rains, river swelling, storm surges, and tide rise.

These factors contribute to the devastating floods in the region causing a danger to life and property. It is important to study the factors leading to this disaster and understand the dynamics of these phenomena for implementing effective mitigation strategies. Additionally, steps should be taken to prioritize sustainable development practices and for a better infrastructure to mitigate the adverse effects of the disaster.

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ADAPTATION STRATEGIES FOR MITIGATING THE IMPACTS OF FLOODS ON AGRICULTURE AND LIVELIHOODS IN RURAL ASSAM

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1. Abstract

Floods pose a significant threat to agriculture and livelihoods in rural Assam, exacerbating existing vulnerabilities and perpetuating cycles of poverty. This study explores adaptation strategies to mitigate the impacts of floods on rural communities, focusing on effective measures to enhance resilience and reduce vulnerabilities. The research investigates the causes of floods in Assam, examining both natural and anthropogenic factors contributing to their frequency and severity. Socio-economic impacts of floods on agriculture are analyzed, highlighting the extensive damage to crops, livestock, and infrastructure, as well as the displacement of populations and economic losses incurred. Challenges faced by rural communities, including riverbank erosion and socio-economic disparities, are identified, underscoring the urgent need for comprehensive adaptation strategies.

The study emphasizes the importance of timely flood forecasting and technology-driven early warning systems in minimizing losses and enabling proactive measures. Infrastructure development, including robust embankments and flood shelters, is crucial for reducing vulnerability and enhancing resilience. Additionally, crop diversification and promotion of flood-tolerant varieties offer opportunities for income stability and food security in flood-prone areas. Drawing insights from successful adaptation strategies in other flood-prone regions, such as Bangladesh and the Netherlands, the study proposes community-based approaches and comprehensive flood management policies tailored to the specific needs of rural Assam.

Keywords: Floods, agriculture, rural Assam, adaptation strategies, socio-economic impacts, early warning systems, disaster risk management.

2. Introduction

Flood refers to the overflow of water onto land that is usually dry, causing inundation and potentially resulting in damage to property, infrastructure, and loss of life. This natural disaster can occur due to various reasons, including heavy rainfall, snowmelt, storm surges, or the overflow of rivers, lakes, or oceans. Floods are among the most common and destructive natural hazards worldwide, affecting millions and causing significant economic and environmental impacts each year. In the context of Assam, floods are a recurring and severe problem, primarily due to its geographical location and climatic conditions. Assam experiences heavy monsoon rains from June to September, coupled with the inflow of water from rivers originating in the Himalayas and other nearby regions. The Brahmaputra River, one of the major rivers in the region, along with its tributaries, often swells during the monsoon season, leading to widespread flooding across the state. The geography of Assam, characterized by low-lying plains and river valleys, exacerbates the impact of floods. The state's

extensive network of rivers, including the Brahmaputra, Barak, and their tributaries, drains a vast area, making it highly susceptible to flooding. The Brahmaputra, in particular, is known for its erratic behavior, frequently changing its course and inundating surrounding areas during periods of high discharge.

Rural Assam grapples with the recurring menace of floods, which inflict devastating blows on its agriculture-dependent populace year after year. The region's geographic location, nestled in the floodplains of the Brahmaputra and Barak rivers, exposes it to heightened vulnerability to flooding. According to the assessment of Rashtriya Barh Ayog (RBA), 31.05 lakh hectares of Assam's land is prone to flooding, which constitutes approximately 39.58% of the state's total area of 78.523 lakh hectares. This accounts for about 9.40% of the total flood-prone area in the country. On average, 9.31 lakh hectares of land in Assam are affected by floods annually. Comparatively, the national flood-prone area is about 10.2% of the country's total area, making Assam's flood-prone area four times larger than the national average. Changes in rainfall patterns and glacial melt in the Himalayan region, attributed to climate change, are intensifying the frequency and severity of floods. These floods wreak havoc on agricultural lands, causing crop submergence, erosion of fertile topsoil, and water source contamination. In Assam, flood-related crop damages significantly decrease agricultural productivity and income, perpetuating a cycle of poverty, particularly affecting vulnerable groups like smallholder farmers and landless laborers.

The purpose of this study is to investigate adaptation strategies geared towards minimizing the detrimental effects of floods on agriculture and rural livelihoods in Assam. By exploring these strategies, the aim is to identify effective measures that can be implemented to enhance the resilience of rural communities in the face of recurring flooding events.

3. Study Area

3.1 Location

Assam, situated in the northeastern part of India, lies approximately between 22°19’ and 28°16’ North Latitudes and 89°42’ and 96°30’ East Longitudes. It covers an area of around 78,438 square kilometers, making it one of the largest states in the region. This region is flanked by Bhutan to the north and Arunachal Pradesh to the east. To the south, it shares borders with Nagaland, Manipur, and Mizoram, while Meghalaya lies to the southwest. West Bengal and Bangladesh are situated to the west. Administratively, the state is segmented into 35 districts.

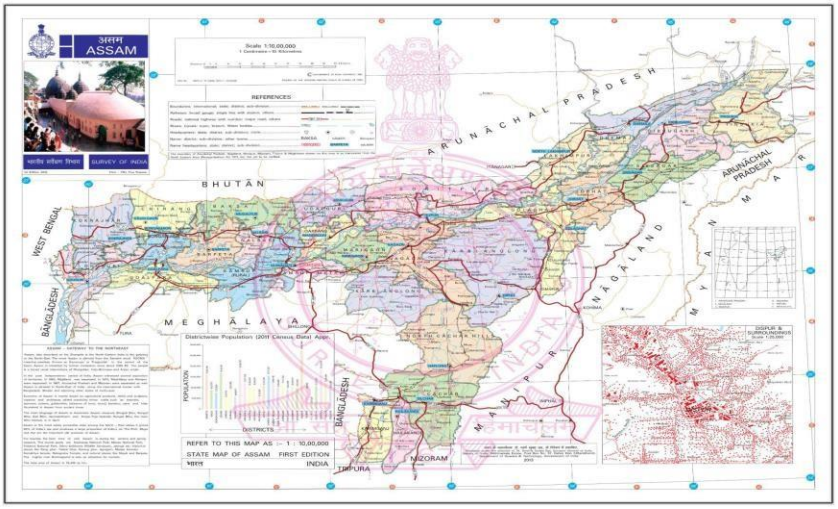

Fig:1 - Map of Assam

Source: Survey of India

3.2 Physiography

Assam can be divided into three main physiographic divisions: the Brahmaputra Valley, Central Assam Hills, including Mikir Hill in Karbi Anglong and North Cachar Hill districts, and Barak Valley, covering Cachar and Karimganj districts.

3.3 Climate

Assam is primarily impacted by the southwest tropical monsoon, typically active from April to October, occasionally interspersed with winter showers. Rainfall across the state ranges between 1600mm and 4300mm annually, with an average of around 2900mm. The peak precipitation occurs in June and July. Winters see temperatures ranging from 4°C to 19°C, while summers experience temperatures between 26°C and 37°C, often coupled with high humidity levels.

3.4 Drainage

Assam's drainage system is primarily governed by several major rivers, the most prominent being the Brahmaputra River. The Brahmaputra, with a length of approximately 2,900 kilometers, traverses through the state, serving as a lifeline for its inhabitants and shaping its landscape. Other significant rivers include the Barak River and the Subansiri River. These rivers have substantial water-wading capacities, especially during the monsoon season when they often swell, leading to floods in certain areas.

3.5 Demography

In the 2011 Census of India, Assam boasted a population of 31.17 million, with a population density of 396.8 individuals per square kilometer and a literacy rate of 73.18%.

3.6 Economy

Economically, Assam is renowned for its tea plantations, which produce some of the finest tea in the world. The state also significantly produces agricultural products such as rice, jute, and pulses. Assam's rich mineral resources, including oil and natural gas reserves, contribute significantly to its economy. The state's diverse ethnic communities engage in handloom and handicraft industries, producing exquisite textiles and crafts that are highly sought after domestically and internationally.

4. Methods of Data Collection

The methods of data collection for this article primarily involved the use of secondary data sources. Secondary data refers to information that has already been collected and published by other sources, such as government reports, academic studies, and reputable organizations. The researcher gathered relevant data on flood impacts, adaptation strategies, and successful interventions from a variety of secondary sources, including government websites, research papers, disaster management plans, news articles, and reports from organizations working in the field of disaster risk reduction and rural development. The collected data were then analyzed to identify trends, challenges, and effective adaptation strategies for mitigating the impacts of floods on agriculture and livelihoods in rural Assam.

5. Results and Discussions

5.1 What are the causes of floods in Assam?

According to a study conducted by Sankam J, Rao AP, Sumit K, and Tiwari RR, the major causes of floods in Assam can be broadly divided into two categories. Viz.

1. Natural Factors
2. Anthropogenic Factors

Among the natural factors, Climate Change and Changing weather patterns are identified as some of the major cause that results in heavy downpours and changes in rainfall patterns. Excessive Rainfall events during the monsoon season are discovered to be one of the significant factors.
Other Natural factors that contributed to the floods in Assam were changes in the course of Rivers and Landslides as studies discovered that river bed rises due to landslides and erosion. Seismic Activities like earthquakes are also considered as one of the major reasons for the rise of Assam Floods. As reports suggest the flood toll increased after the earthquake of the 1950s. with significant events in 1954, 1962, 1972, 1977, 1984, 1988, 1998, 2002, 2004, and 2012.
Among the anthropogenic factors that are taken into consideration are Deforestation as trees act as a natural flood control measure, urbanization, inefficient drainage management, improper construction of roads and dams, and construction of embankments as it further raises river beds due to silt deposition.

5.2 Socio-Economic Impacts of Floods on Agriculture in Assam

Flooding in Assam results in extensive damage to crops, with rice, tea, jute, and pulses being particularly affected. On average, floods submerge approximately 30% of the state's agricultural land each year. Crop damage varies annually but often leads to substantial economic losses for farmers, ranging from 40% to 60% of their annual income, depending on the severity of the flood (Assam Agricultural University, AAU). Additionally, disruptions in agricultural activities due to floods contribute to a decrease in crop yields, affecting food security and increasing the prices of essential food commodities in flood-affected regions.Floods also pose a significant threat to livestock in Assam, with thousands of animals being affected each year. On average, floods result in the loss of approximately 20% to 30% of the state's livestock population, either due to drowning or lack of access to food and shelter (Assam Agricultural University, AAU). Livestock losses not only impact the livelihoods of farmers but also lead to a decline in the availability of milk, meat, and other animal products, exacerbating food insecurity in flood-affected areas.

Floods force communities to evacuate their homes, leading to displacement and loss of livelihoods for a significant number of families. On average, floods displace approximately 5% to 10% of the state's population each year, with vulnerable groups such as women, children, and the elderly being particularly affected. Displaced individuals often face challenges in accessing necessities such as food, clean water, healthcare, and education, further exacerbating their vulnerability and perpetuating the cycle of poverty.The socio-economic impacts of floods extend beyond agriculture to affect various sectors of the economy in Assam. On average, floods cause billions of dollars in economic losses each year, including damage to infrastructure, disruption of transportation networks, and loss of productivity. Businesses suffer significant losses due to damaged infrastructure, disrupted supply chains, and decreased consumer demand, leading to job losses and decreased economic growth in flood-affected areas.

Table 1: Damage Caused by Flood in Assam from 2012 to 2022

Year	Crop Area Affected (lakh hectares)	Population Affected (in lakh)	Human lives lost	Cattle lost	Total Damages Value (in Crores)
2012	3.28	29.14	144	11408	3591.81
2013	0.71	8.48	NA	NA	NA
2014	3.67	42.03	90	28	2534.88
2015	3.38	36.67	66	212	1523.79
2016	2.35	39.81	64	5580	10,339.66
2017	3.98	56.02	160	449	4358.81
2018	0.31	13.22	53	556	2491.59
2019	2.15	73.05	101	250	3237.75
2020	1.88	57.89	150	702	2642.99
2021	0.65	5.74	3	13	NA
2022	1.08	57.5	179	2700	10,000

Source: Flood Memorandum, Revenue & Disaster Management Department, 2022 (Assam State Disaster Management Plan,2022)

5.3 Challenges Faced by Rural Communities

With flood comes river bank erosion. According to a study published by the Water Resouces Department, Govt. of Assam, riverbank erosion has emerged over the past sixty years as a pressing concern, particularly along the Brahmaputra River and its tributaries. An alarming 4.27 lakh hectares of land, equivalent to 7.40% of the state's area, have been lost to erosion since 1950. On average, nearly 8,000 hectares of land vanish annually due to this phenomenon. At certain points, the Brahmaputra's width has expanded to an astonishing 15 kilometers as a direct result of bank erosion. Bank erosion along river embankments has increasingly become a prevalent issue, with new areas falling victim to erosion each year. This erosion is significantly impacting the fertile agricultural lands adjacent to the rivers, leading to a reduction in their size. Consequently, the rural economy of the state is suffering from the adverse effects of this erosion.

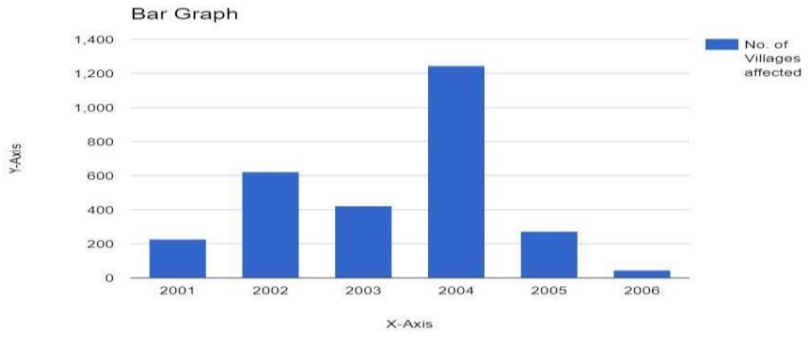

Figure 2: Graph showing no. of villages affected by bank erosion (Source: Water Resources Department, Govt. of Assam)

Rural communities in Assam are particularly vulnerable to flood-related risks due to a combination of geographical, infrastructural, and socio-economic factors. One of the primary vulnerabilities is the lack of adequate infrastructure to withstand and mitigate flood impacts. Many rural areas in Assam lack robust embankments, levees, and flood protection systems, leaving communities exposed to inundation during periods of heavy rainfall. Additionally, poor drainage systems exacerbate flood risks by impeding the flow of water and causing waterlogging in low-lying areas.

Limited access to resources further compounds the vulnerabilities of rural communities to floods. Access to clean water, sanitation facilities, and healthcare services is often inadequate, increasing the risk of waterborne diseases and health emergencies during floods. Furthermore, rural communities may have limited access to emergency services and relief assistance, exacerbating their vulnerability to the impacts of floods.Socio-economic disparities play a significant role in exacerbating the impacts of floods on vulnerable populations in rural Assam. Smallholder farmers, who rely heavily on agriculture for their livelihoods, are disproportionately affected by crop damage and loss of income during floods. These farmers often lack access to crop insurance and financial resources to recover from flood-related losses, perpetuating cycles of poverty and indebtedness. Similarly, landless laborers, who depend on daily wages for their sustenance, face heightened vulnerabilities during floods. Disruptions in agricultural activities and loss of livelihood opportunities exacerbate their economic hardships, pushing them further into poverty. Marginalized groups, including indigenous communities and minority populations, also face unique challenges during floods, such as limited access to relief assistance. Overall, socio-economic disparities exacerbate the impacts of floods on vulnerable populations, deepening their vulnerability and hindering their ability to cope and recover from flood- related disasters. Addressing these disparities requires comprehensive strategies that prioritize the needs and rights of vulnerable communities, including investment in resilient infrastructure, equitable access to resources, and inclusive disaster risk management initiatives.

5.4 Adaptation Strategies

Timely and accurate flood forecasting is crucial for minimizing losses by providing warnings to vulnerable communities. It allows people to evacuate safely, protect their assets, and prepare for potential disruptions. E.g. The early forecasting system used in Odisha has minimized the losses that occurred due to cyclones. Technology plays a vital role in disseminating warnings to rural communities. Mobile phone alerts and community-based monitoring systems enable rapid communication of flood warnings, reaching even the most remote areas. Improved flood protection infrastructure, including embankments, levees, and flood shelters, is essential for reducing the impacts of floods on rural communities. Investments in infrastructure development can enhance the resilience of communities and reduce the vulnerability of agriculture and livelihoods to flood-related risks. Integrating traditional knowledge with modern engineering techniques is essential for building resilient infrastructure. Traditional practices, such as community-managed embankments and water management systems, such as the “doong” system of Assam can complement modern approaches and enhance the effectiveness of flood protection measures.

Crop diversification and the promotion of flood-tolerant varieties can reduce dependence on single crops and enhance resilience to floods. Diverse cropping systems are less susceptible to total crop failure during floods, ensuring food security and income stability for rural communities. Alternative livelihood options, such as aquaculture, poultry farming, and horticulture, offer opportunities for income diversification and resilience-building. These activities are less vulnerable to floods and can provide sustainable sources of income for rural households.

5.5 Successful Adaptation Strategies from Other Flood-Prone Regions

In Bangladesh, the Community-Based Flood Early Warning System has been effective in mitigating the impacts of floods on agriculture and livelihoods. This system involves training local volunteers to monitor river levels and disseminate timely warnings to communities, enabling them to take proactive measures such as evacuating livestock and crops to higher ground. The scalability and community ownership of this approach make it relevant and applicable to rural Assam.

In the Netherlands, the implementation of comprehensive flood management policies has significantly reduced the country's vulnerability to floods. The Dutch approach emphasizes a multi-disciplinary and integrated approach to flood risk management, involving coordination between government agencies, research institutions, and stakeholders. Lessons from the Netherlands' experience can inform the development of policy frameworks and interventions in Assam to enhance flood resilience in agriculture and livelihoods.In India, organizations such as Oxfam India have partnered with local communities to implement livelihood-focused projects aimed at building resilience to floods. These projects involve capacity building, livelihood diversification, and infrastructure development initiatives tailored to the specific needs of flood-prone communities. Collaborative partnerships between NGOs, government agencies, and communities have been instrumental in supporting vulnerable populations and enhancing their adaptive capacity to floods.

6. Conclusion

In conclusion, mitigating the impacts of floods on agriculture and livelihoods in rural Assam demands a holistic approach that integrates various adaptation strategies while addressing socio-economic disparities. Timely flood forecasting and robust early warning systems are critical for preparedness and response, alongside investments in flood protection infrastructure and the incorporation of traditional knowledge. Promoting crop diversification and resilient agricultural practices can bolster the resilience of rural communities against crop losses. Drawing lessons from successful adaptation strategies in other flood-prone regions, like Bangladesh and the Netherlands, offers valuable insights for Assam. However, tackling socio-economic disparities, including equitable access to resources and livelihood opportunities, remains paramount. Inclusive and participatory approaches, guided by collaborative partnerships between stakeholders, are essential for empowering vulnerable communities and fostering sustainable development amidst recurrent floods.

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EXPLORING THE IMPACT OF MANGROVES ON THE CYCLONES OF SUNDARBAN DELTA

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1. ABSTRACT

Mangroves of the Sundarbans delta work as a natural barrier that protects this region (Sundarbans delta) from High-intensity cyclones, storm surges, huge waves, and coastal floods. This research paper analyzes the role of mangroves in protecting Sundarbans from super cyclones and cyclonic conditions, focusing on super cyclone Amphan and the role of mangroves in protecting the Sundarbans delta region and also discusses the sustainable steps for the protection of this mega-diverse mangrove forest.

KEYWORDS — Mangroves, Sundarbans, Cyclone, Super cyclone

2. INTRODUCTION

The huge mangrove environment known as the Sundarbans extends over the Ganges, Meghna, and Brahmaputra deltas. Owing to its location and status as the largest delta in the world, Sundarbans is home to a variety of mangrove forests. In 1987, it was recognized as a UNESCO World Heritage Site.Mangroves are a type of tropical coastal plants that are primarily found in areas with brackish and saline water along the coast. There are over 110 species of mangroves that are known to exist. They are controlled by intricate root systems and intricate salt filtering systems that regulate wave movement and saltwater immersion.Because different types of mangroves react differently to different types of cyclones, mangroves defend the Sundarbans from severe cyclones and storm surges in a variety of ways, including by lessening the destructive force of cyclones.

3. STUDY AREA

3.1 Location

Sundarban Reserve Forest (SRF) world's largest mangrove forest spans between the Baleswar River (Khulna) in Bangladesh and the Hooghly River in India. Its total area is 513.6 sq mi and its coordinates location is 21°56′42″N and 88°53′45 ′.

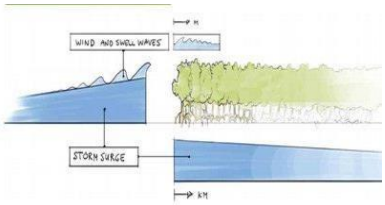
Sundarban mangrove forest covers an area of about 10000 km2. The 60% part of this delta is located in Bangladesh and the remaining part is in India.

3.2 Climate

Sundarban's temperature fluctuates between 34 and 20 degrees Celsius. There is a lot of rain, particularly during the monsoon season. There are more cyclones during the monsoon season. (in the summer) The humid air from the Bay of Bengal keeps the weather moist all year round. (High relative humidity of 80%)

Mangroves of Sundarbans play a crucial role in protecting the coast from cyclones. Some major points regarding this statement

- The dense mangrove forest canopies reduce the wind speeds locally and can reduce storm surge water depths as the surge flows inland.
- Debris movement can also be reduced by mangroves.
- the complex network of roots and branches can serve to trap even large moving objects.
- Mangrove belts several hundred meters wide have been shown to reduce tsunami height by between 5 and 30%, says the report.



As we've already mentioned, different mangrove species offer varying degrees of protection. Sonneratia apetala, for instance, is the species that offers the best protection. In general, mangroves reduce water flow velocity by 29 to 92 per cent with a forest width of 50 or 100 meters, and surge height by 4 to 16.5 cm with mangrove belts of 50 or 2 kilometers**.**

4.1 CASE STUDY

On November 9, 2019, the cyclone Bulbul, which originated in the Bay of Bengal, made landfall in the Sundarban Delta with winds of 130 km/h.

Mangroves are the guardians of the coast; during cyclone, Bulbul, their tangle of salt-tolerant groves stabilized the coastline, reduced erosion from storm surges, currents, waves, and tides mostly affected them, reduced wind intensity, and also significantly lessened the effect of tidal waves. However, nearly 4589 mangrove trees were also damaged during the cyclone Bulbul

5. METHODS OF DATA COLLECTION

Secondary data refers to information that has previously been gathered through primary sources and is readily accessible for researchers to utilize in their investigations. This data has been collected beforehand and is available for subsequent analysis and interpretation.

6. RESULT

The Sundarbans had been spared from the strong winds that gusted between 110 and 135 km/h thanks to the mangroves. "Had the mangroves not been there, it would have been a disaster," river expert and chair of the West Bengal Pollution Control Board Kalyan Rudra stated.

According to Tuhin Ghosh, a professor at Jadavpur University's School of Oceanographic Studies, mangroves have been cleared for aquaculture, embankment construction, and human habitation.
He clarified that mangrove vegetation acts as a screen against cyclones due to its proximity to other trees and its dense foliage, which holds soil in place at the roots. The Hindu, November 13, 2019
Mangroves can absorb between 70 and 90 per cent of typical wave energy, which helps to lessen the destructive power of cyclones and tsunamis.
As per the 2007 assessment by the Intergovernmental Panel on Climate Change and a report by UNESCO, a 45cm rise in sea level caused by human activity by the end of the 21st century, along with other kinds of human influence on nature, will destroy 75% of the Sundarban mangroves.

7. CONCLUSION

The role of mangrove forests in minimizing the effect of cyclones on the coast of Sundarbans is very significant and the diverse species of mangroves contribute in its ways. The protection of these species is very significant and the effect of climate change should also be discussed. Try to take a sustainable approach to the conservation of the mangroves because they are very important to minimize the adverse and severe effects of cyclones on coastal areas or deltas like the Sundarbans.

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RECURRING ASSAM FLOODS: An Analysis

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ABSTRACT
Assam is one of the states in the North-Eastern region of India which connects the other six North-Eastern states to the rest of the country. Its geographic area can be divided into three major regions, namely, the Brahmaputra Valley, the Barak Valley and the Hilly areas of Karbi Anglong, North Cachar and Mikir Hills. Assam is a flood prone region, owing to its topography and climatic conditions, with heavy rainfall during monsoons. Along with natural factors, there also exists human-induced factors which lead to the floods in Assam. Floods hit the state every year, causing damage to the environment, human and animal lives. The Government of Assam has taken measures to mitigate the flood situation, but these measures have not yielded the desired results yet. In order to control the flood situation in Assam, the common people have to work together with the government to improve the situation in the state.

1. INTRODUCTION

Floods refer to the overflow of water on land surface, which usually remains dry. According to the World Health Organisation, "Floods are the most frequent type of natural disaster and occur when an overflow of water submerges land that is usually dry".
Floods can be categorized into for major types:

- Flash Floods- flash floods refer to the fast-moving floods caused by heavy, intensive rainfall. Flash floods occur within a short period, usually within six hours and covers a smaller area.
- Riverine Floods- riverine floods refer to the overflow of water in the river valleys and floodplains, caused by the overflow of river water due to heavy excessive rainfall, or snowmelt.
- Coastal Floods- coastal floods refer to the overflow of water caused in the coastal areas due to high tides and storm surges associated with tsunamis and tropical cyclones.
- Urban Floods- urban flooding refers to the water overflow in urban areas, owing to poor drainage systems.

There are a number of factors which causes the occurrence of floods, which include both natural as well as human induced factors. One of the biggest natural causes of floods is heavy rainfall. When the amount of rainfall exceeds the absorbing capacity of the ground surface, it leads to the occurrence of floods. The other major causes include sea overflow, also known as Storm surges; and rapid melting of snow. Some of the human-induced causes are deforestation; dam failure and breakage; and urbanisation which leads to the creation of impermeable surfaces.
The impacts of floods are disastrous. Floods have negative impact on human & animal lives, as well as the environment. It leads to the loss of human and animal lives, destruction of properties, erosion and siltation, and spreads diseases in humans and animals.

According to National Disaster Management Authority, Government of India, in India, floods ruin 1.5 million hectares of land annually on average, taking 1600 lives and damaging homes, agriculture, and public utilities worth Rs. 1,805 crores.

2. STUDY AREA

2.1. Location

Assam is a state in India's northeast region. The state extends from 24^0 N to 28^0 N and 89^0 $45^/$ E to 96^0 $00^/$ E latitudes and longitudes respectively. It spans over 78,438 square kilometres in terms of area. Assam shares its boundary with seven Indian states namely, Arunachal Pradesh, Meghalaya, Tripura, Nagaland, Mizoram, Manipur, and West Bengal; and two countries- Bhutan and Bangladesh.

2.2. Physiography

Assam's physiography can be categorized into three regions:

- The Brahmaputra Valley: The Brahmaputra Valley is the largest and most significant physio-geographic region in Assam. It is formed by the Brahmaputra River and its tributaries, creating a vast alluvial plain. The valley is characterized by fertile soils, making it an essential agricultural region. It is known for tea plantations, rice cultivation, and other crops. The annual flooding of the Brahmaputra River contributes to the fertility of the soil:
- The Hills & Plateaus: The hilly and plateau regions of Assam include areas like Karbi Anglong, North Cachar Hills, and the Mikir Hills (Karbi Hills). These areas are characterized by undulating terrain, hills, and dense forests. The hills are inhabited by various indigenous communities, each with its distinct culture and traditions. The topography contributes to the region's biodiversity, and it is home to several wildlife sanctuaries and national parks.
- The Barak Valley: Located in the southern part of Assam, the Barak Valley is another significant physiogeographic region. It is formed by the Barak River and its tributaries. The valley is known for its tea gardens, agriculture, and diverse cultural influences.

2.3. Climate

Assam's climate is characterized by Tropical Monsoon type of climate, with heavy rainfall and high humidity. The temperature here during summer varies between 30^0C to 36^0C, and during winters, it varies between 10^0 C to 12^0 C. During the monsoon months of June to September, Assam experiences about 1606 mm of average monsoon rainfall, which accounts for about 70% of the annual rainfall. Heavy rainfall occurs in the Brahmaputra when the eastern part of the monsoon trough shifts towards north, this is also known as the period of 'Break in monsoon', which sets in over the rest of India as the monsoon trough shifts northwards to the foot of the Himalayas.

2.4. Drainage

Assam mainly consists of two drainage systems- the Brahmaputra River and the Barak River. The average width of the Brahmaputra valley is about 80 km. At an elevation of 5300 meters, the river originates in the Himalayan Kailash ranges. Some of the major north bank tributaries of the river Brahmaputra are Subansiri, Ronganadi, Dhansiri (North), Manas, Beki, etc., and some of the south bank tributaries are Noadehing, Buridehing, Dhansiri (South), Jinjiran, etc. All the tributaries are rain-fed, and see a significant number of flood waves. If the flood of the Brahmaputra and its tributaries coincide, it results in severe damage and destruction.

At a height of around 2,995 meters, the Barail Range in the Naga Hills feeds the river Barak, which flows into Assam at 24° N latitude and 93° E longitude. Excluding two hill districts, the geographical area of the Barak Valley is of 6922.00 sq. km. The major tributaries of the valley include the Jiri, Chiri, Modhura, Longai, Sonai, Rukni, and Singla. When precipitation happens, the tributaries, which are primarily fed by rain, cause flooding problems.

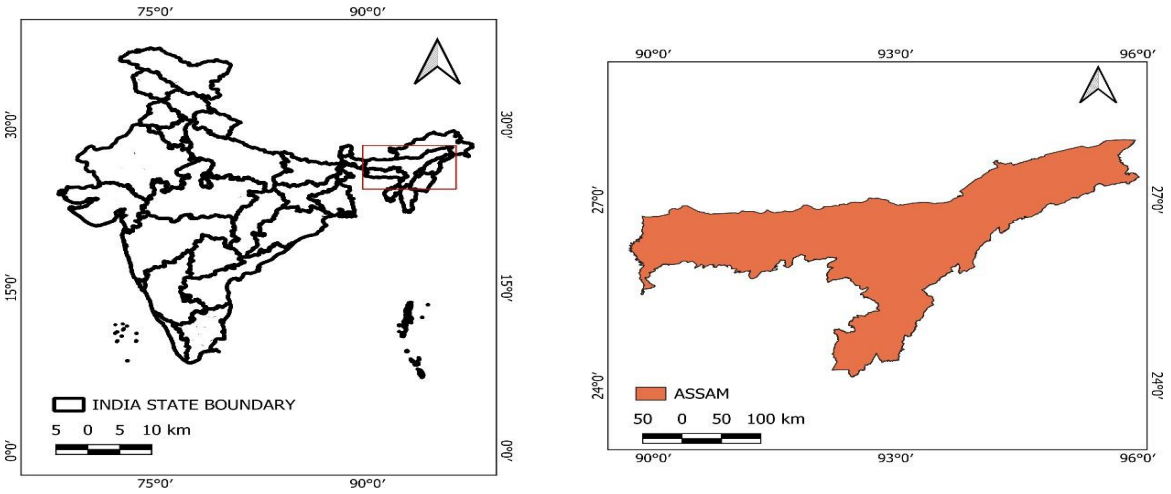


Fig. 1: Map of Assam

3. MATERIALS AND METHODS

The Brahmaputra basin in India experiences massive floods that are known for their frequent occurrence, enormous size, and widespread destruction. The greatest flood [72,748 cubic meters per second (m3s1)] that has been recorded in Pandu over the past forty years happened in 1962. More recently, however, the 1988 flood seems to have been the most destructive, inundating 62% of the Brahmaputra valley in Assam and marked by the highest flood height ever recorded at Pandu. With a recurrence interval of 2.56 years, the river at Pandu has an average yearly flood flow of 47,608 m^3s

Table 1: Losses due to flood in Barak Valley during 2018, as on 25th June 2018

Numbers	Cachar	Hailakandi	Karimganj	Total
No. of villages affected	173	231	314	718
Total cropped area affected (ha)	961	1,890.65	1,150	4,002.65
Population affected	1,06,259	2,05,520	2,36,914	5,48,693
Animals affected	1,52,551	2.03,900	2,84,570	6,41,021
Houses damaged	749	1,902	1,425	4,076
Human lives lost	2	2	1	5
No. of ponds submerged	545	799	1130	2474

Source: A. Borah, Dr. S Barman, 2019, Flood Havoc and Its Strategic Management for Enhancing Farmers Income in Barak Valley Zone of Assam

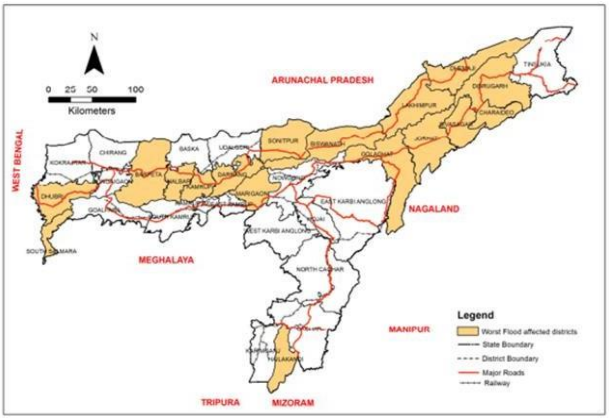
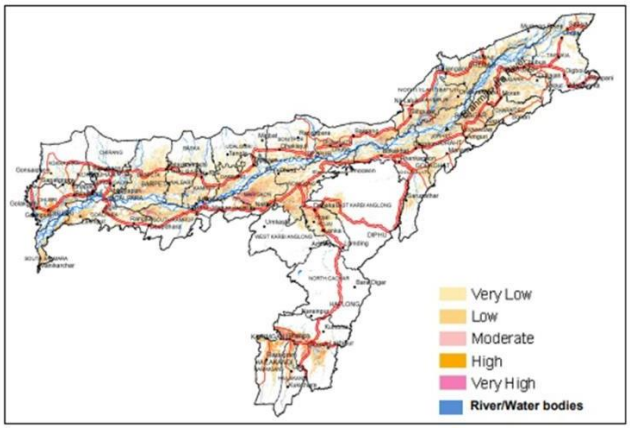


Fig.3: Flood Hazard Map of Assam

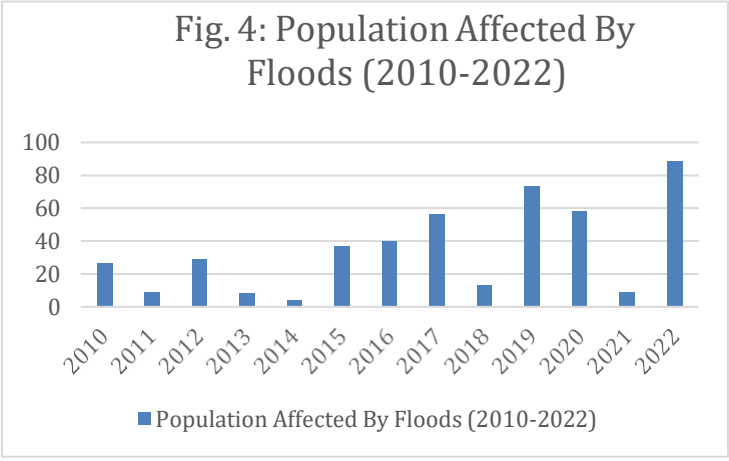


Source: Flood Hazard Atlas for Assam State; NRSC, ISRO

Table 2: Flood Hazard Area under various categories

Sl No.	Hazard Severity	Flood Hazard Area (ha)	% Flood Hazard (wrt state Geographic area)	% Flood Hazard (wrt Total Flood Hazard Area)
1	Very High	48490	0.62	2.16
2	High	106659	1.36	4.73
3	Moderate	282783	3.61	12.54
4	Low	556080	7.09	24.66
5	Very Low	1260562	16.07	55.91
	Total	2254574	28.75	100.00

Source: Flood Hazard Atlas for Assam State; NRSC, ISRO



Source: Assam Floods 2022- Flood Memorandum to the Government of India; Government of Assam

Table 3: Short-term Flood Control Measures Undertaken by the State of Assam

Sl. No.	Brahmaputra Valley		Barak Valley		
1	**Embankments**		**Embankments**		**4458.60 km**
	Brahmaputra	1016.187 km	Barak	251 km	
	Tributaries	2681.24 km	Tributaries	510.17 km	
2	**Anti-erosion/town protection schemes**	531 nos.	**Anti-erosion/town protection schemes**	156 nos.	**689 nos.**
3	**Drainage Channel**	599 km	**Drainage Channel**	251.69 km	**850.69 km**
4	**Sluices**	56 nos.	**Sluices**	29 nos.	**85 nos.**
5	**Raised Platform**	3 nos.	**Raised Platform**	-	**3 nos.**

Source: Flood Hazard Atlas for Assam State; NRSC, ISRO

Methodology:

Information that has been gathered and processed by another party for a reason other than one's own present investigation or analysis is referred to as secondary data. In other words, it is information that already exists and has been obtained in the past by people, groups, or agencies for a variety of purposes, including market research, scholarly investigations, official reports, or business operations

Data has been collected from various articles, government-published reports and government websites.

4. RESULTS & DISCUSSION

The data gives us the insight of the places of Assam affected by flooding and the amount of destruction caused by floods. Most of the districts in upper-Assam is prone to disastrous floods. In lower-Assam, the worst flood affected districts are Hailakandi, Cachar and Karimganj districts.

4.1. The major causes identified for the Recurring Assam floods are-

- Monsoon: The Brahmaputra valley receives an average annual rainfall of 1100 mm. Of this, 70% of the rainfall occurs during the monsoon season. The normal average rainfall of the Barak valley region is 2954.87mm. This leads to the rise in the water level, causing disatrous floods in most of the districts of Assam.
- Vast River Networks: Assam has a vast network of rivers, the Brahmaputra and the Barak being the major rivers of the state, with more than fifty tributaries feeding them. The state also receives river water from neighbouring states of Arunachal Pradesh and Meghalaya.
- Dams: Unregulated release of dam waters from uphill also leads to the influx of water in the state, causing flood.
- Deforestation and unplanned urban expansion: Rapid urban growth and decreasing forest cover also contribute to the floods in Assam. In addition to this, poor drainage systems lead to the accumulation of rainwater in the cities and towns, which ultimately leads to widespread floods.

4.2. Issues & Challenges:

- One of the major issues faced by the state is river bank erosion, which is intensified due to floods in the rivers Brahmaputra and Barak, and their tributaries. Since 1950, more than 4.27 lakh hectares of land have been eroded away by the Brahmaputra River and its tributaries, posing a severe threat to the state's banks. Around 8000 hectares of land are lost per year on average. Due to bank erosion, the Brahmaputra River's width has expanded to as much as 15.00 km in several locations.
- Floods pose great challenges for the people of Assam. Every year thousands of people relocate themselves, and many lives are lost as well. People face serious issues like spreading of diseases, lack of drinking water, supply of food and healthcare systems. The everyday activities of the people of the state are also adversely affected. Schools, offices, banks, and other institutions remain closed, which interrupts the lives of all.
- The state also faces huge economic losses due to floods. Infrastructures like buildings, power and communication lines, get damaged. People cannot travel due to road blockages, which interrupts all the economic activities. Huge quantity of crops and large areas of agricultural fields get destroyed due to the floods. The farmers incur huge economic loses due to the floods and the small scale farmers often tend to get into debts and poverty. The state also has to incur huge expenses for mitigation purposes.
- The flora and fauna of the state is also widely affected due the floods. It leads to uprooting of trees, soil erosion and loss of animal lives. According to the Assam Flood Memorendum, 2022 published by the Government of Assam, 373 big aniamls, 1675 small animals, and 55875 poultry (birds) lost their lives during the 2022 Assam floods.

4.3. Mitigation:

Assam's flood management efforts began primarily following the announcement of the National Water Policy. Following this, a "outlined plan for flood control in Assam" and other plans were created, and the areas of priority that require urgent attention were identified.

Up until now, the main goals of the Water Resources Department's activities have been the safeguarding of important townships in the Barak and Brahmaputra valleys as well as the overall growth of the rural sector. Schemes have also been put into place to lessen the drainage congestion in cities and other important areas.

Since the start of the second five-year plan, till present, the Water Resources Department of Assam has been putting the following flood management plans into practice:

1. Building flood walls and embankments
2. Bank protection and river training programs
3. Town protection and anti-erosion projects
4. Channelization of rivers using pro siltation device
5. Sluices and drainage improvement
6. Raised platforms
7. Flood warnings and forecasts
8. Zoning for flooding

Table 4: Physical Achievement of the Flood Management Plans till date

Length of Embankment	4473.82 Km.
Raising & Strengthening of Embankment	655.502 Km
Anti-Erosion and town protection works	911 Nos.
Drainage schemes	874.966 Km
Sluices (Major)	94 Nos.
Sluices (Minor)	545 Nos.

Source: Water Resources Department, Assam

4.4. Way Forward:

- According to the Water Resources Department, Assam, it has only taken immediate and temporary action till date in order to address the state's flood and erosion issues, and no long-term solutions have been put into place. Thus, the Government of Assam should implement long-term meausures in order to mitigate floods in the state.
- People residing in the state should also take initiatives to plant more trees and limit the cutting down of trees.
- Good drainage systems should be maintained in the cities and town in order to avoid water-logging. Investing in resilient infrastructure, including levees, dams, and stormwater management systems can mitigate the impacts of floods and protect critical assets and infrastructure.

5. CONCLUSION

Assam floods are recurring in nature due to the geographical location and topography of the state, which is further induced by several man-made factors. In conclusion, floods are natural disasters that can cause devastating impacts on communities, economies, and the environment. Mitigating the effects of floods requires a combination of preparedness, early warning systems, improved infrastructure, and sustainable land management practices. Additionally, community education and awareness play crucial roles in minimizing loss of life and property damage. While floods cannot always be prevented, proactive measures can significantly reduce their impact and enhance resilience in vulnerable areas.

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Indigenous Water Management System of South Bihar: Ahar-Pyne Role and its Revival

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1. Abstract

Indigenous water management systems provide important insights and answers for sustainable water use and conservation since they are based on years of traditional knowledge and practices. Communities have been able to adapt to a variety of habitats and climate conditions thanks to the systems that have been built and perfected over millennia. Indigenous peoples have preserved a peaceful relationship with water by referring to their ancestral wisdom, which has allowed them to preserve their cultures and their territories.

In order to achieve inclusive and diversified sustainable environmental and social outcomes, Indigenous water management techniques must be acknowledged. By incorporating their expertise into water planning and policy, society may gain from the wisdom of Indigenous peoples, who have a profound awareness of the intricate relationships between water, land, and life.

Keywords: - Indigenous Water Management System, Ahar-Pyne System.

2. Introduction

"Traditional knowledge is a cumulative body of knowledge, know-how, practices and representations maintained and developed by peoples with extended histories of interaction with the natural environment. These sophisticated sets of understandings, interpretations and meanings are part and parcel of a cultural complex that encompasses language, naming and classification systems, resource use practices, spirituality and world-view**"**.

-International Council of Scientific Unions (ICSU, 2002)

Water is a vital natural resource for various everyday tasks including drinking, cooking, gardening, and other domestic uses as well as for commercial uses like fishing and farming. Even though it is a natural resource that is replenishable, concerns about its use, conservation, depletion, and sustainability are constantly growing in the modern world.

As an agrarian state, Bihar is particularly concerned about the current water management system. As is well known, the northern region of Bihar has annual flood-like conditions due to excessive rainfall, whereas the southern region of the state experiences little, dispersed rainfall, resulting in drought-like conditions at some places. This study highlights the alarming rate at which conservation is needed. To combat this, it has been noted that the conventional water management system is essential and that revival is therefore required given the current circumstances.

➢ What is an Indigenous Water Management System?

Indigenous water management systems are traditional, nature-based approaches to managing water resources that have been developed and practiced by native communities over centuries at a place. These systems are often small in scale affordable and made using locally available resources. It comprises a wide range of practices including water harvesting, distribution, cascaded reuse and conservation. It has been observed that indigenous knowledge has been significantly contributed to

the sustainable use and governance of various resources like water. This system provides assured access to drinking water, irrigation and protection from floods including delivering valuable lessons for modern need of water management approaches.

Many international organizations such as UNESCO have recognized the contribution of indigenous knowledge to water governance and its management. Indigenous water management system provides a deep understanding of nature, and the local environment and hence are essential for promoting sustainable development and resilient and inclusive water management practices.

3. Study Area

3.1 Location: -

Bihar (south), which is situated in eastern India between latitudes 24°20'10"N and 27°31'15"N and longitudes 83°19'50"E and 88°17'40"E, is the focus of the study. The state is completely landlocked in the subtropical portion of the temperate zone. Bihar has a transitional position in terms of climate, economics, and culture because it is situated between the humid West Bengal in the east and the subhumid Uttar Pradesh in the west. Its borders are to the north and south, respectively, with Nepal and Jharkhand.

3.2 Topography: -

The North Bihar planes, South Bihar planes, and Bihar Plateau are the three regions that makeup Bihar based on its physical characteristics. The two main characteristics of South Bihar are (a) little to moderate rainfall and (b) stiff, clayey or extremely sandy soils that are particularly retentive of runoff water and have very low water retention capacities. This area has a noticeable north-slope that slopes fast into the Gangetic valley (average fall northwards: 1.13-0.76 m/km). This allows precipitation to flow quickly northward, resulting in floods. Because of all these reasons, harvesting floodwater is the finest alternative here in South Bihar, and this technique works wonderfully for it.

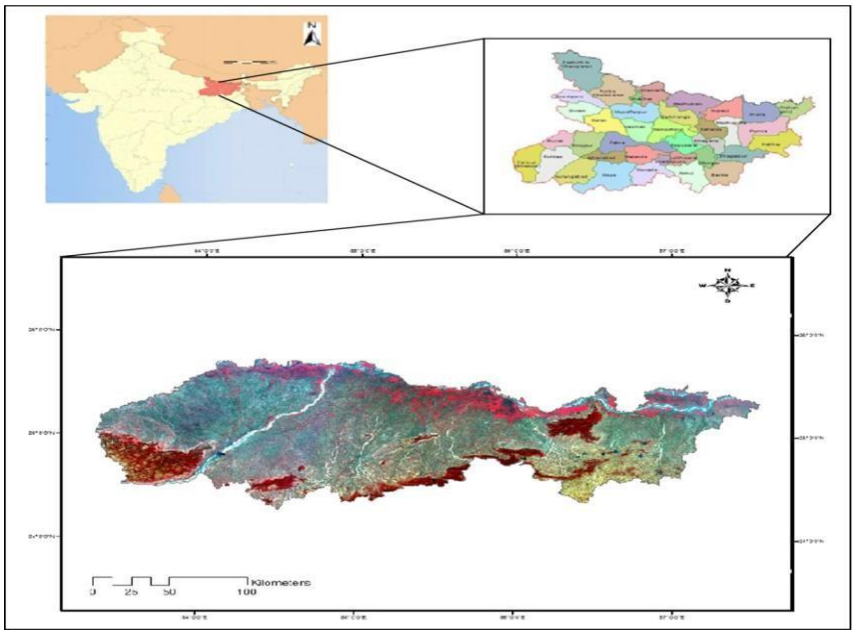

Figure 1: - Study Area South Bihar. Source : - Y. Aradhana 2015.

4. Materials and Methods: -

Historically, South Bihar's primary irrigation source was the indigenous Ahar-Pyne system, which continues to be a model of participatory irrigation management. Although smaller ones are more prevalent, Ahars with sides longer than one kilometer that irrigate over 400 hectares are not uncommon. O'Malley states that this indigenous system developed in response to the challenges that the natural environment and the physical layout of the nation presented to agriculture. The area that is irrigated by Ahar-Pynes is decreasing; it now makes up only around 12% of Bihar's total irrigated land.

Table 1: - Area irrigated by Ahar -Pyne System.

Year	Area irrigated (mha)	Region covered
1930	0.94	South Bihar
1971	0.64	South Bihar
1976	0.55	South Bihar
1997	0.53	Whole of Bihar
Source: Pant,2004 (2)		

In South Bihar, where it was irrigating roughly 35% of 2.5 mha of harvested land during the first two decades of the twentieth century, the Ahar-Pyne irrigation system was far more significant. In contrast, North Bihar's irrigation covered only 3% of the region's 3 million hectares of cropland2. Of the 0.98 mha that were irrigated with ahar-pyne during this time, 0.88 mha were in South Bihar and just 0.1 mha were in North Bihar. The region that this native source irrigates has been steadily declining. The fact that South Bihar's area fell from 0.94 mha in the 1930s to 0.64 mha in 1971 and 0.55 mha by 1975–1976 serves as a barometer for the degree of the reduction.

Table 2: - Timings of Agricultural Operations in Ahar -Pyne System

	Period	Operation
1	June 20 to July 5	Seedbed sowing
2	July 18 to August 15	Transplanting
3	September 12 to September 25	Field water drained out
4	September 25 to October 7	Fields filled again
5	October 8 to October 20	Standing water in fields
6	October 21 to November 3	Field water drained out
7	November 4 to November 15	Harvesting
	Source: Aggarwal & Narain,1997	

The distribution of time for cropping activities, including as planting, watering, and harvesting, is displayed in the above table for the kharif crop(paddy).

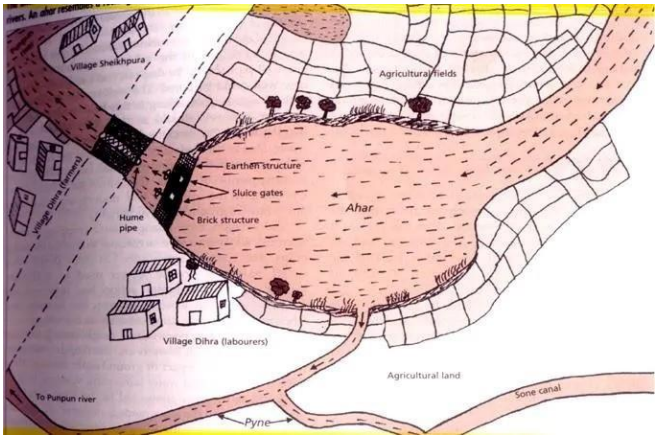

Figure 2: - Diagram of Ahar Pyne System

The traditional floodwater gathering method known as "Ahar-Pyane" is unique to South Bihar. According to the locals, the definition of Ahar is to hold water. The slope in South Bihar is around one meter per kilometre. Using this topography, an embankment that is one- or two-meters high was created in an hour. An Ahar looked like a catchment basin that was rectangular and had embankments on three sides. In order to guarantee the availability of water, Ahar were occasionally constructed at the terminus of tiny ravines or man-made waterways known as Pynes. Pynes were water channels built to harness water flow across the country's rugged terrain. A system of Pynes was typically developed to lead off water from these rivers to agricultural fields because rivers in South Bihar are typically dry for the majority of the year but swell during the monsoon season due to the slope and deep sandy soil. Some of the largest Pynes, which were 20 to 30 kilometers long, fed several distributors and irrigated over 100 villages.

In addition to its irrigation benefits, the system's other usefulness has been well investigated: it may be the cause of South Bihar's high flood risk due to its location between the Gangetic Valley and the Chota Nagpur plateau. However, the quantity of storage structures such as Ahars and the extensive dispersal of torrential floodwater into Pynes reduced the rapidity with which the floodwaters moved across South Bihar. Due to the water in some of the South Bihar's smaller rivers being completely spread out over multiple times, they were never able to reach any of the major rivers like the Ganga or Punpun. The Gaya district made considerable use of Pynes and Ahars.

- **Methods: -**

This research study uses secondary data, which is defined as information that has previously been published in print or online form on a variety of secondary sources, such as research papers, journals, and magazines.

This paper essentially presents an overview of the South Bihar Plain's traditional water management system from a variety of secondary sources that were accessible through a variety of platforms.

- **Need: -**

We must resurrect the ancient systems, even though the area that is being irrigated using traditional ways is declining and has largely been replaced by various modern approaches to superficial and groundwater harvesting systems. The following lists the main causes of the same:

1. Delay in major and medium irrigation projects.
2. Easy maintenance, cost and quality.
3. Sustainability in the longer run.

- **Reasons for the success of the Ahar-Pyne system in the past: -**

- Fragmented land holdings and equity in water distribution

- Cheap source of irrigation
- Uniformity in cropping
- Collective action

Revival and Potential of Indigenous Water Management System:-

One of the key initiatives for the security of a livelihood may be reviving this old irrigation infrastructure. The Ministry of Rural Development reported that a key component of watershed initiatives in South Bihar should be revitalizing this system and guaranteeing its good upkeep through community action.The most important thing that needs to be done to bring back traditional water harvesting systems is to integrate modern and ancient designs. In the 1950s, South Bihar saw the implementation of several diversion programs, mostly in the first and second five-year plans. Particularly in the higher levels, the majority of the areas placed under these systems' control had extremely complex indigenous irrigation networks made up of Ahars and Pynes. The planners enhanced the capacity of the run-of-the-river scheme on a rainfed river intended to service a region susceptible to fitful monsoon by including this indigenous system, appreciating its beneficial contribution to subsidiary storage and water distribution. They planned for roughly two-thirds of the command to be irrigated during the crucial hathia period through the Ahars, which were to be filled up from canal networks by drawing as much water as possible during favorable periods of river flow. This was because they were so dependent on the contribution of the existing Ahars. However, in many instances, the planned integration of ahar-pynes with the new schemes was not possible, and as a result, this native system was allowed to deteriorate over time. According to a recent study, there were 44 Ahars under the control of the Upper Mohar Irrigation Project, which covers the districts of Gaya and Aurangabad, compared to 109 during the pre-project period13. This had a negative impact on irrigation.

Conclusion: -

Conventional water management techniques conclude that they are efficient, environmentally benign, and sustainable based on the search results. Since ancient times, conventional water management techniques have served the demands of the local populace. They stimulate social harmony, foster social solidarity, and are profitable. Many old methods are being improved upon, and newer technologies are being developed even further. In a traditional sense, the various augmentation alternatives extend the bounds of the water resource, assisting in balancing supply and demand. To effectively and sustainably develop and safeguard our water resources, all elements of the hydrological cycle and the impact of human activity on it must be comprehended and measured. Precipitation and weather patterns are being significantly impacted by climate change.

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A Case Study of the 2018 Kerala Floods

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ABSTRACT:
Floods are natural disasters that have existed for centuries and continue to pose a significant threat to communities around the world. This is especially true in India, where several states are highly susceptible to this perilous hazard. The floods that ravaged Kerala in 2018 were one of the worst in its history, causing loss of life, property damage, and billions of dollars in economic disruption. The disaster highlights the urgent need for effective flood management strategies that consider the diverse socio-economic and environmental factors that contribute to this natural hazard.
This research paper provides an overview of floods, their causes, impacts, and mitigation measures. By examining the case study of the Kerala flood in 2018, the paper emphasizes the role of various stakeholders in mitigating flood risks, including governments, non-governmental organizations, and the affected communities themselves. The study uses qualitative data collected from secondary sources, including published research papers, reports, and government documents related to floods in India. The paper highlights the critical need for better operation of water coffers in the region and the government's responsibility to invest in flood management strategies that mitigate the adverse effects of this natural hazard.
Thus, floods pose a significant threat to human lives, economies, and the environment. Effective management of floods requires the implementation of comprehensive flood management plans that consider the diverse factors that contribute to this natural hazard. The study emphasises the importance of effective coordination among various stakeholders and the need for the government to invest in flood management strategies that mitigate the adverse effects of this natural hazard. It is crucial to take immediate action to build a sustainable future for ourselves and future generations. We owe it to ourselves and our planet to act now.
Keywords: Geo-environmental hazards, floods, impacts, management strategies, climate change, flood forecasting, Government, NGOs, proactive measures, sustainable future, NDMA.

Introduction:
Natural disasters are becoming an increasingly pressing issue in today's world, with devastating consequences for both the environment and human life. Geo-environmental hazards are a major contributor to this issue, and they can have catastrophic effects on communities, infrastructure, and ecosystems. These hazards, which include earthquakes, landslides, volcanic eruptions, floods, and wildfires, can cause loss of life and displace entire populations. To effectively manage these risks and respond to disasters, it is crucial to have a deep understanding of the nature, causes, and impact of geo-environmental hazards. This article explores the various types of hazards and disasters, how they are caused, and the effect they have on the environment and society. By gaining this understanding, we can work to mitigate the impact of geo-environmental hazards and disasters and protect our communities and environment.
Floods are natural disasters that have existed for centuries and continue to pose a significant threat to communities around the world. Floods can be caused by various factors such as heavy rains, overflowing rivers, coastal storms, and tsunamis. They can result in loss of life, property damage, displacement of people, and economic disruption. Research on floods is therefore crucial to understanding the causes, impacts, and effective ways of mitigating their effects. This paper aims to provide an overview of the floods in Kerala in 2018 The paper will examine a case study of a major flood in Kerala, India in 2018, as well as the role of various stakeholders in mitigating flood risks, including governments, non-governmental organisations, and

the affected communities themselves. Ultimately, this research paper seeks to contribute to a better understanding of floods and the development of effective strategies to manage them. In 2018, Kerala in India experienced one of the worst floods in its history. The floods were triggered by hefty monsoon rains, which caused widespread flooding and landslides throughout the state. The disaster resulted in the loss of hundreds of lives and caused billions of dollars in damage. Despite the challenges faced by the people of Kerala during this time, their resilience and determination in the face of adversity were truly inspiring.

Floods are one of the most devastating geo-environmental hazards that affect millions of people worldwide, causing significant loss of life, damage to infrastructure, and economic losses. India is one of the most flood-prone countries globally, with several states being highly susceptible to this natural hazard. Therefore, it is crucial to study the causes, impacts, and management strategies of floods as a geo-environmental hazard, especially in India.

Study Area:

India is located in South Asia, with a population of over 1.3 billion people. It faces a diverse range of weather conditions, including monsoons, cyclones, and droughts, making it highly vulnerable to natural disasters such as floods. Kerala is a state located in the southwestern region of India. It is known for its beautiful beaches, serene backwaters, lush green forests, and rich cultural heritage. The state's capital is Thiruvananthapuram and its official language is Malayalam. Kerala is famous for its Ayurvedic treatments and is often referred to as the "Land of Ayurveda". The state's cuisine is also popular for its unique flavours and use of coconut and seafood. Kerala is home to several wildlife sanctuaries and national parks, making it a popular destination for nature lovers and wildlife enthusiasts. Kerala has a diverse population with a mix of people from different religions, castes, and ethnicities, making it an ideal location to study cultural dynamics and the impact of social factors on society.

Additionally, Kerala's natural resources and unique geography. The state has a long coastline with several beaches, backwaters, and estuaries, which can be studied in detail to understand coastal processes, erosion, and sedimentation patterns. The Western Ghats mountain range that runs through Kerala is a biodiversity hotspot and a UNESCO World Heritage Site, making it a prime location for ecological studies.

Case Study on Kerela Floods 2018:

The flood tides that destroyed the Indian state of Kerala in 2018 were a woeful memorial of the ruinous goods of climate change. With over 400 people dead and further than a million displaced, it is clear that action must be taken to help similar catastrophes in the future. The findings of a recent study on the causes and hydrological responses of cataracts are intimidating. The study reveals that the decaying of synoptic exertion within the Indian thunderstorm and the moistening of the tropical troposphere were the dominant motorists of the disastrous downfall. These factors are established goods of climate change, which means that we can anticipate further similar extreme rainfall events in the future. The study also shows that cataracts would have been indeed more ruinous under an end-of-century RCP8.5 climate script. The modelled storehouse, which is not affected by full force position(FRL), reveals that on average, over the four budgets that most nearly represented the downfall trends, 34 further capacity would have been needed to handle all the redundant rush that fell during August 2018. This number rises to 54 in an RCP8.5 script. This is a clear suggestion that action must be taken incontinently to help analogous catastrophes in the future. The study highlights the critical need for better operation of water coffers in the region. With the impact of climate change anticipated to be the strongest in the south of the state, the government must take visionary measures to alleviate the goods of these extreme rainfall events. This includes investing in better structures to store and manage redundant water, as well as enforcing measures to reduce hothouse gas emigrations. We cannot go to stay any longer. The cataracts that destroyed Kerala in 2018 should serve as a wake-up call for all of us. It is time to take action to help similar catastrophes in the future. We owe it to ourselves and unborn generations to act now and ensure a sustainable future for all.

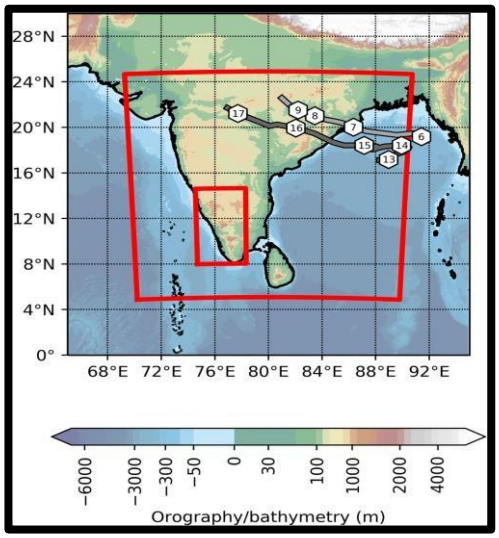

Figure 2: Coverage of the two WRF domains (red), overlaid on a topographic map of India. The tracks of the monsoon low-pressure area and monsoon depression occurring during August 2018 are marked in grey, with markers showing their 00UTC positions for each day

Source: Journal of Earth System Science, 128(6), 144.

The devastating floods that hit the state of Kerala highlight the urgency of effective flood management strategies. The floods, triggered by heavy rainfall, resulted in landslides, flash floods, and riverine floods, causing over 400 deaths and affecting more than 5 million people. The economic losses due to the floods were estimated to be around 4.5 billion dollars. The government of Kerala employed a massive rescue and relief operation that involved using helicopters, boats, and other resources to evacuate people from flood-affected areas. Non-structural measures such as early warning systems, flood forecasting, and community-based disaster management were also employed. The government of Kerala used social media platforms to disseminate information about the floods and provide real-time updates to the public. The state government also involved local communities in the disaster management process, which helped in the effective management of the floods.

The floods in Kerala serve as a reminder of the need for effective flood management strategies that consider the diverse socio-economic and environmental factors that contribute to this natural hazard. Effective flood management requires a comprehensive approach that involves effective coordination among various stakeholders, including government agencies, NGOs, and communities. The government must invest in flood management strategies to mitigate the adverse effects of this natural hazard and protect the lives and livelihoods of millions of people in India.

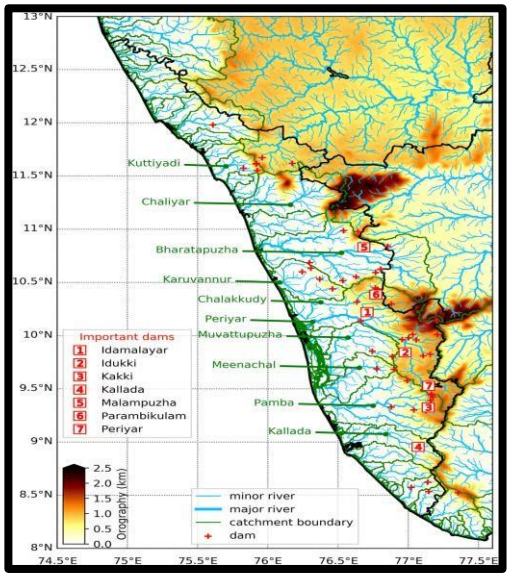

Figure 3: Locations of important hydrological features in the state of Kerala, with state boundaries given in black. Major river catchment boundaries are given in green, with selected rivers labelled accordingly. Plotted river width is a function of Strahler stream order

Source: Journal of Earth System Science, 128(6), 144.

Discussion:

The results of the study reveal that floods in India are caused by both natural and human factors, including heavy rainfall, poor drainage systems, deforestation, and land-use change. Floods significantly impact human lives, including loss of life, displacement, and damage to infrastructure, with economic losses amounting to billions of dollars annually. The management of floods in India involves a combination of structural and non-structural measures, including early warning systems, flood forecasting, and community-based disaster management.

Over five years, from 2013 to 2017, there were a significant number of extreme rainfall events in the Indian region. By combining the INSAT infrared brightness temperature and TRMM-GPM data sets, we were able to observe and analyze the evolution of rainfall and cloud structure with an unprecedented level of detail on a sub-daily timescale. Figure 5 presents a compelling illustration of the impact that extreme rainfall had on the cumulative seasonal rainfall across various regions of the Indian subcontinent. To further our understanding of these intense rainfalls, we used data on the mean cloud heights (inferred from brightness temperatures) for both high-intensity and low-intensity rainy pixels. Our findings provide valuable insights into the dynamics of extreme rainfall events and offer vital information for policymakers and disaster management authorities in the region.

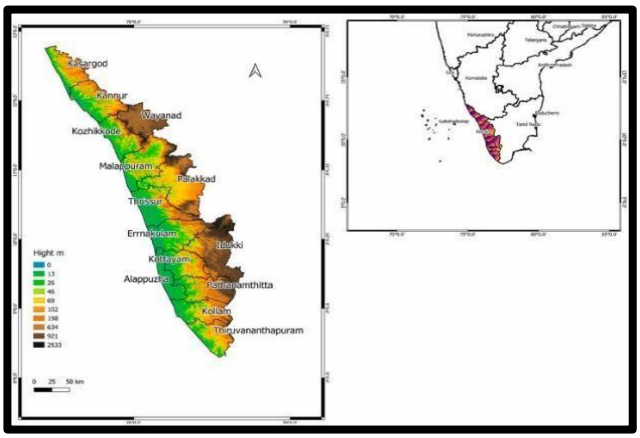

Figure 4: The topography and location of Kerala in the southwest tip of the Indian subcontinent sandwiched between the Western Ghats and the Arabian Sea.

Source: Journal of Earth System Science, 128(6), 144.

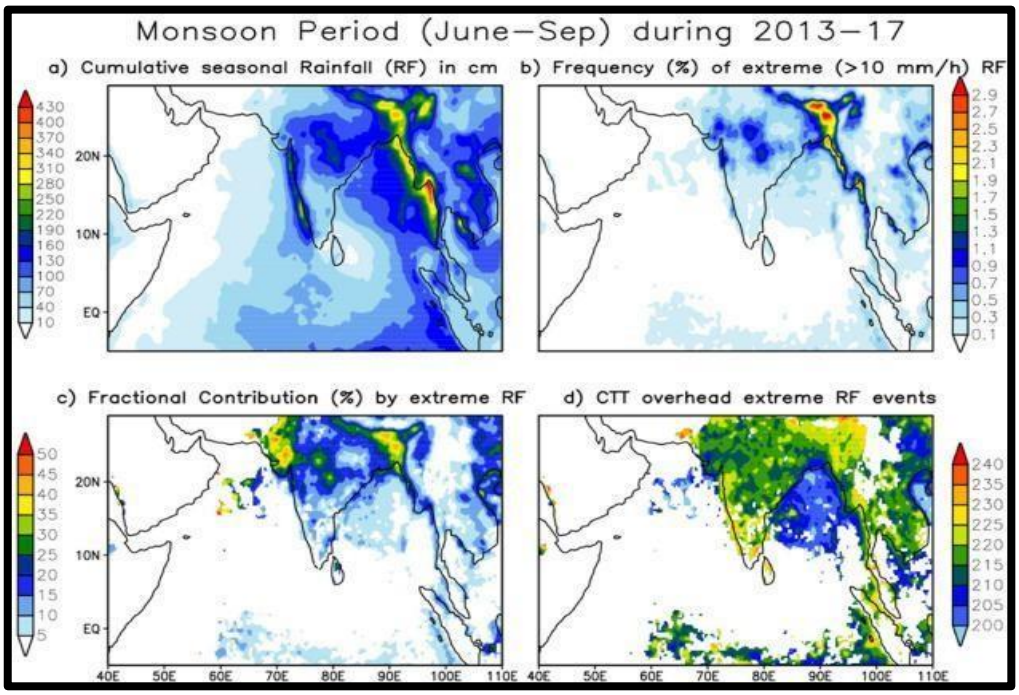

Figure 5: a) Cumulative rainfall in cm for the JJAS period, b) Frequency of occurrence of extreme (>10 mm/h) rainfall events in percentage, c) percentage fractional contribution by extreme rainfall events to the total seasonal rainfall, and d) cloud top temperature overhead the extreme rainfall events. The period of analysis is JJAS during 2013–17.
Source: Journal of Earth System Science, 128(6), 144.

Kerala's extreme rainfall patterns have been a topic of discussion for years, and recent data shows that the state experienced more rainfall in 1924 and 1961 than it did in 2018 from May 1 to August 21. However, the numbers indicate that even during this period, Kerala still received 53% more rainfall than its long-term mean. The research team used the GEV distribution to calculate the return period of extreme rainfall in Kerala during August 2018. The results show that the 1-day maximum rainfall averaged over the entire state had a return period of about 75 years, while the 2 and 3-day maximum rainfall had a return period of about 200 and 100 years, respectively.

Furthermore, the major reservoirs in Kerala had more than 90% of their capacity on August 8th, 2018. Due to unprecedented heavy rainfall in the catchments upstream of these reservoirs, they had to release a considerable amount of water in a short period. Idukki, Kakki, and Periyar reservoirs, which were already almost full, experienced extreme rainfall with a return period of more than 500 years. These findings suggest that improved forecasts of seasonal and extended-range rainfall, as well as extreme rain events at a longer lead time, could have helped in better reservoir operations. The combination of above-normal seasonal rainfall, state-wide extreme rain, high reservoir storage, and unprecedented extreme rain in catchments upstream to major reservoirs played a significant role in the large-scale flooding in Kerala. Understanding these patterns and implementing proactive measures can help Kerala better prepare for future natural disasters.

Conclusion:

The 2018 floods that ravaged Kerala were an unprecedented natural disaster that took the lives of over 400 people and caused massive destruction to infrastructure, property, and crops. The floods were caused by weeks of heavy monsoon rains, which led to rivers overflowing and inundating entire regions. However, the response of the government and stakeholders to this calamity was found wanting. While some efforts were made to evacuate people from affected areas and provide relief, the response of the government was criticized as slow and inadequate. People were left without power, clean water, and medical aid for days, exacerbating their misery and suffering.

Furthermore, there were also concerns about the role of infrastructure development and environmental degradation in worsening the impact of the floods. Experts pointed out that the government's focus on building dams and other infrastructure projects in the region may have contributed to the flood's severity by disrupting natural water flows and exacerbating soil erosion. Thus, the 2018 floods in Kerala brought to the fore the urgent need for better disaster preparedness and proactive measures to address the root causes of such crises in the region. While the government and other stakeholders did make some efforts to respond to the disaster, much more needs to be done to safeguard the lives and livelihoods of those living in flood-prone areas. It is crucial to act now to prevent such a disaster from happening again.

The National Disaster Management Authority (NDMA) was instrumental in managing the devastating Kerala floods of 2018. As a government agency responsible for disaster management in India, the NDMA mobilized crucial resources and support to aid in the rescue and relief efforts during the floods.

Collaborating with the state government and other stakeholders, the agency provided timely assistance and support to those affected by the floods, facilitating the evacuation of stranded people and providing vital food, shelter, and medical aid to those in need. Additionally, the NDMA deployed its technical expertise to mitigate the impact of floods by improving flood forecasting and early warning systems. The NDMA's efforts were pivotal in managing the crisis, minimizing the loss of life, and preventing further property damage caused by the floods. The NDMA's proactive and coordinated response to the Kerala floods is a testament to its crucial role in disaster management. It highlights the importance of investing in effective disaster management strategies to protect communities and minimise the impact of natural disasters.

Floods pose a significant threat to human lives, economies, and the environment. India is a highly vulnerable region due to its geographical location and land-use patterns. The Kerala flood of 2018 serves as a painful reminder of the catastrophic consequences of floods and extreme precipitation events. To prevent such calamities, studying floods as a geo-environmental hazard in India and understanding their underlying causes is essential. Floods in India are caused by both natural and human factors, and their management requires a combination of structural and non-structural measures. The Kerala government's response to the 2018 floods, including early warning systems and community-based disaster management, was commendable. However, proactive measures to address the key drivers of flood severity are necessary to prevent similar disasters in

the future. It's time to take responsibility and work together to protect our environment and communities from the devastating effects of climate change.

In conclusion, floods are a severe geo-environmental hazard in India that causes significant social, economic, and environmental impacts. Effective management of floods requires the implementation of comprehensive flood management plans that consider the diverse factors that contribute to this natural hazard. The study emphasises the importance of effective coordination among various stakeholders and the need for the government to invest in flood management strategies to mitigate the adverse effects of this natural hazard. It is crucial to take immediate action to build a sustainable future for ourselves and future generations.

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FLOOD AND DROUGHT IN INDIA ARE TWO SIDES OF THE SAME COIN

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1. Abstract

This article explores the intertwined dynamics of floods and droughts in India, highlighting their causes, consequences, and mitigation strategies. It emphasizes the increasing frequency and severity of these water-related extremes due to changing climatic patterns and anthropogenic factors. Through an analysis of recent extreme events, the paper underscores the urgent need for holistic water management approaches to build resilience and reduce vulnerability. By examining government initiatives, community engagement, and technological interventions, it outlines a pathway toward a water-secure future for India. Ultimately, it gives insights that addressing floods and droughts requires coordinated action across sectors and stakeholders, underscoring the importance of adaptive capacity and collaborative efforts in confronting the challenges of tomorrow's changing climate.
Keywords – Flood, Drought, River interlinking, Rain water harvesting

2. Introduction

Water is one such essential resource that without it survival of life is not possible however excess of it can also cause calamity and lack of it can cause disaster. Excess water than required can cause floods and on the other hand water deficit can cause drought.

Floods and droughts are extremely negative situations caused due to imbalances of water, we can also say that floods and droughts are two sides of the same coin.

According to IMD flood is a great flow of water especially when a body of water rises in, swelling and overflowing in land usually covered. Generally, flood occurs due to heavy rainfall in the catchment area but sometimes it occurs due to upstream discharge or dam failure.

Drought is the consequence of a natural reduction in the amount of precipitation over an extended time, usually associated with other climatic factors (viz. high temperatures, high winds, and low relative humidity) that can aggravate the severity of the drought event.

Floods and droughts have occurred in the past as well but their frequency has increased in recent years due to changing climatic patterns.

From 1974 to 2003 India experienced 303 disaster events and the number of victims was approximately 1932 a million people (according to CIED USA, 2004)

Flood happens when the water quantity of any region exceeds the normal requirement level damaging the physical infrastructure and economic and social setup of the affected area.

- On average every year 75 lakh hectares of land are affected, 1600 lives are lost, and the damage caused to crops houses, and Public Utilities is Rs 18105 crores due to floods. (according to NDMA)
- 68% of cultivable land is vulnerable to drought, (based on disaster management in India published by the Ministry of Home Affairs Government of India)

3. Study area

India

Location

The Indian peninsula is separated from mainland Asia by the Himalayas the country is surrounded by the Bay of Bengal in the east, the Arabian Sea in the West, and the Indian Ocean to the South

Fig. 1 Map of India (source – www.mapsofindia.com)

Geographic coordinates

India lies entirely in the northern hemisphere, the country extends between 8°4’ and 37°6’ latitude north of the equator and 68°7’ and 97°25’ longitude east of it. Total area 3.3 million square kilometers

Climate

The climate of India can be classified as a tropical monsoon the Indian Meteorological department

(IMD) designates four official seasons

I. Winter from December to early April
II. Summer or pre-monsoon from April to June (April to July in northwestern India)
III. Monsoon or rainy from June to September
IV. Post-monsoon from October to December

Terrain

The mainland comprises four regions namely the Great Mountains zone, the plains of Ganga and the Indus, the desert region, and the southern peninsula.

Coastline

7516.6 kilometers in compassing the mainland Lakshadweep Island and the Andaman and Nicobar Islands

Natural hazards

Monsoon floods, flash floods, earthquakes, droughts and landslides.

4. Materials and methods

Secondary data sources have been utilized and analyzed for this research and data from government websites like the Indian Meteorological Department(IMD), Central Water Commission(CWC), different Indian agencies, and a lot of secondary data which is open source and available for use is used for this research article.

5. Results and Discussion

Flood

A flood is a temporary overflow of water onto land that is normally dry. Floods can result from drains, coastal storms, storm surges, overflows of rivers, and dam failure.

Flood-prone regions/ area

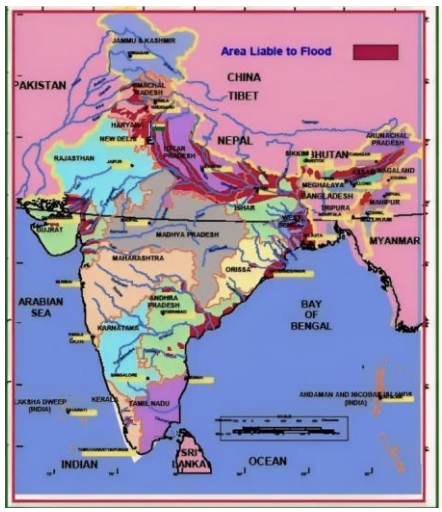

Fig. 2 Flood-prone area of India (source - NDMA Govt. of India)

The Ganga-Yamuna basin states of Haryana, Himachal Pradesh, Uttar Pradesh, Bihar, and West Bengal are prone to floods. Also, Assam gets affected due to floods in Brahmaputra river. The delta parts of river basins of Mahanadi (in Odisha), Godavari, Krishna, Pennar (In Andhra Pradesh), Narmada, Sabarmati and Tapti basin areas in Gujarat are identified as prone to floods. However, of late, the upper reaches of river basins of Krishna, and Godavari caused severe floods in the states of Karnataka and Maharashtra. Even states like Kerala received significant rainfall, in 2018 causing widespread floods and damage to life and property in almost the entire state. The

peninsular India faces flood situation during the retreating NE monsoon cyclones during October-November.

➢ Classification of Floods by Timing

Floods in India can be classified based on their onset timing:

- **Slow onset flood:** Lasting for relatively longer periods, sometimes months, allowing for a gradual rise in water levels.
- **Rapid onset flood**: Occurring suddenly with little warning, posing greater risks to life and property.
- **Flash flood:** Rapid floods that occur within minutes or hours, often caused by intense rainfall, cloud bursts, or dam failures, leaving little time for preventive measures

Causes of floods

Floods in India result from various factors including excessive rainfall, river runoff, faulty agricultural practices, urbanization, deforestation, coastal wind, and tsunamis. The highly sinuous and meandering courses of rivers exacerbate flood risks in many regions.

Consequences of Floods in India

The impacts of floods in India are far-reaching and devastating, leading to loss of human life, infrastructure damage, road closures, erosion, landslides, crop destruction, livestock loss, displacement of housing, economic losses, and threats to aquatic species due to water contamination.

According to India's National Disaster Management Authority (NDMA), the highest death toll from floods in India was recorded at 11,316 in 1977. Government agencies such as the Central Water Commission (CWC) and the India Meteorological Department (IMD) provide data on rainfall patterns, river levels, and flood forecasts.

Table 1. Statements showing important data on damage due to floods or heavy rainfall 1953 to 2016

Year	Affected area in m.ha	Population affected in millions	Cattle lost **Nos**.	Human life lost Nos.	Damage to public utilities Rs crores	Total damages to crops, house, and public utilities(in crores)
1953	2.290	24.280	47034	37	2.900	52.400
1977	11.460	49.430	556326	11316	328.948	1201.848
1978	17.500	70.450	239174	3396	376.100	1454.764
1979	3.990	19.520	618248	3637	233.627	614.203
2013	7.546	25.927	163958	2180	38937.843	47348.751
2015	4.478	33.203	45597	1420	32200.182	57291.098
2016	7.065	26.555	22367	1420	1507.926	5675.325

Total (1953-2016)	460.260	2040.266	6022676	105472	199730.154	347581.201

Data dated 10 May, 2018 CWC

Table 2. Flood-affected area severity categories based district-level 1998- 2022 statistics

Fallout affected area (Ha)	Number of districts affected
>200000	12
1,50,000 -2,00,000	11
1,00,000 – 1,50,000	34
50,000 – 1,00,000	50
25,000 – 50,000	48
10,000 – 25,000	66
5,000 – 10,000	52
1,000 – 5,000	76
100 – 1,000	86
Total	435

Examples of Recent Flood Events

In recent years, India has witnessed several devastating floods that have left a trail of destruction and loss. One such instance occurred in 2018 when Kerala faced unprecedented flooding. The heavy monsoon rains caused rivers like Periyar, Pamba, and Chalakudy to overflow, leading to widespread inundation. The floods claimed over 400 lives and displaced around 1.4 million people from their homes. The economic loss was staggering, estimated at approximately ₹40,000 crores. Additionally, the floods wreaked havoc on the region's biodiversity, causing extensive damage to crops, loss of livestock, and destruction of forests and wetlands.

Similarly, Bihar experienced severe flooding in 2020, affecting millions of people. Overflowing rivers like the Ganges, Gandak, and Kosi submerged vast swathes of land, causing significant damage to infrastructure, agriculture, and livelihoods. The floods claimed hundreds of lives and displaced millions, leading to immense suffering and hardship. The economic losses ran into thousands of crores of rupees, while the disruption of ecological habitats posed long-term challenges for biodiversity conservation.

And in 2015, Chennai was brought to a standstill by devastating floods triggered by heavy rainfall. The overflowing rivers, including the Adyar and Cooum, inundated residential areas, forcing thousands to evacuate. The floods claimed over 300 lives and displaced numerous families, leaving behind a trail of destruction and despair. The floods caused extensive damage to infrastructure, with roads, bridges, and buildings bearing the brunt of the deluge. Economic losses exceeded ₹15,000 crores, while the ecological impact of urban flooding threatened local flora and fauna.

The Uttarakhand floods of 2013 stand out as one of the most catastrophic natural disasters in India's recent history. The heavy rainfall, cloud bursts, and glacial lake outburst floods (GLOFs) led to the overflow of rivers like the Ganga, Yamuna, Alaknanda, and Bhagirathi, causing widespread devastation. The floods claimed over 5,000 lives and displaced hundreds of thousands of people, with economic losses surpassing ₹10,000 crores. The ecological damage to fragile mountain ecosystems was severe, exacerbating soil erosion, loss of biodiversity, and habitat degradation. Similarly, Assam has been grappling with recurrent floods, with the Brahmaputra river often overflowing its banks during the monsoon season. In 2019, heavy rainfall and

overflowing rivers inundated vast areas, causing widespread destruction of homes, crops, and infrastructure. The floods claimed over 100 lives and displaced millions of people, leading to significant economic losses. The ecological impact of the floods posed challenges for wildlife conservation and habitat restoration efforts.

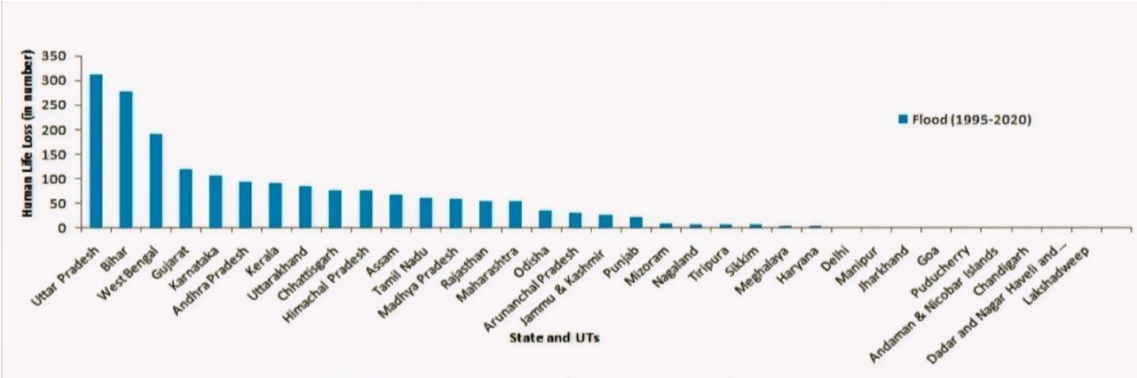

Fig. 3 Annual average number of deaths due to flood incidents at the state level

The Mumbai Floods of 2005 were devastating, causing nearly 1,000 fatalities amidst unprecedented rainfall. Thousands were stranded in flooded streets and trains, requiring extensive rescue efforts. The floods paralyzed Mumbai's economy, disrupting business, transportation, and public services, resulting in billions of rupees in losses. Urban flooding contaminated water sources and harmed green spaces, impacting biodiversity and public health. This event highlighted the vulnerability of densely populated urban areas to extreme weather and emphasized the urgency of better infrastructure and disaster preparedness.

Mitigation Strategies for Flood Management in India

Floods pose a significant challenge to India's development, with recurring events causing extensive damage to infrastructure, agriculture, and livelihoods. While several mitigation strategies have been implemented, there remain opportunities for further action and improvement.

Here are some measures that have been taken and some are upcoming

1. Integrated Water Resource Management (IWRM)

Various IWRM initiatives have been ongoing since the 1970s, with the establishment of river basin organizations and the enactment of the National Water Policy in 2012.

Approximately ₹3,500 crores are allocated annually for river basin management and IWRM projects.

Regional Distribution- Implementation across major river basins, including the Ganges-Brahmaputra, Meghna, Godavari, and Krishna basins, covering states such as Uttar Pradesh, Bihar, Maharashtra, and Andhra Pradesh.

Ongoing initiatives with phased implementation are expected to continue over the next decade, with periodic reviews and updates.

2. Floodplain Zoning and Land Use Planning

Some states have enacted legislation for floodplain zoning and land use planning, with pilot projects initiated in flood-prone regions.

About ₹500 crores was allocated for floodplain mapping and land use planning initiatives.

Regional Distribution- Initial focus on high-risk areas along major rivers such as the Ganges, Yamuna, and Brahmaputra, covering states like Uttar Pradesh, Bihar, and Assam.

Pilot projects are to be completed within the next three years, followed by scaling up to additional flood-prone regions over the subsequent five years.

3. Early Warning Systems (EWS)

Existing EWS infrastructure includes telemetry stations, weather radar networks, and mobile-based alert systems.

About ₹1,000 crores was allocated for upgrading and expanding EWS infrastructure.

It aims to cover all major river basins and coastal areas, reaching approximately 70% of the population in flood-prone regions across states like Assam, West Bengal, Odisha, and Tamil Nadu.

Expansion and enhancement of EWS infrastructure to be completed within five years, followed by continuous upgrades and maintenance.

4. Infrastructure Development and Retrofitting

Construction and retrofitting of flood control infrastructure ongoing in various states, including embankments, drainage channels, and reservoirs.

About ₹10,000 crores is allocated annually for flood infrastructure projects and it targets high-risk areas identified through flood risk assessments, covering approximately 20% of flood-prone districts in states like Bihar, Uttar Pradesh, Gujarat, and West Bengal.

Construction and retrofitting projects are to be completed in phases over the next decade, with priority given to critical infrastructure in densely populated areas.

5. Ecosystem-based Approaches

Ecosystem restoration projects underway in select river basins and wetland areas, supported by government agencies and NGOs.

About ₹2,000 crores allocated for ecosystem restoration and conservation initiatives. It initialy focus on degraded ecosystems with high potential for flood regulation, covering approximately 5% of total wetland and riparian areas in states like Kerala, Uttarakhand, and Madhya Pradesh.

Restoration projects to be implemented over the next five years, with ongoing monitoring and adaptive management.

6. Community Engagement and Capacity Building

Community-based organizations and NGOs actively engaged in flood preparedness and response activities, supported by government funding and technical assistance.

About ₹500 crores was allocated for community-based flood resilience programs.

It is targeting vulnerable communities in flood-prone districts across states like Bihar, Assam, Uttar Pradesh, and Maharashtra.

Capacity building and awareness programs are to be conducted over the next three years, with ongoing support for community-led initiatives.

7. Disaster Risk Reduction (DRR) Strategies

DRR is integrated i were to national and state-level policies, with ongoing efforts to mainstream resilience across sectors.

About ₹3,000 crores were allocated for DRR initiatives, including risk assessments, preparedness measures, and infrastructure upgrades.

This plan covers almost the entire nation with a focus on high-risk areas identified through hazard mapping and vulnerability assessments in states like Assam, Bihar, Uttarakhand, and Maharashtra.

Implementation of DRR strategies is to be phased over the next decade, with periodic reviews and adjustments based on evolving risk profiles.

8. International Cooperation and Knowledge Sharing

Collaborative projects with international organizations are ongoing, focusing on technology transfer, capacity building, and joint research.

It is targeting shared river basins and coastal regions, leveraging global expertise and best practices in states like West Bengal, Tamil Nadu, and Gujarat.

Continuous engagement with international partners, with biennial reviews and updates to collaboration agreements.

By aligning funding allocations with targeted interventions and considering the regional distribution of flood risk, India can enhance its resilience to floods and minimize the socio-economic and environmental impacts of this natural disaster across diverse geographical contexts. Continued investment in flood management initiatives and adaptive management based on lessons learned will be essential for achieving long-term sustainability and resilience.

Drought

Drought is the consequence of a natural reduction in the amount of precipitation over an extended period, usually a season or more in length, often associated with other climatic factors (viz. High temperatures, high winds, and low relative humidity) that can aggravate the severity of the drought event.

With its diverse climatic zones and varied geographical features, India experiences these four different types of droughts

Meteorological drought - According to the India Meteorological Department, meteorological drought over an area is defined as a situation when the seasonal rainfall received over the area is less than 75% of its long-term average value. It is further classified as “moderate Drought” if the normal rainfall deficit is between 26-50% and “severe drought” when the Deficit exceeds 50% of the normal.

Hydrological Drought - Hydrological Drought can be defined as a period during which the stream flows are inadequate to supply established use of water under a given water management system.

Agricultural Drought: It occurs when available soil moisture is inadequate for healthy crop growth and Cause extreme stress and wilting.

Socio-economic drought: Abnormal water shortage affects all aspects of established economy of a region. This in turn adversely affects the social fabric of the society creating unemployment, migration, discontent and various other problems in the society.

These droughts manifest in various regions across the country, each with its unique set of challenges and consequences.

In regions like the Aravali highlands, encompassing areas such as Kachchh and Marusthali, and vast stretches of Madhya Pradesh, eastern Rajasthan, Andhra Pradesh, and Odisha, droughts emerge as severe and recurring phenomena. The adverse effects are felt deeply, with instances of extreme droughts leading to substantial loss of lives, livelihoods, and ecological degradation. For example, in areas like Barmer and Jaisalmer, where annual rainfall barely reaches 90mm, the impact of droughts is particularly severe, exacerbating existing socio-economic vulnerabilities.

These are the Severe drought-prone area Most of Madhya Pradesh, eastern Rajasthan, interior Andhra Pradesh, and Odisha, eastern Maharashtra, substantial portions of the Karnataka Plateau, northern Tamil Nadu, and southern Jharkhand are severe drought-prone areas where also life is hampered by the drought. The consequences of droughts ripple across various sectors, affecting human health, livelihoods, and ecosystems. Reduced water availability and poor water quality pose significant health risks, while declines in agricultural productivity lead to income losses and food insecurity. The toll on mental health, exacerbated by economic losses and personal hardships, adds another layer of complexity to the drought crisis. Moreover, droughts contribute to the displacement of both human and wildlife populations, further straining resources and exacerbating socio-economic challenges.

- The consequences of droughts ripple across various sectors, affecting human health, livelihoods, and ecosystems. Reduced water availability and poor water quality pose significant health risks, while declines in agricultural productivity lead to income losses and food insecurity. The toll on mental health, exacerbated by economic losses and personal hardships, adds another layer of complexity to the drought crisis. Moreover, droughts contribute to the displacement of both human and wildlife populations, further straining resources and exacerbating socio-economic challenges.

Table 3. Summary of major drought episodes

Year	2002	2009	2015
Number of states affected	18	14	11
Number of districts affected	383	338	273
People affected	300 million	400 million	330 million
Cattle affected	150 million	48.03 million	-
Crop area affected	-	30 million hectares	29.89 million hectare
Un-sown Area	18.53 million hectare	47,000,000 hectare	-
Economic loss	3900 crore		-
Economic loss as percentage of GDP	3.10%	0.20%	-

Source Ministry of Agriculture and farmers welfare Government of India

The Great Famine of 1876-78 engulfed vast regions of present-day Maharashtra, Karnataka, Tamil Nadu, and Andhra Pradesh, resulting in one of the deadliest famines in Indian history. Approximately 5.5 million people succumbed to starvation and related

diseases as poor monsoon rainfall and widespread crop failures led to acute food shortages, exacerbating the famine conditions. Following this, the Bengal Famine of 1943 struck Bengal and surrounding regions, claiming between 1.5 to 3 million lives. A combination of wartime policies, supply disruptions, and the failure of the monsoon contributed to acute food shortages and famine conditions. The Drought of 1965-67 ravaged northwestern and central India, including Rajasthan, Gujarat, and Madhya Pradesh, resulting in significant loss of lives due to starvation and related illnesses. Poor monsoon rainfall over consecutive years led to widespread crop failures and severe water scarcity. Similarly, the Maharashtra Drought of 1972 primarily affected the Marathwada region, claiming hundreds of lives due to starvation and related causes. Below-average rainfall and inadequate water management exacerbated the drought conditions, leading to crop failures and water scarcity. Finally, the Odisha Drought of 1986 struck the western and southern districts of Odisha, resulting in several hundred deaths due to famine-related causes. Poor monsoon rainfall and inadequate irrigation infrastructure led to widespread agricultural losses and food shortages, impacting vulnerable populations in the region**.**

In response to the persistent threat of droughts, the Government of India has implemented various measures aimed at prevention, mitigation, and preparedness. Initiatives such as-

- Recognise groundwater potential in aquifers
- Transmit river water from the excess to the shortage areas
- Design for inter-linking of rivers and building of reservoirs and dams
- Use remote sensing and satellite images to identify the possible river basins. These river basins can be interlinked and recognise the groundwater capability
- Distribute knowledge about drought-resistant crops and proper assistance to utilise the same in the long term.
- Rainwater harvesting
- The effect of severe droughts was estimated to have reduced India's gross domestic product by 2 to 5 percent (UNDRR, 2021)

Droughts in India are primarily caused by a combination of natural and anthropogenic factors, including:

- Deficient Monsoon: Irregular monsoon patterns and below-average rainfall contribute significantly to drought conditions.
- El Nino - The El Nino phenomenon, characterized by warming of sea surface temperatures in the Pacific Ocean, often leads to reduced rainfall and drought conditions in India.
- Poor Water Management- Inadequate water conservation and management practices exacerbate water scarcity during periods of drought.
- Deforestation- Large-scale deforestation reduces the natural water retention capacity of forests, contributing to soil erosion and water runoff.

Drought Prevention and Mitigation

- The drought prone area Programme (DPAP) and Desert Development. Programme (DDP) have been implemented by the Government of India since 1973-74 and 1977-78, respectively.

These programmes aim at drought-proofing and reducing desertification of delicate areas. These areas are in the arid, semi-arid, and dry-sub humid regions and are frequently affected by severe drought situations and desertification.

The National Rainfed Area Authority in the Ministry of Agriculture is set up to report the issue of drought mitigation on a long-term basis. It comprises experts who provide knowledge inputs regarding the systematic upgradation of the country's dryland and rainfed agriculture. NDMA guidelines for Drought Management

In 2010, the NDMA issued guidelines for managing droughts that will act as a base for State governments and the Union Territories to minimize the hazard. Its key features are:

- Drought monitoring cells DMCs to be created at the state level
- Use of information and communication technology for real-time drought-related information
- For comprehensive information, the ground-based information is to be collated and synchronized with the satellite-based information to have a broader picture of the onset, occurrence, and severity
- Vulnerability maps must be prepared for each state by the respective state DMCs Agricultural research institutes to research and develop drought-resistant varieties of crops
- Promotion of crop diversification and use of drip and sprinkler irrigation systems All productive animals must be provided with fodder to prevent the distressed sale of animals
- If possible, corporate social responsibility (CSR) initiatives to be coupled with drought management strategies

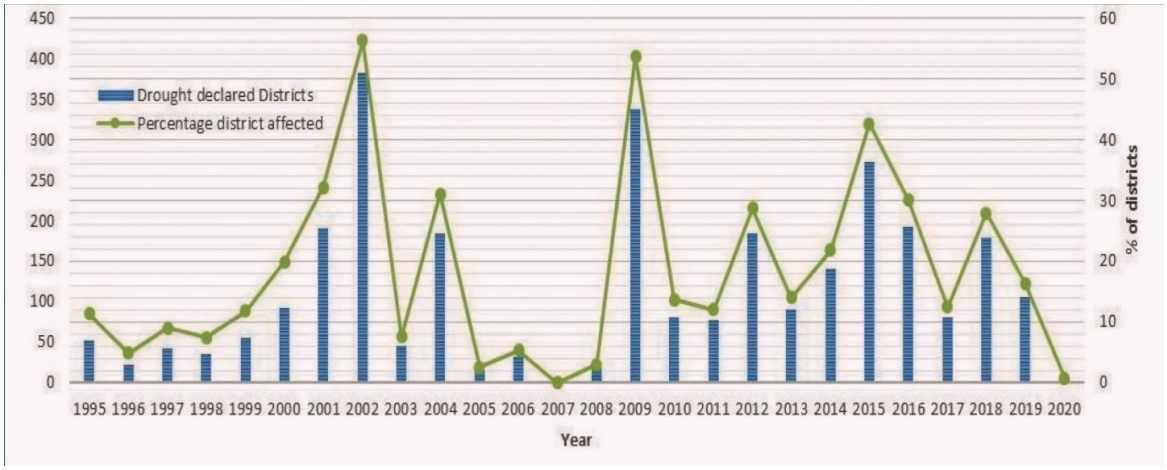

Fig. 4 total number of districts and percentage of dish played as drought affected during 1995 to 2020.

Conclusion and Way Forward of drought

Drought remains a significant threat to India's development and sustainability, it requires coordinated and multisectoral approach to mitigation. By investing in drought-resistant crops, water conservation techniques, and early warning systems, India can build resilience to future drought events. Collaboration between government agencies, NGOs, and local communities is essential to ensure effective drought preparedness and response.

6. Conclusion

In exploring the intricacies of floods and droughts in India, it's evident that these water-related extremes pose significant challenges to the nation's well-being. This paper has delved into

the causes, consequences, and mitigation strategies associated with these phenomena, revealing the urgent need for holistic water management approaches.

From the devastating floods in Kerala to the recurrent droughts in regions like Rajasthan and Andhra Pradesh, the impacts of these extremes are profound, affecting lives, livelihoods, and ecosystems. Through careful analysis, we've outlined a range of interventions—from early warning systems to infrastructure development— that are crucial for building resilience and reducing vulnerability.

Government agencies (IMD, CWC, etc.), NGOs, and local communities play pivotal roles in driving transformative change and fostering adaptive capacity. By leveraging technology, scientific knowledge, and community engagement, India can navigate the waters of uncertainty toward a water-secure future.

After all floods and droughts are not just natural disasters; they reflect broader socio-economic and environmental dynamics. By balancing our responses to these extremes and embracing collaborative action, India can emerge stronger and more resilient, better prepared to confront the challenges of tomorrow's changing climate, and can keep this coin balanced and prevent it from leaning or falling any side.

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- Central Water Commission of India
- India Water Resource Information System

SOCIO- ECONOMIC IMPACT OF MULTI-PURPOSE PROJECTS ON RIVER VAMSADHARA

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Abstract:

In India rivers are one of the most important fresh water sources. Apart from providing water for domestic use they do serve many other purposes, like maintaining the groundwater level to provide livelihood to people. In recent times, we humans have realised the potential of rivers and tried to harness that potential. Thus, we initiated the multipurpose projects a.k.a the dams. However, these turned out to be a double edge swords. Apart from the positive impacts the socio-economic consequences of these projects on the river Vamsadhara of India is discussed. Which also saw and might see the implementation of these projects.

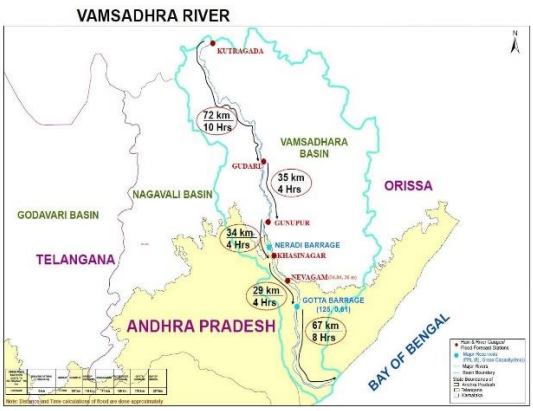
Keywords: Multipurpose projects, River Vamsadhara, Socio-economic consequences

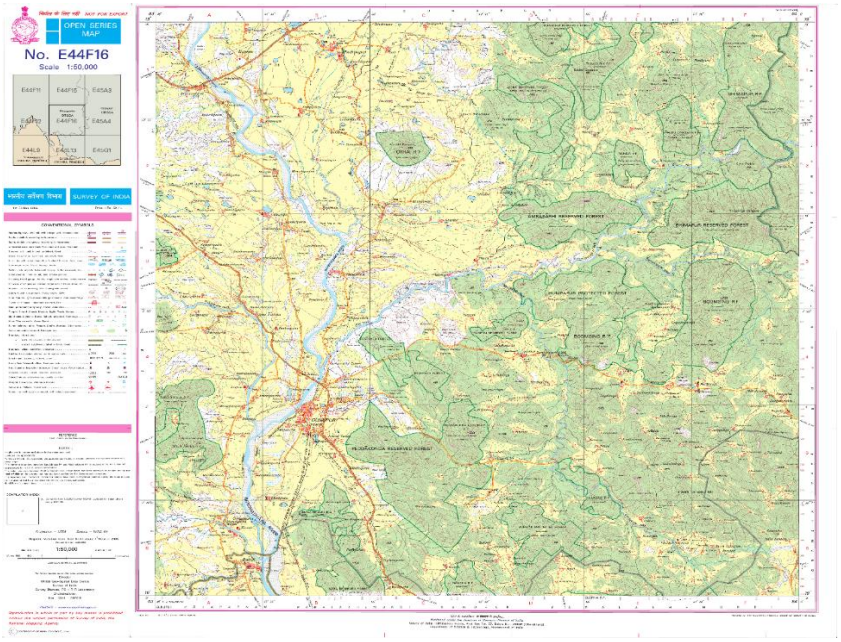
Introduction:

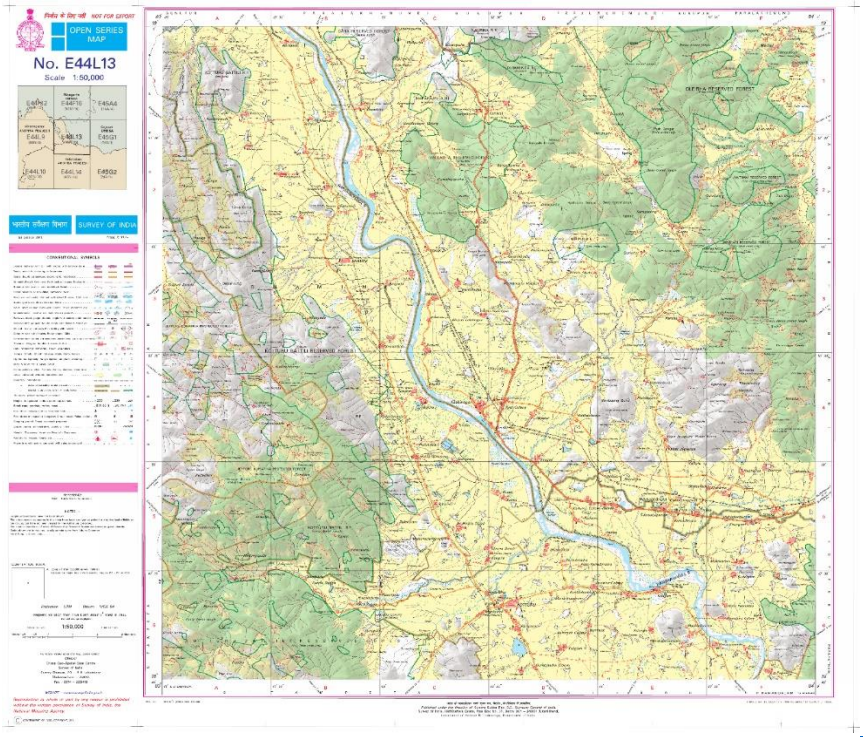
In simple terms, a multi-purpose project is a structure constructed to fulfil multiple needs of people. These structures exist since thousands of years in India. The oldest dams is Kallanai dam in Tamil Nadu and the youngest is Middle Vaitarna Dam in Maharastra.The dams are also known as multi-purpose projects. Dams are built to capture rivers and rainwater for various purposes.They provide water supply for domestic use, water supply for industrial use, generation of electricity, fish breeding, flood control, inland navigation, etc.In India, there are numbers of such project. Apart from these activities they too have severe consequences. They cause displacement of people and wildlife, ecological imbalances, adverse economic impacts, etc.

Study area:

Let's consider the study area, south Odisha and north Andhra Pradesh.







source: survey of india

One major river flow through this region, the river Vamsadhara. The government of Andhra Pradesh has initiated projects like the Lower Vamsadhara project the Gotta barrage, the Heeramandalam reservoirz etc. Whereas the government of Odisha has initiated to construct of structures like Hadubhangi (Harubhangi) dam.

Materials and Methods:

The information is acquired mostly from secondary sources. The method is to analysis, especially the impacts of such projects on the people and river.Here, we have focused on the secondary data available. This includes research papers published by people, the website like google scholar, research gate, etc.

Socio- Economic Impacts and Causes:

The situation of the river itself is very peculiar. The terrain that allows the construction of the dams is present in the state of Odisha and the lands which needs to be irrigated is present in Andhra Pradesh. This means construction of dams in the state of Andhra Pradesh is not feasiable or to simply say it is difficult to construct dams in on the river Vamsadhara in the state of Andhra Pradesh.

The state of Odisha doesn't have the much dams on the river river because the present needs of water for irrigation is met through the usual flow of water in the river. This is not same for the other state.

Nearly 82.86 amount of TMC of water has gone waste to the sea on average, in a water year froUnutilized water[10]

Nearly 82.86 TMC of water has gone waste to the sea on average in a water year from 1 June 2006 to 31 May 2022 (16 years). The yearly water unutilized is given below

Unutilized water

Water year	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22
Unutilized water (TMC)	200.6	129	88.4	66.9	81.6	41.3	55.7	127.2	156.1	25.21	36.61	87	109.7	40.1	57.2	23.2

The state of Andhra Pradesh wants to utilize the unutilized water that flows into the sea.

Owing to it several multi-purpose projects were constructed on the river.

The Boddepalli Rajagopala Rao Project or The 'Vamsadhara Project' was constructed on the river Vamsadhara. It has two canal which provides water for the purpose of irrigation and also helps to control the flood.

The right canal gets water from the Gotta Barrage and the left canal gets water from the river Vamsadhara.The Gotta Barrage is built at the upstream, which is near to the confluence of Mehendratanaya river and Vamsadhara river. The construction of other barrages like Neradi barrage and Regulpadu reservoir and other projects are underway to store the water of Vamsadhara river.The Lower Vasadhara Project was initiated to store the water of the Vamsadhara river at Hadubhangi (Harubhangi). It will help in flood prevention, electricity generation, fishng, etc.However, apart from the constructive usefulness, these projects too have severe impacts on the environment and the people.

In recent times, owing to such projects on the river the flow of the water in the some riverbed is reduced. This might affect the ground water level. The reduced flow of water in some areas also effect the fishing communities and the people engaged in the field of agriculture.The fertile land near these projects are submerged or about to submerge. This takes away the livelihood of the people dependent on those lands. This also leads to submergence of vegetation which crater a rich bio-diversity. Moreover, the displacement of people is caused owing to such projects.

The key important factor is the completion period of these projects and the effects caused due to it, delay in the completion of these projects will affect the lives of the people living near the

construction site. The construction materials themselves might become a hazard and the still water in the dam might cause vector-borne diseases.Out of all these there is also a issues of river water dispute among the two states, which are Andhara Pradesh And Odisha. The 'Vamsadhara Water Tribunal', is speciacally made for this purpose.

Conclusion:

The multi-purpose projects are necessary in the modern and technologically driven time. However, there should be proper and appropriate discussion, agreement and acknowledgement among the stake holders prior reaching to a decisive decision.

The damage to the people and environment should be minimum as possible. The role of judiciary becomes more important when the river flows through more than one state.

The impacts of such projects should be accessed in more intrinsic way. As, ultimately the people are going to avail the productiveness of these projects and they are the one who are at-risk. The projects which will be constructed or are under construction should be re-considered by the governments owing to the current impacts and the impacts which are visible owing to previous actions.

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Map of the Vamsadhara River Basin. The red-colored dots represent the... | Download Scientific Diagram (researchgate.net)
Survey of India

Geo-referenced map of the study area

COMPREHENSIVE EXPLORATION OF KASHMIR'S DRY WINTER IN 2023-24

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ABSTRACT

Owning To the influence of various climatic factors like Jetstream, and western disturbance, EL Nino Kashmir valley is struggling with prolonged dry spells and rising temperatures this winter. This is a matter of various environmental concerns. This research endeavors to analyze various possible factors that have led to dry & harsh winters and what are all their implications.

Keywords: jet stream, western disturbance, EL-Nino

INTRODUCTION

Snowfall in Kashmir fascinates tourists across the globe and is critical for local climate, agriculture, horticulture, and water resources.

According to IMD (India Meteorological Department) data Jammu and Kashmir has noticed an 80% deficit in rainfall in December "This January was Jammu and Kashmir's warmest and driest in 43 years says IMD". This harshest and driest winter period in Kashmir is referred to as CHILAI KALAI. The University of Kashmir has said that the valley is witnessing a snowless winter after seven years. According to various researchers & experts, this is a result impact of the changing climate. Climate change has also caused other impacts in the Kashmir region like

- Sinking and melting of glaciers
- Shortage of drinking water
- Extreme weather events like floods, droughts, etc.

During this dry spell, the precipitation levels in Kashmir plummet, leading to decreased soil moisture, reduced river flows, and diminished snowpacks in the mountains. This not only

affects the region's ability to sustain its agricultural activities but also poses challenges for its hydroelectric power generation, which heavily relies on snowmelt-fed rivers. The drier conditions can threaten biodiversity, and heighten concerns over water scarcity for both domestic and industrial purposes. The Valley has experienced a prolonged dry spell with minimal snowfall this winter, reflecting a 79% deficit in December 2023 and a 100% deficit in January 2024. Kashmir is grappling with a severe water crisis as a prolonged dry winter spell has taken a toll on its water sources, raising alarm among officials about the region's water supply.

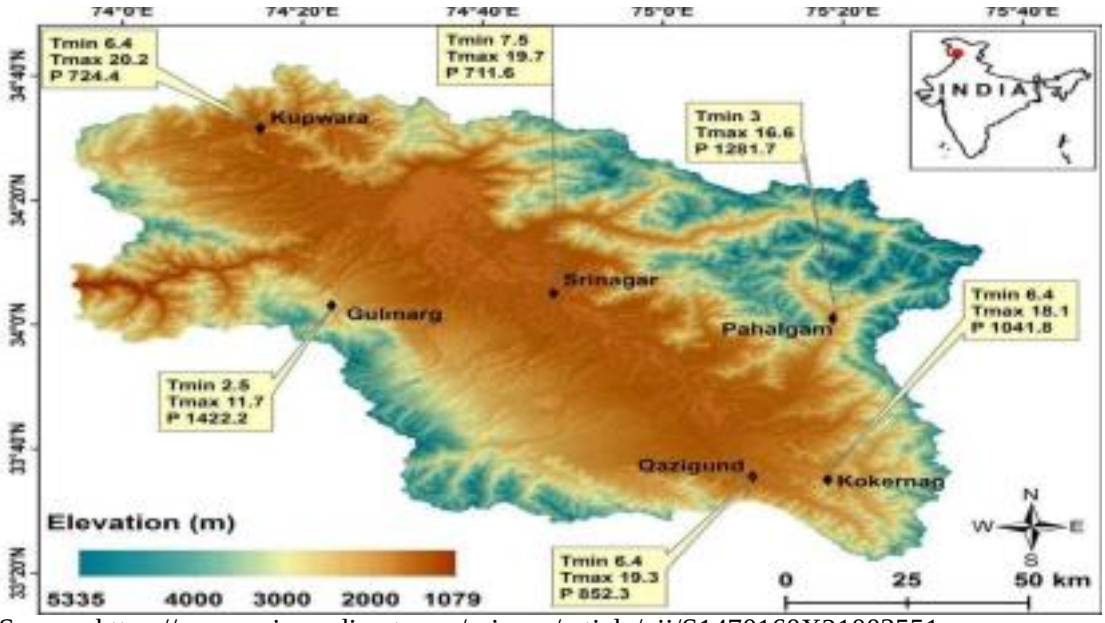
This prolonged dry spell of winter increased temperature in Jammu and Kashmir indicates how climate change affecting our fragile ecosystem. This dry spell of winter in Kashmir impacting the region's tourism industry. Particularly the popular destination sites like Sonmarg, and Gulmarg, etc. this resulted in the cancellation of hotel bookings during this winter period especially in these popular tourist destinations. Which earlier used to be rushed by tourists in winter.

STUDY AREA

This study focuses intensively on the Union Territory of Jammu and Kashmir which is located between 32°17′ and 37°5′ North latitude and 73° 26′ and 80°30′ East longitude. The region has a total geographical area of 42,241 sq. km. Its core area is mountainous and is located in the middle of Asia. India's total mountainous region accounts for 3.5 million hectares wherein two-thirds of the area is covered by Jammu and Kashmir.

The Himalayas in Kashmir have a unique identity of their climate, vegetation, and topography. It enjoys a distinct geographical noteworthiness in the entire Himalayan zone, which lies in the temperate zone. Kashmir is an intermountain valley that lies in the northern Jammu and Kashmir region and stretches between 32°22′ and 34°43'North latitude and 73°52' and 75°42' East longitude. It is drained by the broad Indus River system where Jhelum flows in between this valley. This region of Kashmir valley covers a total area of 15520.3 sq. km with 100 km width. Which is broadly classified into two physiographic zones:- the valley zone and the montane zone. The Valley zone lies at an altitude of 1300-1800 m. above sea level covered by mountains all around the montane zone consisting of various molds and snow-clad mountains with an above elevation of 1800 m. it is covered by valleys, forests & meadows from the surroundings. Both these zones comprise a vast array of habitats which are

typified by their suite of species and physiognomic characteristics.



Source: https://www.sciencedirect.com/science/article/pii/S1470160X21003551

The climate of Kashmir is very unique due to its very harsh topography & vegetation. On account of precipitation and temperature, Kashmir's climate is placed under sub-Mediterranean type. Among the four seasons, Winter is severe & harsh, Summer is mild, Spring is wet and Autumn is drier.

Jammu and Kashmir have a population of around 1.25 crore and the major sectors that account for the region's economy are agriculture, horticulture, tourism, and handicraft. Kashmir is renowned for its scenic beauty and picturesque landscapes. Tourism is one of the most important sectors in Kashmir which has been contributing to its local economy over the years. The tourism industry provides livelihood to a large number of locals, facilitates exchange of the culture, and enhances the economic development in the region. The most popular tourist attractions in the Himalayan ranges are – Gulmarg, Dal Lake, Sonmarg, Shalimar Bagh, Pari Mahal, etc. In particular, during winter there is a large number of tourists attracted to Kashmir because the snowfall intensifies its natural beauty and landscapes.

METHODS OF DATA COLLECTION

Data from this research collected from Secondary data which is refers to the process of gathering information or data that has already been collected, processed, and made available by other sources, rather than collecting data directly from primary sources. This data come from a variety of sources such as books, journals, government publications, websites, and databases.

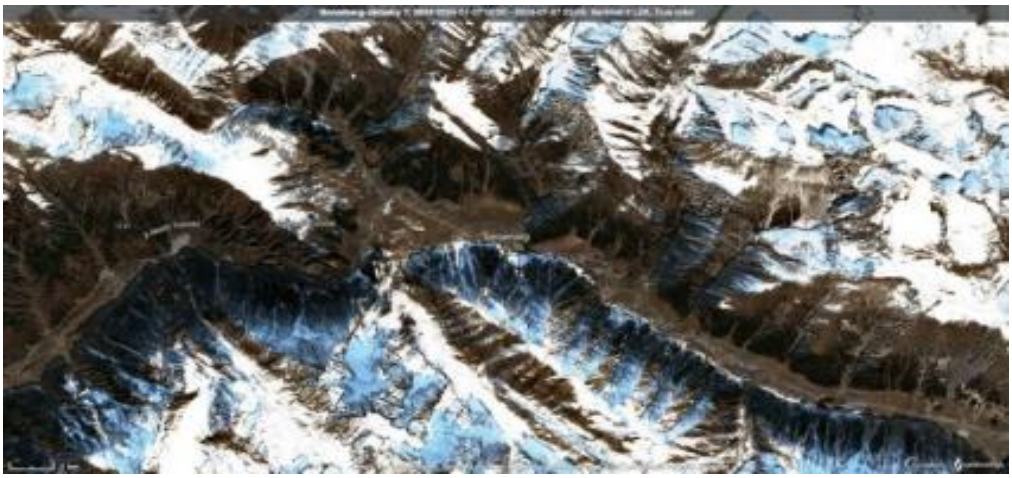
METHODS AND METHODOLOGY

In the past ten years, Jammu and Kashmir experienced drier winters with minimal snowfall, particularly in 2022, 2018, and 2015

Now let's look at satellite images from Google Earth of previous and past years showing significant changes in snow accumulation in the glacier and valley of Kashmir.

Satellite image of Gulmarg taken on January 10, 2024.

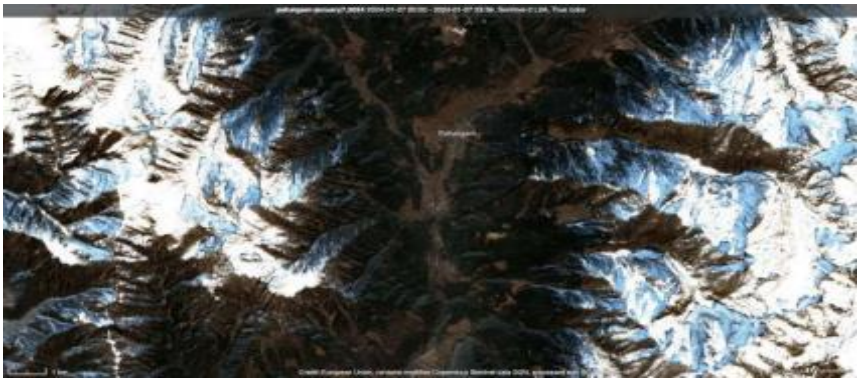
Satellite image of Gulmarg on January 10, 2023.



Satellite image of Sonamarg on January 7, 2024.

Satellite image of Sonamarg on January 7, 2023.

Satellite images of Pahalgam



satellite image of Pahalgam on January 7, 2024.

Satellite image of Pahalgam on January 7, 2023.

This dry spell of winter was taken from the picturesque landscape that defines Kashmir. This not only hampered the visual beauty of the region but also threatened the livelihood of those who rely on the usual snowfall pattern

EXISTING CLIMATIC PATTERN OF KASHMIR—

1. winter precipitation in Kashmir is mainly in the form of snowfall 2. Kashmir normally receives its first snowfall in December and the majority of it in January

CONDITIONS THIS WINTER

- The whole of Jammu and Kashmir has received very little snowfall this winter
- Jammu and Kashmir saw an 80% deficit in this December month
- While the declining trend of snowfall in this region shows the major impact of climate change and other climatic factors

PROBABLE REASONS BEHIND THE DRY WINTER 1) Western Disturbance Events:- Overall decline in intensity and event of western disturbance is a major reason for dry winter in Kashmir.

During winters in the Himalayas and north India region, these western disturbances are responsible for precipitation.

2) Prevailing El-NINO Condition:-

In recent years El-NINO conditions which have persisted over the tropical Pacific region, have impacted the climate of northern India far beyond the Pacific Ocean due to its high intensity.

Historically more than half of the El-NINO Years have caused drought-like conditions in India.

3) Lack Of Strong Jet Stream:-

These are upper air circulation that contribute subsidence of cold air in north India.

Due to climate change warming of the Arctic Sea led to a shift of the jet stream northward which affected the precipitation in Kashmir.

4) Gradual Rise in Temperature:-

The temperature in the region of Kashmir is rising and the rate of increase is seen higher than that of the plains. Some days the temperature is higher than in comparison to Delhi.

5) Impact of climate change:-

- Increasing temperature altered western disturbance
- EL-NINO influence
- Jet stream alteration
- Extreme weather events
- Overall climate change impact

6) Ecological impact:-

Hostels are built by cutting down the forest of Gulmarg. Additionally, the dumping of plastic waste and garbage in forests affects climate and ecological balance.

RESULT

IMPACT OF DRY SPELL IN KASHMIR

1) Decline in crop production especially apple due to drought-like conditions. Or 2) Decline in tourist arrivals by 70% in Gulmarg. Where most of the adventure and sports events like skiing are organized in winter amid snowfall.

3) Impact on 4^{TH} KHELO INDIA WINTER GAMES organized in Gulmarg. Were scheduled to start in the first week of February, might also deferred.

4) Scarcity of water sources due to the absence of snowfall which usually means to provide the water by melting to the rivers and lakes. Which also leads to the scarcity of drinking water

5) Prolonged dry spells and less rainfall lead to a reduction in the generation of

Hydroelectricity or the hydroelectricity power projects across J&K

CONCLUSION

There is a requirement for the adoption of adaptive measures and proper policy to tackle this dry condition in Jammu and Kashmir.

1. Climate Resilient Agriculture: Drought-resistant crops to be grown to ensure sustainable yield during dry winter.
2. Water Management: sustainable management and storage of water is required during low precipitation.
3. Diversification of economies: There needs to a encouragement to have economic grain other than tourism or which depends on precipitation.
4. Disaster preparedness and response: This requires a prepared plan to tackle disasters related to climate change.

These were some cumulative measures that can help in the short term but ultimately there is a need for hours to tackle the climate change problem.

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EARTHQUAKE OF NOTO PENINSULA, JAPAN

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1. Abstract:

This research delves into the seismic event that transpired on January 1, 2024, in Noto Peninsula, Japan, aiming to provide a comprehensive analysis of its geological and structural aspects. Utilizing seismic data, satellite imagery, and ground observations, the study investigates the earthquake's magnitude, epicenter, and depth, along with its repercussions on local infrastructure, communities, and the natural environment. By integrating multidisciplinary methodologies, this research seeks to contribute valuable insights for seismic risk mitigation, urban planning, and disaster preparedness in earthquake-prone regions

KEYWORDS: Earthquake, seismic waves, Noto peninsula, mitigation

2. Introduction

Earthquake, any sudden shaking of the ground caused by the passage of seismic waves through earth`s rocks. Seismic waves are produced when some form of energy stored in Earth`s crust is suddenly released, usually when masses of rocks straining against each other suddenly fracture and slip.The National Earthquake Information Centre says there are about 55 earthquakes a day around the world – that`s 20,000 a year. Most of the time, these earthquakes emerge with low intensity. Though , earthquake with high intensity sometimes may create high devastations, depending on its location.

Earthquake occur more often along geological faults, narrow zones where rock masses move in relation to one another. The major fault lines of the world are located at the fringes of the huge tectonic plates make up earth`s crust. The Ring of Fire is a tectonic belt of volcanoes and earthquakes. It is about 40,000 km long and up to 500 km wide, and surrounds most of the
Pacific ocean. It was created by the subduction of different tectonic plates at convergent boundaries around the pacific ocean.

The Island nation of Japan lies along the western edge of the Ring of Fire and is one of the most tectonically active plates on the Earth. As for this reason, Japan has long history of disastrous earthquakes all over the world while cause loss of lives and damage of assets. Recently, Japan , at the region of Noto Peninsula, have experienced a disastrous earthquake of magnitude of 7.6 onthe Richter Scale at 16:10 on 1st Jan, 2024. The earthquake caused a tremble of an intensity of 7 (says Japan

Meteorological Agency) in Shika Tower and intensity of 6+ and 6- in many

3. STUDY AREA

It comprised of four main islands, from North to South: Hokkaido, Honshu, Kyushu and Shikoku. Among them, Honshu, the largest and most populous island of Japan, consists a peninsular region named as Noto, extending approximately 100 km into the Sea of Japan, is located in Northern Ishikawa region which is well famous for its natural environment and culture. This Noto Peninsular region lies on the DD co-ordinates of $37^0 20`$ N and $136^0 55`$ E.

Japan

Noto Peninsula, Japan

The peninsula is primarily composed of sedimentary rocks, including sandstones, mudstones, and conglomerates, shaped by million of years of geological activity. Its coastline features rugged cliffs, sea caves, and sandy beaches, offering a rich variety of habitats of marine life andcoastal ecosystem along with rich varieties of endangered species such as Japanese crested ibis and Blakiston`s fish owl. The region experiences a temperate climate, with mild winters and warm summers, influenced by its proximity to the sea and surrounding mountain regions, approximately 70 % of Japan`s area consists of mountains and forests. The mean temperature prevailing in the city of Noto is recorded as 13.7^0 C.

3.1 Economy

The economy of the region is influenced by primary activities and industrial activities especiallywith fishing, agriculture textile products industry in the region, with Noto`s Seafood renowned for its freshness and quality. Tourism also play a vital role in developing economy of this region

since it draws attention of visitors to its scenic beauty, cultural attractions and outdoor recreational opportunities. The nominal GDP produced in Ishikawa is about 0.8 % of the total GDP produced in Japan, which is 30th largest among the prefecture. Along with this, textile products industry in Ishikawa is the 7th largest in the nation with a share of 4.8% of the total GDP produced by industry.

3.2 Culture

The peninsula has a rich cultural heritage. It has traditional fishing villages dot coastlines, where communities practice age-old fishing, where communities practice age-old fishing techniques and maintain deep connection to the sea. Occupations such as Ama female free diving fishers are still handed down from generation to generation. Historical temples, shrines, and traditional ryokan offer glimpses into Japan`s cultural past, attracting researches interested in anthropology and cultural studies.

4. Methodology

In conducting this research, secondary data sources were employed as the primary methodology. Utilizing existing datasets, published literature, reports, and other sources, comprehensive information was gathered to address the research objectives. The selection criteria for these secondary sources were based on relevance to the research topic and the credibility of the data. Methodological approaches included thorough review, synthesis, and analysis of the secondary data to derive meaningful insights and conclusions. It's important to acknowledge potential limitations such as data availability, reliability, and inherent biases associated with secondary data sources. Despite these challenges, leveraging secondary data allowed for a robust

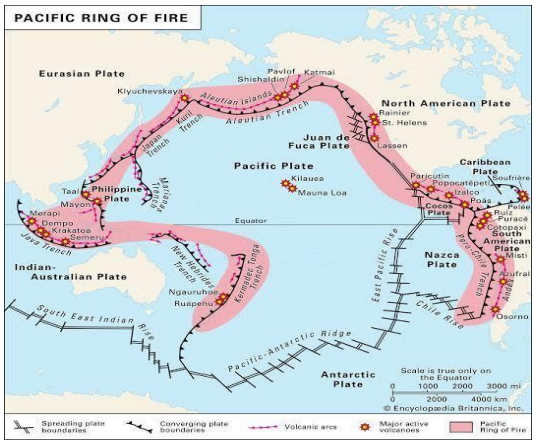
examination of the research questions and facilitated a deeper understanding of the phenomenonunder investigation.

5. Discussion and Results

On 1st January 2024, Western Japan have experienced scenes of devastations in the form of 7.6 (reported by Japan Meteorological Agency) magnitude of Earthquake hitting the region of Noto Peninsula. It is estimated that more than 155 earthquake was observed in a single day.

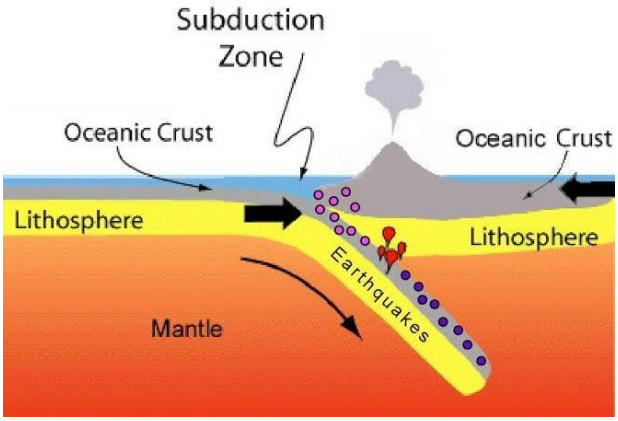
But question is still the same. Why do Japan experiences such earthquakes frequently? Study reveals that location of the Japan is the most important factor beyond such disastrous tremblings.It says that Japan is situated on the location where four tectonic plates come together – the
Pacific plate, the Philippine plate, the Eurasian plate and the North American Plate. This is thebiggest reason why so many earthquakes are experienced in Japan.

Among them, the Pacific plate stands out a bit since it has the highest amount of tectonic activity.So, the boundary of the Pacific plate is known as the Pacific Ring of Fire. It is because this caused the highest number of earthquakes in the world that accounts for 90 % roughly as well as the ring is dotted with 75% of all active. To some extent, this is true for the other plates as well which witness a higher frequency of earthquakes.

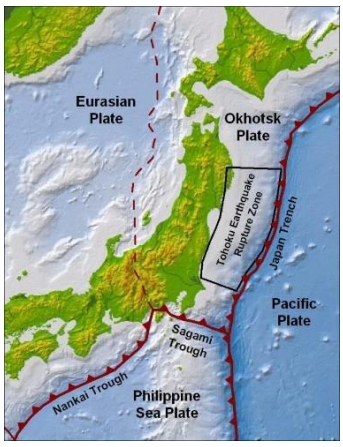


The Pacific Ring of Fire

The boundary of the Pacific plate is a convergent boundary, when one plate collides and slipsunder the other. It generates a subduction zone along with continental Okhotsk plate (a microplate formerly a part of the North American Plate). As Japan is located over this subductionzone thus it is termed as Japan trench, which depth accounts for about 8.4 km , created as the oceanic Pacific plate subducts beneath the continental Okhotsk Plate. Therefore, due to the process of regular subduction , with the rate of 7.9 – 9.2 cm/yr, and as Japan is located directly over on the location , it experiences earthquake frequently. According to the USGS, the earthquake occurred because of shallow reverse faulting on the west coast of Japan where crustaldeformation created by boarder plate motion is accommodated in shallow crustal faults.



Subduction Zone

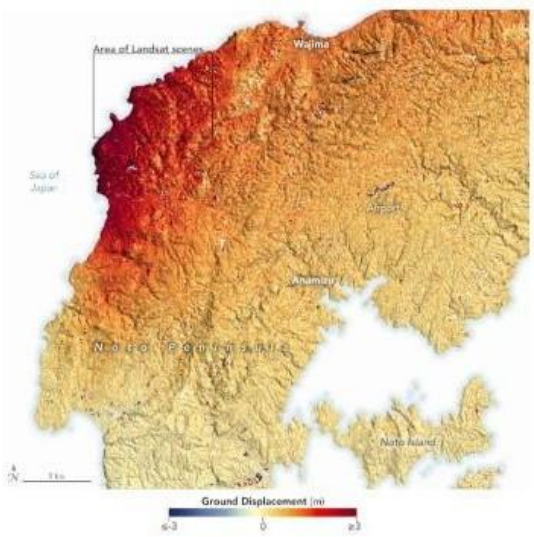


Japan Trench

This study reveals a basic understanding about the reasons beyond why Japan was devastated with such powerful earthquake recently. The tremorous was such hard that Tokyo, almost 500 km away from epicenter of the earthquake, which was Suzu, have felt it. This earthquake have effected Japan in terms of geology, infrastructure, economy, human lives and others.

5.1 Impact on Geology

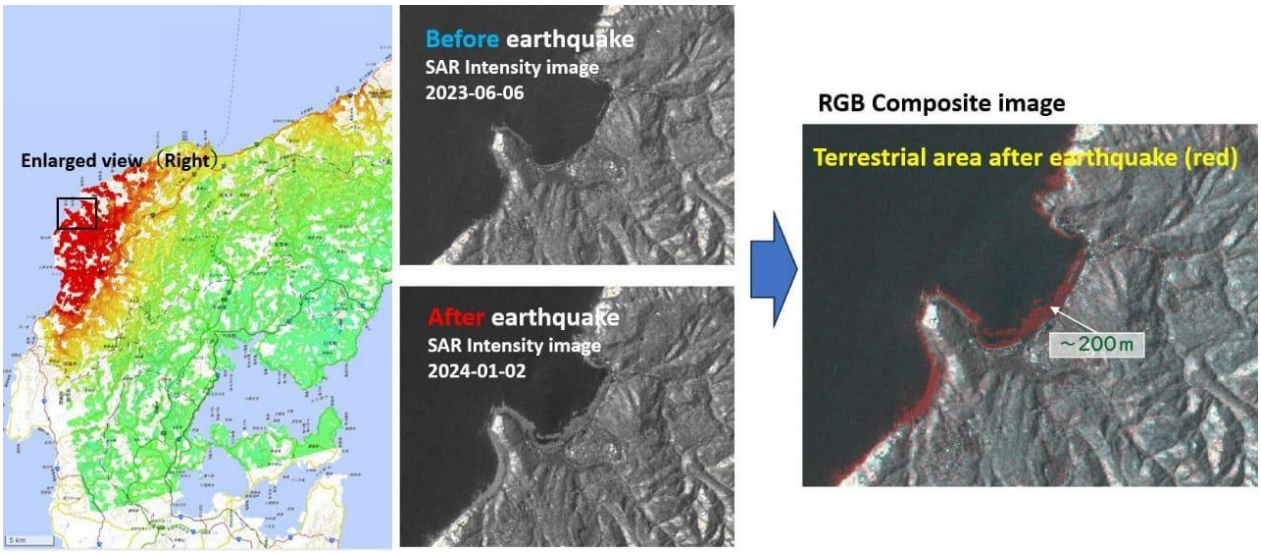
- Eric Fielding, a geophysicist at NASA`s JPL, said that " the surface moved upward asmuch as 4m on some part of the north coast of the Noto Peninsula" of Japan.



Earthquake Lifts the Noto Peninsula

The map above shows the amount ground displacement – the shifting of the land - caused by earthquake . Red areas are pushed upward and towards the Northwest.

- It is also observed that around Minazuki- Bay, the shoreline shifted seaward approximately 200m at most.



Before and After Earthquake

5.2 Impact on Economy

Japanese PM Fumio Kishida says that it is “Battle against Time”. As the govt. said, “ Fullattention should be given to the economic impact” thus PM Fumio Kishida pledged an additional budget 150 billion yen spending from the state budget reserved for a relief of package for the quake-hit area.In addition, the US govt. on 5 Jan announced that it would
provide $100,000 in assistance to Peace Winds Japan, an NGO working in the affected areas.This

is because:

- Moddy`s RMS estimated that total insured losses from Noto Peninsula, Japan earthquakewill likely to fall within the range of between US $ 3 Billion to US $ 6 Billion.
- The earthquake in the northern part of Ishikawa prefecture in the Hokuriku region inJapan on Jan 1 led to shutting down atleast 1.2 GW coal fired power capacity at the Nanao Ota thermal power plant and reducing output at the Toyama-Shinko gas firedpower plants.

5.3 Impact of Human lives and Infrastructure

The Japanese Government applied the Disaster Relief Act towards 35 cities, 11 towns and 1village in 4 prefectures including Niigata, Toyama, Ishikawa and Fukui in order to lead the national-level relief operations.

- As of 14:00 on 9 February, the local government confirmed 241 deaths in Ishikawa prefecture. On top of this, 11 people in Ishikawa prefecture remain unaccounted for.

- According to the data, about 90 percent, died under collapsed homes. About 60 percent of those victims were in their 70s or older. At least 1,291 people were injured. More than 45,231 houses are reported to be collapsed/damaged, which brought about 13,469 people remained in 522 evacuation centers.

- As reported on 14 feb 2024, by “The Guardian”, the lives of 14000 people affected by the New Year`s day disaster.

According to Japan Meteorological Agency, 1.2 m of Tsunami were observed along the westerncoast of Japan, damaged at approximately 160 hectares in Suzu city and Noto City.

Conclusion :

Japan has made significant strides in protecting against earthquakes through various measures such as strict building codes which includes : Taishin Standard (says about minimum thickness of the pillars, walls, and beams of the buildings); Seishin standard (recommended for tall buildings which says to install dampers to absorb the earthquake`s energy) and most advanced one is Menshin Standard(in this the entire structure of the building is isolated from the ground by the help of layers of lead, steel and rubbers); advanced early warning systems, public
education, and disaster preparedness drills. However, given Japan's geographical location and the frequency of earthquakes in the region, complete protection is challenging. While these measures have reduced the impact of earthquakes, Japan continues to innovate and improve its strategies to enhance safety and resilience.

Dealing with earthquakes in high-intensity tectonic zones requires a comprehensive approach that combines various measures to mitigate risks and enhance resilience. Some of the best
measures include:

- Stringent Building Codes: Implement and enforce strict building codes that require structures to be designed and constructed to withstand seismic forces. This includes using reinforced materials, seismic bracing, and flexible building techniques.
- Advanced Early Warning Systems: Develop and deploy sophisticated earthquake early warning systems that can detect seismic activity and provide timely alerts to the public, businesses, and critical infrastructure operators, allowing for preparedness and rapid response.
- Infrastructure Resilience: Retrofit existing infrastructure and design new infrastructure to be resilient to earthquakes. This includes reinforcing bridges, roads, dams, and utilities to minimize damage and ensure continuity of essential services.
- Public Education and Preparedness: Conduct public education campaigns to raise awareness about earthquake risks and promote preparedness measures such as creating emergency kits, developing evacuation plans, and participating in drills.
- Land-Use Planning: Implement zoning and land-use regulations that restrict development in high-risk areas and prioritize safer locations for critical infrastructure, residential areas, and commercial centers.

- Community Resilience Programs: Support community-based initiatives that enhanceresilience at the local level, such as establishing neighborhood emergency response teams, strengthening social networks, and fostering collaboration among stakeholders.
- Disaster Response and Recovery Plans: Develop comprehensive disaster response and recovery plans that outline roles, responsibilities, and procedures for government agencies, emergency services, and private sector partners to coordinate efforts and mobilize resources effectively in the aftermath of an earthquake.
- International Cooperation: Collaborate with neighboring countries and international organizations to share knowledge, expertise, and resources for earthquake preparedness, response, and recovery efforts, recognizing that earthquakes can transcend political boundaries and require a collective response.

By implementing these measures in high-intensity tectonic zones, communities can reduce vulnerability, minimize the impact of earthquakes, and build resilience to future seismic events.

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B.A (H) GEOGRAPHY BATCH (2023-24)

First Year

Second Year

Third Year

GBRDF 10 वां स्थापना दिवस समारोह - 2022, अधिवेशन भवन, बिहार पुराना सचिवालय, पटना

मातृ शक्ति वन्दन समारोह, अभियान (40) IAS

प्रादेशिक

यूपीएससी में सफलता के लिये परिवेश व भाषा बाधक नहीं : प्रो. डीपी अग्रवाल

ईमानदार प्रयास सफलता की राह बनाता है आसान - गिरिवर दयाल सिंह

अभियान -40 (आईएएस) परिसर में सिविल सेवाओं का वर्तमान परिदृश्य चुनौतियां एवं संभावनाएं विषय पर सेमिनार

भानपुर कलां (बीएल कांकरेलिया) सिविल सर्विसेज की तैयारी को लेकर प्रतिभागियों में वर्षों से यह भ्रम की स्थिति रही है कि सफलता के लिए अंग्रेजी माध्यम व बेहतर परिवेश का होना जरूरी है, जबकि ऐसा नहीं है। सच्चाई यह है कि यूपीएससी में सफलता के लिए भाषा एवं परिवेश कभी बाधक नहीं बनती। आज भी यूपीएससी में सफल होने वाले ज्यादातर प्रतिभागी ग्रामीण परिवेश के होते हैं। इसी प्रकार, भाषा ज्ञान प्रकट करने का सिर्फ माध्यम है न कि उसका मापन। ये बातें यूपीएससी के पूर्व अध्यक्ष प्रो. डीपी अग्रवाल ने रविवार को जयपुर के मानसरोवर स्थित अभियान - 40 (आईएएस) में %सिविल सेवाओं का वर्तमान परिदृश्य चुनौतियां एवं संभावनाएं% विषय पर आयोजित राष्ट्रीय सेमिनार में कही। सेमिनार में बिहार कैडर के आईएएस गिरिवर दयाल सिंह, फाउंडेशन के संस्थापक सह राष्ट्रीय अध्यक्ष बिलास कुमार, जीएसटी के अपर आयुक्त मोना शर्मा, डॉ. निशा शर्मा, पटना विश्वविद्यालय के अतिथि शिक्षक व भूगोल विषय के विशेषज्ञ प्रमोद कुमार, आवड़दान, दीपक कुमार, सेवा निवृत्त आरएएस पदाधिकारी उमेश सिंह तोमर, अभिषेक वर्मा समेत कई गणमान्य लोग शामिल हुए। सेमिनार में, यूपीएससी के पूर्व अध्यक्ष ने छात्र-छात्राओं, शिक्षकों एवं अभिभावकों को प्रशासनिक सेवाओं की तैयारी को लेकर महत्वपूर्ण जानकारी दी। सेमिनार में, ओपेन सत्र का भी आयोजन किया गया, जिसमें प्रतिभागी चयन प्रक्रिया को लेकर यूपीएससी के पूर्व अध्यक्ष से कई सवाल पूछे। इस मौके पर, बिहार कैडर के 2008 बैच के वरिष्ठ आईएएस पदाधिकारी गिरिवर दयाल सिंह ने कहा कि इस दुनिया मे सिर्फ मुर्दे को जिन्दा नहीं किया जा सकता है, बाकि कुछ भी असम्भव नहीं है।यदि पूरी मेहनत और लगन से की जाए तो सफलता निश्चित रूप से आपकी कदम चूमेगी। उन्होंने कहा कि सभी के मस्तिष्क एक ही जैसे ही होते हैं, आपकी सफलता बस इस बात पर निर्भर करती है कि आप अपने समय का उपयोग किस तरह करते हैं। श्री सिंह ने कहा कि बैड लक कुछ नहीं होता। माता पिता अगर साथ हैं तो सब गुड लक है। उन्होंने कहा कि लक्ष्य को पूरी शिद्दत से पाने के लिए जुट जाइए आप जरूर सफल होंगे। यदि सिविल सेवा परीक्षा की तैयारी कर रहे हैं तो ईमानदारी पूर्वक प्रयास करें। गौतम बुद्धा ग्रामीण विकास फाउंडेशन के राष्ट्रीय अध्यक्ष सह संस्थापक बिलास कुमार ने संस्था के विभिन्न क्षेत्र में किये जा रहे कार्यों का विस्तारपूर्वक उल्लेख किया। उन्होंने घोषणा की कि जयपुर में बहुत जल्दी ही सिविल सर्विसेज की तैयारी करवाने वाले ख्याति प्राप्त कोचिंग के शिक्षकों, विशेषज्ञों, यूपीएससी के टॉपर रहे आईएएस पदाधिकारियों का महासमगम किया जाएगा, जो प्रतिभागियों के लिए एक विशेष अवसर होगा। विदित हो कि जीबीआरडीएफ द्वारा पिछले 10 वर्षों से शिक्षा, स्वास्थ्य, पर्यावरण, मानवाधिकार आदि क्षेत्रों में कार्यक्रम चलाए जा रहे हैं। शिक्षा के क्षेत्र में सिविल सर्विसेज की तैयारी करने वाले छात्र-छात्राओं को समुचित तैयारी करवाने एवं मार्गदर्शन के लिए अभियान-40 आईएएस की स्थापना की गई है, जहां ख्याति प्राप्त शिक्षकों द्वारा पढ़ाई करायी जाती है। उसमें भी सबसे अच्छी बात यह है कि विद्यार्थियों पर आने वाले कुल खर्च का 70 प्रतिशत भाग फाउंडेशन की ओर से दिया जाएगा।

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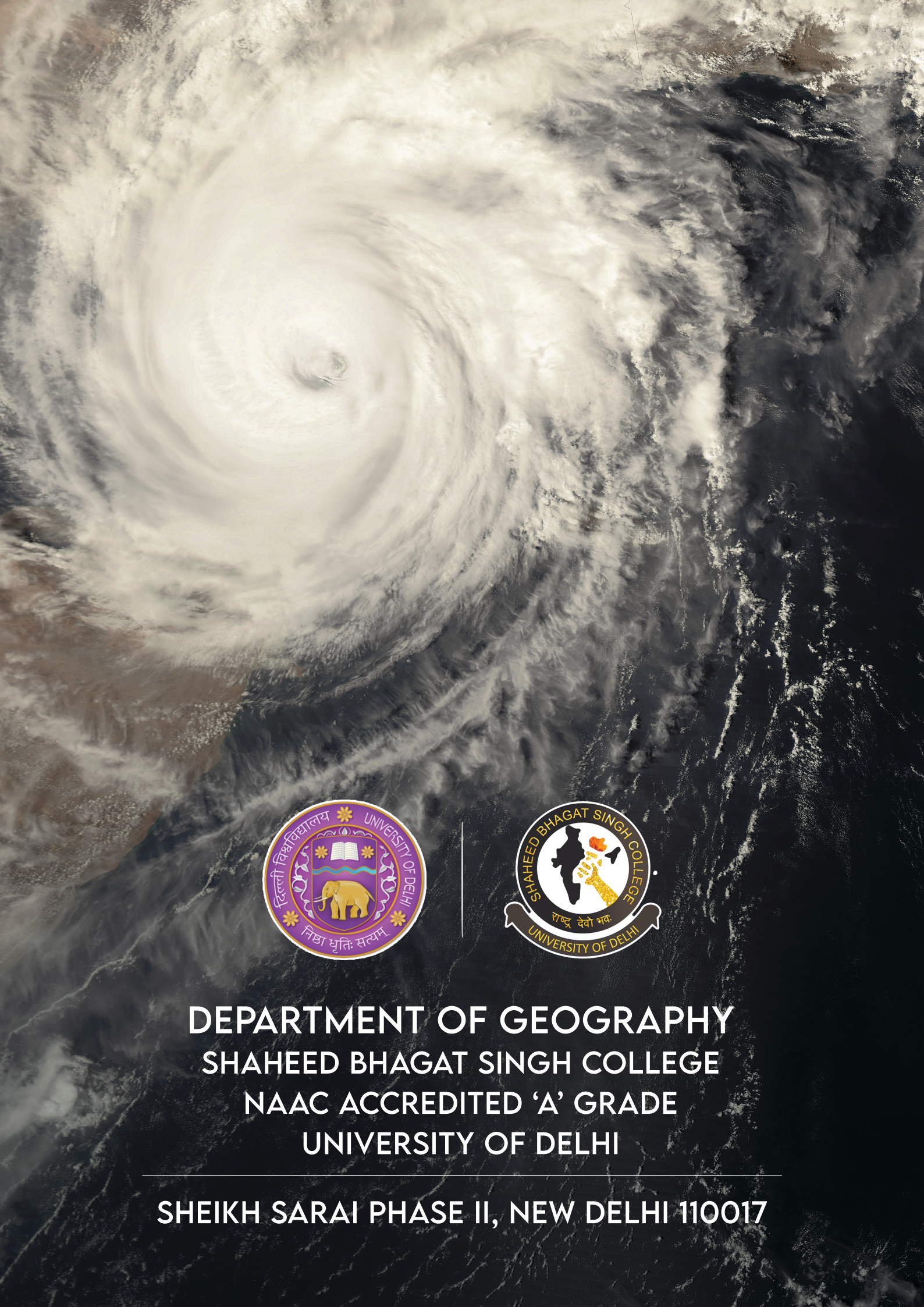

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