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Editor-in-Chief

As we release this latest edition of Journal on Disaster and Development, I am reminded of the critical role that knowledge and research play in the face of growing global challenges. Disasters whether natural, technological, or human-induced are becoming more frequent and severe, with increasingly complex socio-economic and environmental implications. Our journal stands at the intersection of academia, policy, and practice, aiming to bridge the gap between cutting-edge research and real-world application.

In this issue, we have gathered a diverse collection of articles that reflect the ever-expanding field of disaster risk reduction (DRR) and developmental issues. This volume explore a wide range of themes, from community-based disaster resilience strategies and innovative technological interventions to policy frameworks. Notably, there is a growing recognition of the significance of multi-disciplinary approaches in addressing the multifaceted nature of disasters, particularly in the context of climate change and rapid urbanization.

Authors have highlighted the role of vulnerable communities and indigenous populations, in the disaster risk reduction process. Their participation is essential to building comprehensive, context-specific solutions that can withstand the complexities of today's risk environment.

We are also proud to feature articles on community involvement that are transforming the landscape of disaster management. From the use of geospatial technologies and remote sensing in hazard mapping to the integration of latest technology in DRR are paving the way for more efficient and proactive DRR efforts.

However, as we celebrate these advancements, we must also acknowledge the ongoing challenges. As several contributors in this issue have pointed out, there remains a significant gap between the policies laid out in international frameworks, such as the Sendai Framework for Disaster Risk Reduction, and their implementation on the ground. Overcoming these barriers requires sustained efforts, not just from governments and institutions but from all stakeholders, including the private sector and civil society.

It is our hope that the research presented in this edition will inspire further dialogue, collaboration, and action across sectors. As always, we are committed to fostering an inclusive platform for sharing knowledge that can drive meaningful change in disaster risk management and development.

I would like to extend my deepest gratitude to our authors, reviewers, readers, editorial board members, hardworking and conscientious editorial and publication team for their continued contributions and support. Together, we are building a body of work that not only advances academic understanding but also has the potential to save lives and protect communities.

Thank you for being a part of this important journey.

Shri Rajendra Ratnoo, IAS

Editorial Note

It is with great enthusiasm that I welcome you to the latest edition of Disaster and Development. As our journal continues to grow, it remains committed to addressing the increasingly urgent and complex challenges that disasters pose to societies worldwide. This edition brings together a series of insightful contributions from researchers, practitioners, and policymakers who are dedicated to advancing the discourse on DRR and sustainable development.

Disasters, as we know, are not isolated events; they are deeply intertwined with development patterns, environmental degradation, and socioeconomic inequities. As the global community faces the escalating impacts of climate change, urbanization, and population growth, it is crucial that we examine disaster risk through an integrated lens. This issue highlights such interdisciplinary approaches, offering innovative perspectives on how we can strengthen resilience at local, national, and global levels.

One of the key focal points in this edition is the intersection of disaster risk reduction with developmental issues. Several articles in this issue delve into the community participation in disaster risk management and related issues. The articles featured in this issue underscore the importance of engaging local populations, especially those most vulnerable, in disaster preparedness and resilience-building efforts. Whether through local knowledge systems, grassroots advocacy, or participatory decision-making processes, the inclusion of communities is paramount to creating solutions that are both effective and sustainable.

As we reflect on the insights shared in this edition, it is clear that the path to a more resilient and equitable world requires continuous collaboration across disciplines, sectors, and borders. The knowledge exchanged here is not only an academic exercise but a call to action for all of us involved in disaster and development.

I sincerely thank our contributors, reviewers, readers, editorial board members, and our dedicated publication team (especially Dr. Ravinder Singh, Shri S. K. Tiwari, Shri Shubham Badola and Ms Karanpreet Kaur Sodhi) and diligent editorial team for their steadfast commitment to this important field. Your continued engagement with the journal empowers us to advance the frontiers of disaster risk reduction and work towards a safer, more sustainable future for everyone.

Surya Parkash, Ph.D.

Kerala Flood 2018 and the Socio-Economic Deprivation of Households in Alappuzha District

Lavanya Sivan[1] and Anitha V.[2]

Abstract

Kerala faced unforeseen floods in August 2018, which simultaneously affected natural and human resources. The impact of floods on households, particularly in the coastal area of the Alappuzha district, was very high. The main focus of this paper is to assess the socioeconomic deprivation of households in the Pampa River basin of the Pandanad panchayat of Alappuzha district. This study discusses the causes and effects of the flood and the unique recovery strategy of the state. The socio-economic deprivation index of flood-affected households is estimated by taking the arithmetic mean of the three indices, such as the health domain index (HDI), the economic domain index (EDI), and the standard of living index (SDI). Each dimension is calculated based on the general formula that UNDP used to calculate the Human Development Index. This empirical study found that most of the households in the study area have come in the high socio-economic deprivation category in the post-flood scenario.

Keywords: *Kerala flood 2018, PARIRAKSHA project, Disaster, Flood recovery strategy of Kerala, Socio-Economic Deprivation, Deprivation index*

1. Introduction

Globally, flooding is the most dangerous disaster for economic loss and human fatalities. During the last decade of the 20th century, floods washed out 100,00 lives and impacted more than 1.4 billion people (Jonakman, 2005). A study by Parvin et al. (2016) among the rural poor in Bangladesh, reveals that the floods increase their vulnerability leading to joblessness and depletion of their income and resources. Khayyam (2020)

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surveyed the northwest region of Pakistan and found that floods significantly impact the economic and livelihood impact of the rural poor. The flood destroyed their agriculture and livestock, which led them into poverty syndrome by washing out their savings and forcing them to borrow money.

The causes behind floods are heavy rainfall in the monsoon period, cyclones, cloud bursting, tsunamis, outbursts of glacial lakes, urbanisation, unauthorised construction, river bank erosion, sedimentation of channel beds, inefficient rivers, reservoirs, and drainage management (Tripathi, 2015; Mohanty et al., 2020; Parida, 2020). Floods have both social and economic impacts, such as the loss of people's lives, private and public property damage and agricultural land and crop destruction (Parida, 2020).

Floods constitute 84% of fatalities among India's 10 most significant disasters from 2005 to 2014. Riverine floods are the most common type of floods in India, followed by flash floods and coastal floods (Tripathi, 2015). Socio-hydro climatological variables complicate flood control in India by affecting the severity and frequency of flood occurrences. Factors like climate change, rising sea levels, and socioeconomic dynamics hamper flood management, resulting in significant socioeconomic losses and fatalities, despite substantial expenditure and ongoing flood-control initiatives throughout the nation (Mohanty et al., 2020). The central and state governments relationship is crucial for effective disaster management and economic development, as it enhances the efficiency of funding and support during disasters (Parida, 2020).

Recently the occurrence of floods is common across India (Narayanan, 2022), particularly in Kerala. After a hundred years, Kerala experienced a severe flood in 2018. In 2019 also, the state witnessed a flood that affected 1038 villages from 13 districts, 21264 houses were fully or severely damaged, and 125 people lost their lives (Kerala State Disaster Management Authority, 2019). Flood is a common phenomenon in coastal areas of the Alappuzha district of Kerala due to its topographical structure and people adapted to some extent (Santhi & Veerakumaran, 2019). However, the 2018 flood is unexpected and affects other parts of the state. The socioeconomic deprivation of people is entirely different as compared to the usual one. This paper tried to analyse the socio-economic deprivation of households in Pandanad panchayat of the Alappuzha district in the context of the Kerala flood of 2018.

According to the Global Data Lab of Radboud University (2021), the state had the highest HDI of 0.782 in 2019, comparable to developed countries. The socio-economic characteristics such as health, education, and living standards helped the state achieve this top position. The Kerala flood of 2018 severely threatened the state's socio-economic and human development. That led Kerala into a socially and economically worse situation. Human deprivation is a lack of human capabilities, opportunities, choices, values, and basic needs such as food, shelter, education, clothing, health etc. (Sivakumar & Sarvalingam, 2010). Natural disasters like floods severely impact these variables, indispensable to human development. Hence, it is necessary to assess the changes in the socio-economic variables and the level of deprivation to develop suitable policies to overcome the future impact of floods.

The paper is organised into different sections. The second section explained the data and research methods of the study. It is followed by the analysis of socio-economic effects, government actions, and the recovery strategies of the state of Kerala flood in 2018. The final section concludes the whole study with policy recommendations.

2. Data and Methods

Among the 14 districts of Kerala, Alappuzha (popularly known as Alleppey) district is the smallest in terms of geographical area. The district's geographical speciality is that it lies on the coastal plain of the Arabian Sea and is the only district without forest cover. Kuttand, renowned as the 'Rice Bowl of Kerala,' is situated in this district and is the only location globally where farming occurs up to two meters below sea level. The state has two monsoon seasons: namely, southwest monsoon from June to September and northeast monsoon from October to November. Alleppey is renowned globally for its water tourism. The word 'Alappuzha' consists of two words: 'ala' and 'puzha'. In Malayalam, 'ala' means broad and 'puzha' means river. Due to the extensive network of canals and backwaters, this district is known as 'the Venice of the East'. The existence of rivers, lakes and other aquatic bodies makes the region the most susceptible to flooding in the state (District Disaster Management Authority, Alappuzha, 2015).

The rivers flowing through Alappuzha district are Pampa, Manimala, and Achankovil. The Thottappilly Spillway in Vembanad Lake receives water from these rivers. Furthermore, of all the principal rivers, only the Pampa River is regulated

by the Kakki dam. The Pampa River, Kerala's third longest river, enters Alappuzha at Chengannur taluk and travels through Pandanad, Veeyapuram, Thakazhi, and Champakulam regions over a distance of about 177.08 km, and culminates in Vembanad Lake via multiple branches (District Disaster Management Authority, Alappuzha, 2015; Santhi & Veerakumaran, 2019).

Both primary and secondary data were used for the study. An extensive household survey was conducted in Pandanad panchayat, a rural local body, in the Chengannur taluk of Alappuzha district to gather primary data. A significant portion of the Pandanad panchayat is located on the banks of the Pampa River. Agriculture is the main economic activity in this area. Therefore, climate change significantly influences the livelihood of the people. The total area of the panchayat is 10.45 cm^2, and the density of the population is 1276.74. The total number of households is 4285, having a population of 13342. In this study, the flood-affected households were the sampling units. Among the 13 wards in Pandanad panchayat, the most flood-affected area, ward number two, was selected for the household survey. This ward is situated along the banks of the River Pampa, and all the households inside it were impacted by the floods. The strategy of selecting households at regular intervals was deemed a more effective approach in this context. Out of the 349 households in ward number two, 50 were selected through systematic sampling.

Secondary data were collected from the Post Disaster Needs Assessment conducted by UN agencies and various government reports from the Central Water Commission, Ministry of Earth Science, and Kerala State Disaster Management Authority.

Floods resulted in the loss of materials, money and lives, which directly affected socioeconomic deprivation. Deprivation of the households is assessed based on the socio-economic conditions of the households in connection with floods. The significant variables used in this study were loss of materials such as food grains, home appliances, vital documents, vehicles, jewellery, cash, agricultural products, and poultry, damage to houses and wells, sources of drinking water, occupation before and after the flood, income, health expenditure, the amount spent to clean the house after the flood, financial aid from the government and satisfaction level. A few variables are

used from the questionnaire on the Eviction Impact Assessment Tool developed by the Housing and Land Rights Network, which is based on the UN Basic Principles and Guidelines on Development-Based Evictions and Displacement (2007).

In the context of the measurement of socioeconomic deprivation, the Human Development Index (HDI) is considered the primary key indicator. The three dimensions of the deprivation index include health, economic domain, and standard of living (Pampalon & Raymond, 2000; Sivakumar & Sarvalingam, 2010; Lamnisos et al., 2019; Kiran, 2021). Here health aspects are measured through mental and physical health; economic dimensions through income and livelihood of the household; and standard of living through drinking water, housing, electricity, and assets.

The general formula used by the UNDP for calculating human development is used to calculate each deprivation index (United Nations, 2021). As such

$$\text{Deprivation Index} = \frac{\text{(actual value-minimum value)}}{\text{(maximum value-minimum value)}}$$

For getting the indices such as health domain index (HDI), economic domain index (EDI) and standard of living index (SDI), the arithmetic mean of variables under each dimension is calculated. Then for the socio-economic deprivation index (SEDI), the arithmetic mean of the three is calculated. That is,

$$\text{SEDI} = \frac{\text{(HDI+EDI+SDI)}}{3}$$

The values range from 0 to 1, where 0 means the lowest and 1 means the highest deprivation. High, low, and medium values are below 0.33, 0.34 to 0.66, and 0.67 to 1, respectively.

3. The Kerala Flood 2018

In 1907 the state of Kerala witnessed the highest rainfall. Till August 2, the rainfall has been 780 mm which was 150 per cent higher than the normal average. Kerala experienced the highest rainfall in 1924 (3368 mm), whichever happened before.

Almost all parts of Kerala were flooded due to the high rainfall and more than 1000 people died (Khelkar, 2018; Kondapally et al., 2020). After 1924, Kerala experienced the

worst flood in August 2018. This is because of the rains that have been halted for days. The rainfall in Kerala is controlled by southwest and northeast monsoons. The annual average rainfall in Kerala was 3000 mm (Central Water Commission, 2018). According to Indian Meteorological Department data (2018), from 1st June 2018 to 19th August 2018, Kerala received 2346.6 mm of rainfall instead of the expected 1649.5 mm. The rainfall over Kerala during June, July, and 1st to 19th of August was 15%, 18% and 164%, respectively, above the normal average. The state possesses 57 large dams. Major reservoirs in Kerala had above 90 per cent of their capacity in August 2018 (Shaharban & Rathnakaran, 2019). Hence, the release of water from reservoirs was essential. On August 15th, most reservoirs became near total capacity and 37 dams were opened (Government of India, 2018; Kondapally et al., 2020).

3.1 Causes of the Flood

The primary causes behind the Kerala flood of 2018 can be divided into natural causes and anthropogenic causes. The natural factors that influenced the flood were the low-pressure system which formed in the Bay of Bengal (Hunt & Menon, 2020), landslides, climate change and global warming (Kumar et al., 2020; Vanamaet al., 2021). The anthropogenic causes were inefficient dam management (Kondapally et al., 2020; Sudheer et al., 2019), extensive quarrying and mining in the Western Ghats, illegal encroachment of forest land, developmental activities on the ecologically sensitive zones as part of tourism, absence of proper drainage system and unscientific use of land (Central Water Commission, 2018; Government of Kerala, 2018; Sudheer et al., 2019). Excessive human encroachments in ecologically sensitive areas like the Western Ghats worsened the situation. The Gadgil report (Government of India, 2011) highlighted that many reservoirs, especially in the steep valleys, are silting up prematurely due to the massive encroachment and deforestation of catchments consequent to dam construction. This report warned about landslides from the ecologically sensitive areas in the Western Ghats due to the increased mining and quarrying.

The Special Centre for Disaster Research of Jawaharlal Nehru University submitted a report citing heavy rainfall, inefficient dam management, environmental degradation, infrastructural development, and a lack of preparedness as the causes of the 2018 Kerala flood. This report criticised the performance of the Kerala State Disaster

Management Authority (KSDMA) on several grounds. The KSDMA was found to have failed to ensure effective coordination and communication among various departments, failed to update disaster management plans on time, had a poorly functioning early warning system, and the fund utilisation was also not effective. This report also criticised the state government for neglecting the recommendations of the Gadgil's report. The government focused more on profit-making through electricity generation than the safety of the people in dam management (Singh et al., 2018).

3.2 Socio-economic Effects of the Kerala Flood 2018

The unexpected flood and landslides in Kerala affected 5.4 million people, 2 million people were displaced, and more than 400 people lost their lives. The non-stopped torrential rainfall leads to 341 landslides in this small state. The worst affected districts were Idukki, Wayanad, Ernakulam, Alappuzha, Kottayam, Pathanamthitta, and Thrissur. Due to the flood, close to 14 lakh people evacuated to relief camps as their homes were flooded. According to the post-disaster needs assessment, the entire economic loss from the 2018 flood was 26,720 crores of rupees (Government of Kerala, 2018).

Natural disasters have diverse economic impacts across economic sectors depending on the disaster type and intensity (Panwar & Sen., 2019). The flood and landslides caused severe damage to houses, and infrastructural facilities like bridges, railways, roads, communication networks and power supplies. About 13,362 houses were fully damaged; more than one lakh houses were severely damaged. Nearly 25 lakhs of electricity connections were disrupted. More than 300 bridges and approximately 50,000-kilometre roads collapsed. Access to drinking water was disrupted for 20% of the state's population. Around 3,17,000 shallow wells and over 95,000 latrines were substantially damaged. In the case of the agricultural sector, about 59,345.37 hectares of crops and livestock were washed away, and 3 lakh farmers were affected. The total agricultural loss exceeded 1300 crores of rupees. Many private properties, including business units, shops, showrooms, vehicles, schools and hospitals, were damaged. The primary workforce in Kerala, such as agricultural labourers, construction workers and workers in micro, small and medium enterprises, had a wage loss of 45 days or more (Government of Kerala, 2018).

Over 1.75 lakh buildings have been damaged either fully or partially. The households in the affected area lose their electronics, clothes, utensils, beds, certificates, property documents and other valuable things within hours. The children lose their study materials, bags, and uniforms. Students from classes X and XII are anxious due to the loss of books and notes, which may affect their learning. Owing to the loss of families, friends, neighbourhoods and properties, many people faced trauma and stress. The houses, vehicles, jewellery etc., are the result of many years of hard work for each one of them. Workers from the informal sector were the worst affected victims of the flood. Households are the major consumption unit and a source of savings as far as an economy is concerned. The flood slows the economy for over a month (Government of Kerala, 2018).

3.3 Immediate Action Taken by the Government

The state government of Kerala immediately responded to the situation with rescue operations. The mobilisation of forces such as the Coast Guard, National Disaster Response Force, Kerala Fire and Rescue Services, Army, Navy, Air Force, Central Reserve Police Force, Border Security Force, and fishing community of the state saved many lives. About 15 lakh people have been moved to camps and relatives' houses. More than 1700 schools, worship centres, colleges, and other institutions were used as relief camps. More than 10000 camps were opened (Government of Kerala, 2018).

The people of Kerala have overcome the unexpected natural calamity with perfect determination. The Kerala youth restlessly worked for the rescue of flood victims without any discrimination in the form of religion, caste, wealth and politics. To disseminate government instructions and speed up rescue operations, social media played an important role. The fishermen in Kerala deserve special gratitude for their timely intervention in rescuing those trapped in flooded areas (Government of Kerala, 2018). The army's rescue team could not reach all flood-affected locations, particularly in river basins, due to the overflowing of floodwater, whirlpools, large trees, and large walls. However, the fishermen overcame these challenges to rescue the lives of children, pregnant women, and the elderly. Because of these courageous actions, the Chief Minister of Kerala described the fishermen as the 'Army of Kerala'(Dhanya, 2019).

3.4 Recovery Strategy of the State

Under the guidance of the state and the local government institutions, other organisations and civil society, Kerala conducted a massive drive to clean flood-affected houses and wells and supply essential commodities and medicines. Various organisations and individuals helped the flood victims clean their houses to ensure basic needs like water, food grains, clothing, medicines, footwear etc. About 6,93,287 mud-coughed houses were cleaned, and about 14,657 dead bodies of the creatures were buried. About 25 lakhs of power supply connections were restored quickly (Government of Kerala, 2018).

The floodwaters contained sewage, dead bodies of birds and animals, and other contaminants, which increased the risk of infectious diseases. Nonetheless, no contagious diseases were reported in Kerala. However, the fact that no epidemics have been detected in Kerala due to this flood has astounded the entire world. This resulted from the door-to-door work of the efficient health workers in Kerala (Venu, 2019).

The central government, foreign countries, non-residential Indians, film stars, business people, various organisations, and many individuals, especially ordinary citizens, contributed to the chief minister's relief fund (Thummarukudy, 2019). This support helped the government to speed up post-flood relief activities.

The government of Kerala provides immediate relief in cash and kind. About 7,37,484 flood-affected families received 10,000 rupees immediately as financial support. The state also allow an additional 5000 rupees to SC/ ST families. The government provided financial aid to damaged houses in Kerala. Households from the economically backward class received food grains for three months through supply co. The authorities ensured interest-free loans up to rupees 1 lakh through Kudumbasree to the flood affected to refurbish their houses. The flood victims also got relaxation to pay the electricity bill for four months. The labourers included in the Mahatma Gandhi Rural Employment Guarantee Scheme got extra working days of 150 days. About three lakh farmers in flood-affected areas benefited from 200 crores of rupees as financial support against losing their crops. Around 21.70 crores of rupees were given to 27363 families who lost their animals in the flood (Government of Kerala, 2018). Furthermore, the government immediately provided duplicate certificates, property documents, ration cards, and identity cards to those who had misplaced them (Venu, 2019).

The psychological impact of the 2018 flood on the people of Kerala was crucial. The unexpected flood spontaneously washed out their relatives, friends, neighbours, animals, land, buildings, vital documents and other earnings of a lifetime. Hence, to recover the flood victims from the mental shock, the state government introduced a project known as "PARIRAKSHA". This project was designed to support flood-affected people, especially low-income people. The main focus of this project is to reduce the long-term psychological impact of the disaster. This project covered two million people from 93 severely flood-affected panchayats in Kerala. Accredited Social Health Activists have been used for earlier identification of individuals with psychological problems in the affected zones. This project started in March 2019, and due to the outbreak of COVID-19, the activities of PARIRAKSHA have been interrupted (Kiran et al., 2019).

4. Results and Discussion

Out of the 50 sample households, fifty per cent are Hindus, and fifty per cent are Christians. It is noteworthy that irrespective of religion and caste, the people of Kerala faced the flood together without any discrimination. More than 70 per cent of the respondents said that their interaction with neighbours improved after the flood. For almost two weeks, they cohabited and assisted one another. The presence of relatives, friends, political representatives, officials, and neighbours offered psychological assistance throughout the flood. Due to the overflow of the River Pampa and the heavy rainfall, more than 75 per cent of the households could not reach relief camps. For around 14 days, they stayed on the terrace with their neighbours. During that period, they felt insecurity and stress, among them, few respondents, especially the aged, had not recovered from the mental stress yet. The average size of the family is 4.4. The age-wise classification shows that the majority of the people were adults. They played a significant role in the rescue operations during the flood. The family's average monthly income is Rs. 27130.4, and the per capita income is Rs.73992/- which is less than half of the state per capita income of Rs. 245,323 (Planning Board, 2021). The working population in the study area included fisher folks, drivers, farmers, sales executives, MNREGA workers, and painters. The flood affected their working days. On account of the psychological and financial impact of the flood, they were unable to do work for more than a month.

Agriculture is one of the major sources of livelihood for most of the households in the study area. Fifty-four per cent of the households lost agricultural products, and 22 per cent lost poultry in flood. The total loss of this sector was Rs. 630200. The respondents had received compensation from the government, but the amount was not sufficient for them. Another effect of the 2018 flood is identified in the case of drinking water. In the pre-flood period, households in the study area depended on the Pampa River, wells and public taps for drinking water, and they did not spend money on drinking water. But, during the flood, almost all the wells were submerged in the floodwaters, and the toilet wastes contaminated drinking water sources. Due to that, 20 per cent of the families started to pay for drinking water.

Following the calamity, the state government provided flood-affected households with necessary food grain kits worth Rs 500 per month. More than fifty per cent of the respondents got this kit of food grains for three months. That was excellent support from the government, particularly to low-income families. Moreover, other organisations and individuals also distributed essential goods to the flood-affected people. To replace the damaged home appliances in flood, the State government developed a plan to provide loans of up to one lakh to each family through commercial banks. This loan amount was distributed through Kudumbashree. Among the respondents, 18 per cent of the total households took those loans, and others were not interested in raising their debt after the flood.

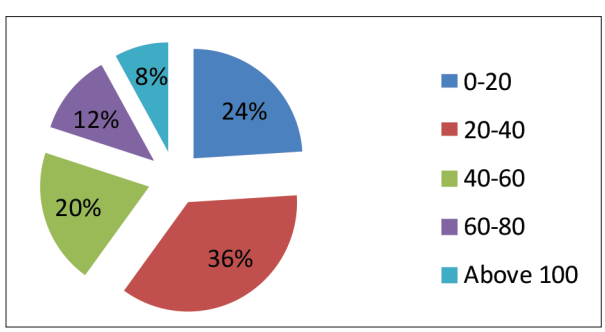

Figure 1: Number of years living in Pandanad

Figure 1 depicts that comparatively, more families have lived in Pandanad panchayat for 20 to 40 years. Eight per cent of the households have lived here for generations.

In their opinion, this was the first time such a flood had occurred, and they hadn't had any previous experience facing this kind of disaster. Because of the fear of future flooding, many of them started thinking about shifting to other regions.

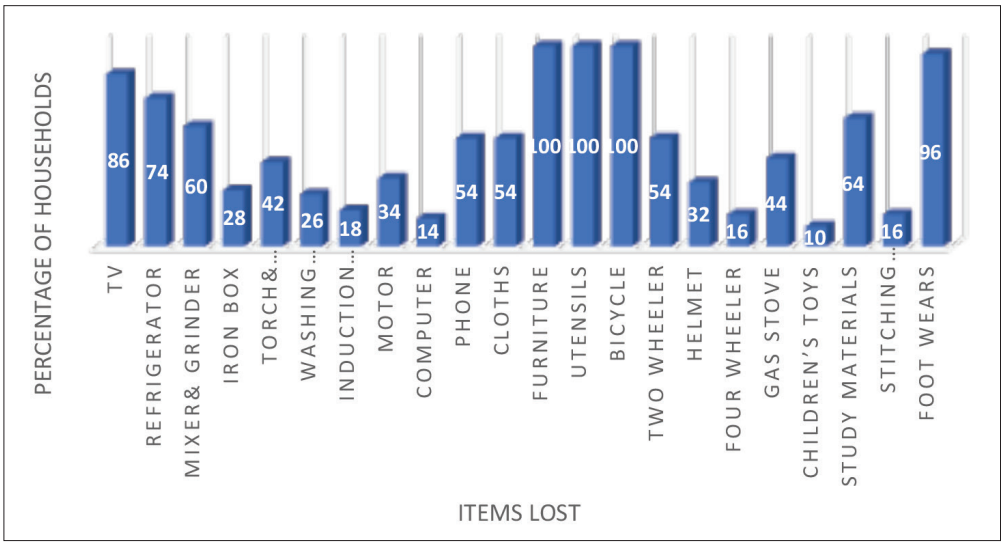

Figure 2 : Loss of household items

Figure 2 shows that the household items commonly lost were utensils, clothes, furniture, footwear, televisions, and refrigerators. The respondents required more money to replace these items. In economically backward families, the respondents lost much of their long-term earnings in the flood. That made the burden of the flood too severe.

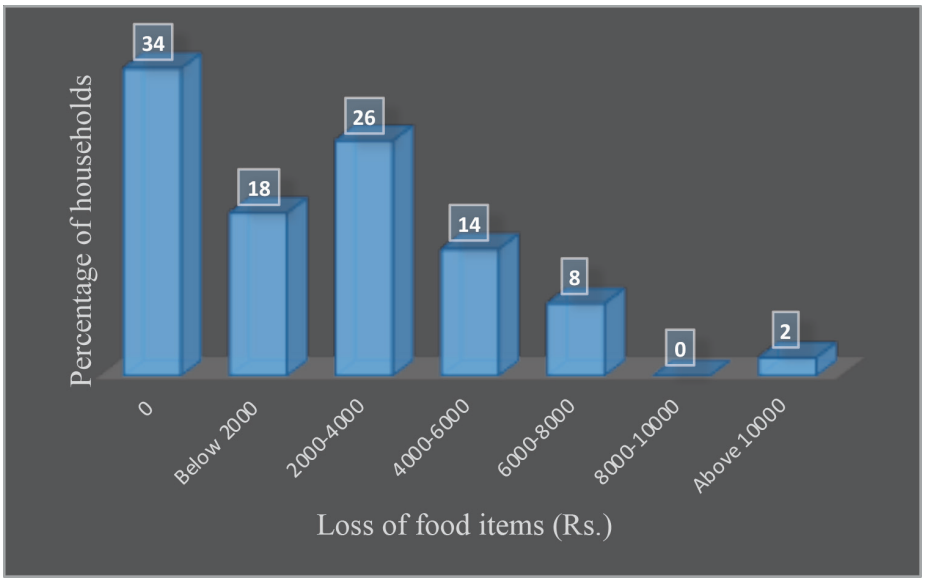

Figure 3 : Loss of food Items

Figure 3 reveals that around 66 per cent of the total respondents lost food stuff. Even before the flood came, households reserved more food items to celebrate the biggest festival of Kerala, 'Onam'. During the flood, most of the families in the study area stayed on the terrace, and they used these items for cooking. The extra stock of food grains helped them to avoid starving.

Table 1 : Loss of vital documents

Document	Number of Household	Total number of Documents
Voter ID	5	8
Ration Card	0	0
Aadhar Card	0	0
Passport	1	1
Birth Certificate	1	1

Driving Licence	1	1
Medical Documents	3	12
Property Documents	3	4
Others	1	2
Total	**15**	**29**

From Table 1, it is clear that no respondents left their Aadhar card and Ration card. Around 70 per cent of the people moved to a safe place with all essential documents. Owing to the sudden arrival of a flood, others forgot to take their documents. To collect financial support from the government, households faced some difficulties in the post-flood period. The government of Kerala issued valid duplicates to those who lost their documents within months.

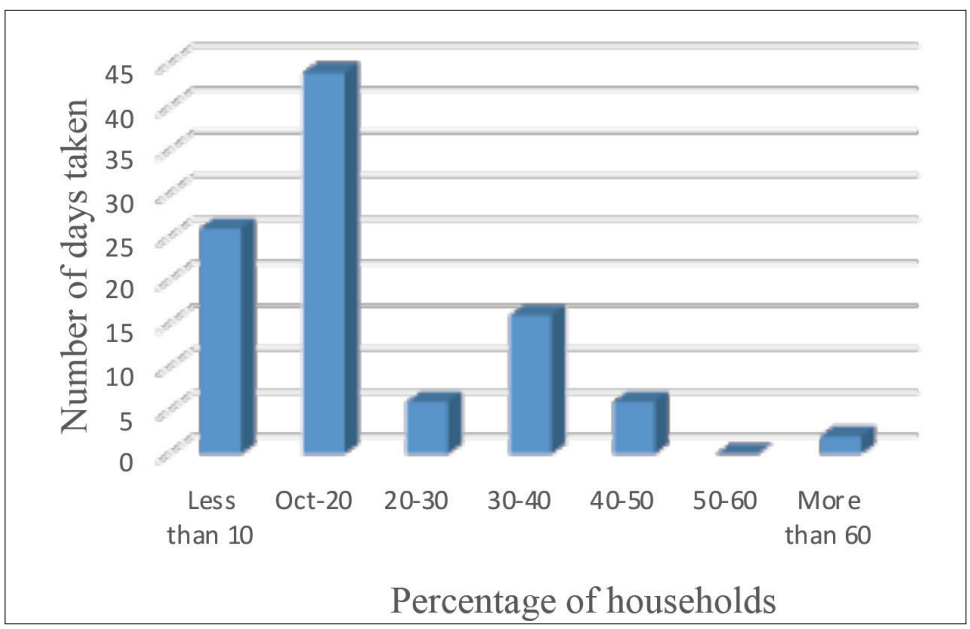

Figure 4 : Number of days taken to clean the house

Figure 4 shows that cleaning the houses of respondents took time. After the flood, the victims' most significant challenge was removing mud from their houses. Local

government institutions, various organisations, and individuals helped them to clean the houses. Those buildings were uninhabitable due to the stench of dirt for months. These issues affected the physical and mental health of the people too.

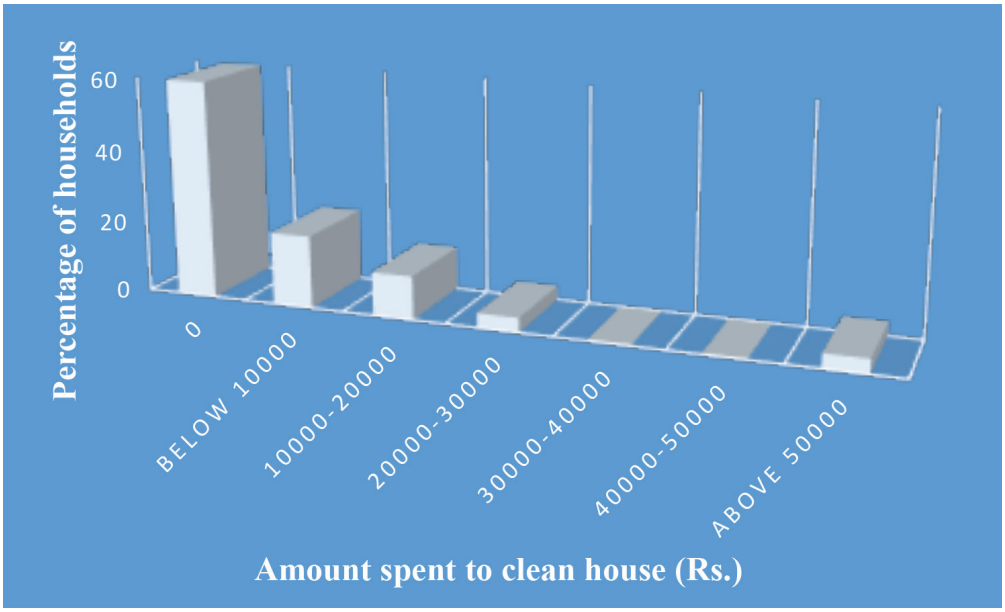

Figure 5 : Amount spent to clean the house

Figure 5 shows that more than half of the households did not spend money cleaning their homes and surroundings. Various groups and individuals helped them. Some of the victims had washed their houses themselves. Forty per cent of the respondents spent money on this. Among them, most of the households spent below 2000 rupees.

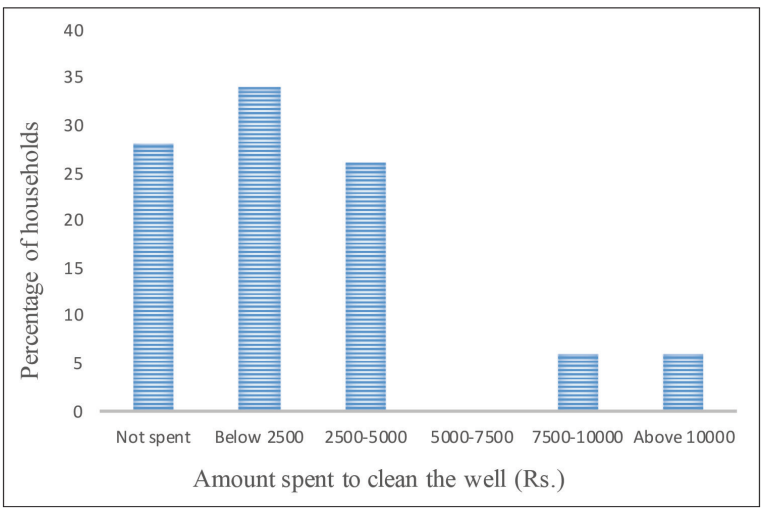

Figure 6 : Amount spent to clean the well

Figure 6 represents that 66 per cent of the families spent cash to clean wells. Those were filthy with mud and other wastes. Government institutions and other groups helped them to clean the well. For quick reuse, most people spent money to clean wells. Because of financial problems, 28 per cent of them did not clean their wells which were damaged in the flood.

Table 2 : Financial aid from the government for damaged house

Percentage of damage on house	Financial aid from Government	Number of households	Percentage
0-15	10000	15	30
16-29	60000	27	54
30-59	125000	6	12
60-74	250000	1	2
75-100	400000	1	2

Table 2 exhibits that one of the households was fully damaged in the flood and had to rebuild. The government provided financial assistance to the households based on the damage percentage. More than half of the families got worth of rupees 60,000. This financial support from the government helped the affected people to make their houses habitable.

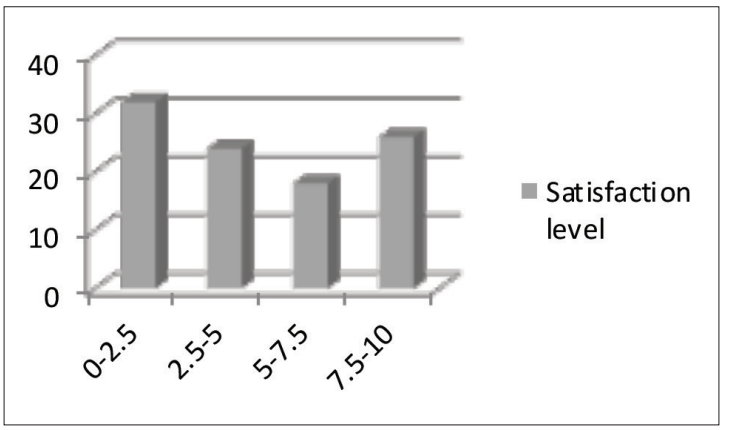

Figure 7 : Satisfaction level of victims to government's support

The Figure 7 depicts that comparatively more people were not satisfied with government support. Insufficient compensation and unfair allocation were the primary reasons for the dissatisfaction.

Table 3 : Monthly income and total economic loss of households

Monthly Income (Rs.)	Number of households	Average income	Average loss
0- 10000	7	8285.71	141850
10001-20000	11	17000	209671
20001-30000	17	25705.88	180780
30001-40000	10	35476	235531

40001-50000	1	46000	64680
50001-60000	3	59586.66	72887
More than 60001	1	95000	580550
Total	50	27,130.4	1,91,835.8

The flood affected almost all the households in the study area and had a considerable impact on the socio-economic life of the people. Table 3 shows that the average direct cost of the flood is Rs 1,91,835.8 that is seven times higher than the average income of the households.

4.1 Socio-economic Deprivation of Households

Townsend P. (1987) defined deprivation as "a state of observable and demonstrable disadvantage relative to the local community or the under society or nation to which an individual, family or group belongs". Broadly, it can be classified into two categories- material and social, indicating a lack of access to the necessities and social weakness, respectively (Pampalon et al., 2012; Sarkar, 2014). Socio-economic deprivation means the lack of social and economic advantages that are considered necessities of a community. The disadvantage of society regarding control access over material, social or economic resources and opportunities also shows socio-economic deprivation. It is a multi-dimensional concept (Lamnisos et al., 2019).

Table 4 : Deprivation index of the study area

Income groups (Rs.)	Number of households	Health Domain Index	Economic Domain Index	Standard of Living Domain Index	Socio-economic deprivation index
0- 10000	7	0.848979592	0.82857143	0.842857	0.840136054
10001-20000	11	0.737662338	0.81818182	0.741818	0.765887446
20001-30000	17	0.788571429	0.82285714	0.748	0.78647619
30001-40000	10	0.765714286	0.72857143	0.744	0.746095238

40001-50000	1	0.771428571	1	0.82	0.863809524
50001-60000	3	0.857142857	0.76190476	0.786667	0.801904762
More than 60001	1	0.771428571	0.57142857	0.68	0.674285714
Average		0.791561092	0.79021645	0.766192	
Total deprivation of the study area			**0.782656418**		

Table 4 exhibits that the highest socially and economically deprived families belong to between Rs. 0-10000 income groups. Most of the respondents in this group were daily wage earners, and after the flood, they lost working days for nearly two months. Compared to the high-income group, the burden of the flood was higher in this category. The standard of living deprivation is the highest in this income group due to the adverse impact of the flood on their housing, drinking water, electricity and accumulation of assets.

The flood highly deprived families in the income group of Rs. 10001 to 20000. Compared to health and standard of living domains, economic deprivation was higher. More than half of the respondents in this group worked in the unorganised sectors. Due to the flood, most of them could not go to work, and working places like shops and small-scale units collapsed. The people lost more than 45 working days during this time. Moreover, the flood affected other sources of income, especially the people's occupational equipment, livestock, and rickshaws.

Thirty-six per cent of the total respondents belong to Rs. 21,000 to 30,000 income group. The economic deprivation was higher because respondents were taken into debt and used their savings to maintain houses and vehicles and replace furniture and electronics. Besides that, the income of the respondents decreased after the flood. The total deprivation of this category is higher than the previous group.

The flood highly deprived the households with an income of Rs. 31,000 to 40,000. Among this group, health deprivation was comparatively elevated than economic and standard of living domains. The flood led to psychological damage like emotional shock, stress, and trauma among the respondents (UN et al., 2018). The impact of the flood on people's psychological health was higher than their physical health.

There was only one family that had an income range between Rs. 40,001 and 50,000. The noted thing is that this was the only family in the study with the highest economic deprivation value. The income source of this family was a shop, which entirely collapsed in the flood. This household lost its savings, and it took debt to reconstruct the building. That made the family economically more deprived. The economic impact adversely affected mental health and standard of living. Therefore the socio-economic deprivation index showed that this family was highly deprived in the 2018 flood.

Among the income group of Rs. 50,001 to 60,000, health deprivation was relatively high. From the field survey, it is identified that the people's mental health worsened than the physical health due to the deluge. They had fear about future flooding, and some of the respondents decided to migrate to other regions. The government of Kerala implemented a project, "PARIRAKSHA", in 2018 to reduce the long-term psychological impact of the flood (Kiran et al., 2020). This category was also highly deprived in flood.

In the sample, only one family had a monthly income above Rs. 60,000. In this household, the health deprivation and standard of living deprivation were high and economic deprivation was moderate. The respondent feared protecting his assets from the continuous future disasters that made them mentally weak and deprived them of health status. This is the only household in the study which had moderate economic deprivation. The socio-economic deprivation of this family was just high and close to a moderate level. The high-income level reduced the financial burden due to the flood.

The total socio-economic deprivation index of the study area (0.78) showed that the 2018 flood worsened the health, economic and standard of living status of all the households. This deprivation will lead the economy back from the path of development.

Table 5 : Low, moderate and high deprivation of the study area

	Percentage of Households		
	Low Deprivation (0 - 0.33)	**Moderate Deprivation (0.33 – 0.66)**	**High Deprivation (0.66 – 1)**
Health Domain Index	-	6	94

Economic Domain Index	-	4	96
Standard of Living Domain Index	-	28	72
Socio- Economic Deprivation	-	**12**	**88**

It is clear from Table 5 that the 2018 flood negatively affected the socio-economic aspects of all the households in the study area. The condition of no family improved in health, economic and standard of living after the flood. A few families (12%) were moderately deprived, especially those above Rs. 30,000 per month. Out of the total respondents, the standard of living deprivation of 28% families was moderate. Most of the families in the study were highly deprived in economic terms because the flood worsened their sources of income and thereby reduced income. A society characterised by high demand and a low supply of necessities exhibits poor economic and social status (Pampalon et al., 2000). The overall deprivation showed that most households were socially and economically deprived in the 2018 disaster.

5. Conclusion and Policy Suggestion

The Kerala flood in 2018 was a big challenge in the development path of the state. This deluge made a significant change in the health, economic and standard of living aspects of the people in Alappuzha. Most of the households lost their lifetime earnings, which pushed down low-income people to be more vulnerable. The study found that the majority of households in the study area come in the highly deprived category in the case of the three indices such as health (HDI), economic (EDI) and standard of living (SDI). No households come in the low level. A comparison of the three indices shows that EDI is high compared to the other two. The flood affected their possessions, such as buildings, crops, poultry, livestock, vehicles, shops, utensils, cloths, electronics. To rebuild and repurchase these items, the households used their past savings and lent money from both financial and non-financial institutions. They also lost their working days for over two months. This amplified the flood's economic impact on households. The economic burden due to the flood

in the high-income category in the study area is relatively lower than the low-income households. This demands more financial and livelihood support for the low-income category.

The study reveals that the Kerala flood of 2018 primarily resulted from abnormal rainfall. However, the impact of floods was accelerated by inefficient dam management, a lack of proper early warning system, developmental activities, an outdated disaster management plan, and the exploitation of river basins. The study area is located in a coastal district with highly flood-prone lowlands. In the context of this study, we propose the following recommendations for future policy-making:

- Ensure more accurate weather forecasting in the flood-prone areas.
- It is important to update the early warning system to guarantee timely and precise distribution of information, thereby mitigating the effects of natural disasters. Kerala's high literacy rate facilitates the efficient dissemination of disaster notifications among the people.
- The government should ensure the protection of river basins and efficient reservoir management for the safety of people should be ensured by the government.
- Regulate the extensive quarrying, mining and deforestation in the Western Ghats. These activities cause landslides and increase the destructive capacity of floods.
- Timely updating of disaster management strategies is very important in the unexpected climate-changing scenario.
- It will be better to ensure the displacement of people from flood-prone areas.
- The government should ensure proper long-term counselling sessions due to high psychological impact of disasters.
- Provide more flood relief to those with low incomes, as their economic deprivation as high.

The implementation of these recommendations is important for the existence of flood-prone areas in Kerala.

6. Acknowledgements

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References

1. Central Water Commission (2018), "Study Report: Kerala Floods of August 2018", New Delhi: Ministry of Water Resources, River Development & Ganga Rejuvenation, Government of India.
2. Centre for Development Studies (2006), "Human Development Report 2005", Thiruvananthapuram, State Planning Board, Government of Kerala.
3. Dhanya, k. R. (2019), *August 2018 Keralam: Pralayam, Athijeevanam and Punarnirmanam*, Chennai: Westland Publications Private Limited.
4. District Disaster Management Authority, Alappuzha. (2015). *District disaster management plan: Alappuzha*. Kerala State Disaster Management Authority, Department of Revenue and Disaster Management, Government of Kerala.
5. Government of India (2011), "Report of the Western Ghats Ecological Expert Panel", New Delhi: The Ministry of Environment and Forests, Government of India.
6. Government of India (2018), "Report on the Exceptionally Heavy Rainfall over Kerala during 1st – 19th Aug. 2018", New Delhi: Earth System Science Organisation, Ministry of Earth Sciences.
7. Government of Kerala (2019), "Floods and Landslides 2019", Thiruvananthapuram: Kerala State Disaster Management Authority, Govt. of Kerala.
8. Government of Kerala (2021), "Economic Review 2020", Thiruvananthapuram: Kerala State Planning Board, Government of Kerala.
9. Government of Kerala. (2018), "Kerala Post Disaster Needs Assessment Floods and Landslides – August 2018", Thiruvananthapuram: Government of Kerala.
10. Hunt, K. M., and Menon, A. (2020), "The 2018 Kerala floods: a climate change perspective", *Climate Dynamics*, 54(3), 2433-2446.
11. Jonkman, S. N. (2005). Global perspectives on loss of human life caused by floods. *Natural hazards*, 34(2), 151-175.
12. Khayyam, U. (2020). Floods: Impacts on livelihood, economic status and poverty in the north-west region of Pakistan. *Natural Hazards*, 102(3), 1033-1056.
13. Kiran, P. S., Mohan, B., Abhijith, V., Abraham, A., Anoop, G., Dinesh, R. S., Krishnan, H., Mahadevan, K., Peethambaran, M., Kunheen, M., Sidharthan, M., Prathibha. S., Sukesh, S., Thomas, K. P., Jayaprakashan, K. P., and Jaisoorya, T. S. (2021), "Framework for strengthening primary health care and community networks to mitigate the long-term psychosocial impact of floods in Kerala", *International Journal of Disaster Risk Reduction*, 52, 101947.
14. Kiran, V. V., (2021). "Mapping the water Literacy of women in Palakkad district of Kerala", M Phil to thesis. Thiruvananthapuram: University of Kerala.
15. Kondapalli, S., Nagamanickam, R. K., and Ghosh, S. (2020), "Utilizing Insights from 2018 Kerala Floods Damage Survey in Catastrophe Flood Modelling", Hyderabad: Hydro 2019 International Conference.
16. Kumar, V., Pradhan, P. K., Sinha, T., Rao, S., and Chang, H. P. (2020), "Interaction of a Low-Pressure System, an Offshore Trough, and Mid-Tropospheric Dry Air Intrusion: The Kerala Flood of August 2018", *Atmosphere*, 11(7), 740.
17. Lamnisos, D., Lambrianidou, G., and Middleton, N. (2019), "Small-area socioeconomic deprivation indices in Cyprus: development and association with premature mortality". *BMC Public Health*, 19(1), 1-11.
18. Mohanty, M. P., Mudgil, S., & Karmakar, S. (2020). Flood management in India: A focussed review on the current status and future challenges. *International Journal of Disaster Risk Reduction*, 49, 101660.
19. Narayanan, A., Beye, R., & Thakur, G. M. (2022). Natural Disasters and Economic Dynamics: Evidence from the Kerala Floods.
20. Pampalon, R., and Raymond, G. (2000),"A deprivation index for health and welfare planning in Quebec", *Chronic Diseases Canada*, 21(3), 104-113.
21. Pampalon, R., Hamel, D., Gamache, P., Philibert, M. D., Raymond, G., and Simpson, A. (2012), "An area-based material and social deprivation index for public health in Québec and Canada", *Canadian Journal of Public Health/ Revue Canadiennede Santee Publique*, S17-S22.

22. Pankaj P. Khelkar (2018), India Today Newspaper: 22/08/2018, https://tinyurl.com/2ktthh6p
23. Panwar Vikrant and Sen Subir. (2019), "Economic Impact of Natural Disasters: An Empirical Re-examination", *The Journal of Applied Economic Research*, 13: 1.
24. Parida, Y. (2020). Economic impact of floods in the Indian states. *Environment and Development Economics*, 25(3), 267-290.
25. Parvin, G. A., Shimi, A. C., Shaw, R., & Biswas, C. (2016). Flood in a changing climate: The impact on livelihood and how the rural poor cope in Bangladesh. *Climate*, 4(4), 60.
26. Radboud University (2021), "Human Development Indices", Netherlands: Global Data Lab, Institute for Management Research, Radboud University.
27. Santhi, S. L. and Veerakumaran, G. (2019), "Impact assessment of Kerala flood 2018 on agriculture of farmers in EdathuaPanchayat, KuttanadTaluk of Alappuzha District", *Shanlax International Journal of Economics*, 7(4), 24-28.
28. Sarkar, B., Banerji, H., and Sen, J. (2014), "Patterns of socio-economic deprivation and its impact on quality of life: Case of a less developed region in West Bengal, India", *Athens Journal of Health*, 1(4), 271-285.
29. Shaharban, V., and Rathnakaran, A. (2019), "Disaster Prevention and Management in the Era of Climate Change with Special Reference to Kerala Flood 2018" Landslides, 50(5619.7), 2799482.
30. Singh, A., Reddy, S., Kamthan, M., & Chug, G. (2018). 2018 Kerala floods: A report on governance and legal compliance. New Delhi: UP E2, SCDR-NIDM Research Publications.
31. Sivakumar and Sarvalingam A. (2010), "Human Deprivation Index: A Measure of Multidimensional Poverty", *MRPA Paper No. 22337*, Germany: Munich University Library.
32. Sudheer, K. P., Bhallamudi, S. M., Narasimhan, B., Thomas, J., Bindhu, V. M., Vema, V., & Kurian, C. (2019). Role of dams on the floods of August 2018 in Periyar River Basin, Kerala. *Current Science*, 116(5), 780-794.Thummarukudy, M. (2019), *PerumazhaPakarnnaPadangal*, Kerala: D C Books.
33. Tripathi, P. (2015). Flood disaster in India: an analysis of trend and preparedness. *Interdisciplinary Journal of Contemporary Research*, 2(4), 91-98.
34. United Nations Development Programme. Retrieved from https://tinyurl.com/a5ja2bsr (accessed on 14/06/2021),
35. Vanama, V. S. K., Rao, Y. S., and Bhatt, C. M. (2021), "Change detection based flood mapping using multi-temporal Earth Observation satellite images: 2018 flood event of Kerala, India." *European Journal of Remote Sensing* 54, no. 1 (2021): 42-58.
36. Venu, V. (2019), *August 2018 Keralam: Pralayam, Athijeevanam* and *Punarnirmanam*, Chennai: Westland Publications Private Limited.

Implications of Cloud Burst and Heavy Precipitation during the Uttarakhand Disaster (2013) on the Frontal Dynamics of the Gangotri Glacier

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Sanjay Deswal[2], Rakesh Saini[3], Syed Umer Latief[4] and Milap Chand Sharma[5]

Abstract

The monsoon-dominated north-western region of the Garhwal Himalaya is highly susceptible to hydro-metrological disasters due to its location, physiography, climate and high-energy environment. The landform mapping, terrestrial records, and multispectral satellite data depicted that the glacier in the north-western Garhwal Himalaya region has been retreating for the last 150 years at varying rates over time and space. On June 16–17, 2013, almost 500 times more precipitation was observed in the north-western Garhwal Himalayan region due to the fusion of the monsoon trough and western disturbances. The availability of supra-glacial lakes within the vicinity of the Gangotri glacier and subsequent heavy precipitation associated with the Uttarakhand disaster resulted in a retreat of 57±21.23 m on the right flank of the Gangotri glacier due to either detachment or calving effects. The retreat between May and August 2013 is almost equal to the retreat between the last thirteen years, from 2000 to May 2013.

Keywords: *Uttarakhand Disaster, Cloudburst, Gangotri Glacier, Supra-glacial Lake, Glacier Retreat*

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1. Introduction

The Himalayan glaciers have been continuously retreating since the end of the Little Ice Age (LIA) (Bhambri and Bolch, 2009; Deswal et al., 2023; Mayewski et al., 1980; Raina, 2004). Many Himalayan glaciers have shown rapid retreating patterns (Bolch et al., 2008), and many glaciers have had stable fronts since 2000 (Bahuguna et al., 2014; Kulkarni et al., 2007). The aforementioned irregular behaviour of the Himalayan glaciers in general could be attributed to glacier topography (Oerlemans, 1989), climatic systems of the region (Kargel et al., 2005), glacier hypsometry and geomorphological characteristics (Furbish and Andrews, 1984), glacial surface characteristics and supraglacial debris (Scherler et al., 2011) and their morphological properties(Mehta et al., 2014) and their sizes and response time. However, glaciers are sensitive to both internal and external factors, high-energy metrological events and land surface processes, and their dynamics within the vicinity of the glacier terminus or a combination of all the factors mentioned above have the potential to accelerate or decelerate the glacier retreat. The high-energy Himalayan environment, metrological triggering, and topographical factors all together resulted in a massive disaster on June 16–17, 2013, in the Garhwal region of the western Himalaya, named the 'Uttarakhand Disaster'. Present study accessed the impacts of 'Uttarakhand Disaster' on the frontal dynamics of the Gangotri glacier with remotely sensed data and field-based verification.

2. Study Area

The Gangotri glacier is located in the north-western region of the Garhwal Himalaya in the western Himalayan region (Figure 1). The Gangotri is the main and largest glacier of the Bhagirathi Basin; it originates from a narrow and large depression along the northern slopes of Chaukhamba peaks; and avalanches mainly feed the accumulation glacier mass.

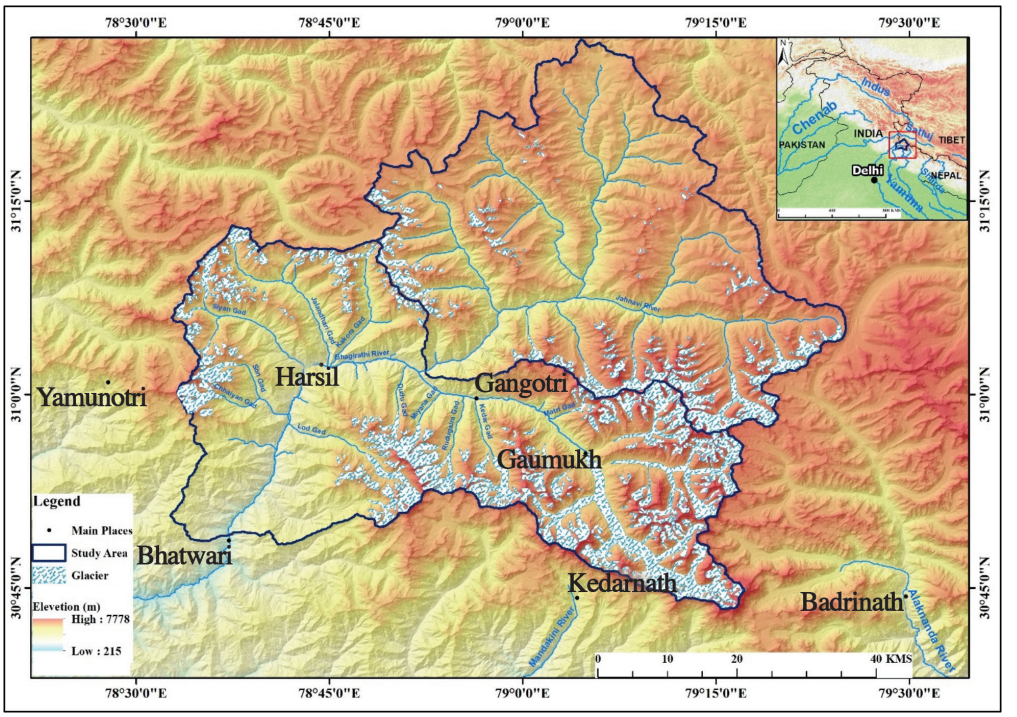

Figure 1 : Map of the study area in the Upper Bhagirathi Basin, Uttarakhand

The Gangotri glacier is about 30.2 k.m. long with a glacier-covered area of about 120 km², ranging from 4000 m.a.s.l. to 7036 m.a.s.l. (Raina, 2004). The holy river Ganga originates from Gaumukh, the snout of the Gangotri glacier, at an elevation of 4050 metres (Figure 1), which is an important source of life and livelihood for millions of peoples living in mountain and downstream.

3. Data Source & Methods

The distribution of precipitation over time and space during the Uttarakhand Disaster (short and long duration) has been accessed from the Tropical Rainfall Measuring Mission (TRMM) data, obtained from the Giovanni portal of NASA. Snout mapping of the Gangotri glacier has been performed with the help of Multispectral Landsat Satellite Data from 2000 to 2013, but Sentinal-2A data has been used for snout mapping since 2017. Further details of the data, sensor, scene ID, acquisition date and spatial

resolution are given in Table 1. Extensive fieldwork was carried out in 2013 (May 17–27, 2013) and 2015 (May 21–June 7, 2015) for the ground truthing, collection of GCP and terrestrial records of the glacial dynamics in the Gangotri region.

However, the dynamics of the terminus of the Gangotri glacier have been mapped through manual digitization of the multispectral data. However, the mean retreat was measured through the overlaid line with a horizontal distance of 50 metres as per methodology (Bhambri and Bolch, 2009; Bhambri et al., 2011; Chand and Sharma, 2015), as represented in figure 2. The remotely sensed data has been processed, and glacier retreat length and area have been measured 1with the help of QGIS and R software.

Table 1: Details of the Satellite Data used for the Present Study

Data Type	Scene ID	Acquisition date	Spatial Resolution
Landsat 5 TM	LT05_L1TP_145039_20000923_20201029_02_T1	23.09.2000	30 * 30 m
Landsat 8 OLI/TRIS	LC08_L1TP_145039_20130522_20200912_02_T1	22.05.2013	
	LC08_L1TP_146038_20130801_20200912_02_T1	01.08.2013	
TRMM	TRMM_3B42RT_Daily_7	1.06.2013	0.25°
		10-17.05.2013	
Sentin-al-2A	S2A_OPER_MSI_L1C_DS_SGS__20171014T104205	14.10.2017	10 * 10

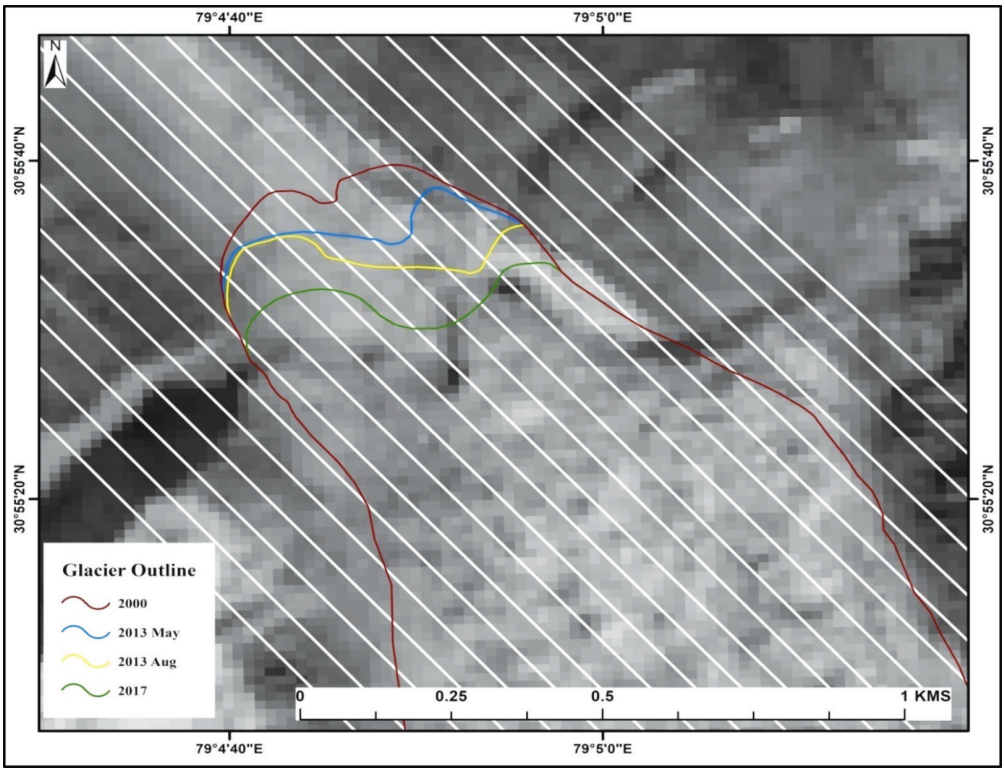

Figure 2 : Glacier outlines delineated from different satellite data and overlaid line with 50 m horizontal distance

4. Uttarakhand Disaster

The northwest Garhwal Himalayan region is highly vulnerable to Hydro-metrological disasters due to its geographical location, physiography, orographical forcing, overlapping dominant regional climatic systems (southwest Indian summer monsoon and Mid-latitude western disturbances), occasional fusion, high energy environment and dynamic glacio-fluvial processes (Dimri et al., 2017). As per the India Disaster Report (2013), the Uttarakhand disaster was caused by torrential precipitation in the middle of June (between June 14 and June 18, 2013) due to the fusion of the southwest monsoon trough and western disturbances over the Himalayan region. However, other studies reveal that the Uttarakhand disaster was caused by the early onset of the

monsoon, heavy downpours, cloud bursts, and subsequent lake bursts, resulting in massive flash floods and landslides (Allen et al., 2016). Although some research anticipated that the lake breach was due to ground saturation caused by enhanced runoff due to rain-on-snow type melting (Dobhal et al., 2013).

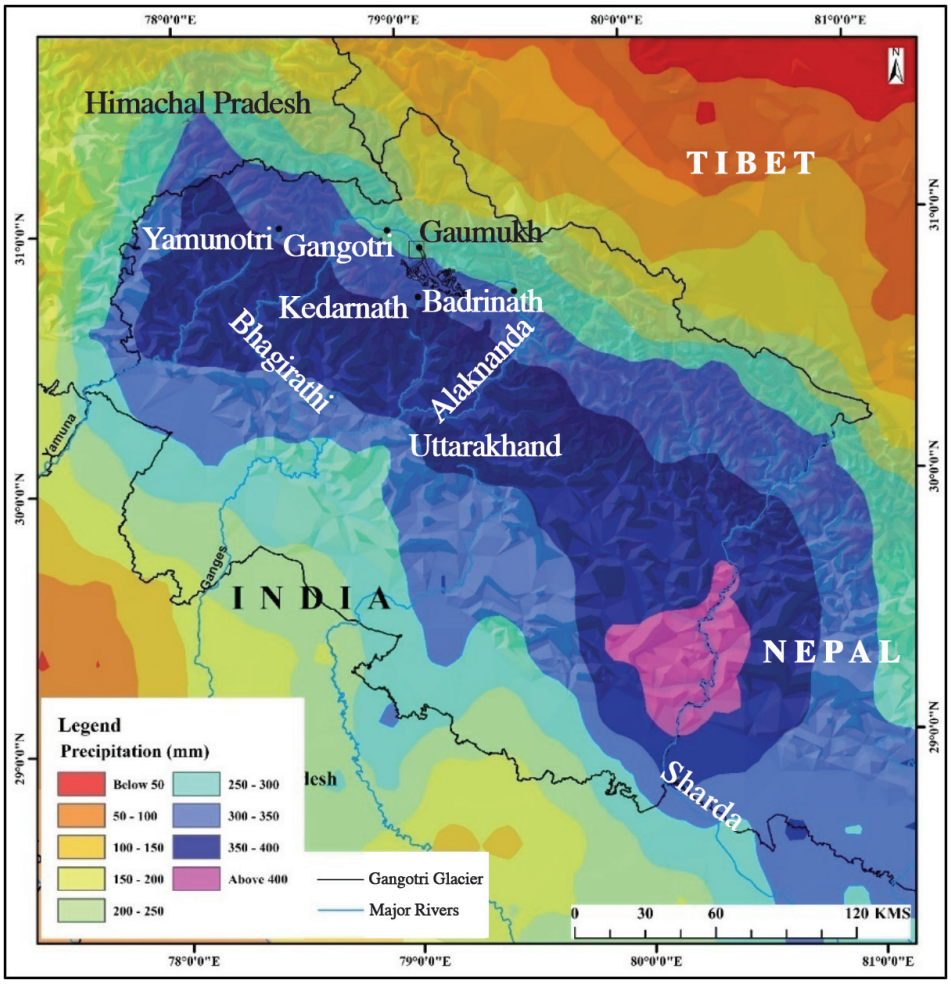

Figure 3 : Total Precipitation in the study area from June 10, 2013 to June 17, 2013

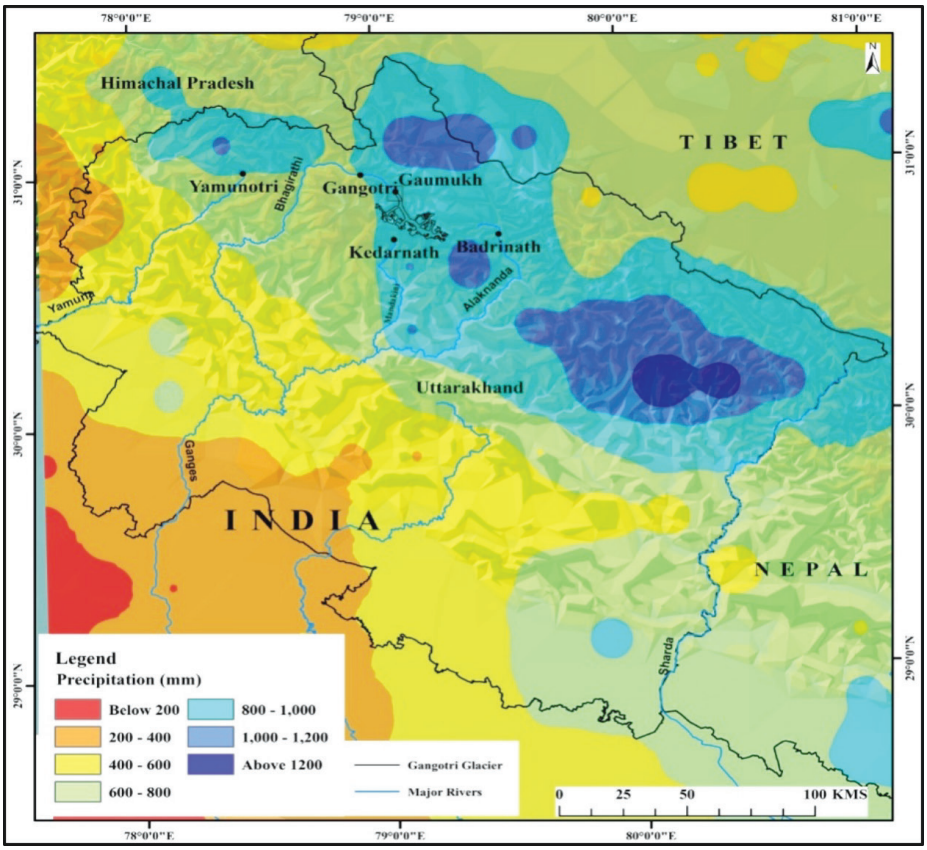

Figure 4 : Total Precipitation in the study area between May 13, 2013 and July 15, 2013

As per the TRMM 3B42 data, between June 10 and June 17, 2013; more than 350 mm of precipitation against the average precipitation of 71 mm (as per the IMD record) occurred in the north-western Garhwal Himalayan region (Figure 3), which was almost 500 times more than the normal precipitation in the region.

In the Uttarakhand disaster, as per the Uttarakhand state govt. official record 6,054 peoples were either dead or "presumed dead", over 100,000 pilgrims and tourists were stranded (Martha et al. 2014), and more than 30 hydropower plants were either destroyed or damaged (Sati and Gahalaut, 2013). The massive impact of

the Uttarakhand disaster in terms of loss of life and livelihood was observed in the Alaknanda Valley. Further investigation of the TRMM data revealed that more than 1200 mm of precipitation had occurred between May 13 and July 15, 2013, in the northwest Garhwal Himalayan region. The high energy event also resulted in significant changes in the geomorphology and climatology of the upper reaches of the Alaknanda and Bhagirathi rivers.

5. Impact of Uttarakhand Disaster (2013) on the Retreat of the Gangotri Glacier

Glacier behaviour is dynamic; it varies with time, and the retreat rates calculated are never identical for even a single glacier over time. The Gangotri glacier in the northwest Garhwal Himalaya is well-documented because of its significance in Hindu mythology. Well-documented terrestrial records of over 150 years are available for the Gangotri glacier (Raina, 2009; Raina et. al., 2015). Frontal changes on the Gangotri glacier can be inferred from the terrestrial records by identifying and interpreting associated landforms. The signatures from the deglaciated valley in the foreland basin of the Gangotri glacier revealed that it has been retreating over the last 150 years. Continuous and comprehensive mapping of the Gangotri glacier has been carried out by the Geological Society of India since 1935, which reveals that in the last 61 years (between 1935 and 1996), the Gangotri glacier retreated about 1100 metres with an average annual retreat rate of 18 metres (Raina, 2004). Bhambri et al. (2012), reported a total retreat of 819 ± 14 meters of the Gangotri glacier from 1965 to 2006 with a varying rate of retreat; 5.9 ± 4.2 m/year from 1965 to 1968, whereas the highest rate of retreat (26.9 ± 1.8 m/year) was observed from during 1968 to 1980. Subsequently, the glacier retreated at an annual rate of 21.0 ± 1.2 meters between 1980 and 2001. The Gangotri glacier's retreat rate declined during 2001–2006, during which the Gangotri glacier receded with an annual retreat rate of 7.0 ± 4.0, almost 1/3 of the earlier retreat rate (Bhambri et al., 2012).

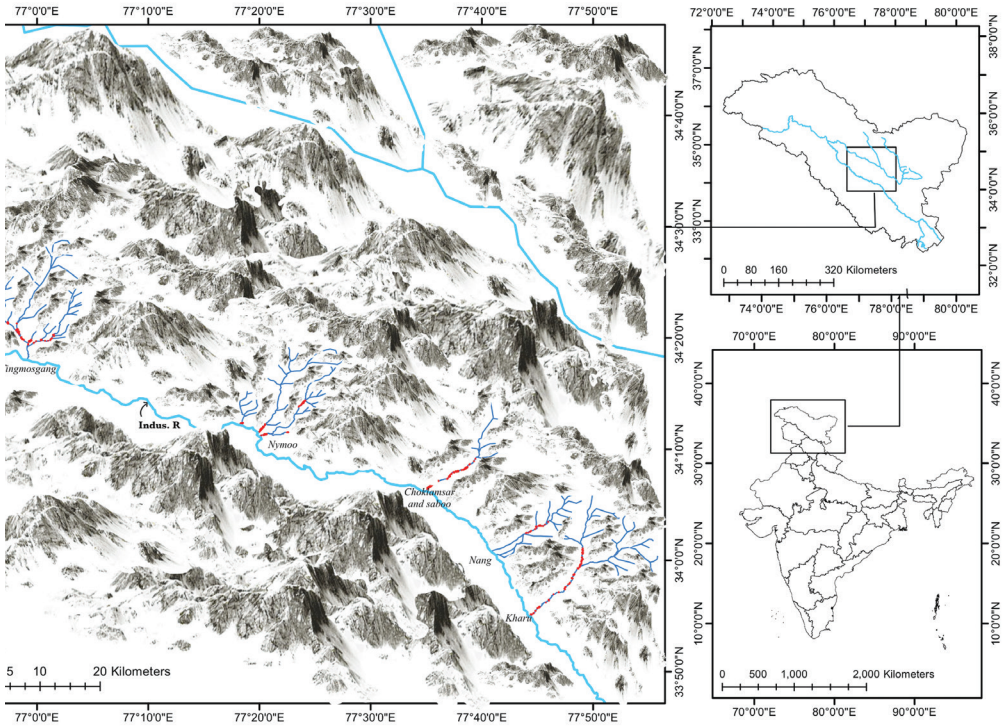

Figure 5 : Retreat of the Gangotri glacier. (A) Sept 2000, (B) May 2013, (C) August 2013 (D) Oct 2017, (E) Retreat of Gangotri Glacier from 2000 to 2017

However, the Gangotri glacier's retreat rate was accelerated very drastically between 2006 and 2017, during which Gaumukh retreated at a rate of 21.9 ± 1.9 m per year (Bhambri et al., 2023). On the contrary, stability was observed on the snout of the Gangotri glacier between 2001 and 2010 (Bahuguna et al., 2014), meaning the retreat rate was accelerated from 2010 onwards. The present study also observed a total retreat of 64.25±21.23 metres of the Gangotri glacier from 2000 to May 2013, with an annual rate of retreat of 4.94±1.63 m per year (Table 2).

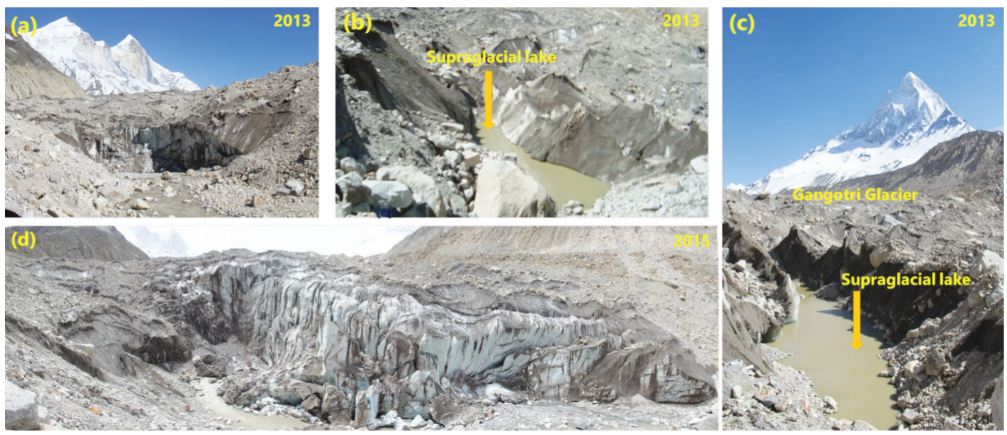

Figure 6 : Field photographs of the Gangotri glacier. (a) Snout of the Gangotri glacier, May (2013), (b) Supraglacial Lake near the Snout of the Gangotri glacier (May 2013), (c) Large Supra Glacial Lake on the Gangotri glacier (May 2013) and (d) Snout of the Gangotri glacier (May 2015)

Table 2 : Total Glacial Retreat and Mean Retreat Rate of the Gangotri glacier (2000-2023)

Year	Total Retreat (m)	Retreat rate (m/year)
2000 - 2013	64.25±21.23	4.94± 1.63
2013 (May - Aug.)	57.01±21.23	57.01±21.23
2013 (Aug) - 2017	95.75±15.83	23.98±3.96

Table 3 : Total area vacated and mean area vacated near snout from 2000 to 2023 in m^2

Year	Total Area Vacated (m^2)	Vacated mean Area (m^2/year)
2000 - 2013	24531±450.71	1887.0±34.67
2013 (May - Aug.)	22344±450.71	22344.0±450.71
2013 (Aug) - 2017	44375±244.59	11093.8±61.15

However, due to the heavy downpour in the Gangotri region associated with the Uttarakhand disaster (Figures 3 and 4) and the presence of the large supraglacial lakes (Figure 6a and c) within the vicinity of Gaumukh during May 2013, those lakes might have flooded due to heavy precipitation in subsequent months and either resulted in the detachment of a large section from the right flank of the Gangotri glacier or accelerated the melting on the right flank due to the strong calving effect, resulting in the accelerated retreat on the right flank of the Gangotri glacier somewhere between May and August 2013 (figure 5). During May and August 2013, the Gangotri glacier observed a total retreat of 57.01±21.23 m within the period of 04 months and subsequently, the Gangotri glacier retreated with an annual rate of 23.98±3.96 m from 2013 to 2017 (Table 2). From 2000 to 2013, the Gangotri glacier vacated 1887.0±34.67 m^2 area annually and 22344±450.71m^2 area between May to August 2013 (Table 3). However, between 2013 and 2017, the Gangotri glacier vacated11093.8±81.53 m^2 area annually. On the Gangotri glacier, unprecedented retreat has been observed in length and area between May and August 2013 (Figure 5, Tables 2 and 3). During the fieldwork in May and June 2015, the retreat on the right flank of the Gangotri glacier was also confirmed by field and terrestrial records (Figure 6d). The accelerated retreat of the glacier, coupled with slope instability and sedimentation from the lateral moraines of the Gangotri glacier near Meru glacier in 2017, caused the Bhagirathi river channel to shift, leading to the formation of a lake near the snout of the Gangotri glacier (Figure 5 D and E). This newly formed lake holds the potential to further accelerate the retreat of the Gangotri glacier in the near future.

6. Discussion and Conclusion

The Uttarakhand disaster in the north-western Garhwal Himalaya, marked by intense precipitation and a catastrophic cloudburst, triggered significant geomorphological changes, including the redirection of river courses, severe landslides, and the devastating loss of life and property. In the case of the Gangotri glacier, the presence of large supraglacial lakes, coupled with heavy rainfall, played a key role in accelerating its retreat. This event likely initiated calving and the detachment of large glacier sections, further intensifying the retreat process.

This study highlights the critical influence of glacier surface characteristics and extreme hydro-meteorological events, particularly in monsoon-dominated regions, on

rapid glacial retreat. The findings reveal that the retreat rate of the Gangotri glacier is driven not only by mass balance but also by the interaction between surface processes and large-scale climatic forces. Notably, the glacier's right flank experienced a retreat of 57.01 ± 21.23 m between May and August 2013—nearly equal to the retreat recorded over the previous 13 years. This accelerated retreat is attributed to the combined effects of supraglacial lakes and intense precipitation, which likely accelerated calving or led to the detachment of glacier sections.

The study further identifies a significant shift in glacier dynamics, with a relatively stable retreat rate prior to 2013, followed by a sharp escalation post-disaster. This shift underscores the critical role of extreme weather events in altering glacier behavior. The evidence strongly indicates that high-energy climatic events, combined with specific glacial surface features, can drive accelerated retreat, particularly in monsoon-affected regions of the Himalaya.

In light of climate change, with the projected increase in extreme precipitation events, glaciers in the Garhwal Himalaya may experience more rapid retreat, leading to slope instability and increased mass movements. This, in turn, heightens the risk of hydro-meteorological disasters for downstream communities and critical infrastructure. The findings underscore the intricate interplay between local topography, glacial characteristics, and extreme weather events, carrying significant implications for future scientific research, climate resilience, and disaster management strategies.

Acknowledgements

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References

1. Allen, S. K., Rastner, P., Arora, M., Huggel, C., & Stoffel, M. (2016). Lake outburst and debris flow disaster at Uttarakhand, June 2013: hydrometeorological triggering and topographic predisposition. *Landslides*, 13(6), 1479–1491. https://doi.org/10.1007/s10346-015-0584-3
2. Bahuguna, I. M., Rathore, B. P., Brahmbhatt, R., Sharma, M., Dhar, S., Randhawa, S. S., Kumar, K., Romshoo, S., Shah, R. D., Ganjoo, R. K., & Ajai. (2014). Are the Himalayan glaciers retreating? *Current Science*, 106(7), 1008–1013.

3. Bhambri, Rakesh, & Bolch, T. (2009). Glacier mapping: A review with special reference to the Indian Himalayas. *Progress in Physical Geography*, 33(5), 672–704.
4. https://doi.org/10.1177/0309133309348112
5. Bhambri, Rakesh, Bolch, T., Chaujar, R. K., & Kulshreshtha, S. C. (2011). Glacier changes in the Garhwal Himalaya, India, from 1968 to 2006 based on remote sensing. *Journal of Glaciology*, 57(203), 543–556. https://doi.org/10.3189/002214311796905604
6. Bolch, T., Kulkarni, A., Kääb, A., Huggel, C., Paul, F., Cogley, J. G., Frey, H., Kargel, J. S., Fujita, K., Scheel, M., Bajracharya, S., & Stoffel, M. (2012). The state and fate of himalayan glaciers. *Science*, 336(6079), 310–314. https://doi.org/10.1126/science.1215828
7. Bolch, Tobias, Buchroithner, M., Pieczonka, T., & Kunert, A. (2008). Planimetric and volumetric glacier changes in the Khumbu Himal, Nepal, since 1962 using Corona, Landsat TM and ASTER data. *Journal of Glaciology*, 54(187), 592–600. https://doi.org/10.3189/002214308786570782
8. Bhambri, R., Sain, K., Chand, P., Srivantava, D., Tiwari, S. K., Yadav, J.S., (2023). Frontal Changes of Gangotri Glacier, Garhwal Himalaya, between 1935 and 2022. *J Geol Soc India* 99, 169–172 (2023). https://doi.org/10.1007/s12594-023-2283-3
9. Chand, P., & Sharma, M. C. (2015). Frontal changes in the Manimahesh and Tal Glaciers in the Ravi basin, Himachal Pradesh, north-western Himalaya (India), between 1971 and 2013. ***International Journal of Remote Sensing***, 36(16), 4095–4113. https://doi.org/10.1080/01431161.2015.1074300
10. Deswal, S., Sharma, M. C., Saini, R., Chand, P., Prakash, S., Kumar, P., Barr, I. D., Latief, S. U., Dalal, P., & Bahuguna, I. M. (2023). Reconstruction of post-little ice age glacier recession in the Lahaul Himalaya, north-west India. *Geografiska Annaler, Series A: Physical Geography*, 105(1), 1–26. https://doi.org/10.1080/04353676.2022.2148082
11. Dimri, A. P., Chevuturi, A., Niyogi, D., Thayyen, R. J., Ray, K., Tripathi, S. N., Pandey, A. K., & Mohanty, U. C. (2017). Earth-Science Reviews Cloudbursts in Indian Himalayas : A review. *Earth-Science Reviews*, 168, 1–23. https://doi.org/10.1016/j.earscirev.2017.03.006
12. Dobhal, D. P., Gupta, A. K., Mehta, M., & Khandelwal, D. D. (2013). Uttarakhand disaster: Facts and plausible causes. *Current Science*, 105(2), 171–174.
13. Furbish, D. J., & Andrews, J. T. (1984). The use of h ypsometry to i nd icate long-ter m stabi lity and response of v alley glaciers to ch anges in mass tr ansfer. *Journal of Glaciology*, 30(105), 199–211.
14. Kargel, J. S., Abrams, M. J., Bishop, M. P., Bush, A., Hamilton, G., Jiskoot, H., Kääb, A., Kieffer, H. H., Lee, E. M., Paul, F., Rau, F., Raup, B., Shroder, J. F., Soltesz, D., Stainforth, D., Stearns, L., & Wessels, R. (2005). Multispectral imaging contributions to global land ice measurements from space. *Remote Sensing of Environment*, 99(1–2), 187–219. https://doi.org/10.1016/j.rse.2005.07.004
15. Kulkarni, A. V., Bahuguna, I. M., Rathore, B. P., Singh, S. K., Randhawa, S. S., Sood, R. K., & Dhar, S. (2007). Glacial retreat in Himalaya using Indian Remote Sensing satellite data. *Current Science*, 92(1), 69–74. https://doi.org/10.1117/12.694004
16. Martha, T. R., Roy, P., Govindharaj, K. B., Kumar, K. V., Diwakar, P. G., & Dadhwal, V. K. (2015). Landslides triggered by the June 2013 extreme rainfall event in parts of Uttarakhand state, India. *Landslides*, 12(1), 135–146. https://doi.org/10.1007/s10346-014-0540-7
17. Mayewski, P. A., Pregent, G. P., Jeschke, P. A., & Ahmad, N. (1980). Himalayan and Trans-Himalayan glacier fluctuations and the South Asian monsoon record. *Arctic and Alpine Research*, 11(2), 171–182. https://doi.org/10.2307/1550514
18. Mehta, M., Dobhal, D. P., Kesarwani, K., Pratap, B., Kumar, A., & Verma, A. (2014). Monitoring of glacier changes and response time in Chorabari Glacier, Central Himalaya, Garhwal, India. *Current Science*, 107(2), 281–288. https://doi.org/10.13140/2.1.4435.0083
19. National Institute of Disaster Management. (2012). *India Disaster Report - 2011*. 1–85.
20. Oerlemans J. (1989). On the response of valley glaciers to climatic change. *In: Oerlemans J, editor. Glacier fluctuations clim chang*. Springer; p. 353–371.
21. Raina, V. K. (2004). Is the Gangotri glacier receding at an alarming rate? *Journal of the Geological Society of India*, 64(6), 819–821.
22. Sati, S. P., & Gahalaut, V. K. (2013). The fury of the floods in the north-west Himalayan region: The Uttarakhand tragedy. *Geomatics, Natural Hazards and Risk*, 4(3), 193–201. https://doi.org/10.1080/19475705.2013.827135
23. Scherler, D., Bookhagen, B., & Strecker, M. R. (2011). Spatially variable response of Himalayan glaciers to climate change affected by debris cover. *Nature Geoscience*, 4(3), 156–159. https://doi.org/10.1038/ngeo1068

Community Involvement in Disaster Risk Management (CBDRM) A Study of Disaster Management Volunteers

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Abstract

Communities are always the first to respond in any disaster situation, and they are the ultimate sufferers. Local communities, as first responders, often become a key stakeholder in all stages of disaster management. Numerous actors, including governments, technical and educational institutions, and local communities, need to be involved in the disaster risk reduction strategy since it is based on an ongoing risk and risk assessment strategy. Their efforts will need to be combined with planning and development techniques that empower people and encourage broad dissemination of knowledge. In this article, the authors aim to understand the involvement of the community in disaster risk management. The article explores the knowledge and awareness of the community regarding types of disasters, hazards, vulnerability and involvement of the community in disaster risk management programmes. The relevance of social work to ensure community involvement in disaster risk management is also explored in this article. The article employs both qualitative and quantitative methods to understand people's participation in community based disaster risk management plans and the preparedness of the community. Findings reveal that although communities were aware regarding types of disasters, hazards, and vulnerability, they were not aware of any linkage between risk, capacity, and vulnerability. The study revealed the need for greater involvement of the community in the development of disaster management plans. The principle of community organization in social work was found to be relevant to ensuring community participation in disaster risk management.

Keywords: *Disaster Management, Community Participation, Community Based Disaster Risk Management, Social Work*

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1. Introduction

Disaster Management has undergone a paradigm shift in recent years, beginning from relief and response to disaster risk reduction (DRR) and evolving into community based management. Community-focused disaster management is a more proactive way to address disaster management as compared to the earlier reactive model. Involving communities in managing their risks – along with necessary stakeholder support, is not only a moral imperative but also a practical management strategy (Bhagat, 2017), to leverage the strength of local wisdom, social leadership, collective action, and the role of social work. The recent scenario of disaster emergence has made it inevitable for communities across the world to keep themselves prepared for any natural and even human-made disasters, as the probability of any unexpected disaster may hit anywhere, irrespective of any previous history, culture, and location.

Several definitions of CBDRM are available that are developed by CBDRM practitioners based on their perceived experience. Although, in general, some agreed definition defines CBDRM as a process of disaster risk management that involves active participation of the community at risk in the identification, analysis, management, monitoring, and evaluating disaster risk in order to reduce their vulnerability and increase capacities (Pribadiet. al. 2008). CBDRM is "the efforts in empowering the community to be able to manage disaster risk with some levels of involvement of community groups or stakeholders in the planning as well as the use of local resources for the implementation by the community themselves" (Abarquez & Murshed, 2004). Others define CBDRM as the framework of inclusive and sustainable disaster management where the community is involved or facilitated to be actively involved in disaster management (planning, implementation, monitoring, followed with an evaluation) with the use of most optimal possible local resources as well as possibly the least external resources (Delica-Willison, 2003).

The community-based disaster risk management (CBDRM) approach seeks to actively involve the community in the identification, analysis, implementation, and monitoring of any disaster risk situation with the aim of reducing their vulnerabilities and concentrating on enhancing their related capacities. This is because the community is the first responder in the event of any disaster. Community participation is therefore very crucial, as it is the primary source of information on

knowledge about local requirements and suitable actions to reduce the risk of disaster. This enables the community to enhance its capacity to absorb, monitor, and recover from any disaster (National Institute of Disaster Management, 2021).

The involvement of the concerned community in the management of the risk of disaster at the regional level is supported by the Community-Based Disaster Risk Management (CBDRM) approach. This calls for a series of actions and efforts, including community self-interpretation of hazards and disaster risk, monitoring, reduction, and evaluation of their performance in disaster risk reduction. Apart from this, an optimal mobilisation of resources in the community is also essential (Davies & Murshed, 2006).

CBDRM holds the principle of "leave no one behind," which means including everyone irrespective of age, gender, race, religious group, minority group, and ethnicity. In addition, CBDRM is also seen as a unique process of empowering communities that lessens stakeholders dependency, especially during disaster emergencies. The affected community gradually becomes self-reliant and more capable. Once community capacity is strengthened with reduced vulnerability by using internal resources, the impact of the external vulnerability is reduced (Department of Disaster Management, n.d.).

Table 1 below presents CBDRM approaches in comparison with the conventional disaster management approach. CBDRM ensures sustainability as a result of the involvement of sufficient internal local stakeholders. The CBDRM approach focuses on the preparedness of the community to avoid and reduce damage and loss (United Nations Office for Disaster Risk Reduction, 2015; Helu & Samra, 2015).

Table 1 : Comparison of CBDRM Approach with Conventional DM

S.No	Aspect	CBDRM	Conventional
1.	Communication on disaster risk	Data and information are more symmetrical and richer; rapid information sharing among stakeholders	Asymmetrical and only based on experts' view and the knowledge of the elite. Risk communication is top-down

2.	Transaction of knowledge and practice	Transaction of knowledge is done "peer-to-peer" between the community and experts/facilitators. Cross-fertilisation of knowledge among stakeholder take place	Community indigenous knowledge is overridden by experts' opinion that is not sensitive to the context of local risk
3.	Time effectiveness	More time investment is necessary at the beginning but in the long term it is considered more sustainable	Profitable at the shorter term but not sustainable in the longer term
4.	Cost effectiveness	Local resources (knowledge, labour, skills, capital) are made available to the maximum extent possible	More cost for longer work
5.	Effectiveness	Involvement of many stakeholders result in many more local cadres with the skills in local risk reduction	Less skilled local actors, dependency to external parties (experts, the government, NGO)
6.	Legitimacy	Community perceives program in a more friendly way. The root causes of vulnerability and risk such as gender inequality, age, and class can be reduced with participation because it	Low participation, resulting in low legitimacy due to marginalisation of the highly vulnerable of the marginalised

		opens up the space for the marginalised	
7.	Equality	Equality is a not negotiable. The level of risk distribution and the most vulnerable is the target	Lack of vision on reduction of vulnerable groups and not capable of reducing root causes of vulnerability

(**Note:** Adapted from Community-Based Disaster Risk Management (CBDRM) Guidelines, pg. 21, by Lassa et al., 2017, MPBI)

Understanding of the CBDRM process is essential as the community living with hazards is the ultimate sufferer. Ignorance towards such understanding will result in an unsustainable disaster risk reduction implementation at the basic level. Thus, disaster risk management plans must emerge with the awareness of local community capacity and community priority, only then implemented efforts remain destined sustainable (National Disaster Management Authority, 2019). CBDRM plans should also include social workers at micro, mezzo, and macro levels during preparedness, response, recovery, and mitigation (Javadian, 2007). Globally, communities are constantly facing new challenges, and most of the disasters are imposed as a threat to development plans, poverty reduction strategies, and the achievement of Sustainable Development Goals (SDGs) (United Nations, 2023).

In India, the National Disaster Management Plan was prepared in 2015 in consonance with the Sendai Framework for Disaster Risk Reduction, a global blueprint for disaster losses (United Nations Office for Disaster Risk Reduction, 2016). In Delhi, effort towards Community Based Disaster Risk Management (CBDRM) has included collaboration of the Delhi Government with the National Disaster Management Authority (NDMA) and the National Institute of Disaster Management (NIDM) to develop community based strategies. A Common Alerting Protocol based on an integrated alert system has been initiated by the National Disaster Management

Authority for the dissemination of targeted alerts to people in multiple languages through SMS. Emergency Response Support System through State EOC is now managing incidents with geo-tagging support to locate the incident site so the nearby Emergency Support Functionaries can immediately respond. Under the Apda Mitra scheme, the NDMA is providing training to volunteers for effective disaster response search and rescue. Apart from the Delhi Government, NGOs and voluntary organizations are also actively involved in capacity building, generating awareness, and conducting training sessions to empower local communities. Posters, leaflets, and manuals are used for awareness generation. The disaster preparedness planning is being done at all levels of the community, especially in schools where a large number of children are available. (National Disaster Management Authority, 2024a; National Disaster Management Authority, 2024b; NIDM, 2021).

The efforts of the government would remain limited without the active participation of the community members. Studies indicate that community members including professionals, housewives, retired persons, members of the Resident Welfare Associations, and students- both school students, college and university students were unaware of the disaster plan and the authorities responsible for implementation of such a disaster plan in Delhi. Members were also ignorant about their role during pre- and post disaster and the importance of training for disaster (Gautam & Tewari, 2020). A similar study reported unsatisfactory knowledge and practices regarding disaster preparedness (Chetry, et.al, 2013).

Although several international and national institutional frameworks provide platforms for integration of CBDRR at the community level, these provisions would be effective only when specific local needs are met. The involvement of all sections of the community is essential for the effective implementation of the already available disaster risk management plans. Thus, the present study attempts to explore the involvement of the community volunteers in disaster risk management programmes in Delhi.

2. Objectives

The broad objective of the study is to understand the involvement of the community in disaster risk management programmes.

The specific objectives of the study are the following:

1) To explore knowledge regarding hazards, vulnerability, and awareness regarding types of disasters;

2) To examine the involvement of the community regarding disaster risk management programme; and

3) To understand the relevance of social work to ensure community involvement in disaster risk management.

3. Research Methodology

Both quantitative and qualitative methods were employed to study the community involvement in CBDRM. Employing stratified and random sampling techniques, quantitative data were collected from civil defense volunteers, NYKS, NSS volunteers, school students, school authorities, RWA representatives, village Pradhan, etc. using an interview schedule from 220 respondents (20 from each of the 11 districts). A qualitative method was applied to understand the relevance of social work in CBDRM. Respondents for qualitative data were selected using the purposive sampling method. Qualitative data were collected by employing an interview guide consisting of open-ended questions to facilitate in-depth interviews with 15 practitioners from the fields of disaster management and social work. 5 FGDs were conducted in total. The sample size of FGDs was 75 (5x15).

For the present study, the National Capital Territory (NCT) of Delhi was selected. As the research was based in Delhi, eleven revenue districts were selected for the study based on hazard profiles using stratified random sampling.

Primary data gathered through the interview schedule, field note, and observation were coded and classified. Data analysis was done using an Excel spread sheet, an advanced excel tool, as well as SAS software for theme-based graphical representation of data. Qualitative data were analysed by looking for similarities and differences, under different themes, and finally developing categories as per the research objectives.

4. Results and Discussion

To assess the impact and effectiveness of the CBDRM programme in various districts of Delhi, a detailed interview schedule was prepared for a total of 220 volunteers who

had engaged in Community Based Disaster Management activities at the field level such as civil defense volunteers, NYKS, NSS volunteers, school students, school authorities, RWA representatives, village Pradhan, etc.

4.1 Concern Regarding Disaster Affecting the Community

In order to map the sensitivity index of the study participants towards any emergency or disaster that may affect the community, four questions were asked to the respondents on how much concerned they were about emergency/disaster affecting their community. The received sensitivity index is illustrated in the graph (Figure 1) below. Half of the respondents (50%) indicated that they were concerned below any emergency disaster that may affect their community, 35% of the participants claimed that they were not concerned, 14% showed a neutral approach.

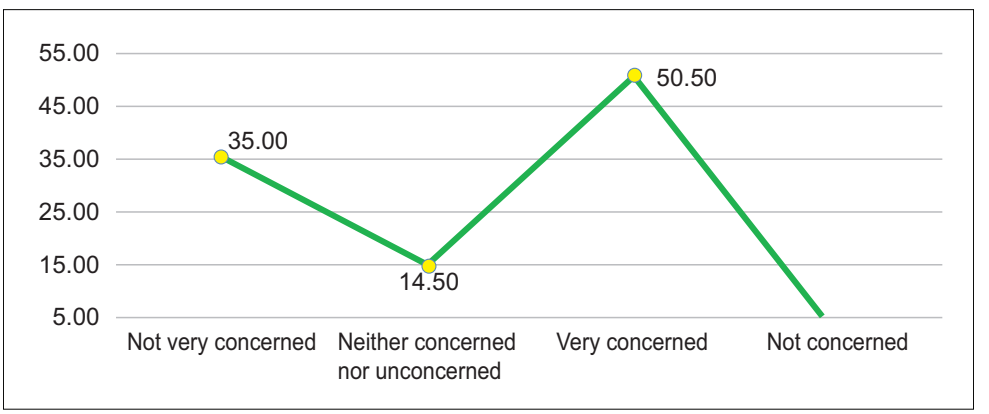

Figure 1 : Sensitivity index of the community

It is pertinent to mention here that the local community can be extremely important in terms of disaster readiness, response capabilities, and disaster mitigation, including advocacy. For this reason, a disaster management programme may be created in collaboration with the affected communities while keeping in mind the existing socio-economic realities. It can put the community on a path of sustainable development with the inclusion of several cross-cutting issues such as gender, environment, and social cohesion to measure the social impact of recovery action in India (National Research Council, 2006).

4.2 Knowledge and Awareness Regarding Disaster

4.2.2 Awareness Regarding Types of Disaster

A total of 220 study participants were asked questions on the basic knowledge regarding the types of disasters. The observed results are illustrated in Figure 1. Among all the responses received, an almost equal proportion of participants were aware of manmade disasters (39%) and natural disasters (38.50%).13.50% were aware of both natural and manmade disasters, 8.50% were not aware of any of the disasters and, 0.50% of study participants did not respond to the question. The following figure (Figure 2) represents a graphical representation of the awareness of respondents regarding types of disasters.

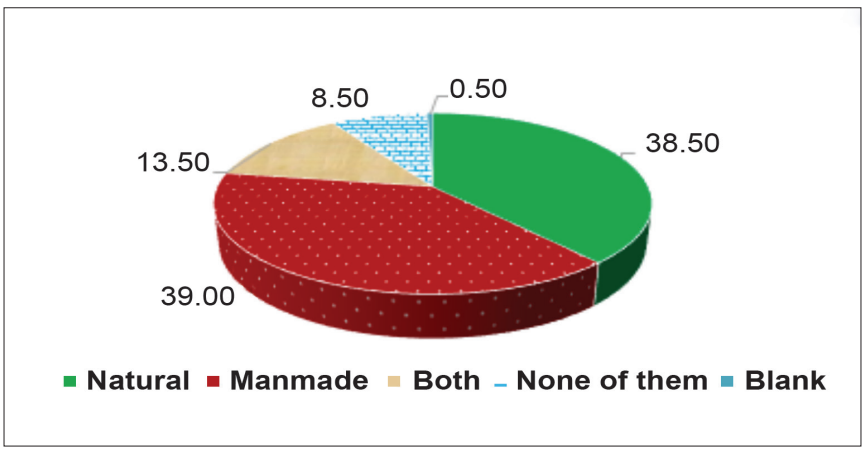

Figure 2 : Awareness regarding types of disasters

It is important to have knowledge and awareness about disasters because local communities, as first responders, can play a crucial role in disaster preparedness, mitigation, response, and recovery. The potential of local communities to deliver on this expectation has been recognized in global and national frameworks (United Nations, 2023; Ministry of Law and Justice, 2005). Thus, appropriate awareness, adequate preparedness, and effective mitigation strategies at the local level involving the most vulnerable communities are imperative for minimizing the impact of any disaster at the local level. District Disaster Management Authorities of Delhi must organise more community-level programme for creating awareness about disaster management.

4.2.3 Knowledge Regarding Hazard and Vulnerability

In order to assess the knowledge of the study participants regarding hazard, and vulnerabilities associated with the disaster, respondents were asked the following four statements:

- Hazards turn into disasters.
- Hazards are everywhere.
- If prepared well, we can avoid the impact of hazard and
- There is no connection between risk, capacity, and vulnerability.

The majority of the participants (45.50%) agreed hazards are everywhere, 14.50% agreed to the fact that "if prepared well, we can avoid the impact of hazards" as a correct statement. 39.50% of the respondents were not able to develop linkages between risk, capacity, and vulnerability, whereas 0.50% avoided giving any response (Figure 3).

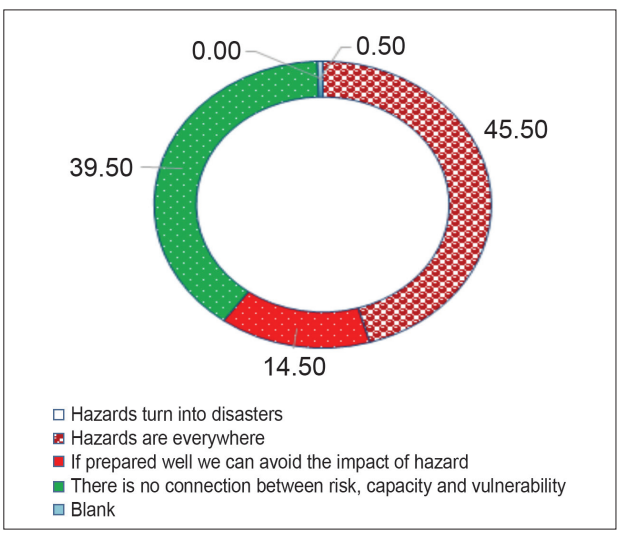

Figure 3 : Concept of Hazard and Vulnerability

Although the term 'vulnerability' is usually used in the context of natural hazards and disaster situations, it has got varying meanings in different disciplines involved in risk research (Fuchs et.al., 2012). Knowledge regarding hazard, and vulnerability

enables preparedness, response, and recovery from a disaster (Du et. al. 2015). Also, understanding regarding risk and vulnerability is an important component of the pre-disaster phase of the hazard and disaster management cycle (Berry, 2009).

4.3 Involvement of Community in Disaster Risk Management (DRM) Programme

The importance of awareness of the community about the disaster risk management programme was observed in the responses received from the study volunteers. While almost 45% of the study participants confirmed that they were aware of the DRM programme around 55% indicated that no such programme was conducted in their community and they were not aware of any such programme. According to the International Federation of Red Cross and Red Crescent Societies (2023), reducing the impact of local hazards requires raising community awareness on disaster risk reduction in accordance with the local hazard context, and on the basis of the findings of vulnerability capacity assessment (VCA) in target communities. Preparedness and capacity building of local communities are essential for effective response (National Disaster Management Authority, 2009).

4.3.1 Involvement of Community in The Process of Disaster Management and Awareness of Potential Hazards

To envisage the information about the community's involvement in the process of disaster management development plan and their awareness about the associated potential hazard, respondents were asked questions on whether they were involved in creating community awareness on potential hazards and disaster management plan. The majority of respondents (54%) confirmed that communities were aware and involved themselves in the process of disaster management development plans, and they were also aware of the associated potential hazard. Only 14% of the study participants felt that communities were not well aware about the associated hazards and were not involved themselves in the development of DM plans, whereas 32% did not respond to the present question as they were not aware of any such programme being conducted by District Disaster Management Authorities in the communities. Observations are depicted in the Figure 4 below:

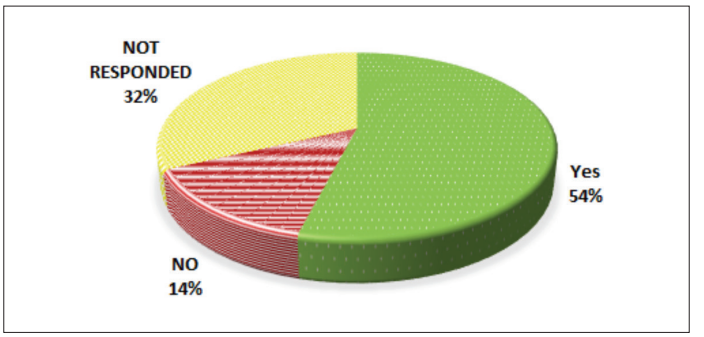

Figure 4 : Awareness of Community towards potential hazard and involvement in process of DM plan

To provide disaster risk information through the involvement of community-based organizations and nongovernmental organizations, the United Nations Office for Disaster Risk Reduction (2015) emphasizes community mobilization and improving collaboration among individuals at the local level. It also talks about conducting public and community consultations and assigning concrete roles and responsibilities to community representatives, as necessary. Decision-making is done through appropriate legal frameworks.

4.3.2 People's Participation in Community Based Disaster Risk Management Plans

The compiled data below presents the responses received from the study participants about people's equal participation in CBDRM plan development. Respondents were asked to respond on the effectiveness of the people's participation in the CBDRM plans. Most of the respondents (around 50%) agreed that equal participation of the people is essential for effective CBDRM plans, while 14% of the study volunteers disagreed with that. 21% of the participants gave neutral responses and 15% of respondents strongly disagreed. The responses have been depicted in the table below through the Likert scale:

Table 2 : People's Participation in CBDRM Plan

People's participation in CBDRM Programme	Agree	Neutral	Disagree	Strongly disagree
Respondents' views	50%	21%	14%	15%

In order to lessen vulnerability and increase capacity, CBDRM seeks to actively involve the community in the identification, analysis, assessment, monitoring, implementation, and evaluation of disaster risks. Such an approach aims to address local issues, difficulties, and problems from the perspective of individuals experiencing it every day. Thus, for an effective CBDRM programme, equal participation of communities in the planning and decision-making process may be ensured (Department of Disaster Management, n.d.).

4.3.3 Importance of Disaster Management in Community-Based Risk Reduction

The following figure (Figure 5) depicts the views of the respondents regarding the importance of the Disaster Management Programme for Community-Based Disaster Risk Management. Although the majority (39%) of the participants agreed that the disaster management programme was important for CBDRM, almost an equal number of participants (37%) were unable to decide for the claimed statement. 10% of the study participants strongly disagreed that a disaster programme is important for CBDRM, 14.50% participants disagreed with the significance of the disaster management programme in CBDRM.

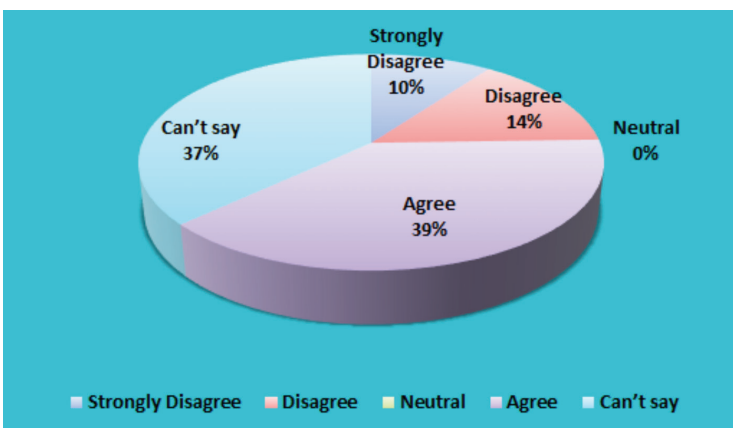

Figure 5 : Importance of Disaster Management Programme in CBDRM

It is now acknowledged that the role of communities during disasters is not limited to first responders but key stakeholders in managing risk and building long-term resilience to disasters. Based on the experiences and learning, the Disaster Risk

Management programme was found to be very effective in CBDRM at all levels (Myanmar Red Cross Society, 2013).

4.3.4 Preparedness for Disaster

The next question was formulated to gain an insight into the level of preparedness and confidence for taking action during a disaster and how it had impacted the overall disaster management process at the community level. The results of the observations are illustrated below in Figure 6:

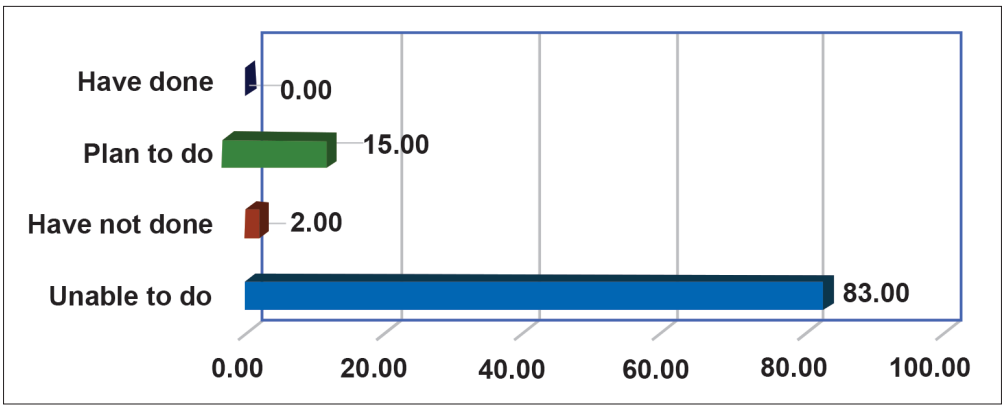

Figure 6 : Preparatory steps taken by trained volunteers for probable disaster

While 15% planned to take some steps, a negligible number (2%) didn't do anything. The majority of the trained study volunteers (83%) were unable to take any preparatory steps for probable disasters. It is observed that although most of the respondents were trained in the basics of disaster management skills, they were not able to take any preparatory steps at their respective communities for minimizing the impact of any probable disasters.

CBDRM is a comprehensive process of participation, partnership, inclusiveness, and ownership of the communities. CBDRM primarily focuses upon mobilizing the community to prepare and respond to extensive risk events. However, due to the lack of its effectiveness at the community level in addressing underlying risk factors of the community falling in various districts of Delhi, ownership of the programme has not been created.

It is noteworthy to mention here that community participation and self-help groups (SHGs) by women have been instrumental in drought mitigation programmes, as indicated by the National Disaster Management Guidelines on Management of Drought (National Disaster Management Authority, 2010a). Some of the important tasks undertaken by the SHGs involved rainwater harvesting, running Public Distribution System, and overseeing water distribution (National Disaster Management Authority, 2010b).

4.3.5 Preparedness of the Community

The final agreement of the study participants was analyzed with respect to linking the preparedness of the community and the safety of the community. Respondents were asked if a prepared community is a safe community. While a majority of the respondents (47%) agreed, almost an equal number of participants could not give any response, and 7.50% of study participants gave neutral responses.

Table 2 : People's Participation in CBDRM Plan

A prepared community is a safe community	Percentage
Agree	47.00
Can't Say	45.50
Neutral	7.50

The response to Cyclone Phailin in India serves as a reminder of how enhanced community readiness to the changing impact of catastrophe hazards can lead to a notable decrease in fatalities. This has been possible because of ten years of preparedness training, disaster management planning exercises, raising awareness, and several structural and non-structural measures (including the construction of multi-purpose cyclone shelters) by multiple stakeholders, including state and national governments, UN agencies, NGOs, etc. However, the extensive damage caused to livelihoods, shelter, and other assets, as well as challenges to the long-term recovery of those affected, highlight the need for a systematic approach to building the resilience of communities (Parida etal., 2018).

4.4 Relevance of Social Work in CBDRM

4.4.1 Role of Social Workers in CBDRM

To assess the varied roles of social workers in disaster risk management, respondents were asked the following questions regarding the role of social workers:

a) Mobilizing people;

b) Providing awareness and training;

c) Supporting in the development of Disaster Management Plan;

d) Organising mock drills; and

e) All of these.

While a majority (40.50%) of respondents felt that social workers will be able to mobilize affected people, 37.50% of participants confirmed all the enlisted significant roles to be played by social workers in the CBDRM process, and 7.50% of participants confirmed that the role of social worker involved providing awareness and training. None of the participants felt that social workers only will provide a supporting role in the development of a disaster management plan. Figure 7 provides the details of the response below:

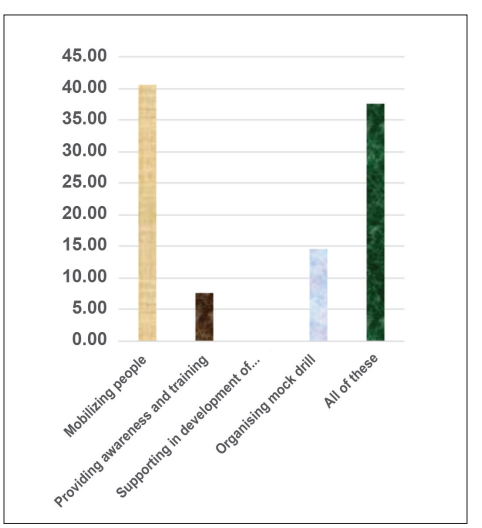

Figure 7 : Roles of Social Workers in CBDRM

Qualitative data revealed that all the experts from the field who were interviewed and the present study participants agreed that social workers play a significant role in the process of community-based disaster risk management. A pool of volunteers from organizations like AAPDA MITRA, NSS, NYKS, etc. contributed towards mitigating the impact of disasters at the community level. All these local facilitators including volunteers, leaders, CSOs, and NGOs, are an important aspect of the CBDRM process. However, all these volunteers need to get trained at regular intervals frequently on all significant aspects of CBDRM in order to support the community. Equal participation of the local community and volunteers is significant in the risk reduction process. Transparency and partnership are two significant components of CBDRM, which may be ensured with the support of local social workers and volunteers.

Social workers engage in a wide range of activities and collaborate with varied groups and organizations, including those involved in disaster response and also those focused on readiness. Thus, social workers can help in lowering the risk of disasters. Social workers play a crucial role as educators, community workers, and disaster planners during disaster preparedness and prevention; counsellors, case managers, and administrators of social protection during disaster response; and as advocates, monitoring and evaluation officers, and development facilitators during disaster recovery (Dickson et al., 2022).

4.4.2 Importance of Participatory Tools to Ensure the Participation of People in the Disaster Management Process

In order to ensure the participation of the people in the disaster management process, respondents were interviewed regarding the inclusion and implementation of any participatory tools. The collected responses are represented in Table 4 below. While 39.50 % of respondents agreed that participatory tools by social workers ensure the participation of people in the DM process, almost 45.50% of the participants disagreed, and 5% gave neutral responses for the same.

Table 4 : Use of Participatory Tools by Social Workers

Participatory tools by social workers may ensure participation of people in the DM process	Percentage
Agree	39.50
Disagree	45.50
Neutral	15.00

Participatory approach, wherein all members are encouraged to participate in decision-making, is vital in fostering effective community ownership. A participatory approach involves coordination and cooperation among various stakeholders of the community through mutual learning and voluntary participation. Social workers can encourage disaster risk reduction and preparedness by acting as a facilitator, enabler, and resource provider. They can play an important role in facilitating participatory disaster risk assessment by involving local people, community leaders, and subject experts.

Qualitative data revealed the following tools that may be used by social workers for ensuring people's participation:

- **A Seasonal Calendar** may be developed with the support of local people in the community meeting. The timeline and historical profile show when hazards occur and when livelihood activities and other significant events take place.
- **Venn Diagram** : A Venn diagram may be used to assess the needs of the community. The size of the circle represents the importance, significance, and impact of various felt and perceived needs of the community.
- **Interview Method** : Individual, group, and key informant interviews may be used to get historical data of disasters, develop resource inventory, and do hazard mapping.

  Focus Group discussion: Focus Group Discussion may be employed to ensure the perspectives and experiences of all stakeholders in the community across class, caste, and strata.
- **Transect Walk** : A systemic walk could be done within the community with a

semi-structured format to learn more about hazards, vulnerabilities and exposures of the potentially affected people.

Qualitative data revealed the relevance of the principle of community organization to CBDRM. Community Organisation is a means and not an end. Fact-finding, and needs assessment, identification, mobilization, and utilization of the available resources, participatory planning, community rights for self-determination, etc. are essential in community organisation. The notion of community organization developed when a variety of institutions and organizations came together to meet the basic needs of the community.It is a strategy that focuses attention on the needs of the community, fosters a sense of community integration, and facilitates interpersonal cooperation (Siddiqui HY, 1997). Most of the participants confirmed that some of the common and overlapping principles include ownership, partnership, and participation.

The most common principles of community organization and development include the following :

1. **Community Participation** encourages everyone in the community to participate at any level and welcome their valuable contribution. At all organizational levels, volunteers and community members play a crucial role in planning, decision-making, provision, participation, direction setting, and evaluation.

2. **Community Ownership** means members of the community actively participate in decision-making and also own all the activities.

3. **Inclusive Approach** : It is necessary to mainstream women, children, especially abled persons, aged in all government schemes and policies wherever possible and promote disaster management plans inclusive with defined Standard Operating Procedures for these vulnerable sections. A dual approach is required to strengthen the disability induced disaster response in the country by building the capacity of local and state level actors, including health practitioners, grassroots organizations, and social workers.

The fundamental principle of community-based disaster risk management (CBDRM) and community organization involves the development of bottom-up processes arising from the communities themselves. Social workers prefer to use three

primary methods, viz. casework, group work, and community organisation during natural hazards. They provide psychosocial counselling, and perform different roles of educator, counsellor, and broker, and work with other stakeholders during and after the occurrence of a natural hazard (Matlakalaetal., 2022).

5. Conclusion

This study attempted to understand the involvement of community volunteers in disaster risk management programmes. As evident from the result, half of the participants were concerned about the occurrence of any emergency disaster, and it is apparent to mention here that more concern of the community is essential towards any disaster affecting their community. This will ensure greater participation of people in the planning of disaster management programmes. The study indicated that the awareness of the community regarding the types of disasters was significant, with an equal proportion of participants being aware of both natural and man-made disasters. Although the majority of the study participants agreed about the presence of hazards everywhere, a significant proportion of respondents were not able to develop any link between risk, capacity, and vulnerability. It is imperative to conclude that the awareness of the community regarding types of disasters and knowledge regarding hazards, and vulnerability is essential in planning any disaster management programme. The study also explored the involvement of the community regarding disaster risk management programmes, and it was found that a significant percentage of the study population (32 percent) were not aware about programmes being conducted by the District Disaster Management Authorities in the communities. Just half of the study respondents agreed for the need of people's participation in community-based disaster risk management plans. Similarly, a significant proportion of respondents (37 percent) couldn't decide on the importance of disaster management in community-based disaster risk reduction programmes and a majority of study participants reported being unable to take any preparatory steps for minimizing the impact of any probable disasters in their respective communities. It may be concluded that although there is a well placed mechanism in the prevention and management of disasters in India, the involvement of the community remains limited. The Community should be made aware of the presence of the disaster

management programme for more involvement and participation. Ensuring people's participation and envisaging their role in CBDRM plans is the need of the hour for making the community better prepared for any future occurrence of disaster. This study highlighted the relevance of social work and its methods, especially community organization, in ensuring greater community involvement in CBDRM programmes. A majority of the study participants reported that social workers are better equipped in mobilizing affected people. Tools of social work, viz. preparing a seasonal calendar, Venn diagram, interview method, focus group discussion, and transect walks may be used for ensuring people's participation. Community participation, community ownership, and an inclusive approach are some of the common principles in social work and CBDRM that may ensure greater involvement of the community in disaster risk management programmes.

References

1. Abarquez, I. & Murshed Z. (2004). Community-Based Disaster Risk Management: Field practitioners' handbook. Bangkok. Asian Disaster Preparedness Centre. Pp 1-163, Retrieved on August 28, 2023 from https://www.adpc.net/igo/category/ID428/doc/2014-xCSf7I-ADPC-12handbk.pdf
2. Berry, R. (2009). A review of the use of GIS in hazard and disaster management. Division of Earth, Space and Environment & GIS Research Centre. Retrieved on August 31, 2023 from https://www.researchgate.net/publication/283572836_A_review_of_the_use_of_GIS_in_hazard_and_disaster_management/download
3. Bhagat, S.N. (2017). Community-Based Disaster Management Strategy in India: An Experience Sharing. PDPU *Journal of Energy & Management*. Issue III. October. pg 11-17. Retrieved on August 30, 2023 from https://www.pdpu.ac.in/downloads/1%20Community-Based-Disaster-Management.pdf
4. Chetry, B., Charu, N., Guite, T., Gupta, A.K., Kishore, J. (2013). Awareness and Preparedness Regarding Disasters among Residents of An Urban Slum in Delhi. *Research and Reviews: A Journal of Medicine*. Special Issue, 63-66.
5. Davies, I. & Murshed, Z. (2006). Critical Guidelines of CBDRM. Retrieved on August 28, 2023. Proceedings of 'Regional Workshop on Standards of Community Based Disaster Risk Management' held on 24-27 January 2006 in Bangkok Thailand. Retrieved on August 28, 2023 from https://www.preventionweb.net/files/9440_ADPCCriticalGuidelines.pdf.
6. Delica-Willison, Z. (2003). Community-Based Disaster Risk Management: Gaining Ground in Hazard-Prone Communities in Asia. *Philippine Sociological Review*, 51, 49–64. http://www.jstor.org/stable/44243072
7. Department of Disaster Management (n.d.). Training Curriculum Community Based Disaster Risk Management. Ministry of Home and Cultural Affairs Thimphu, Bhutan. Retrieved on August 28, 2023 from https://www.adaptation-undp.org/sites/default/files/downloads/draft_cbdrm_maunal.pdf
8. Dickson, M., Louis, N., & Jabulani, M. (2022). The importance of social work roles in disaster risk management in Zimbabwe. Technium Social Sciences Journal. 27. 717-726.
9. Du, Y., Ding, Y., Li, Z. & Cao, G. (2015). The role of hazard vulnerability assessments in disaster preparedness and prevention in China. *Military Medical Research*. 2:27 DOI 10.1186/s40779-015-0059-9
10. Fuchs, S., Birkmann, J., Glade, T. (2012). Vulnerability assessment in natural hazard and risk. *Nat Hazards*. 64 (1969–1975). DOI 10.1007/s11069-012-0352-9
11. Gautam, U. & Tewari, D.B. (2020). Community Preparedness for Disasters in Delhi: An Empirical Evaluation. *European Journal of Sustainable Development*, 9(4), 71-83. Doi: 10.14207/ejsd.2020.v9n4p71
12. Helu, M.F.A. & Samra, M.A. (2015). Managing Urbanization & Risk Accumulation Processes: Cases From East Jerusalem Occupied Palestinian Territories. Associated Asia Research Foundation. Retrieved on August 28, 2023

from file:///C:/Users/IGNOU/Downloads/internatinal.pdf
13. International Federation of Red Cross and Red Crescent Societies. (2023). World Disasters Report 2022 Trust Equity and Local Actions. Retrieved on August 30, 2023 from https://www.ifrc.org/sites/default/files/2023-03/2022_IFRC-WDR_EN.0.pdf.pdf
14. Javadian. R.(2007). Social work responses to earthquake disasters A social work intervention in Bam, Iran. *International Social Work*. 50(3). 334–346. DOI: 10.1177/0020872807076047
15. Lassa, J., Paripurno, E.T., Jannah, N.M., Pujiono, P., Magatani, A., Pristianto, J., Sudira, C., & Parlan, H. (2017). Community based Disaster Risk Management (CBDRM) guidelines. Indonesia: MPBI. Retrieved on August 28, 2023 from file:///C:/Users/IGNOU/Downloads/20180222_cbdrm-book-2017.pdf
16. Matlakala, F.K., Makhubele, J.C. &Nyahunda, L. (2022). 'Social workers' intervention during natural hazards'. *Jàmbá: Journal of Disaster Risk Studies*. 14(1), a1176. https://doi.org/10.4102/ jamba.v14i1.1176
17. Ministry of Law and Justice (2005). The Disaster Management Act, 2005 (No. 53 of 2005). Government of India. Retrieved on August 30, 2023 from https://ndma.gov.in/sites/default/files/PDF/DM_act2005.pdf
18. Myanmar Red Cross Society. (2013). Manual on Community-Based Disaster Risk Reduction. Retrieved on August 30, 2023 from https://www.rcrc-resilience-southeastasia.org/wp-content/uploads/2015/12/CBDRR-Manual-ENG-WEB.pdf
19. National Disaster Management Authority. (2024a, September 28). *Aapda Mitra*. https://ndma.gov.in/Capacity_Building/Admin_Coordination/Aapda-Mitra
20. National Disaster Management Authority. (2024b, September 28). *Common Alerting Protocol Integrated Alert System*. https://sachet.ndma.gov.in/
21. National Institute of Disaster Management (2021). Fundamentals of Community Based Disaster *Risk Reduction and Management* [Report Summary of Webinar]. https://nidm.gov.in/pdf/trgReports/2021/November/Report_18November2021sk.pdf
22. National Disaster Management Authority. (2009). National Policy on Disaster Management. Retrieved on August 30, 2023 from https://nidm.gov.in/PDF/policies/ndm_policy2009.pdf
23. National Disaster Management Authority. (2010a). National Disaster Management Guidelines Management of Drought. Retrieved on August 30, 2023 from https://nidm.gov.in/PDF/pubs/NDMA/13.pdf
24. National Disaster Management Authority. (2010b). National Disaster Management Guidelines Management of Urban Flooding. Retrieved on August 30, 2023 from https://nidm.gov.in/pdf/guidelines/new/management_urban_flooding.pdf
25. National Disaster Management Authority. (2019). National Disaster Management Plan. Retrieved on August 30, 2023 from https://ndma.gov.in/sites/default/files/PDF/ndmp-2019.pdf
26. National Institute of Disaster Management. (2021). Report Summary of Webinar on, Fundamentals of Community Based Disaster Risk Reduction and Management. Retrieved on August 28, 2023 from https://nidm.gov.in/pdf/trgReports/2021/November/Report_18November2021sk.pdf
27. National Research Council. (2006); Facing Hazards and Disasters: Understanding Human Dimensions. Washington, DC: The National Academies Press. https://doi.org/10.17226/11671.
28. Parida, B.R., Behera, S.N., Oinam, B., Patel, N.R. & Sahoo, R.N. (2018). Investigating the effects of episodic Super-cyclone 1999 and Phailin 2013 on hydro-meteorological parameters and agriculture: An application of remote sensing. Remote Sensing Applications: *Society and Environment*. 10. 128–137 DOI: 10.1016/j.rsase.2018.03.010
29. Pribadi, K.S., Kusumastuti, D., &Rildova D.K. (2008). Learning from Recent Indonesian Earthquakes: An overview to improve Structural Performance. Proceedings from the 14th World Conference on Earthquake Engineering. October 12-17, 2008. Beijing, China. Retrieved on August 28, 2023 from file:///C:/Users/IGNOU/Downloads/LEARNING_FROM_RECENT_INDONESIAN_EARTHQUAKES_AN_OVE.pdf
30. Siddiqui H.Y., (1997). Working with Communities. New Delhi, Hira Publications.
31. United Nations. (2023). The Sustainable Development Goals Report. The sustainable development Goals Report. Retrieved on August 29, 2023 from https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf
32. United Nations Office for Disaster Risk Reduction. (2015). Sendai Framework for Disaster Risk Reduction (2015-2030). Retrieved on August 28, 2023 from https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
33. United Nations Office for Disaster Risk Reduction. (2016, June 1). *India puts Sendai Framework into operation*. https://www.undrr.org/news/india-puts-sendai-framework-operation

Target Analysis of Sendai Framework for Disaster Risk Reduction 2015-2030: Kerala Flood, 2018

Neenu S. Pillai[1]

Abstract

The UN World Conference in Sendai, Japan, endorsed the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030, recognizing the necessity for an all-hazards approach to disaster risk management. The framework prioritizes improved disaster risk governance, accountability, preparedness, stakeholder recognition, risk-sensitive investment mobilization, health infrastructure resilience, global collaboration, and donor policies and programs. The 2018 Kerala flood was terrible, killing 433 people, displacing 5.4 million people, and uprooting 1.4 million. The flood also wreaked havoc on physical and social infrastructure, such as roads, bridges, electrical lines, communication networks, and educational institutions. Kerala's Post Disaster Need Assessment was a participatory strategy that included discussions with impacted communities and stakeholders. The State Government and international organizations undertook post-disaster needs assessments, prioritizing social sectors. Early warning systems and disaster risk information are critical for preparing for and recovering from hazard events. The media is critical in disseminating catastrophe risk information. Response and recovery are critical steps in reducing disaster-related injuries, fatalities, property loss, and environmental impact. The National Disaster Response Force, Indian Army, state-led volunteers, fishermen, women volunteers, non-state actors, and technical advancements all responded well to the Kerala floods. The Kerala government initiated the 'Rebuild Kerala Initiative' (RKI) to address the root causes of the floods and prepare for future catastrophes.

Keywords: *Disaster risk, Rebuild Kerala Initiative, Response, Sendai Framework, Volunteers*

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1. Introduction

Among the most destructive natural catastrophes, floods affect millions of people all over the world. Many factors can contribute to flooding, such as sudden flooding, which is frequently associated with hydrologically small regions. Although it doesn't last long, the condition can cause serious harm. The frequency of floods has increased recently. Policies for sustainable development may be determined by using certain geographical parallels and differences found in flood-prone areas. (Sharma D.D, 2006).

The Third UN World Conference in Sendai, Japan, approved the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030 as the outcome of stakeholder discussions and intergovernmental negotiations aided by the UN Office for Disaster Risk Reduction. The Hyogo Framework for Action (HFA) 2005-2015, which was designed to further the work being done around the world in accordance with the International Framework for Action and the Yokohama Strategy, is being replaced by the Sendai Framework (UN, SFDRR, 2015-2030). It also aimed to promote a more coordinated approach to risk reduction and resilience building (UN. IOM, 2018). The Sendai Framework acknowledges the need for an all-hazards approach to managing disaster risk, including enhanced disaster risk governance, accountability, preparedness, recognition of stakeholders, mobilization of risk-sensitive investment, the resilience of health infrastructure, global cooperation, and donor policies and programs (Rishma Maini, 2017).

The 17 Sustainable Development Goals (SDGs) are the worldwide objectives for 2030 that were created by the UN; in fact, every SDG incorporates elements of the Sendai framework. Risk is starting to take on a more systemic meaning. In order to lower risk, it is also need to integrate our methods more fully: working together across and within institutions, cooperating across sectors, and making sure that policies and actions are in line. The first widely recognised policy agenda in history to support the idea that development that takes risks can be sustained was the Sendai Framework. Direct economic losses from catastrophes have grown by almost 150% over the past 20 years, with vulnerable developing nations bearing a disproportionate share of the costs. The accomplishment of the Sustainable Development Goals (SDGs) and the Sendai Framework are both products of interrelated social and economic processes.

As a result, there is a great deal of overlap between the two policy instruments (Sendai Framework for Disaster Risk Reduction 2015-2030, United Nations, 2015).

The Great Flood of '99 in 1924 caused a significant flood in Kerala, with over 3,368 mm of rain recorded. This was the heaviest recorded rainfall to date and 64% greater than the average. In 2018, Kerala faced the worst floods in its history, with 42% more rainfall than usual. The floods led to over 400 deaths and devastated seven districts. Rapid urbanization changed the drainage pattern, causing landslides in hilly areas. Kerala was unprepared for major disasters due to insufficient policies, inadequate institutional frameworks, urban sprawl, poorly managed construction, exclusion of disaster risk preparedness in socioeconomic sectors, weak institutional capacity to foresee and respond to extreme events, and constrained financial resources.

The progress of the SFDRR target is analyzed in the study with the data collected from secondary means. For the same purpose, the 7 targets of the framework are being analysed and how it is framed in the study area of Kerala state, especially addressing the 2018 Kerala floods.

2. Study Area

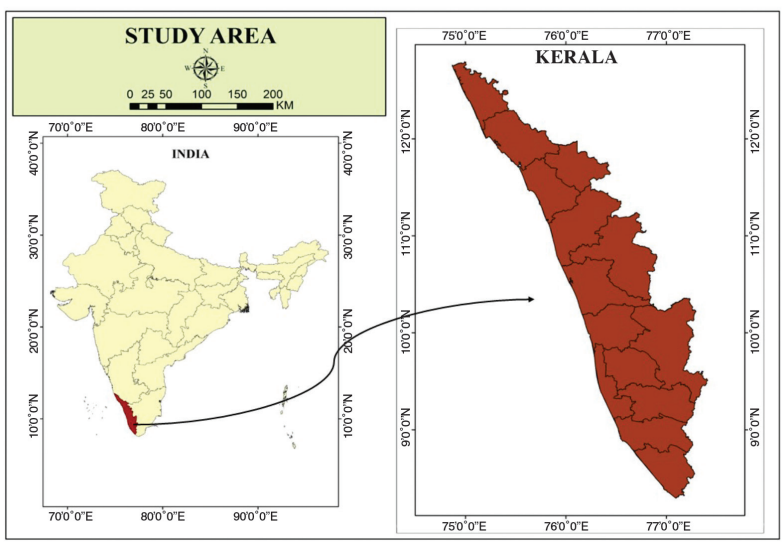

Figure 1 : Location Map

3. Methodology

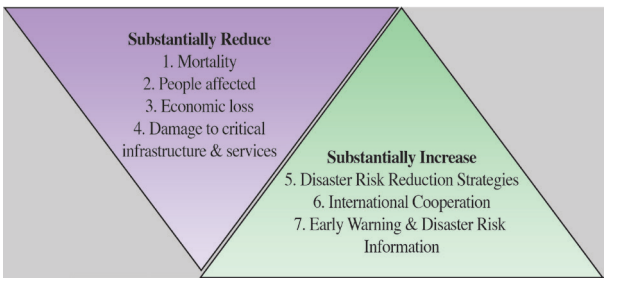

Figure 2 : Methodology

Analysing the Target Action of SFDRR by United Nations in the context of 2018 Kerala flood.The concept of risk is becoming more systemic. Here the 7 target of Sendai Framework on Disaster Risk Reduction is analysed based on the context of Kerala flood 2018. There are 4 targets which is needed to substantially reduce the impact from the past events to achieve the goal while 3 targets needed to improve or substantially increase to reduce the after effect and for a proper mitigation. The existing state of these targets is analysed based on the 2018 Kerala flood event.

4. Sendai Framework Target Analysis (7 Targets)

Global aims and indicators that are successful must be motivating, easily understood, limited in number, ambitious but doable, and measurable. It's important for metrics and targets to be consistent with other worldwide programmes. Indicators created by the Inter-Agency and Expert Group on Sustainable Development Goal Indicators, which are closely integrated with the Sendai Framework, have recently been confirmed by the UN Statistics Division. By gathering data on these factors, UN Member States can gauge their success in reducing catastrophe risk by 2030 (Rishma Maini, 2017). The designation of seven global targets, the expectation that disaster risk will decrease, a goal centered on preventing new risk, decreasing current risk, and enhancing resilience, along with a set of guiding principles, represent the most fundamental changes in disaster risk management (UN, SFDRR, 2015-2030).

The 7 global targets are being analyzedin state level as wells in local level to get an idea of the functioning of the achieving capacity of the targets in the Kerala State.

Basically, the targets are classified into two different groups. One as the targets need to be substantially reduced and the other is to increase the substantial potentiality. The first four targets come in the category of the reducing group and the final three comes in the increasing group.

4.1 Mortality

The 2018 Kerala flood hits catastrophically over the region which washes out so many lives in a few days. That was such an unexpected experience for the people of Kerala who were not supposedly experienced such previous incidents. Extreme rainfall resulted in disastrous floods and landslides that killed 433 people, affected 5.4 million people, and uprooted 1.4 million people. According to information that has been made public, the tragedy had some impact on 1,259 of the 1,664 communities dispersed over the state's 14 districts. According to the information available, among the 433 people that died, 14 (3.2%) Adivasis and 44 (10%) Scheduled Castes. Alappuzha, Ernakulam, Idukki, Kottayam, Pathanamthitta, Thrissur, and Wayanad were the seven worst affected districts (CSSC, 2018). The mortality rate due to disastrous event like flooding in the study area is reduced comparatively. The Kerala State Disaster Management Authority already reported in their recent study.

4.2 People Affected

In Sendai framework, number of people affected by a hazard like flood is needed to be substantially reduced by taking actions based on the previous events. While The Economic Times stated that 33,000 people were saved, over 489 people perished, 15 are missing, and 140 are hospitalized. To house the flood victims, over 3,274 relief camps were built in various areas. A total of 1,247,496 persons are said to have taken shelter in these camps. Numerous communities were impacted, thousands of homes were damaged or destroyed, and an estimated 10,000 km (6,200 km) of highways were devastated (Kerala Flood Case Study, 2019).

The local body, disaster management authority, officials and people work together to make the situation better during the flooding time and later they help the people to build a resilience capacity. It is very important for people to overcome from the shock even if it is physical or mental. Later in 2019, 2020, 2021 and also in 2022 a continuous

hit of the flood is faced this by various regions of Kerala but not to the extent and intensity of 2018 flood situation. But the people who were affected by the very next events were comparatively very less in number and because of the preparedness and mitigation methods taken the impact in both physical, social and economic means were substantially reduced.

4.3 Economic Loss

According to research by the Associated Chambers of Commerce & Industry of India (Assocham), the severe floods in Kerala may have resulted in losses of between Rs 15,000 and 20,000 crore (India Today, 2018). With 96% more rain than normal in August 2018, Kerala had one of its worst floods since 1924, leading to significant flooding in most areas. Significant losses occurred in the areas of housing, fishing, animal husbandry, agriculture, and natural flora and wildlife. 330 landslides were recorded by the State Land Revenue Department, and the estimated economic damage topped INR 31,000 crore. Over 300 acres of coffee and tea plantations were damaged, and over 100 individuals lost their lives. This was just the after effect of the floods which is resulted in the form of top soil erosion or landslide (Chinnasamy, 2020)

The agriculture industry has suffered enormous losses as a result of the exceptionally severe rains, storms, and floods. It should be emphasized that small- and medium-sized farmers make up the majority of the population in Kerala. Only small and marginal farmers (SMF) file damage claims through NDRF/SDRF. Because of this, a damage estimate and claim are only provided for the SMF part. The relief assistance paid for land and agricultural loss by the government in total each district was 12,200/ha. The loss from the commercial sector is not clearly recorded and self-employed people also suffer from such a situation (KSDMA, 2018).

In order to evaluate damage and loss and determine recovery needs, the Government of Kerala commissioned a post disaster needs assessment (PDNA). Participants in the process, as well as the people in the impacted areas, were consulted. The Joint Rapid Damage and Needs Assessment (JRDNA), which concentrated on infrastructure sectors, served as the foundation for the PDNA. The PDNA included a recovery strategy, an examination of the impact of macroeconomic factors on human development, and

15 sectors and cross-cutting issues (Ajinder Walia, 2020). As per the target of SFDRR, the economic loss is carefully analyzed and gave relief assistance to the needful.

4.4 Damage to Critical Infrastructure & Services

Damages that occur to critical infrastructures during a flood is needed to be reduced to attain the target of SFDRR. During the Kerala flood in 2018, all the physical and social infrastructure was mostly damaged all over the state. Especially the road network is closed, bridges collapsed, power connection was destructed, the communication network was damaged, and educational institutions were affected and closed for many days. Many camps were set up in those schools and large auditoriums. Health institutions were affected tremendously, not because it is drowned during the flood but the need of medical facilities were huge during flood time. Emergency services were completely blocked. Especially in the state many health institutions including government hospitals and PHC were affected by the flood. Basically, they are geographically located in the flood-prone regions. The same goes for educational institutions as well.

This damage occurring to the critical infrastructure and services also needed to be substantially reduced. So those will be the helping element for people during flooding. Restoring power and water connections was most important in the critical infrastructure. The damage and recovery needs from infrastructure sectors of transport, power, water resources and irrigation were taken into more consideration after the event and the government also makes accessibility of those infrastructures to people as soon after the event.

4.5 Disaster Risk Reduction Strategies

Disaster risk reduction strategies are something which is needed to be understood importantly because it is the way to mitigate the disaster event. In SFDRR, strategies to reduce the disaster risk is needed to be improved even in the local body level. That is the only way to make the situation better. In the case of many districts in Kerala, the district disaster management plan was last prepared before the flooding event so it is needed to be updated for the improvisation of strategy making. The state disaster management authority of Kerala and the district disaster management authority is under the control of the preparation of strategies, plans, early warning and alerts.

The disaster risk reduction strategies from (Kerala Sate Disaster management Plan, 2016) includes,

- To lessen the severity of floods, the Kerala Conservation of Paddy Land and Wetland Act 2008 must be put into effect.
- Pond and open well preservation as well as rainwater collection on slopes lower than 20 should also be carried out.
- Competent organizations should also follow SOPs for varying rainfall levels.
- The Proceedings of Chairman, DDMA, Thiruvananthapuram No. H1-33275/15 (2) dated 2-05-2015, which was upheld by the High Court of Kerala, provides an example of flood mitigation.
- It is mandatory for government local bodies to put up with local-level disaster management plans.
- Before obtaining environmental clearance, make sure to study disaster management plans and hazard susceptibility maps and include suitable risk reduction measures in project proposals.
- From lower primary through professional education, make an effort to include subject-specific and general concepts of disaster risk reduction in the curriculum and syllabus.
- Help DDMAs run training sessions and spread awareness of disaster risk reduction using audio, video, and print marketing.
- Now it is mandatory for preparing masterplans to involve risk information regarding any natural and manmade hazard and plans need to be prepared.

4.6 International Cooperation

International cooperation is something which is needed to be boosted up to get better from any disastrous circumstances. A participatory approach, the Kerala PDNA included talks with affected communities and stakeholders. Following the floods, detailed damage and loss assessments of both direct and indirect losses were conducted by both the State Government and foreign organisations as part of the

post disaster needs assessment (PDNA), which placed a priority on social sectors. A renowned International NGO worked in order to offer survivors in relief camps with food, hygiene kits, toiletries, soaps, water containers, cutlery, bedsheets, blankets, clothing, water purifiers, and other necessities, Rise Against Hunger India (RAHI) and Save the Children India (SCI) worked together. Children's psycho-social well-being was also supported by Save the Children India through educational and recreational opportunities. The Central Ministry of Agriculture received a project proposal for $745 million, which included financing assistance of $500 million from the "International Fund for Agricultural Development." This assistance was received by the entire state during and after the 2018 flood and the fund allocations and support were tremendously helpful for the purpose of "Rebuild Kerala" (Ajinder Walia, 2020).

4.7 Early Warning System & Disaster Risk Information

A hazard, vulnerability, and risk assessment (HVRA) is the process of quantifying the spatiotemporal return probabilities of various hazards, the expected level of damage to which a given element or set of elements-at-risk is exposed, and the expected financial losses when a given area is exposed to hazards within a given time period. It assists community members in preparing for reaction to and recovery from hazard events, addressing vulnerabilities, reducing hazards, and making risk-based decisions. To allow enough time for evacuation and the implementation of emergency plans on the eve of a disaster, early warning systems can be created and implemented in areas designated as possible danger hotspots. IMD and SOEC are the main agency that gives update about weather events and give alerts to all departments and public about disaster. Media also played a crucial role in giving disaster risk information to public. The significance of delivering early warnings and actionable alerts, the method of transmitting the alert message, and the information's content are the three key elements. The general people were unaware of the full meaning of the color-coded signals in the absence of awareness campaigns and readiness exercises during the past flood event occur. Ironically, the public and the media downplayed the coded signal, and social media posts even expressed concern about the shutters not opening in the event of a decrease in rainfall. but now the situation changed, and people are now aware of the significance of colour coded alerts and early warnings. Other than these weather

alerts now the KSDMA's official website also declares alerts regarding water level increases in dams, rainfall intensity and so on (Ajinder Walia, 2020).

5. Response & Relief

It's important to keep disaster-related injuries, fatalities, property damage, and environmental harm to a minimum. It involves evacuating people, animals, and cattle in addition to giving survivors refuge, food, clothes, and medical care. Stakeholders including the NDRF, Indian Army, state-led, community volunteers, fishers, women volunteers, non-state actors, and technological innovations efficiently responded to the Kerala floods. The National Disaster Response Force (NDRF) dispatched 57 teams, 435 boats, five paramilitary, military, and coast guard companies, 40 helicopters, 20 aircraft, two ships, ten columns, and ten Engineering Task Force teams. Red Cross and Airbus Foundation collaborated to travel farther, and 4537 fishermen deployed 669 boats to save at least 65,000 lives.

6. Community Participation In Disaster Risk Reduction

The Sendai Framework recognized the crucial role that the community plays in disaster risk reduction. Community, as well as local government, join their hands during any hazardous situation simply to reduce the impact of the situation and for resilience building. Disaster risk management uses this paradigm to determine the decrease in catastrophic risk. It offers numerical measurements for damages at the local and national levels. Our understanding of the effectiveness of disaster risk reduction strategies is improved through the compilation and evaluation of disaster damages under the Sendai Framework (Gacu, 2022). The cognitive sense of people is taken into action when a disaster hits. The community themselves become the first responders against such catastrophic events.

Kudumbashree units are self-help groups organized for empowering women. Simply during flood time the activities of this unit are said to be as women in response. In total, 1,13 lakh residential buildings, 3,100 public spaces, and 11,000 impacted individuals received psychological treatment from Kudumbashree Workers in Kerala. From the first days of the disaster, Kudumbashree employees worked hard to provide boxed meals to those in need. The work done by these groups during those times,

particularly in Pathanamthitta, was outstanding, and they are still such active volunteers today. They are the people who were living as one among the affected community and they even participated in the volunteer work.

Community Volunteers, Kerala's response to the floods was the consequence of a sense of community and a desire to help that transcended political, religious, and class boundaries. The planning of rescue and relief operations was done by mass organizations, trade unions, volunteers, students, regular farm laborers, carpenters, electricians, and plumbers from all over Kerala. Thousands of volunteers, including medical professionals, cooked food, unloaded supplies of relief items, took care of the old or sick or looked after children at the relief camps. Students, regular agricultural laborers, carpenters, electricians, and plumbers from around Kerala visited each home to clear the muck, repair the water and power connections, and replace broken doors or windows.

Fishermen, were considered as the actual rescue teams which comes in time for the local community. They single-handedly carried out the rescue mission and came forward to help based on their own will.

Role of technology, Kerala floods made clear how crucial information technology is to rescue and relief efforts. To identify victims, find camps, and sign up volunteers, Kerala Rescue.in, a web-based program, social media, and conventional information broadcast methods were used. A significant number of volunteers were recruited for one-time cleaning tasks through the use of social media.It served as a tool for connecting with those who were in need.

7. Rehabilitation & Recovery

Utilizing public funds, the Kerala government started an immediate recovery programme. The government's major departments all got to work on the restoration and recovery initiatives, which are expected to cost 4,000 crores. The majority of Keralans returned to their homes within a week of the flood waters receding, demonstrating the incredible resiliency of the local population. The 'Rebuild Kerala Initiative' (RKI) was launched by the Kerala government to address the underlying causes of floods and make plans for any future disasters. The RKI aims to enhance the lives and

livelihoods of its citizens by implementing higher standards for recovery and reconstruction infrastructure and by building ecological and technological protections so that the restructured assets may better endure floods in the future.

8. Conclusion

Floods result in extensive property, crop, and environmental damage, as well as a higher risk of diseases including cholera and dysentery. Due to their lower levels of readiness, economic resilience, and health, the poorer people are more vulnerable. Flooding can have more negative non-economic repercussions than negative economic ones. Local governments can help with disaster response since they have a personal understanding of a community's social, economic, infrastructure, and environmental needs.

The analysis based on SFDRR for Kerala is scrutinized with the help of 7 global targets which are locally achieved or the level of achievement of those global targets at a local body level. The lack of availability of recent data can be considered as a negative part of the analysis so many targets achieved only a partial level of success. The Sendai Framework introduced the notion that risk-averse development is sustainable as the first well-known policy agenda in history. Direct economic losses from catastrophes have climbed by more than 50% in the previous 20 years, with vulnerable developing nations bearing a disproportionate share of the costs. The achievement of the Sustainable Development Goals (SDGs) and the Sendai Framework are both outcomes of interconnected social and economic processes. As the matter of Kerala state the flooding incidents that ocuur after 2018 not much severe in the previous case but still progressed to achieve the global targets of SFDRR to a great extent. The reason behind this achievement is the proper strategic planning that they implemented after the face to the great floods. Not just the government is being a part of risk reduction in the state but also the community itself is being engaged in any mitigation and preparedness activities voluntarily. It proves that the human cognitive sense can change the existential reality.

By pointing out more effective mitigation measures, real-time data on flood-prone people and areas can help with emergency planning, land use, river basin management, and policy development. This work may be used to provide accessible flood effect

information for decision-makers and the general public by being integrated into virtual reality settings or transformed into a web-based geospatial analytical system. The unique economic and human ramifications of mitigation methods can augment the advantages of community and property measures.

References

1. Ajinder Walia, N. N. (2020). *Kerala Floods 2018*. NIDM, Ministry of Home Affairs.
2. Chinnasamy, P. P. (2020). Slipping away from the surface: Impact of Kerala 2018 floods on soil erosion. Retrieved from https://rnd.iitb.ac.in/research-glimpse/slipping-away-surface-impact-kerala-2018-floods-soil-erosion
3. CSSC. (2018). Retrieved from Centre for Studies in Social Sciences Calcutta: www.cssscal.org
4. Gacu, J. G. (2022). Flood Risk Assessment using GIS based Analytical Hierarchy Process in Municipality of Odiongan, Romblon, Philippines. *Applied Sciences*.
5. India Today. (2018). *Kerala floods caused damage worth Rs 20,000 crore: Assocham*. Retrieved from India Today: www.indiatoday.in
6. Kerala Flood Case Study. (2019). Retrieved from internet geography: /www.internetgeography.net/topics/kerala-flood-case-study/
7. Kerala Sate Disaster management Plan. (2016). *Disaster Mangement Plans*. Retrieved from Kerala state Disaster Mangement Authority: https://sdma.kerala.gov.in/disaster-management-plans/
8. KSDMA. (2018). Retrieved from Kerala State Disaster Management Authority: https://sdma.kerala.gov.in/2018/
9. Rishma Maini, L. C. (2017). The Sendai Framework for Disaster Risk Reduction and Its Indicators—Where Does Health Fit in? *International Journal of Disaster Risk Science*.
10. UN, SFDRR. (2015-2030). *Sendai Framework for Disaster Risk Reduction 2015-2030*. Retrieved from UNDRR: https://www.undrr.org
11. UN. IOM. (2018). Retrieved from International Organization for Migration | IOM, UN Migration: https://www.iom.int/

Assessment of Fire Safety Knowledge, Perception, and Practices Among Healthcare Workers in Srinagar City, India

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Abstract

Fire safety knowledge, perception, and practices among healthcare workers are fundamental for ensuring the safety of patients, staff, and infrastructure within hospital settings, especially in areas like Srinagar, Jammu & Kashmir, which are susceptible to natural calamities. Notably, Srinagar has experienced a high incidence of fire events in recent years, resulting in significant loss of life and property damage. This research emphasizes the necessity of evaluating fire safety awareness and preparedness among healthcare professionals. The methods employed in this research encompassed a cross-sectional survey design, utilizing structured questionnaires to assess fire safety knowledge, attitudes, and behaviour among healthcare workers. The results of the study revealed significant gaps in fire safety knowledge and preparedness among healthcare workers in Srinagar. Despite a positive perception of the importance of fire safety, there was a notable lack of awareness regarding fire prevention strategies, emergency response protocols, and proper utilization of firefighting equipment. Implications of these findings underscore the urgent need for targeted interventions aimed at improving fire safety training programs and raising awareness among healthcare workers in Srinagar City. Enhanced education and training initiatives should focus on fostering a culture of safety, enhancing emergency response capabilities, and promoting interdisciplinary collaboration to mitigate fire hazards effectively within hospital settings. Future research should include longitudinal studies to evaluate the impact of training interventions, qualitative research to identify factors affecting fire safety practices, and the creation of specific guidelines and protocols that address the distinct challenges of hospitals in Srinagar and similar environments.

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This study contributes to improving fire safety practices in healthcare facilities, ensuring the safety of patients, staff, and infrastructure in Srinagar and comparable regions.

Keywords: *Fire safety, Healthcare workers, Perception, Practices, Emergency preparedness, Srinagar City*

1. Introduction

Fire is a chemical reaction involving rapid oxidation, producing heat, light, and flames at the ignition point. It is classified into five types based on fuel. Class A includes combustible solids, Class B includes flammable liquids, Class C includes flammable gasses, Class D includes combustible metals and Class K includes cooking oils. A fire hazard in buildings refers to the potential risk of accidental or intentional fires that pose a threat to life, structural integrity, and property safety. As global development accelerates, fire hazards in buildings have evolved significantly in both severity and complexity, becoming an increasing concern in recent years. Between 1993 and 2015, there were 86.4 million recorded fire incidents, resulting in over one million fatalities (Brushlinsky et al., 2017). Fire safety refers to a set of practices aimed at preventing or minimizing the occurrence of fires and controlling their spread and impact, with the goal of keeping potential losses within acceptable limits. In modern buildings, fire safety measures are implemented by adhering to the guidelines outlined in building codes of practice (Kodur 2014; Martin et al., 2016). Fire can make homes unsafe. Homes can become dangerous after a fire. It may result in property destruction, house collapses, or even fatalities (Supermedia, 2011). The study by Chandrakantan Subramanian (2004) titled "Human Factors Influencing Fire Safety Measures" focuses on the human factors affecting fire safety in India. Ramachandran (1999) analyzed the impact of fires, noting they cause fatalities, injuries, and material damage to buildings, along with indirect losses like reduced production and unemployment. G.B. Menon, in his handbook on building fire codes, emphasized the need for updated fire protection measures due to technological advancements and increased fire hazards. Studies, including one by Ramesh Holla et al. (2016) in Karnataka, India, and another by Khademian et al. (2019) in Iran, found healthcare workers had adequate general knowledge of fire safety but lacked specific knowledge about fire extinguishers and hazard response.

The NCRB Report 2022 states that there were 7,566 fire accident instances reported in India during year 2022, resulting in 7,435 fatalities and 329 injuries. The location-wise analysis of fire incidents showed that in the year 2022, residential/dwelling buildings accounted for 53.5% of all reported fatalities (3,979 out of 7,435). Approximately 25,000 people in India lose their lives to fires and associated incidents/causes each year. India has seen a number of significant fires, according to India Risk Surveys 2022, which is why the country's fire risk was placed third in the year 2012 and fifth in the year 2013. Subsequently, it fell to the lowest position in the year 2014. It grew gradually until 2018, when it once more secured the third position. It fell to tenth place once more in 2019. However, in 2021, it surged to the fourth position once more. A fire outbreak puts operations and business continuity at risk. India ranks third in the world for fire occurrences, with the majority of them occurring in the country's northern and western regions. Most of the fire seen in the hospital areas is due to the gaseous and chemical substances. Thus, fire safety precautions and measures are essential for preventing fires or other worsening complications of existing fires. A crucial element and prerequisite of constructing infrastructure planning is fire safety. Even in hospitalized areas, the provision of fire safety measures like as emergency exits, various kinds of fire extinguishers, safe assembly areas, and fire hydrant systems is required. In Japan, General Provisions, Building Codes, and Zoning Codes make up the Building Standard Law (BSL), which also include fire safety standards. The BSL was established in 1950 and has had multiple amendments since then. The most recent fire safety reform placed a strong emphasis on the adoption of globally recognized fire test procedures as well as the potential for performance-based fire rules. The year June 2000 saw the implementation of the Enforcement Order and Notifications outlining the specifics of the new fire classification system. The cone calorimeter test ISO 5660-1 is the primary test technique used in the new Japanese fire classification system. It is applicable to all classes of materials referred to as fire preventative products. Providing adequate fire protection for property and ensuring life safety are the main objectives of fire safety regulations. To achieve this objective, requirements for structures, building materials, evacuation arrangements, and relative location of buildings are set to define how building should be designed and constructed for their respective use. The requirement is related to prevention of ignition and fire spread, limitation of fire growth, evacuation provision, load-bearing capacity of structures, and prevention of spread of fire between

buildings. Most fires can be prevented by a few simple precautions and maintenance of fire safety measures. These measures can be incorporated in to buildings either during construction or renovation works. In addition, well trained staff with their knowledge, perception and appropriate attitude can play an equally important role in preventing and tackling fires.

The World Bank and US Geological Survey estimated that economic losses worldwide from natural hazards in the 1990s could be reduced by $280 billion if $40 billion were invested in preparedness, mitigation and prevention strategies (Dilley and Heyman, 1995). Understanding the knowledge, perception, and practices of healthcare workers regarding fire safety is crucial for effective risk management and the prevention of fire-related incidents, Rather et.al (2019), Perception of fire safety among healthcare workers also plays a significant role in shaping preparedness and response efforts. A study by Nguyen et al. (2017) in Vietnam revealed that while healthcare workers perceived fire safety as important, there was a lack of confidence in their ability to effectively respond to fire emergencies. This discrepancy between perceived importance and perceived competency underscores the need for targeted training and education programmes to bridge the gap between awareness and action. In terms of practices, studies have shown varying levels of adherence to fire safety protocols among healthcare workers. A study by Gershon et al. (2019) in the United States found that while the majority of healthcare workers reported receiving fire safety training, there were inconsistencies in the application of safety practices, particularly during high-stress situations such as emergencies. Similarly, research by Al Thobaity and Plummer (2016) in Saudi Arabia identified deficiencies in fire safety practices among healthcare workers, including inadequate fire drills and evacuation procedures.

In the context of Srinagar City, Jammu & Kashmir, there is a paucity of research specifically addressing fire safety knowledge, perception, and practices among healthcare workers. Given the unique socio-economic and environmental factors present in the region, such as and extreme weather conditions, understanding the preparedness of healthcare facilities for fire-related emergencies is essential for safeguarding both personnel and patients.

This study aims to fill the gap by accessing perception, and practices among healthcare workers regarding Fire hazards gap by assessing the fire safety knowledge,

perception, and practices among healthcare workers in selected hospitals of Srinagar City. By identifying areas of strength and weakness, the findings of this research can inform targeted interventions and policy recommendations to enhance fire safety preparedness within the healthcare sector, thereby reducing the risk of fire-related incidents and minimizing their impact on public health and safety.

2. Method and Materials

2.1 Need of the Study

Several hospital fires in India have exposed critical gaps in fire safety. The 2011 AMRI Hospital fire in Kolkata killed over 90 people due to inadequate safety protocols (Chatterjee, 2011), and a 2021 fire at Vijay Vallabh Hospital, Maharashtra, claimed 13 lives (PTI, 2021). In the study area, a 2018 fire at Jammu's Government Medical College Hospital and a 2022 fire at a Baramulla district hospital led to evacuations but no casualties (Mir, 2018). In Srinagar, a fire at SMHS Hospital in 2019 caused significant damage, emphasizing the need for better fire safety in hospitals (Raina, 2019). These incidents underscore the importance of improving fire safety knowledge and preparedness in healthcare settings (Holla et al., 2016; Khademian et al., 2019). Based on official data from the Directorate of Fire and Emergency Services, J&K, there were 448 fire occurrences in the summer capital (Srinagar), which is more than any other district of the Kashmir Division of the UT of J&K, in which five individuals died and 12 persons were injured as a result of the fire, which is the second-highest number of casualties across the district in Kashmir Division. Property in Srinagar valued at Rs. 26.32 crore was also damaged in these fire incidents. Several cases of fire incidences have been witnessed in various hospitals of Srinagar City. On 04.03.2022 at 21.25 hours fire had broken out in the only State Level Orthopedic 250 beded Hospital under the name of Bone & Joints Hospital Burzulla, Srinagar. The U-shaped IPD Block sprawled over an area of more than 300 sq. meters in which 113 orthopedic patients were admitted in the hospital at the time of the incident. Some patients were operated upon three hours before and these patients were not in a position to move. The second floor of the hospital comprising of Operation Theatre and In-patient Wards was fully involved in fire. Besides pressing into dozens of Fire Tenders and imported portable fire pumps, Hydraulic Platform (Bronto Sky Lift) played a vital role in aerial extinguishing the fire from the rooftop of the hospital which made rescue operation possible. The

rescue team was able to launch the rescue operation and the prompt and effective firefighting and rescue operation simultaneously resulted in saving the life of hundreds of trapped patients without any harm or injury to them during the rescue operation. In another incident, the fire broke out in the 1st floor of Ward 16 store room of the SMHS Hospital, Srinagar, however, no injuries were reported, patients and attendants including the hospital staff were rescued to safer places.

This study was conducted in response to concerns over fire safety and readiness that were raised by many, widespread fire incidents that were reported in different hospitals throughout the city of Srinagar. Thus, the goal of this study was to find out how healthcare staff in the various buildings perceived, knew about, and were prepared for fire risks. The study's conclusions and recommendations can help the City Administration of Srinagar, hospital administrators and owners and occupiers by providing them with knowledge that will help them redefine and improve fire safety on their properties and raise public awareness. The scope of the study was reduced to include just hospitals and healthcare facilities.

2.2 Objectives of the Study

i. To assess the fire Safety knowledge among Health Care Workers in Srinagar city.

ii. To assess the levels of perception of satisfaction of health care workers on fire preparedness and mitigation measures in Hospitals of Srinagar city.

2.3 Data Base and Methodology

The Study Area

Spread across 294 square kilometers, Srinagar City is situated at an elevation of 1585 meters located between 34o5/ N and 74o 47/ E. Srinagar City is situated on both banks of the Jhelum River, also known as Vyath in Kashmir. The river flows past the city and into the valley, where it meanders before deepening into Dal Lake. Srinagar has a humid subtropical climate (Saleem, S. et al.,2021; Mushtaq, S. et al.,2024; Saleem, H. et al.,2024), much cooler than what is found in much of the rest of India, due to its moderately high elevation and northerly position. Srinagar city has a population of 1273312 as per census January 2011. The population density of Srinagar city is

8523/Km^2. The sex ratio is 888/1000. According to the January 2011 census, Srinagar city has a literacy rate of 71.45%, while the national average has 74.04%. Approximately 12% of the entire population lives in the city and the metropolitan agglomeration as children. The population is made up of 47% females and 53% males.

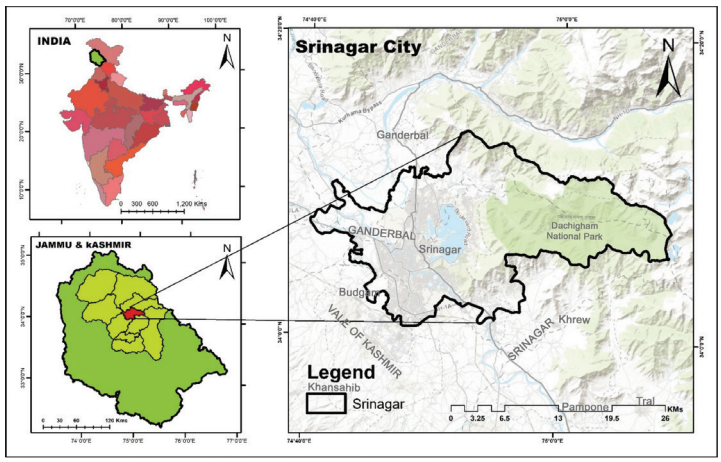

Figure 1: Location Map of Srinagar City

Both primary and secondary sources of data were used in the present study. The Census of India manual, Jammu and Kashmir Series, the Directorate of Fire and Emergency Services, J&K, Srinagar, journals, books, etc. are the sources of the secondary data. The information has been compiled and analyzed using various statistical methods. The study's target population for primary data consisted of medical staff from a few chosen hospitals in Srinagar City. Due to the limited time and financial resources available for the study, a sample size of 160 respondents was chosen as a representative of all healthcare personnel working in Srinagar City hospitals who were accessible at the time of study.

Two data collection instruments consisting of two kinds of questionnaires (including both closed and open-ended questions) and an observation schedule were constructed in order to investigate the objectives, hypotheses, and relevant literature. The questionnaires served as a schedule for the interviews as well. Conducting an interview facilitated additional questioning to get additional details. The questionnaire was chosen as the primary data collection tool because it saved time and made it

possible to get information from a wider range of people. Important research components that were actually visible were documented using the observation schedule. These included the fire safety precautions that the buildings had in place, such as the availability of escape routes, fire assembly locations, the presence of detecting equipment, and other firefighting supplies. To guarantee a high return rate, the researcher physically administered each instrument, which asked for specific information from the respondents.

Data Analysis Techniques

To ensure correctness, consistency, and completeness, the compiled data was modified. After then, Microsoft Excel was used to cross-tabulate the data so that statistical analysis of the responses was possible. The compiled Data was analyzed using descriptive statistics and displayed using charts and graphs, as well as percentages and means. Tables, percentages, charts, and graphs were used to analyze the objectives based on the questionnaire replies. The responders were asked to check the appropriate response or responses out of the available options given. Additionally, space was also given for the respondent to express any opinions they may have regarding the suitability of the response selections. The majority of respondents' recommendations were tallied against the frequency and percentages. Microsoft Excel was used for data analysis.

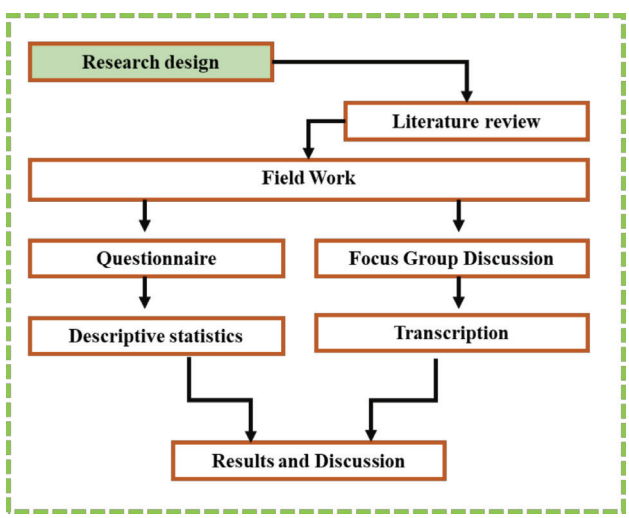

Figure 2 : Methodological Flow Chart

3. Results and Discussions

Fire Risk Profile: Srinagar City; Fire risk profiles are essential tools for understanding the vulnerabilities and potential hazards within a specific geographic area. In the case of Srinagar City, several factors contribute to its unique fire risk profile. Overall, Srinagar City's fire risk profile is characterized by a combination of urban density, environmental factors, socio-political dynamics, and cultural practices. Understanding these factors is crucial for developing effective fire prevention and mitigation strategies to protect lives, property, and infrastructure in the city. The Directorate of Fire and Emergency Services, J&K, reports that from 2016 to 2021, there were 2288 fire incidents in the summer capital (Srinagar), which is more than any other district in the Kashmir division. During that time, 1568 structures were involved in fires. The total property (in crores) involved in fire for the said period was 1693.91 crores, out of which 79.94 crores were damged and 1613.97 crores were saved. According to sources and data on fire incidents, the fire resulted in 29 fatalities, the highest number of casualties across the district Srinagar in Kashmiri division. 43 other persons were injured in fire incidents throughout Srinagar, according to the data. It is now become necessary to implement comprehensive fire hazard planning for mitigation and preparedness measures in order to reduce the fire hazard risks associated with the study area, particularly in the down town area of Srinagar City, as a result of the alarming fire incidents in the city, as revealed by the fire statistical data.

Table 1 : Fire Statistical Data from the Year 2016-2021 of Srinagar City

Year	No. of Fire Calls	Structures involved in fire	Property Involved	Property Damaged	Property Saved
2016	485.00	344	476.56	23.03	444.53
2017	469.00	324	340.07	21.455	314.11
2018	488.00	326	203.57	19.88	183.69
2019	389.00	279	173.27	10.55	162.72
2020	478.00	265	2.13	0.16	1.97
2021	448.00	354	838.38	26.32	812.06

Source: Directorate F&ES, J&K, Srinagar

Figure 3 and 4 : Show Fire call, structures involved property values affected and saved in crores from 2016 to 2021

3.1 Distribution of Respondents by Socio-economic Characteristics

Understanding the demographic profile of the respondents facilitated identification of the age cohorts active within the hospital premises and their awareness levels regarding fire safety. Participants were requested to specify their socio-economic characteristics.

Table 2 : Distribution of Respondents by Socio-economic Characteristics

S. No	Demographic variables		Frequency	%
1	Age in years	i. Below 30 (18-30)	51	31.87
		ii. 30 to 40	45	28.12
		iii. 41 to 50	39	24.38
		iv. Above 50	25	15.63
2	Gender	i. Male	88	55
		ii. Female	72	45
3	Profession	i. Nurse	61	38.12
		ii. Doctor	49	30.63
		iii. Class IV workers	27	16.88
		iv. Others	23	14.37

4	Work experience	i. 1 to 10 years	97	60.62
		ii. 11 to 20 years	43	26.88
		iii. Above 20 years	20	12.50
5	Educational qualifications	i. Illiterate	0	0
		ii. SSC	23	14.37
		iii. HSC	19	11.88
		iv. Graduate	84	52.50
		v. Post Graduate	34	21.25
6	Fire safety training attended	i. Yes	120	75
		ii. No	40	25

Table 2 provides the frequency and percentage distributions of demographic variables among healthcare workers. The largest proportion of the sample, comprising 51 individuals (31.87%), fell within the age range of below 30 years (18-30). Additionally, the majority of the sample, accounting for 88 individuals (55%), were male. Furthermore, 61 individuals (38.12%) reported nursing as their profession, while 97 individuals (60.62%) indicated having work experience ranging from 1 to 10 years. Moreover, a significant majority of the sample, totaling 120 individuals (75%), had participated in fire safety training. Lastly, 84 individuals (52.50%) possessed a graduate-level educational qualification.

3.2 Fire Safety Measures, its Availability and Knowledge

The respondents were asked to identify the firefighting equipment that is available in the buildings where they work. Out of the 160 respondents surveyed, 101 said that dry chemical extinguishers were present in the buildings where they worked, whereas 46 respondents said they were not.

Table 3 : Fire Safety Measures and Responses

Fire Equipment	Exists	Do Not Exist	Not sure	Total
Dry chemical extinguishers	101	46	13	160
Halon extinguishers (vaporising liquids)	10	135	15	160
Foam cylinders	11	135	14	160
Carbon dioxide extinguishers	95	55	10	160
Sprinklers/Hose reels (pressurised water extinguishers)	50	103	07	160
Wet chemical	03	146	11	160
Fire blankets	09	144	07	160
Any other (specify)	0	160	0	160

Source: Field Survey, 2022

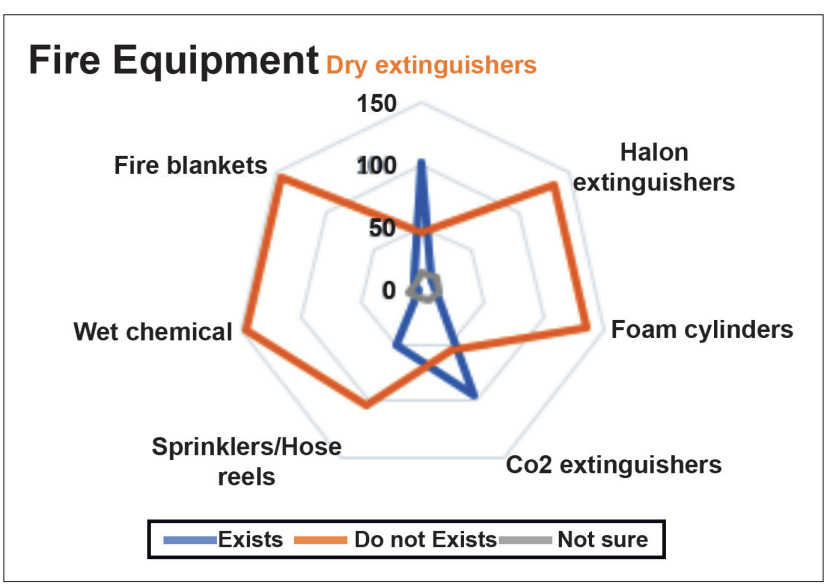

Figure 5 : Illustrate Fire Safety Measures and Responses

According to the responses gathered from the study, it was revealed that there are notable disparities in the reported presence of various types of firefighting equipment within buildings. Among the surveyed respondents, a substantial proportion, consisting of 135 individuals, asserted the absence of halogen extinguishers in buildings. Conversely, merely 10 respondents confirmed the existence of such extinguishers, indicating a stark contrast in perceptions regarding their prevalence. Likewise, research revealed that 135 respondents claimed that foam cylinders were not present in structures. Moreover, ninety-five respondents claimed that most buildings had carbon dioxide extinguishers. Wet chemical extinguishers and fire blankets, on the other hand, were said to be absent from most buildings as stated by 146 and 144 respondents, respectively). Remarkably, only a negligible number of respondents, specifically 3 and 9 individuals, respectively, confirmed the presence of wet chemical extinguishers and fire blankets.

Additionally, when queried about the existence of any other fire equipment in their respective buildings, none of the respondents indicated its presence, with 160 individuals confirming the absence of any additional fire equipment. Conversely, a noteworthy proportion of respondents, comprising 103 individuals, supported the existence of sprinklers or hose reels within their buildings. The study findings suggest that only two types of firefighting equipment, namely dry chemical extinguishers and carbon dioxide cylinders, were commonly reported as present in the surveyed buildings.

3.3 Perception of Availability of Fire Equipment

The study sought to gauge the perceptions of respondents regarding the availability of firefighting equipment within their respective environments. Among the 160 participants included in the analysis, a notable majority of 55 individuals, constituting 65.62% of the sample, expressed dissatisfaction with the current state of fire equipment availability. Conversely, 55 respondents, comprising 34.38% of the sample, conveyed satisfaction with the existing firefighting resources. These findings suggest a prevalent sentiment of dissatisfaction among the surveyed individuals regarding the accessibility and adequacy of fire equipment. The observed high level of dissatisfaction underscores potential concerns regarding the effectiveness of current fire safety measures and the perceived preparedness for fire incidents within the surveyed environments.

Table 4 : Perceptions on Availability of Fire Equipment

Perception	Satisfied	Not satisfied	Total
Respondents	55	105	160
Percentage	34.38	65.62	100

3.4 Proficiency to Operate Fire Equipment

The responders were questioned about their proficiency to use any of the firefighting apparatus that was currently in use. Table 5 shows the respondents' proficiency levels and possible training needs in using the firefighting equipment already in use. Figure 6 presents a comprehensive breakdown of respondents' responses to the inquiry, revealing in their capabilities across various types of firefighting apparatus. It becomes apparent that a considerable proportion of respondents expressed difficulty in operating specific types of firefighting equipment. Notably, 127 respondents indicated their inability to operate dry chemical extinguishers, while an even larger cohort of 152 individuals reported similar challenges with halon extinguishers. Conversely, a modest number of respondents, 30 and 38, respectively, demonstrated proficiency in operating dry chemical and carbon dioxide extinguishers.

Table 5 : Proficiency to Operate Fire Equipment

Fire Equipment	Able to operate/use	Not able to operate	Not sure	Total
Dry chemical extinguishers	30	127	3	160
Halon extinguishers (vaporising liquids)	5	152	3	160
Foam cylinders	7	151	2	160
Carbon dioxide extinguishers	38	120	2	160
Sprinklers/ Hose reels (pressurized water extinguishers)	0	146	2	160
Wet chemical	0	146	2	160
Fire blankets	0	147	1	160
Any other (specify)	0	0	0	0

Field Survey, 2022

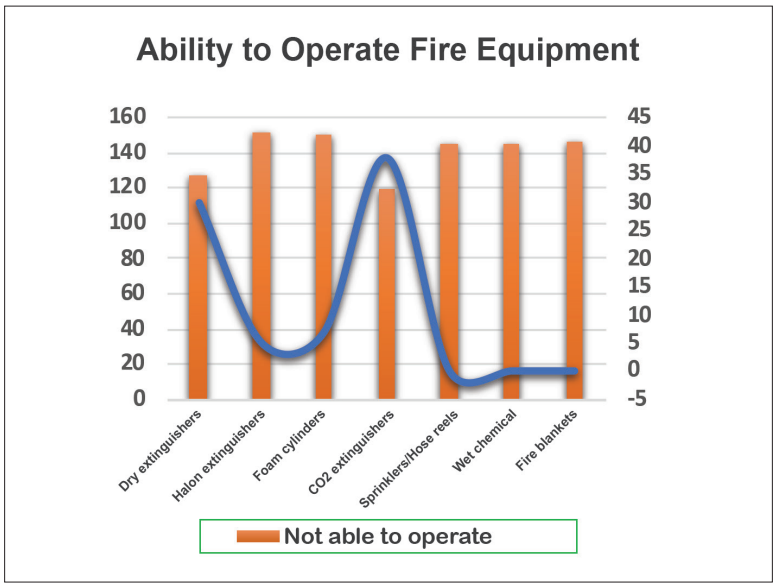

Figure 6 : Shows the Proficiency of Respondents to Operate Fire Equipment

Furthermore, the analysis unveils substantial impediments in respondents' aptitude to handle foam cylinders, sprinklers/hose reels, wet chemicals, and fire blankets. Specifically, 151, 146, and 146 respondents conveyed their inability to operate foam cylinders, sprinklers/hose reels, and wet chemicals, with a marginal number of respondents expressing uncertainty regarding their handling. Similarly, a significant majority of 147 respondents expressed their incapacity to utilize fire blankets effectively, with a lone respondent indicating uncertainty in this regard. Interestingly, the absence of any specified proficiency in operating additional fire equipment highlights potential gaps in respondents' training or familiarity with broader firefighting apparatus beyond those explicitly queried. This observation underscores the need for comprehensive training programs to equip healthcare professionals with the requisite skills to navigate diverse fire safety scenarios effectively. The findings suggest that while a subset of respondents demonstrates proficiency in operating available firefighting equipment, their capabilities are predominantly limited to apparatus that are currently accessible. Moreover, the distribution of proficiency across different types of equipment appears varied.

3.5 Perception of the Proficiency to Operate Fire Equipment

Table 6 : Perceptions on the Proficiency to Operate Fire Equipment

Perception	Satisfied	Not satisfied	Total
Respondents	32	128	160
Percentage	20	80	100

The respondents when questioned about their proficiency using the firefighting apparatus at workplace, the responders answered in the affirmative. The responses to the question are displayed in Table 6 above. When asked how satisfied they were or not with their competence to operate fire equipment, 32 (20%) respondents said they were, while 128 (80%) said they were not. The study's findings indicate that the majority of these medical professionals lack the knowledge or skills necessary to operate the firefighting equipment that was p1ut in place in the buildings in which they worked.

3.6 Preparedness to Fire Disasters

The respondents were questioned about their knowledge of the fire preparedness measures that were in place at their place of employment. The answers to the query are displayed in Table 7. The study revealed noteworthy insights into respondents' awareness and preparedness regarding fire safety protocols within their respective environments. The findings shed light on the presence of emergency communication systems, maintenance practices for fire equipment, training in fire emergency services, and the existence of fire assembly points. A substantial majority of respondents, totaling 148 individuals, demonstrated awareness of the existence of an emergency communication system in the event of a fire incident. Further exploration elucidated that these systems encompassed fire alarm mechanisms that enabled individuals to swiftly alert firefighting personnel, complemented by access to an emergency contact number, notably 101. Conversely, findings concerning the regular inspection and maintenance of fire equipment unveiled a concerning trend, with a significant majority of 125 respondents indicating a lack of awareness regarding such practices.

Table 7 : Preparedness to Fire Disasters

Preparedness	Yes	No	Not Sure	Total
Being aware of an emergency communication system (alarm, phone, cell number, etc.) in the event of a fire	148	0	12	160
Frequent regular inspection and maintenance of firefighting equipment	20	125	15	160
Training on emergency services in case of fire outbreak	40	107	13	160
The structure has an emergency shelter or fire assembly point in case of a fire	110	36	14	160
The structure is equipped with an emergency fire disaster kit.	100	47	13	160
Fire hydrants' efficiency and accessibility during fire outbreaks.	12	135	13	160
Existence of Emergency population warning methods in the building.	48	106	6	160
Conducting of Regular fire drills	10	146	4	160
Other preparedness strategies	0	-	-	0

Field Survey, 2022

Merely 20 respondents reported awareness of regular inspection and maintenance procedures, while a meagre 15 respondents expressed uncertainty regarding the implementation of these protocols. Regarding training in fire emergency services, the study revealed a notable gap, with a majority of 107 respondents asserting a lack of training in this domain. Conversely, only 13 respondents indicated uncertainty regarding their training status, highlighting potential deficiencies in fire safety education and preparedness initiatives among the surveyed cohort. In terms of infrastructure, responses regarding the existence of fire assembly points varied. While a substantial number of buildings were reported to have designated fire assembly points,

with 110 respondents affirming their presence, a notable proportion of 36 respondents indicated the absence of such facilities within their buildings. Additionally, 14 respondents remained indifferent to the presence or absence of fire assembly points, suggesting potential inconsistencies in fire safety infrastructure across surveyed environments. In addition, when asked if their building had an emergency fire disaster kit, the majority of respondents (100) said that it did. Of the total responders, 47 admitted that it didn't exist. 13 respondents were indifferent. When asked how easy it is to reach fire hydrants in the event of a fire, the majority of respondents (135) believed that they are difficult to reach, ineffective, and typically remain non-functional. Just twelve people said it was easily accessible to get there. Thirteen respondents had no opinion. Subsequent investigation revealed that the fire hydrants, which are primarily run by the local authorities, were ineffectual in past fire breakouts in and around the study areas because they were empty at the time.

When asked whether emergency population warning systems were in place at their work places, 48 respondents said they were, while 106 said they weren't. There were only six who had no opinion. Casual observation showed that the most typical population warning sign was “No Smoking” sign and was in written on the walls. Additionally, the respondents were questioned about whether or not fire drills were conducted in the buildings and if so, how frequently. Ten (10) of the respondents said they had ever been present for or participated in a fire drill. Four (4) respondents expressed indifference, while the majority of respondents (146) said it had never been done. From the study it can be concluded that health professionals are mostly aware of emergency communication system, warning signs and fire assembly points.

3.7 Perceptions on Level of Preparedness in the Buildings

Table 8 : Perceptions on Level of Preparedness in the Buildings

Perception	Satisfied	Not satisfied	Total
Respondents	47	113	160
Percentage	29.37	70.63	100

The table displays the responses to the question about respondents' perceptions of the preparedness level in their buildings. 47(29.37%) of the total respondents said that they were satisfied, while the majority (70.63) said they were not. The study's findings indicate that the majority of these respondents knew insufficiently about fire safety precautions.

4. Conclusion

In conclusion, the study examined the preparedness and satisfaction levels of healthcare workers regarding fire safety measures in selected hospitals in Srinagar City. This had to do with the fact that numerous other installations had experienced fires that resulted in property loss and fatalities. As a result, Srinagar City's fire authority could be able to take action based on this information and implement the necessary preventative and preparation measures. At this regard, it was crucial to take into account the different precautions implemented at a number of carefully chosen hospitals that may guard against potential fire hazards and prevent them from happening. After evaluating the fire safety protocols and equipment used by the hospital owners/administrators in the chosen hospitals, the study found that the majority of buildings only had carbon dioxide and dry chemical extinguishers. In order to increase preparedness, additional equipment must be installed or supplied by those being responsible, because different types of fires require different types of fire extinguishers. Similarly, it was discovered that relatively few inhabitants could operate the two regularly encountered types of equipment; as a result, training is required to ensure that they are prepared to handle any emergency involving a fire. The purpose of this study was to evaluate the healthcare personnel's degree of fire preparation. These are the individuals using these spaces to conduct their daily emergency business. The results clearly demonstrate that the level of preparedness is still below expectations, as the majority of respondents only demonstrated knowledge of the fire assembly point and an emergency communication system. For this reason, it is essential that the relevant authorities take the necessary steps to raise the level of preparedness, such as regular inspections, fire drills, emergency services training, and the availability of fire disaster kits. The study also aimed to find out how health care workers were satisfied with the degree of preparedness and mitigation. The study found that the majority of healthcare professionals were not entirely content. In this instance, the

tenants suggested that, in order to increase their level of satisfaction, they must receive frequent training in fire safety and that warning signs be positioned in a way that makes them visible to patients, guests, and building attendants. They also want exits to be well indicated. On their part, healthcare professionals sought routine inspections of fire apparatus. Collaboration among building administrators/owners, property managers, and occupants is therefore essential in raising their level of satisfaction and firefighting proficiency. Since hydrants serve as a backup source of water supply in the event of a fire, the study also aimed to ascertain the opinions of healthcare professionals regarding the functionality of the hydrants in the city. The investigation found that although there were fire hydrants in the city, they were either broken or inefficient.

5. Recommendations

This present study investigated the level of Knowledge, Perception and Practices of Health Care Workers, besides the fire risk preparedness and mitigation in selected hospitals in Srinagar City. Following the analysis of the data from respondents, it is recommended that there is need to inspect the firefighting infrastructure in existence in buildings in all the health institutions of Srinagar City with a view of upgrading them to an acceptable standard. Programs for emergency procedures and evacuation drills, routine fire safety inspections, upkeep and servicing of fire apparatus, staff and trainee training, informing building occupants, maintaining records, and emergency situations should all be implemented to improve fire safety measures. The effectiveness and functionality of the fire hydrants in the urban area need to be inspected. The authorities and owners/property managers of the medical facilities should invite fire professionals to speak to the residents of their buildings about fire safety and the actual application of firefighting and safety equipment.

References

1. Chandrakantan Subramaniam, (2004) "Human factors influencing fire safety measures", Disaster Prevention and Management: An International Journal, Vol. 13 Iss 2 pp. 110- 116.
2. Rather Et.al (2019) “Risk Perception and Knowledge in Fire Risk Reduction in an Urban Environment: A Study of Srinagar City”.

3. Rather, (2023) Urban Environment and People's Perception on Risk Reduction in Fire Related Hazards in Srinagar City.
4. Supermedia (2011)
5. Fire safety in India [Internet]. Journals of India. 2021 [cited 2023Feb3]. Available from: https://journalsofindia.com/fire-safety-in-india/
6. Derek, J. (1986) Fire Prevention Handbook. London: Butterworth and company (publishers) Limited.
7. Drabek, T. E. (1986) Human System Responses to Disaster. New York: Springer-Verlag.
8. Duke, S. (2012) Classes of Fire. Retrieved January 3, 2013, from Safety Duke: www.safety.duke.edu/safetymannuals/lab/section3firesafety/chap4classes of fires.pdf
9. Data from the fire and emergency services department for the period of 15 years.
10. K. A. T. Kumara, R ferdinando knowledge, attitudes and practices on fire safety amongst office workers at government offices in Thamankaduwa divisional secretariat. International Journal of
11. Scientific & Engineering Research. 2016; 7(9): 1073
12. Directorate General NDRF & Civil Defense (Fire) Ministry of Home Affairs, East Block 7, Level 7, NEW DELHI, 110066,
13. Fire Hazard and Risk Analysis in the Country for Revamping the Fire Services in the Country, Final Report – State Wise Risk Assessment, Infrastructure and Institutional Assessment of Pilot States (Delhi, Jammu & Kashmir, Rajasthan, Pondicherry, Maharashtra, and Andaman & Nicobar Islands); December 2011; Submitted by RMSI A-8, Sector 16 Noida 201301, INDIA
14. Grant, C. (2012). History: National Fire Protection Association. Retrieved March 2, 2013, from Wikipedia: www.wikipedia.org/nationalfireprotectionassociation
15. Handbook on Building Fire Codes by G.B.Menon Fire Adviser, Govt. of India {Retd.} Cochin Ex-Chairman CED-22 Fires Fighting Sectional Committee Bureau of Indian Standards.
16. J.N. Vakil, Asst.General Manager {Retd}, TAC/GIC, Ahmedabad, Ex-Chairman CED-36 Fire Safety Sectional Committee, Bureau of Indian Standards.
17. FIRE HAZARD PLANNING: General Plan Technical Advice Series Governor's Office of Planning and Research California November 2003, Gray Davis GOVERNORTal Finney INTERIM DIRECTOR.
18. Kothari, C.R. (2003). Research Methodology, Methods and Techniques. New Delhi: WishwaPrakshan.
19. Langdon, G. (1972) Fire Safety in Buildings. London: London A & C Black.
20. National Fire Protection Association an adaptation of the U. S. Fire Administration Public Fire Education Planning: a Five-Step Process
21. Pyne, S. (1982) Fire in America: A cultural History of Wild land and Rural Fire (paperback edition ed.). Washington: University of Washington press, 1997. Retrieved January 3rd, 2013, From National Wildfire Coordinating Group:www.wikipedia.org/glossaryofwildlandfire terminology.
22. Thomas, R. (1974) Science and Fire Fighting. Wheaton: Exeter.
23. UN Habitat. (2002) Living with Risk: A Global View of Disaster Reduction Initiatives. Geneva: UN International Strategy for Disaster Reduction, 330-34.
24. Kanade AB, Sarwan S, Said P, Kadam S, Dhakne G, Gore P. A Study to Assess the Academic Stress and Coping Strategies used among the undergraduate nursing students from selected colleges of Pune City. Asian Journal of Nursing Education and Research. 2021; 11(2):183-8.
25. M. Jahangiri, F. Rajabi, F. Darooghe, Fire risk assessment in the selected Hospitals of Shiraz University of Medical Sciences in accordance with NFPA101. Iran Occup. Health. 13(1), 99–106 (2016)
26. 2. A. Rahmani, M. Salem, Fire risk assessment in high-rise hospitals in accordance with NFPA 101. Rev. Latinoam. Hipertens. 13(3), 242–245 (2018)
27. Rather Et.al (2019) "Risk Perception and Knowledge in Fire Risk Reduction in an Urban Environment: A Study of Srinagar City".
28. Chatterjee, P. (2011). AMRI hospital fire kills 90 in Kolkata. The Lancet, 378(9807), 2071.
29. PTI. (2021). Maharashtra hospital fire: 13 COVID-19 patients dead in ICU blaze at Vijay Vallabh hospital. The Times of India.
30. Mir, S. (2018). Fire at Jammu Medical College hospital, patients evacuated. Greater Kashmir.
31. Raina, A. (2019). Fire breaks out at SMHS Hospital in Srinagar. Kashmir Observer.
32. Holla, R., et al. (2016). Knowledge and awareness of fire safety measures among health care staff in hospitals of Mangalore, Karnataka. International Journal of Health Sciences.
33. Khademian, Z., et al. (2019). Fire safety knowledge among healthcare workers in Iranian hospitals. International Journal of Occupational Safety and Health.
34. Ramesh Holla Et.al (2016) " Fire Safety Measures: Awareness and Perception of Health Care Professionals in Coastal Karnataka"
35. Supermedia. (2011). The dangers of fire and smoking. Damage/Fire and water Damage.

36. Saleem, S., Ahmed Hajam, F., Rather, J.A., 2021. Spatio-temporal Analysis of land use land cover changes in Sind catchment of the Kashmir Valley, India. Geo. Eye 10 (2), 35–42.
37. Saleem, H., Ahmed, R., Mushtaq, S., Saleem, S., & Rajesh, M. (2024). Remote sensing-based analysis of land use, land cover, and land surface temperature changes in Jammu District, India. International Journal of River Basin Management, 1–16.
Kodur, V. (2014), "Properties of concrete at elevated temperatures", ISRN Civil Engineering, Vol. 2014, pp. 1-15.
Martin, D., Tomida, M. and Meacham, B. (2016), "Environmental impact of fire", Fire Science Reviews, Vol. 5 No. 1, pp. 1-21

Multi-criteria Based Assessment of Coastal Vulnerability Along Biodiversity Rich Tropical Coastline in Karnataka

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Abstract

Sea level rise, climate change, and coastal deforestation significantly impact coastal environments, posing threats to unique ecosystems and rich biodiversity. Thorough monitoring and assessment of coastal regions are essential to mitigate economic losses. Satellite imagery offers improved spatial and temporal resolution compared to in-situ data collection. However, detailed spatial datasets are still lacking for the extensive and resourceful Indian coastlines. Additionally, comprehensive vulnerability assessments, considering both single parameters and clusters, are needed to understand future threats. This study computed and mapped the coastal vulnerability index by integrating conventional and remote sensing data. The analysis utilized 46 years of dynamics for eight significant parameters along the west Indian coast, with a 10 m resolution mapping. Results indicated that 37.42 km (27% of the total area) exhibited high or very high vulnerability, with the Karwar shoreline in the north being particularly susceptible across seven out of the eight characteristics. To safeguard this crucial coast for future development, recommended measures include building regulation, urban growth planning, integrated coastal zone management, strict implementation of the Coastal Regulation Zone Act of 1991, and ongoing monitoring and research.

Keywords: *Sea level rise, Coastal morphology, Vulnerability assessment, Remote sensing*

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1. Introduction

Coastal areas are incredibly dynamic settings. Dissimilar geospheres intermingle here to produce unique ecologies. Various such biodiversity hotspots are currently at risk as the global sea level is rising at an accelerated rate. A new record high of 97 mm (above 1993 sea levels) was observed in 2021 (Climate Change: Global Sea Level 2022). Sea level rise and associated wave activities can result in erosion, increased storm impact, accretion, reshaping of the coasts, flooding, creation of continental shelves and even drowning of river valleys (Management 2013). This changing morpho-dynamics is likely to have sensitive impacts on the environment (Hegde 2015). Scott et al. (2012), estimated inundation of 29% of the coastal resort properties in the Caribbean with one meter sea level rise (SLR). The island of Maui in Pacific experienced beach erosion in over 78% of the region due to SLR and associated wave actions. It has hence become pertinent to monitor coastal morphology at regular intervals and in a detailed quantitative fashion. The well-being of coastal residents and protection of valuable coastal ecosystems thoroughly depend on reliable information on the vulnerability of coastal regions. Conventional methods like beach surveys and in situ geographic positioning system shorelines do not offer continuous and frequent data coverage for entire coastlines. However, the emergence of computer science tools, such as Geographic Information Systems (GIS), has greatly facilitated the identification and analysis of coastal areas. Recent advancements in photogrammetry, topographic data collection, and digital image-processing techniques have enabled precise shoreline detection methods (Esteves et al., 2000; Bio et al., 2015).In order to evaluate the danger faced by coastal locations, a variety of predictive methods have been used, including historic rates of erosion, static inundation, erosion caused by sea level rise, and the use of sediment dynamics (Burningham, 2017). The Coastal Vulnerability Index (CVI) is one of the techniques that is most frequently used in every country for assessing coastal risk (McLaughlin & Cooper, 2011; Koroglu et al., 2019; Pantusa et al., 2022). The approach combines the coastal system's tendency for change with its inherent ability to adapt to shifting environmental conditions. In order to offer a relative assessment of the system's innate sensitivity to the effects of sea level rise, the CVI ranks various variables according to their physical contribution to shoreline change. By weighing several variables according to their physical impact on shoreline change, the CVI gives a relative estimate of the system's sensitivity to the effects of sea level rise.

India, having a very long coastline of around 7500 km, is vulnerable to potential loss of natural and man-made resources (Hossain et al. 2022; Princy et al. 2023). In India, even up to this point of time this issue of vulnerability assessment is paid little attention though it costs much less compared to the huge investments on early warning systems.Other nations which experience similar population growth and urban sprawl have an increasing number of densely built settlements, ports, cities growing along the coasts. Accurate prediction of shoreline retreat, beach loss, cliff retreat, and land loss rates is essential for effective coastal zone management planning. These predictions have the potential to enhance the assessment of biological impacts resulting from habitat change or destruction. To support territorial planning and decision-making processes, it is important to incorporate spatial data based on multiple criteria. Integrated Coastal Zone Management (ICZM) offers a valuable approach in this regard, allowing for the integration of measures to control socio-economic development patterns, mitigate natural hazards, and conserve natural resources. By adopting ICZM, coastal areas can benefit from a comprehensive and coordinated approach that addresses various aspects of sustainable coastal management.

This study aimed to create a comprehensive inventory of location-based data on hazard zones and multi-criteria based maps along a specific segment of the Indian coastline. The objectives included assessing parameters such as shore change rate, tidal range, significant wave height, coastal elevation, coastal slope, sea level changes, and coastal geomorphology. Coastal Vulnerability Indices (CVIs) were calculated and used to map the relative vulnerability of the coast to future sea-level rise. To capture a broader range of coastal behaviors, a secondary level of investigation using cluster analysis was proposed. By improving the quantitative understanding of shoreline indicators and their spatial relationship with the land-water boundary, this research contributes to the knowledge of coastal management strategies.

2. Significance of the Study Area

The study was carried out over the northern coast of Karnataka in Uttara Kannada district. The study area extends from 13.9254°N to 14.8992°N latitude and 74.0921°E to 74.5822°E longitude. The coastline stretches over185 km in length. The location and extent of the area is shown by Figure 1. This coastal region is of immense significance due

to the presence of rich biodiversity. The Western Ghats or the Sahyadri mountains run here from north to south nearly parallel to the coast. Between the Sahyadri and the sea there is a narrow coastal strip which is known as the Payanghat. This zone varies from 8 m to 24min width. The brackish water present in these estuaries is a mixture of salt and fresh water and it provides valuable nutrients for marine life. Several backwaters and coastal wetlands also help various species to thrive. The study area is home to fourteen coral species, four sponge species, the protected small giant clams, hundred and fifteen zooplanktons, three threatened Mollusca species, five species of star fish and many more (Karnataka Biodiversity Board, 2010).

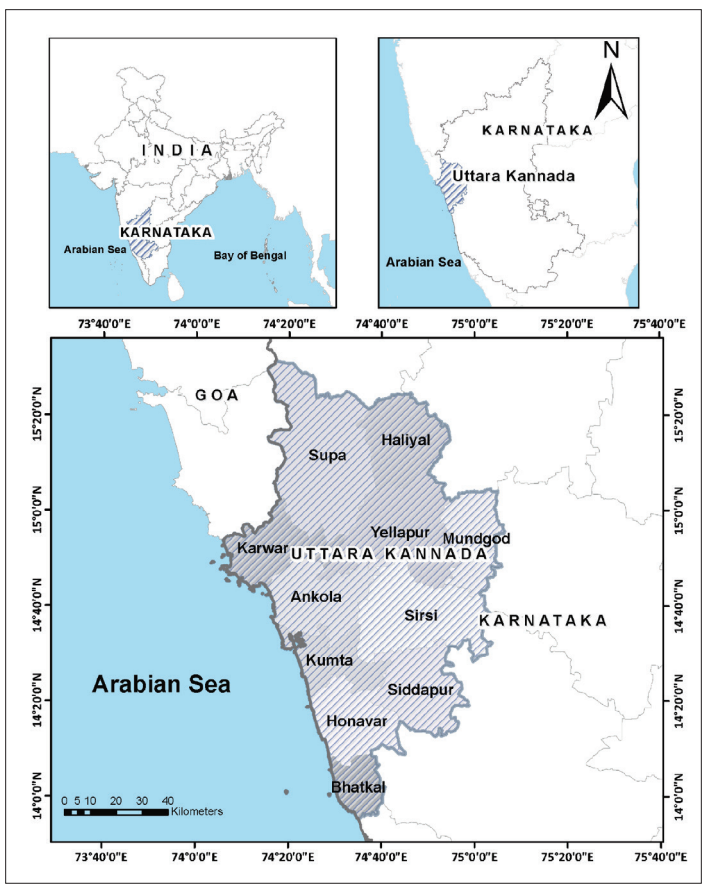

Figure 1 : Extent and location of the study area

Any change in the coastal landscape is likely to disrupt irreplaceable ecologies. Apart from the environmental significance, the coast also has major settlements and numerous tourist attractions. So, submergence or loss of coastal strips will affect economy and human activities in various ways. Hence, detailed monitoring, risk assessment and creation of quantitative databases for future analysis is mandatory for this region.

3. Datasets Description

A set of remote sensing data was used in the study ranging between the years 1973 and 2019.Landsat data from Multispectral Scanner (MSS), Thematic Mapper (TM), Enhanced Thematic Mapper (ETM), Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) sensors were obtained from U.S. Geological Survey (USGS). The list of the data along with other details is shown by Table 1.

Table 1 : List of Landsat data used in the study

Sl. No.	Satellite	Sensor	Path / Row	Date	Spatial resolution (m)
1	Landsat 8	OLI/TIRS	146/050	14.01.2019	30
2	Landsat 7	ETM+	146/050	29.12.2018	30
3	Landsat 7	ETM+	146/050	05.01.2010	30
4	Landsat 7	ETM+	146/050	11.02.2006	30
5	Landsat 5	TM	146/050	14.03.2000	30
6	Landsat 5	TM	146/050	19.11.1989	30
7	Landsat 1-5	MSS	157/050	02.03.1973	30

Several studies (Yang et al., 2022; He et al., 2022) have indicated changes in rainfall patterns during and following the Covid-19 lockdown. Given that the coastal regions are significantly influenced by Indian monsoon rainfall, precautions were taken to avoid any abnormal trends or outcomes in the data. Therefore, data collection was limited to 2019 and did not include the subsequent two years. In addition to Landsat images, various other datasets were utilized to derive specific parameters. They are shown in Table 2.

Table 2 : List of Additional Data for Generating Various Parameters

Sl. No.	Parameter	Data
1	Shoreline Change Rate	Landsat-ETM+
2	Geomorphology	Digital Globe QuickBird
3	Coastal Slope	GEBCO
4	Coastal Regional Elevation	SRTM
5	Beach Width	Digital Globe QuickBird
6	Tidal Range	WX-Tide
7	Significant Wave Height	simulated waves using mike-21
8	Sea Level Change	PSMSL

*GEBCO = General Bathymetric Chart of the Oceans; SRTM = Shuttle Radar Topography Mission; PSMSL = Permanent Service for Mean Sea Level

ERDAS IMAGINE, ArcGIS, Digital Shoreline Analysis System (DSAS) and WXtide-32 software were utilized to pre-process and process the remote sensing data.

4. Methodology

The primary objective of the work was to assess coastal vulnerability with CVI while incorporating the relative contributions and interactions of eight risk variables. The overall methodology of the work is shown by a flowchart in Figure 2

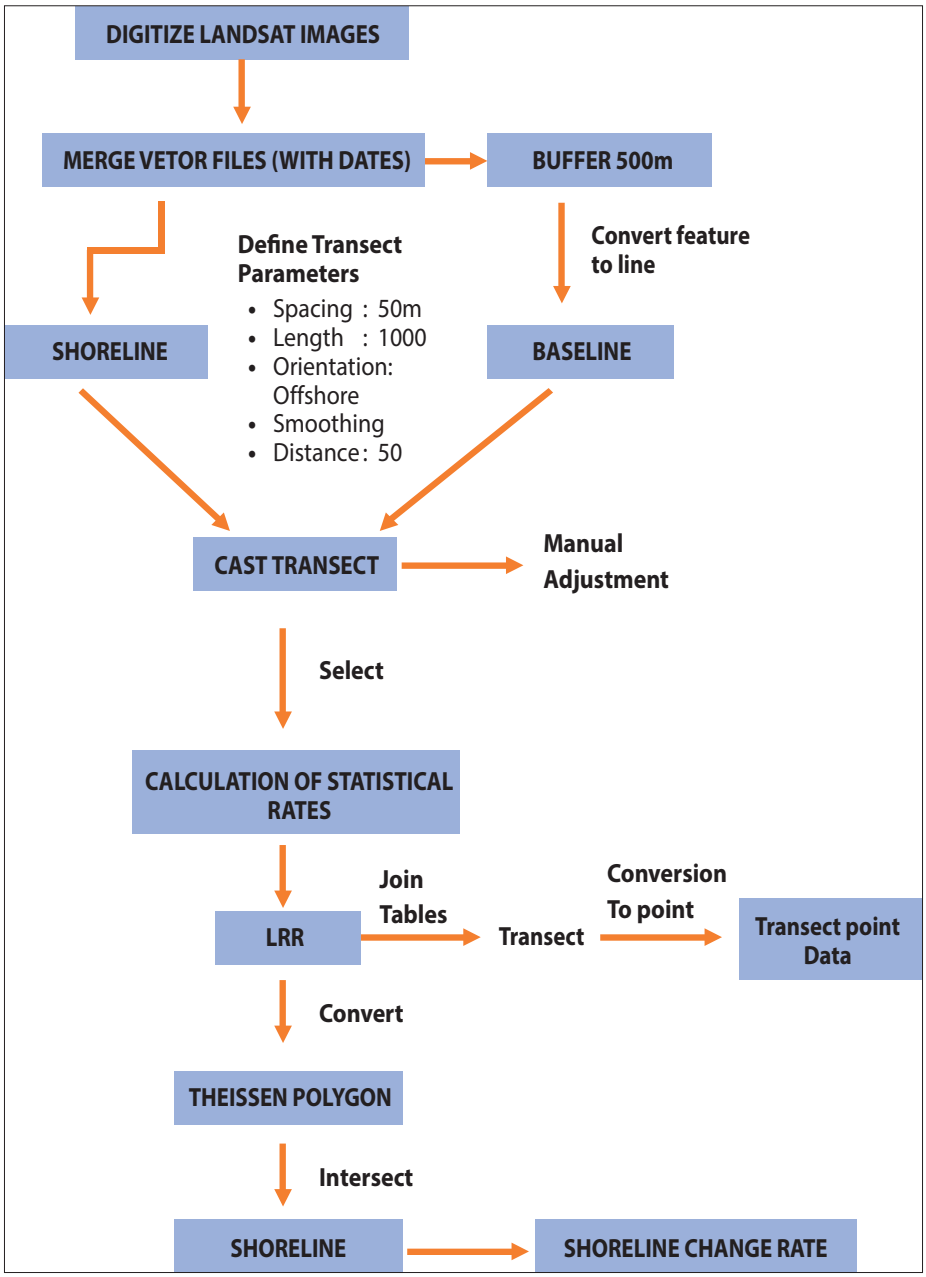

Figure 2 : Layout of the current work

4.1 Creating Spatial Layers of the Risk Variables

4.1.1 Coastal Geomorphology (G)

The parameter in question represents the erosivity risk associated with the coastal area. The Uttara Kannada coast exhibits various geomorphology types, such as very low rocky head, rocky beach, low vulnerable mud flat, moderate vulnerable rocky beach, and highly vulnerable areas like sandy beach, ports, or sea walls. The classification of these different geomorphologic regions along the coast was accomplished through a visual interpretation technique utilizing interpretation keys. Subsequently, these segments were grouped into different risk rate classes and assigned linear rankings before computing the Coastal Vulnerability Index (CVI).

4.1.2 Shoreline Change Rate (SCR)

The measure used to assess the historical tendency of a shoreline to either retreat or advance in response to sea level rise was employed. Shorelines exhibiting accretion were classified as low-risk categories, while those experiencing erosion were assigned correspondingly higher risks. Vector layers representing the shorelines for the years 1973, 1990, 2000, 2006, 2010, 2018, and 2019 were created using ArcGIS software. To analyze the data, the Digital Shoreline Analysis System (DSAS), an add-in software developed by the U.S. Geological Survey (USGS), was utilized. The Linear Regression Rate (LRR) method, as described by Thieler et al. (2009), was applied to quantify the rate of shoreline change over the 45-year period. Subsequently, the shorelines were categorized into risk classes ranging from very high to very low based on their relative values (Thieler et al., 2009).

4.1.3 Sea Level Change (SLC)

The sea level was defined as the average height of the ocean's surface between high tide and low tide. To determine this parameter, the primary source of information utilized was the tide gauge data set from the Global Sea Level Observing System (GLOSS) spanning the past century. Additionally, a secondary dataset consisting of monthly mean tide gauge data recorded by Indian tide stations was selected to estimate sea level trends. In order to standardize changes in tides and wave conditions over time, an average was taken. This allowed for the identification of sea level changes and

the measurement of land height above the sea level, referred to as the still water level. Based on the observed values along the shoreline of the study area, they were subsequently classified into five risk categories.

4.1.4 Tidal Range (TR)

This parameter has risks of both continuous and intermittent inundation. Wide intertidal zones with little relief are characteristic in coastal areas with large tidal waves, making them susceptible to ongoing flooding from sea level rise. Additionally, when storm surges coincide with high tides, these places are more vulnerable to sporadic flooding brought on by storm surges. Tidal range information for January 2018 was gathered for the current study from the WX Tide programme. For several coastal areas in India, the base data and maximum amplitudes of the tide were determined, and risk rates were assigned according to the corresponding values.

4.1.5 Coastal Regional Elevation (E)

Understanding the possible effects of future sea level rise depends heavily on coastal regional elevation, which is the average height of a given area above mean sea level. It helps to identify places that could be impacted by rising sea levels. Data on coastal elevation are useful for evaluating the amount of land accessible for wetlands migration in reaction to sea level rise and determining how sea level rise would affect urban settings. In this project, a coastal regional elevation model was created using data from the Shuttle Radar Topography Mission (SRTM). Theisen polygons were created after the data was transformed into point data. The elevation data was then intersected with the current shoreline using these polygons. Higher elevation coastal locations were thought to be less vulnerable, but lower elevation places were thought to be extremely exposed to the effects of sea level rise.

4.1.6 Coastal Slope (S)

The rate of shoreline retreat and how susceptible a coast is to flooding are both influenced by the coastal slope. The relative susceptibility to flooding and the possible speed of coastline retreat are both determined by the slope. Using the General

Bathymetric Chart of the Oceans (GEBCO) data, the slope tool of the QGIS programme was used in this work to calculate regional slope values. Regions with lower slope values were categorised as higher risk zones (Rao et al., 2008). The slope values were expressed in degrees.

4.1.7 Beach Width (W)

This was obtained as the horizontal measurement of the beach. High beach width values represented the lower risk rates or accretion, and the lower beach width values depicted that the risk rates or erosion were high. The width was determined from the Google Earth Pro software. A path file was created along the beach horizontally i.e., perpendicular to the coast. These paths were exported into ArcGIS as vector layers. Their respective lengths were then calculated, and they were converted into point files first and then into Thiessen polygons. The polygons were then intersected with available shoreline information. In the case of sea walls, ports, headlands or rocky beaches the beach width value was zero.

4.1.8 Mean Significant Wave Height(H)

The average significant wave height is a useful indicator of wave energy, which plays a key role in coastal sediment transport. Significant wave height refers to the average height of the one-third highest waves over a 12-hour period, measured from trough to crest. This parameter directly influences the amount of beach material that can be transported offshore, potentially leading to permanent removal from the coastal sediment system. As wave height increases, wave energy also increases, resulting in a higher risk of land loss due to increased erosion and inundation along the shoreline. Therefore, coastal areas characterized by greater wave heights were considered more vulnerable, while those with lower wave heights were deemed less vulnerable.

4.2 Risk Rating

The five risk classifications of extremely low, low, moderate, high, and very high were applied to all eight criteria. The following table displays the ranges used to group the risk rates for all parameters.

Table 3 : Categorization and Risk Rating of Input Parameters

Data Range	Very low 1	Low 2	Moderate 3	High 4	Very high 5
Shoreline change rate (m/y)	>0.5	±0.5	-0.5 to -4	-4 to -8	<-8
Sea Level Change Rate (mm/y)	<1.25	1.25 to 1.27	1.27 to 1.29	1.29 to 1.30	>1.31
Geomorphology	Rocky Head	Rocky Beach	Headland	Seawall & Port	Sandy Beach
Tidal Range (m)	<2.13	2.13 to2.17	2.17 to 2.23	2.23 to 2.27	>2.27
Elevation (m)	>80	60 to 80	40 to 60	20 to 40	<20
Slope (degree)	>1.3	1.1 to 1.3	1.1 to 0.7	0.4 to 0.7	<0.4
Beach width (m)	>120	80 to 120	40 to 80	10 to 40	<10
Significant wave Height (m)	<1.479	1.479 to 1.484	1.484 to1.489	1.489 to 1.494	>1.494

4.3 CVI Computation

The Coastal Vulnerability Index (CVI), which provides a measure of the comparative vulnerability of a shoreline to physical changes brought on by future sea level rise, enables a measurable relationship among the factors mentioned above. The total research area's 1-minute grid cells were used to get the composite index value. Four general levels of susceptibility were determined using a macro-synoptic scale (at a ratio of 1:100,000): very high, high, medium, and low vulnerability. When calculating the CVI, this classification was used. The CVI was then calculated as the square root of the ranked variables, divided by the total amount of variables, by allocating vulnerability values to each individual data variable.

$$CVI = \sqrt{\frac{(G \times SCR \times SLC \times TR \times E \times S \times W \times H)}{8}}$$

It was ranked from 1 to 5 on a linear scale basis indicating the vulnerability level due to shoreline change. Vector Algebraic techniques were applied on the risk values assigned to input parameters to calculate the index values for coastal segments. This was executed with ESRI Arc Map software.

4.4 CVI Ranking

The final mapping of CVI ranks was performed with percentile values. CVI incorporated aspects of both geology and structure along the coast (Kumar & Kunte 2012; Mujabar & Chandrashekhar 2013). The percentile values for CVI were calculated as,

$$\text{CVI to percentile} = \frac{(\text{CVI-minimum})}{(\text{maximum-minimum})} \times 100$$

Thus, the actual values were converted to a 0 to 100 range. The CVI values ranging from 0 to 25 are lower risk rates. Values ranging from 25 to 50 are Moderate risk areas. High risky areas range from 50 to 75 and the values from 75 to 100 are the areas which are highly vulnerable areas which are prone to severe damage. The categorization of CVI percentiles is shown by the Table 4.

Table 4 : Ranking CVI for Risk Assessment

Data Range	Low 1	Moderate 2	High 3	Very High 4
CVI Percentile Rank	0 to 25	25 to 50	50 to 75	75 to 100

5. Results and Discussion

The parameters indicating coastal vulnerability were first assessed and also compared in terms of risk rates. In the later section, the obtained CVI results were evaluated.

5.1 Coastal Geomorphology

As for coastal geomorphology, the highly vulnerable sandy beaches dominated the

study area. These zones' spatial distribution is displayed by Figure 3. Beaches like Murudeshwar, Belekeri, Belambar, Honnavar, Shirali, Bhatkal which in total extends 102.20 km came under the highly vulnerable category. Alternately, parts of the northern coast with seawalls and ports have lower risk rates. In the Uttara Kannada coastline, the sea walls and ports together covered a stretch of around 15.80 km. The rocky beaches and rocky headlands dominated this part of the coastline constituting only 21% of the study area.

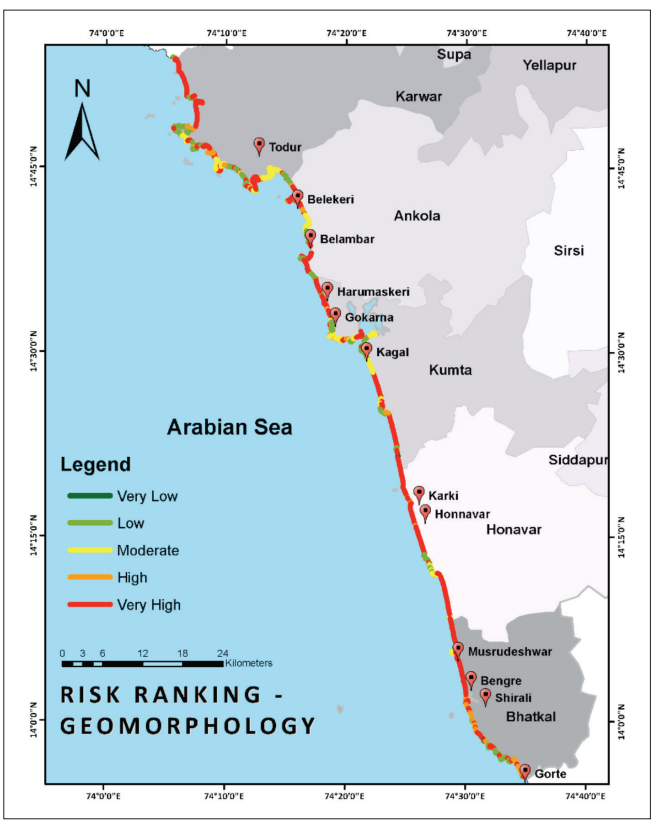

Figure 3 : Coastal geomorphology risk rate categories

5.2 Shoreline Change Assessment

The dynamic nature of shoreline along the study area over forty-six years is shown by Figure 4. The results depicted that only 0.87 km stretch of the coast was under very

high-risk class; 0.42 km shoreline was under high-risk class. A considerable stretch of 35.2 km was under moderate risk class. This zone extended over the coasts of Karwar, Ankola, Murudeshwar. The erosion rate in the study area is low and limited to very few pockets. This has happened due to elevated coasts, pocket beaches adjoining rocky headlands, etc. The low-risk areas covered the majority of the Uttara Kannada coast extending for about 76.48km. A long stretch of 73.03 km of the study area was found to be under very low risk classes. Overall, the current study proved that during these 46 years from 1973 to 2019 the majority of the coast is facing accretion than erosion.

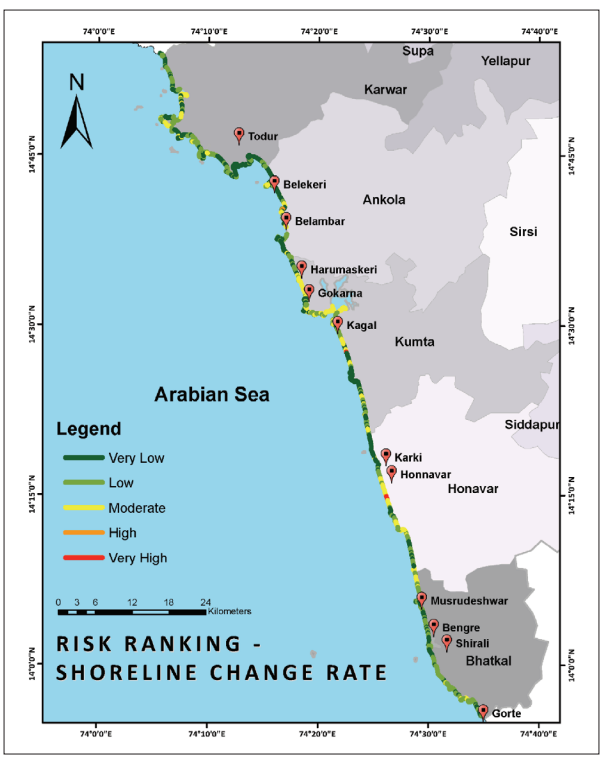

Figure 4 : Shoreline change risk rate categories

5.3 Sea Level Change

The relative distribution of the risk class along the Uttara Kannada Coastline for the sea level changes is shown through Figure 5. Only around 5.11 km length of the study area

belonged to the low sea level change risk rate category. This was solely concentrated near Karwar in the northern most parts. The value of sea level rise was around 1.237 mm/year over here. On the other hand, the study showed the coasts starting from the southern parts like Bhatkal, Bengre, Murudeshwar, Honnavar up to the north like Ankola, Todur were prone to much higher risk. The sea level change rate was around 1.340 mm/year over these regions.

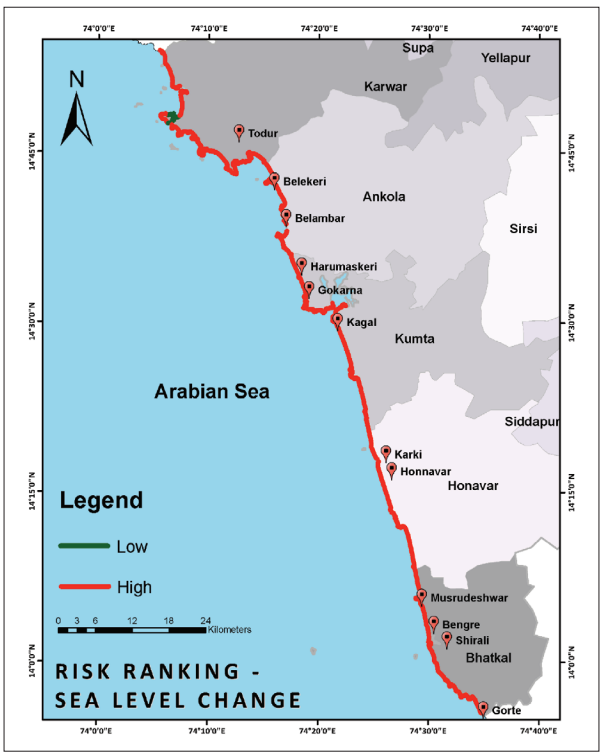

Figure 5 : Sea level change risk rate categories

5.4 Mean Tidal Range

A greater tidal range was observed at the northern parts of the region. Around 51.41 km of the present study area extending mostly over the coasts of Karwar came under very high-risk zone in terms of the mean tidal range values. The value was noted to

be more than 2.17m. The risk rates gradually dropped towards southern sections. Near Gokarna the coastline indicated moderate risk rate stretching for around 31.61 km. A length of 18.21 km between Kumta and Honnavar reflected lower risk rate. An extensive 54.23 km coastline between Bhatkal and Honnavar belonged to the very low risk rate. The location based tidal risk categories are shown in the following Figure 6.

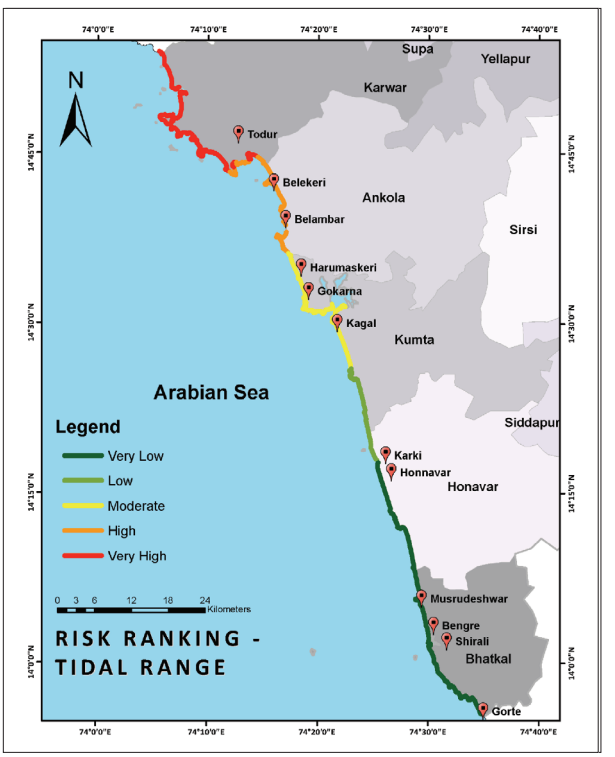

Figure 6 : Mean tidal range risk rate categories

5.5 Coastal Elevation

A vast majority of the study area reflected very high risks in terms of coastal elevation. The region with low-risk rates constituted only 1% of the total coastline. The low-risk areas were mostly the cliffs and rocky beaches from northern parts. Only 8.08 km length depicted moderate risk and 3.49 km showed low risk rates. These low to moderate risk category areas spread throughout the coast in patches. The remaining stretch of

the coast mostly came under very high-risk class. This class covered 86% of the area, extending up to 157.51 km length. A stretch of 16.88 km came under high-risk zones. So, based on this parameter it can be concluded that the study area is greatly under threat due to low lying zones. The variation in spatial pattern of coastal elevation risks is shown by Figure 7.

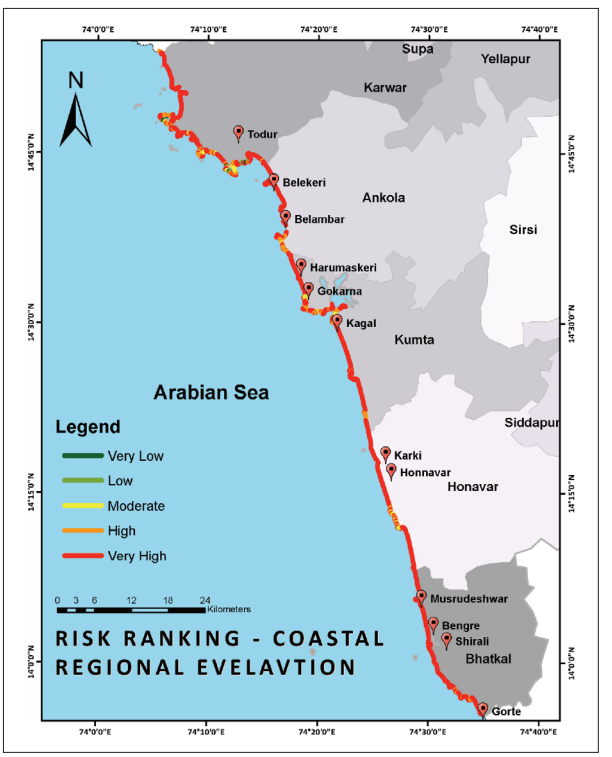

Figure 7 : Coastal elevation risk rate categories

5.6 Coastal Slope

The results depicted that slope values for the current study region ranged between 0.046° to 8.877°. The very high coastal slope risk rate category was dominant extending up to a length of 169.31 km. This class was primarily present between Bhatkal and Karwar. Further 4.78km of the study area was dominated by the high coastal slope risk

rate category. On the contrary, very low, low and moderate risk zones as per coastal slope only covered 8.79 km, 1.75 km and 1.35 km respectively. Higher slope and low risk were observed at the southern parts of the shoreline. The spatial distribution of various risk zones as per the coastal slope is shown by Figure 8.

Figure 8 : Coastal slope risk rate categories

5.7 Beach Width

A considerable stretch of 82.76 km of this study area had very narrow beaches and hence was under the very high-risk rate category. The areas with such low beach width were prominent along the coasts of Karwar and some parts of Bhatkal. Another 49.11 km area came under the high-risk rate class. These zones also laid along the coasts of Karwar and Bhatkal. The moderate risk rate category was spreading for about 41.05 km

of coastal length. Only 13.07 km of the study area expected low risk rate in terms of beach width. Here, the beaches were nearly 100 m wide. Overall, only a few parts of the region have accretion and led to the development of broad beaches. The spatial pattern of the above mentioned zones is shown by the following Figure 9.

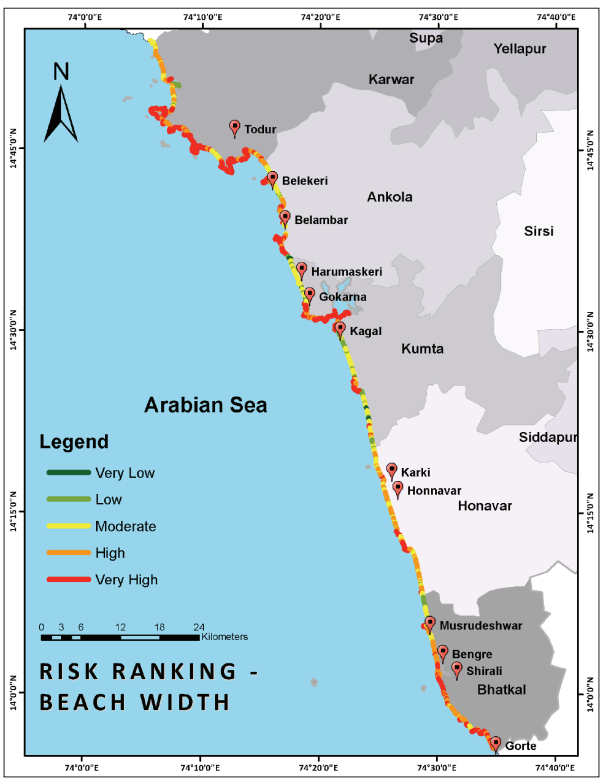

Figure 9 : Beach width risk rate categories

5.8 Significant Wave Height

The distribution of risk levels along the coast in terms of wave height is shown by Figure 10. The coasts of Karwar were notably vulnerable due to waves reaching up to 2m height. High-risk rate classes also extended along Karwar and parts of Ankola. This category stretched up to 36.95 km. Coastal regions of Gokarna mostly depicted the presence of moderate risk rate covering 24.33 km of the coastline. Uttara Kannada coast had lower

wave height and hence was less prone to be a vulnerable coast. The wave heights have gradually decreased from north to south. Around 76.51km of the study area, particularly towards the southern side of the coast, had low risk rates. Such low vulnerability was especially notable along the coastal regions of Honnavar and Bhatkal.

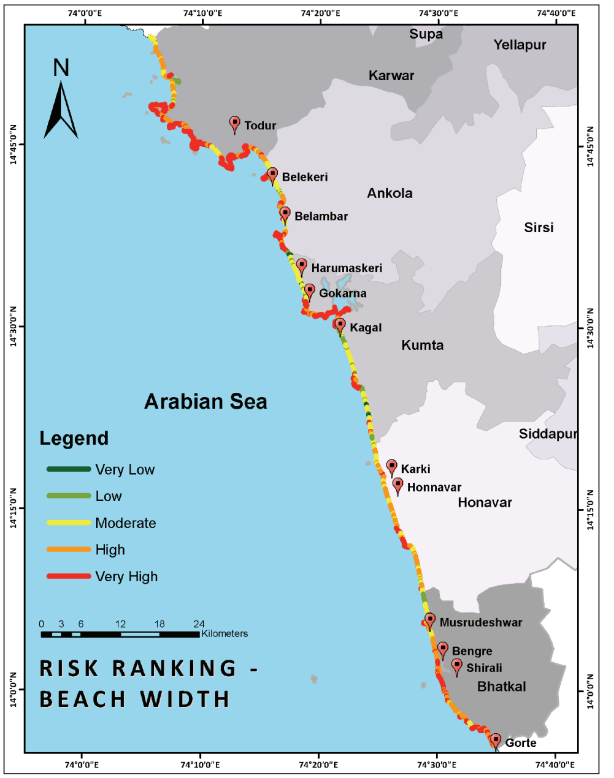

Figure 10 : Significant wave height risk rate categories

5.9 Comparative Analysis of Various Parameters

The percentage of risk areas varied considerably from one parameter to the other. These divisions are shown by the following pie charts in Figure 11. Results suggest that out of all the parameters, the study area was most vulnerable in terms of sea level change, coastal slope and coastal elevation. On the other hand, very low percentage area was vulnerable in terms of shoreline change rate. In case for factors like

geomorphology, tidal range, beach width and significant wave height, the study area had mixed nature covering all the risk category zones.

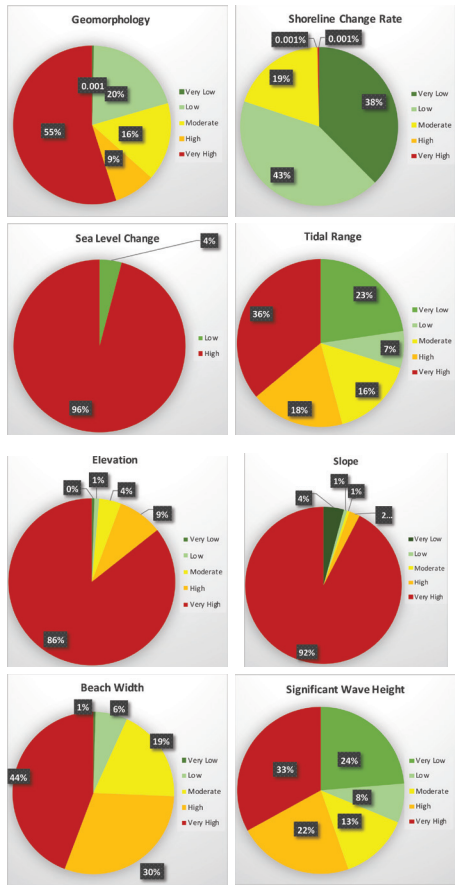

Figure 11 : Percentage risk areas for various parameters

5.10 Coastal Vulnerability Index

The total coastal vulnerability was calculated taking into account all of the input variables. The following illustrates how the four risk zone categories are distributed. Figure 12 shows the percentages of the four risk classes' coverage. As per the final CVI

values, about 5% of our total study area was facing very high risk. The northern parts of Uttara Kannada, especially the Karwar coast depicted very high vulnerability for a stretch of around 6.35 km. About 22% of the total study area was under the high vulnerability category. This category extended up to 31.07 km of and was also seen along the coasts of Karwar. Some places of Gokarna coast were additionally part of high-risk zones as per the CVI. Urgent preventive measures and sustainable planning should be applied on these critical areas. Around 34% of the total study area was under moderate risk category. Moderate risk coasts ranged up to 60.02 km of Uttara Kannada. This category was dominant along the Gokarna and Ankola coasts. Low risk values were primarily observed in the southern coasts of this region. Parts of the coastline from Bhatkal to certain stretches of Gokarna and also some parts of Ankola coast were recorded with low vulnerability. Very few patches of Karwar coast reflected low risk. The low vulnerability category covered nearly 39% of the study area, with a length of 88.55 km.

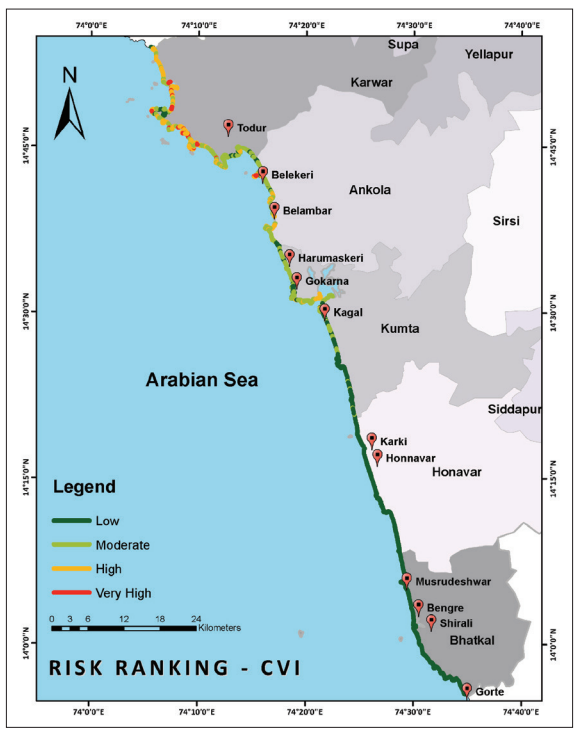

Figure 12 : Spatial depiction of Coastal Vulnerability Index

6. Conclusions

The study successfully carried out the coastal vulnerability assessment of Uttar Kannada Coast in India. The separate analysis of multiple significant parameters along coastline have created a much needed spatial database for the Indian coast. Useful insights were provided for upcoming morphological changes. The southern parts of the study area were comparatively less vulnerable than the northern parts. The relative potential of coastal damage was very high for parameters like, geomorphology, coastal elevation, slope and sea level change rate. As per the CVI, 34% of the study area came under moderate risk while 22% and 5% area were under high and very high risk respectively. The most severely affected area was one of the main developing cities of the Uttara Kannada district, Karwar. The region consists of residential areas, public infrastructure, agricultural sectors, recreational areas, fishery facilities, ports and also natural ecosystem hotspots. Long-term sustainable development necessitates an Integrated Coastal Zone Management (ICZM) strategy. A spatiotemporal dataset based on many criteria is required for this strategy. The information and methods employed in this investigation were appropriate for this goal and provide a framework for subsequent assessments of coastal risk.

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References

1. Arun Kumar, A., & Kunte, P. D. (2012). Coastal vulnerability assessment for Chennai, east coast of India using geospatial techniques. Natural Hazards, 64, 853–872. https://doi.org/10.1007/s11069-012-0276-4
2. Bio, A., Bastos, L., Granja, H., Pinho, J. L. S., Goncalves, J. A., Henriques, R., et al. (2015). Methods for coastal monitoring and erosion risk assessment: Two Portuguese case studies. Journal of Integrated Coastal Zone Management, 15(1), 47–63. https://doi.org/10.5894/rgci490
3. Burningham, H. (2017). Understanding coastal change using shoreline trend analysis supported by cluster-based segmentation. Science Direct.
4. Hegde, B. J. (2015). Shoreline Transformation Study of Karnataka Coast: Geospatial Approach. Aquatic Procedia.

5. Hossain, S. K., Mondal, I., Thakur, S., & Fadhil Al-Quraishi, A. M. (2022). Coastal vulnerability assessment of India's Purba Medinipur-Balasore coastal stretch: A comparative study using empirical models. International Journal of Disaster Risk Reduction, 77(103065). https://doi.org/10.1016/j.ijdrr.2022.103065
6. Karnataka Biodiversity Board. (2010). "BIODIVERSITY OF KARNATAKA" At a Glance. Retrieved from http://www.indiaenvironmentportal.org.in/files/Biodiversity%20of%20Karnataka%20at%20a%20Glance_0.pdf
7. Koroglu, A., Ranasinghe, R., Jiménez, J. A., &Dastgheib, A. (2019). Comparison of Coastal Vulnerability Index applications for Barcelona Province. Ocean and Coastal Management, 178, 104799. https://doi.org/10.1016/j.ocecoaman.2019.05.001
8. Lindsey, R. (2022). Climate Change: Global Sea Level. Retrieved from https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level
9. Management, N. C. (2013). Coastal Hazards and Storm Information: Protecting Oceanfront property from erosion. North Carolina.
10. McLaughlin, S., Andrew, J., & Cooper, G. (2010). A multi-scale coastal vulnerability index: A tool for coastal managers? Environmental Hazards, 9(3), 233–248. https://doi.org/10.3763/ehaz.2010.0052
11. Nageswara Rao, K., Subraelu, P., Venkateswara Rao, T., & Vijaya Kumar, G. (2008). Sea-level rise and coastal vulnerability: an assessment of Andhra Pradesh coast, India through remote sensing and GIS. Journal of Coastal Conservation, 12, 195–207. https://doi.org/10.1007/s11852-009-0042-2
12. Princy, J. R., Ramesh, M., Jyothi, J., Swathy Krishna, P. S., & Sheela Nair, L. (2023). Non-monsoonal Coastal Erosion Due to the Tropical Cyclone (OCKHI) and Its Impacts Along Thiruvananthapuram Coast, Southwest Coast of India – A Geospatial Approach. In N. Jayaraju, G. Sreenivasulu, M. Madakka, & M. Manjulatha (Eds.), Coasts, Estuaries and Lakes (pp. 373–380). Springer. https://doi.org/10.1007/978-3-031-21644-2_29
13. Scott, D., Simpson, M. C., & Sim, R. (2012). The vulnerability of Caribbean coastal tourism to scenarios of climate change related sea level rise. Journal of Sustainable Tourism, 20(6), 883–898. https://doi.org/10.1080/09669582.2012.699063
14. Sheik Mujabar, P., & Chandrasekar, N. (2013). Coastal erosion hazard and vulnerability assessment for southern coastal Tamil Nadu of India by using remote sensing and GIS. Natural Hazards, 69(3), 1295–1314. https://doi.org/10.1007/s11069-011-9962-x
15. Thieler, E. R., Himmelstoss, E. A., Zichichi, J. L., & Ayhan Ergul, A. (2009). The Digital Shoreline Analysis System (DSAS) Version 4.0 - An ArcGIS extension for calculating shoreline change. Open-File Report 2008-1278. https://doi.org/10.3133/ofr20081278
16. Yang, Y., Ren, L., Wu, M., Wang, H., Song, F., Leung, L. R., et al. (2022). Abrupt emissions reductions during COVID-19 contributed to record summer rainfall in China. Nature Communications, 13(1), 1–7. https://doi.org/10.1038/s41467-022-28537-9

Local Perception of Flood Risk: Evaluating Risk Awareness and Indigenous Knowledge Among Flood-Prone Communities in the Trans-Himalayan Valley, Leh District

Isha Kaushik[1] and Tsering Dorjay[2]

Abstract

The incidence of flash floods has demonstrated a consistent upward trend since the catastrophic events of 1999 in the Leh district. Notably, every settlement in Ladakh occupies floodplains within the river valley, which have been shaped by historical river erosion, deposition activities, and significant flood occurrences. The encroachment of urbanization into flood-prone areas has heightened the vulnerability of local populations to flooding events. Often, susceptibility to floods is exacerbated by a lack of awareness regarding one's natural surroundings. Central to the research is an analysis of risk perception, encompassing individuals' risk awareness, emotional responses, and behavioural patterns towards flood risk. Recognizing risk perception as a key determinant of vulnerability, the study seeks to evaluate local perceptions of flood risk. This involves examining risk awareness and indigenous knowledge, as well as assessing administrative readiness for flood events. Additionally, the research endeavours to provide a retrospective overview of historical flood occurrences in Leh, offering crucial contextual insights into the region's flood risk landscape.

Keywords: *Ladakh, Risk perception, Risk awareness, Indigenous knowledge, Ladakh flood, Vulnerable houses*

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1. Introduction

Ladakh, characterized by its mountainous terrain, is encompassed by three trans-Himalayan Mountain ranges: the Karakoram, Ladakh, and Zanskar. Noted for its diverse geological formations, tectonic structures, minerals, and geological history spanning from the Archean period (approximately 3.5 billion years ago) to the recent past (10,000 years BP) (Mir, Dar, and Ahmad 2023). Leh, the principal urban settlement in the area, typically witnesses an annual precipitation ranging from 80 to 100 mm (Spate et al., 1976), with considerable increases during the summer monsoon months of July and August. Environmental conditions in Ladakh are notably arid, and the area is vulnerable to natural disasters such as floods, avalanches, earthquakes, and landslides. Among these, flood disasters, particularly cloudbursts and flash floods, are prevalent in hilly regions (Sharma et al., 2020) causing significant damage and fatalities in Ladakh. Studies indicate that during the Quaternary period approximately 2.56 million years ago, Ladakh experienced considerable glaciation, as evidenced by (Owen et al., 2006). The unique topography of Ladakh owes much to the pervasive influence of glaciers, which have been dynamically active across various geological epochs, shaping the landscape through erosion and deposition. This geological process has yielded a diverse array of landforms, including valleys, low-slope valleys, aretes, cones, and thang between hills (Mir et al., 2023). However, the escalation of global temperatures has triggered snowmelt, resulting in the formation of U- and V-shaped valleys that have further eroded mountains and given rise to plains. Subsequently, large-scale floods and sporadic glacier melts have occurred, contributing to the creation of floodplains and other landforms. Presently, every settlement in Ladakh is situated on these floodplains within river valleys, which bear testament to past instances of regular flooding.

Notably, in the Nubra Valley, approximately 80% of settlements are situated on alluvial fans, characterized by their triangular sand deposits formed as a consequence of flood occurrences. Thus, whenever instances of natural calamities such as cloudbursts or glacial lake outburst floods (GLOFs) arise, floods inherently follow their course, engulfing settlements in their trajectory. In Ladakh, a yearly flood disaster incident, specifically a cloudburst, happens, bringing devastation to the communities located near the river. The vulnerability to floods in certain areas of Ladakh has been on the rise due to encroachments into flood-prone zones. The process of urbanization in

contemporary times has often disregarded environmental indicators of flood risk, such as those delineated in sedimentary records of various streams (Ziegler et al., 2016). Encroachment into flood-prone areas has been identified as a contributing factor to the escalating flood vulnerability globally, particularly as urban areas expand and intensive land use near floodplains proliferates (Chang et al., 2009; Jalis & Abbasi, 2016). Following the year 1974, coinciding with the growth of the economy and tourism, Leh town and surrounding villages witnessed a rapid and unplanned urbanization trend. This trend saw the establishment of hotels, home stays, and residential areas in close proximity to the river, reflecting a departure from environmental determinism towards a perspective rooted in possibilism.

In the major flood incident that occurred in Leh district in 2010, 224 fatalities were reported, and approximately 9,000 individuals were affected by the cloudburst event, the imperative of understanding the risk perception within flood-impacted communities has been underscored. This recognition dates back to the seminal publication of Gilbert White's "Human Adjustment to Flooding" in 1945 (Whyte, 1986), a work that has significantly influenced discourse on flood risk management. Within contemporary flood risk management paradigms, risk perception stands as a crucial facet of subjective risk analysis (Schanze, 2007). A nuanced comprehension of citizens' perceptions of flood risk is essential for informing policy decisions, shaping effective flood mitigation strategies, and facilitating decision-making processes. Indeed, the perception of flood risk among community members not only aids in understanding vulnerability to floods and their potential ramifications but also plays a pivotal role in determining the efficacy of flood impact mitigation efforts (Filatova et al., 2011; Shen X, 2010). Research has highlighted that neglecting public risk perceptions in flood management endeavours, even if technically sound, can result in suboptimal outcomes and may foster maladaptation. Risk perception serves as a critical factor in gauging the vulnerability levels of individuals or social groups to environmental hazards (Neil, 1999). (Mileti, 1980) defines risk perception as the cognitive assessment or belief in the severity of the threat posed by an environmental extreme, coupled with the subjective estimation of the likelihood of encountering such detrimental environmental events. Understanding risk perception is integral to anticipating and comprehending public responses to hazards, setting priorities, efficiently allocating resources, and effectively

communicating risk information to both laypersons and experts. Therefore, the objective of this study is to evaluate local perceptions of flood risk through an examination of risk awareness and indigenous knowledge, as well as assessing the preparedness of the administration for flood events. Additionally, the research aims to provide a historical retrospective of flood events in Leh for contextual understanding.

2. Research Objectives

a. To examine how riverfront communities perceive flood risk and to assess their awareness and indigenous knowledge regarding flooding.

b. To evaluate the historical frequency of flood occurrences in the Leh district.

3. Methods

The methodology employed in this study entailed a multistage purposive sampling approach, focusing on riverfront households as the primary units of investigation. Selection criteria were established based on the identification of villages and rivers delineated as high-risk areas in the District Disaster Management Plan Leh (DDMP), with particular emphasis placed on households situated in close proximity to the riverbanks. Leveraging Geographic Information System (GIS) technology, 36 villages adjacent to 29 rivers, identified as risk sites by the DDMP, underwent digitization in the software. Subsequently, 20 village households located along the riverbanks were identified, with 7 villages demonstrating a notable concentration of such riverfront residences. From these targeted areas, a total of 48 households were identified, dispersed across Choklamsar (23), Kharu (2), Nang (3), Tia (3), Tingmosgang (4), Nimoo (5), and Saboo (8).

During September 2023, the second author conducted face-to-face interviews schedule with occupants of 48 riverfront households. These interviews employed both structured and unstructured questionnaires to assess the participants' perceptions of flood risk. Each interview was conducted with a representative of the household, typically the head of the family. The age range of the participants spanned from 35 to 66 years, and the gender distribution included 36% male and 64% female respondents.

The collected data were subsequently analyzed using thematic analysis, facilitated by the use of computer-assisted qualitative data analysis software (CAQDAS), specifically ATLAS.ti. This approach enabled the identification of key themes and patterns in the participants' responses, providing a nuanced understanding of flood risk perceptions among the surveyed households. In addition to interview data, historical information on early flood events in Leh district was collected through news articles and the District Disaster Management Plan (DDMP) of Leh district. This secondary data was also analyzed using ATLAS.ti, further enriching the analysis by providing contextual insights into the region's historical flood events.

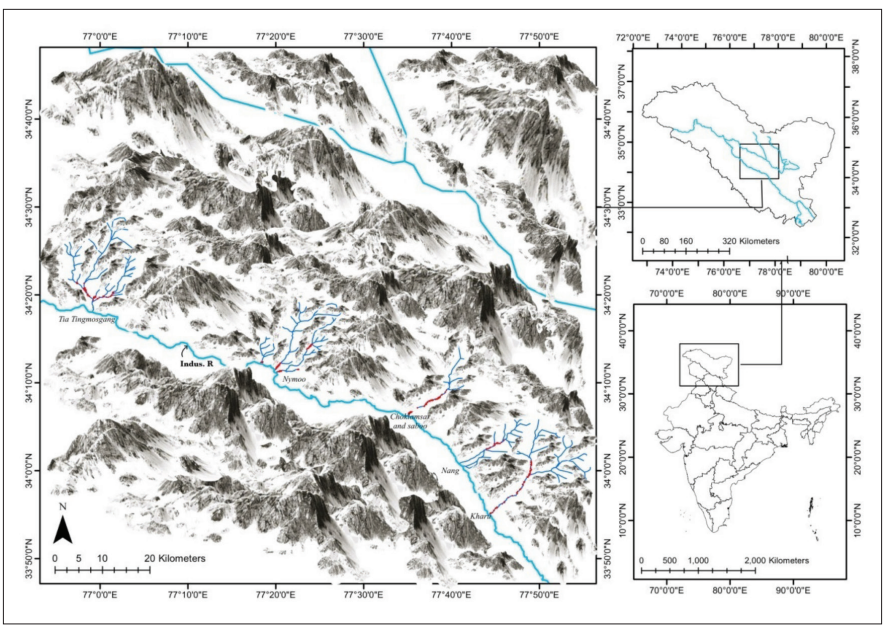

Figure 1 : The map illustrates the study region, highlighting the selected villages and river within it. (PNG has been used for the physiography visualisation)

4. Result and Discussions

4.1 Early settlement and Flood Events in Leh district: Historical Retrospective

During the early settlement period, the town of Leh was strategically situated close to higher elevations adjacent to mountains as a means of flood protection. Notably, each

community featured a Buddhist monastery erected atop a hill, with human habitation largely confined to the areas surrounding these monasteries (Suri, 2018a). For instance, it is believed that the earliest permanent villages in present-day Leh city were established around 1400 AD in the marshy offshoot of the Chubi settlement, situated behind Tsemo Hill. Subsequently, in the seventeenth century, the construction of the Leh Palace on the hilltop marked a significant development. Consequently, the entire settlement gradually relocated to the softer south-facing slope of the hill, providing natural protection against floods originating in the Leh Valley, as outlined by (Morup & Chodon, 2018). With the increase in population towards the end of the nineteenth century, Leh experienced significant urban expansion, characterized by an unplanned growth pattern (Jest & Sanday, 1983). This surge in population was attributed to migration from rural areas of Ladakh (Dame et al., 2019), such as the Changthang, Nubra Valley, and Sham regions, with settlers dispersing along the valleys. The opening of Ladakh to tourists in 1974 further accelerated the process of urbanization in Leh.

Figure 2 : A satellite image of the Phyang River reveals evidence of past flooding and erosion scars, (sourced: Google Earth)

Despite the entire Leh valley being populated at present, it remains vulnerable to the threat of flash floods, capable of causing widespread devastation. The Nimoling Valley during the 2010 flood event serves as a poignant illustration of an unorganized or unplanned settlement. The examination of historical catastrophic events offers valuable insights for strengthening flood risk mitigation strategies by cultivating a heightened awareness of risk (Cœur & Lang, 2008). Analysis of flood river marks along various watercourses has uncovered evidence of significant past flood occurrences in numerous villages, including Nymoo, Phyang, Saspol, Ney-Basgo, and others (see Figure 2). The potential recurrence of a flood event of similar magnitude in the future could result in the complete devastation of entire settlements. Moreover, given the dynamic shifts in climate patterns, the likelihood of large-scale and potentially catastrophic floods occurring in this region is significantly heightened.

4.2 Historical Flood Events

In 1833, a glacial flood swept through the Shyok Valley, resulting in the destruction of every settlement from Nubra to Skardo that lay in its path. Similarly, major glacial flooding in 1841 devastated most communities along the Shyok River. A Glacier Lake Outburst Flood (GLOF) in 1907 engulfed the Leh Valley in mud. Local accounts from the 1930s recall the Kumdan Glacier Lake Outburst Flood, originating from the Kumdan glacier in Tibet, which caused widespread devastation, impacting the entire Nubra Valley from Khardong to Turtuk village (Suri, 2018a). In 1971, Nymoo Village experienced extensive destruction due to a GLOF, resulting in 13 to 16 reported fatalities (Ikeda et al., 2016). Subsequently, a flood in 1999 ravaged homes, farms, and claimed numerous lives in the Leh Valley. Flash floods in Ganglas and Gompa caused minimal impact in Leh, although some fields in Sankar were covered in mud, attributed to the rupture of a glacial meltwater lake on Khardung-la. Domkhar Village witnessed a GLOF in 2003 (Narama et al., 2011). Flooding occurred in Phyang and Leh in 2005, followed by flooding in Igu, Phyang, Khalsar, and Tsati Village in 2006, resulting in damage to several homes. Flood events were also recorded in Stok Village in 2008 and Uleytokpo in 2009 (DDMA, 2011).

Table 1 : Showing the Historical Flood Events in Leh District

Year of flood	Area of Flood
1833	Glacial flood down the Shyok valley. Destroyed every village in its path, from Nubra to Skardo
1841	Major glacial flood. Hit most of the villages along the Shyok
1907	Flood in Leh valley (GLOF)
1929	Great flood, Shyok river (Famine induced by flood)
1930	(GLOF) Hunder Valley
1932	Major flood, Shyok
1933	Major flood, Shyok
1971	Houses and fields at Neymo were destroyed by a cloudburst
1999	Flash floods, in Gompa and Ganglas. Not much impact in Leh, though some of the fields of Sankar were covered with a thick layer of mud. This was caused by the bursting of a dam impounding a lake of glacial meltwater on Khardung-la
2003	GLOF in Domkhar
2005	Flood in Leh and Phyang
2006	Flood in Leh, Igoo, Khardong(Rongju) and Phyang, Khalsar, Tsati
2008	Flood in Uleytokpo
2009	Flood in Stok
2010	Flash flood in Nimoo, cloudburst around Leh, GLOF in Nidder
2014	Flood in Gya and Markha valley
2015	Flood in Wakha river, GLOF in Phugtal and Nubra valley
2017	Flood in Achinathang
2018	Flood in Saboo, Shey(Stakmo) and Tirisha
2019	4 houses damaged in Nubra valley and 5 houses from Durbuk block
2020	8 houses damaged in Nubra valley and two house from Leh tehsil

2021	11 from Kharu village, 92 from Nubra valley, 2 from Khaltse and 2 from Durbuk block
2022	10 from Nyoma block, 2 from Leh tehsil, 8 from Khaltse block and 1 from Nubra valley
2023	37 from Khaltse block, 3 from Likir, 3 from Kharu, 14 from Nubra, 8 from Durbuk, 2 from Nyoma, 74 from Leh tehsil

In the aftermath of the 2010 cloudburst in Ladakh, the term "cloudburst" likely entered the lexicon of local inhabitants for the first time (Suri, 2018a). According to the administration of the Union Territory of Ladakh, the disaster resulted in the loss of

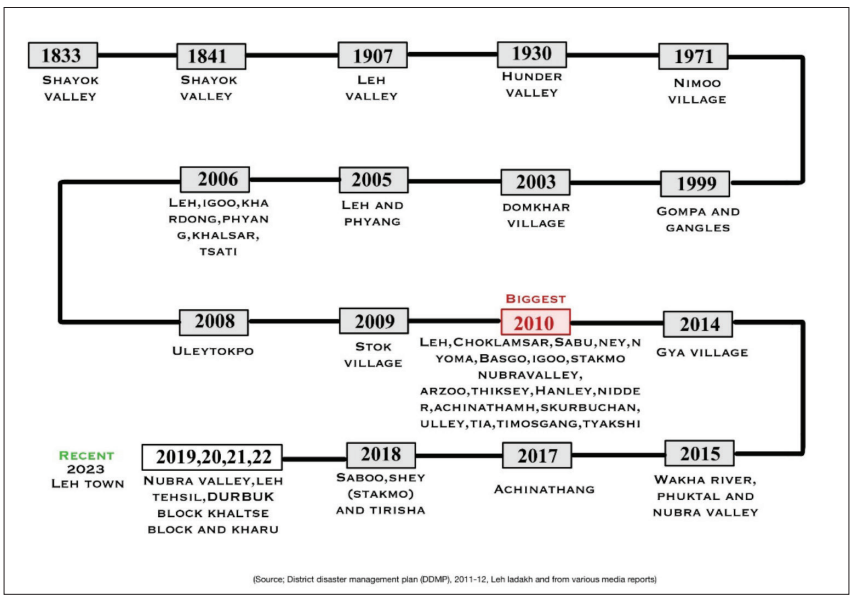

Figure 3 : The figure depicts a chronological timeline detailing flood occurrence within the Leh district.

224 lives and affected 9000 individuals. Public properties suffered extensive damage, estimated at 133 Cores, impacting 71 villages. Among the worst-affected areas were Leh town, along with Taru, Nymoo, Basgoo, Stakna, Shey, Arzoo, Thiksey, Kungyam,

Anlay, Nidder, Achinathang-Lungba, Skurbuchan, Rezong, Ulley, Tia, Tingmosgang, and Tyakshi in the Turtuk area (DDMA, 2011). In Choglamsar, a particularly hard-hit locality, debris flow resulting from the cloudburst swept away 40 houses, expanding up to 2 km after traveling approximately 10 km from the epicentre near Saboo (Khattri, 2012). Within the Shaksaling stream's catchments, debris flow travelled approximately 3 kilometres from an elevation of 3800 meters to 3410 meters. The Sonam Norboo Memorial Hospital, radio station, Nimoling settlements, Bus Stand, and BSNL mobile communications centre were among the devastated infrastructure. The disaster resulted in 424 injuries, 224 fatalities, and 79 individuals still unaccounted for (DDMA, 2011). In 2014, the community of Gya experienced flooding due to a Glacial Lake Outburst Flood (GLOF), while Nubra Valley faced flooding in 2015. Achinathang village witnessed a flood on August 4, 2017, resulting in the deaths of four individuals, including three non-local labourers and one native resident. Subsequent floods occurred in August 2018 in Saboo, Shey, Stakmo, and Tirisha (Suri, 2018b) following that Minor flooding incidents were observed in Ladakh during the years 2019, 2020, 2021, and 2022. In July 2023, a cloudburst triggered a flash flood during the night in the Chok-hang, Chubi, Khalshal, Katpa, and Lamdon areas of Leh town. This event led to the rush of debris into market areas, resulting in damage to several houses, vehicles, and shops. Since the flood event of 1999, there has been a noticeable increase in the frequency of flooding incidents. Consequently, the months of July and August have become periods of heightened flood risk, prompting concerns among both the public and administrative authorities. Particularly, residents living near the river express heightened apprehension regarding potential flood hazards.

4.3 Local Perceptions of Flood Risk: Examining Risk Awareness and Indigenous Knowledge within Community Contexts

The ability to perceive and mitigate adverse environmental conditions is essential for the survival of all organisms. Furthermore, the capacity to encode and learn from past experiences contributes significantly to survival. Human beings possess an additional capability to both adapt their environment and respond to it, thereby introducing both potential hazards and opportunities for risk mitigation (Slovic, 1987). Various academic fields, including geography, sociology, political science, anthropology, and psychology, have made significant contributions to our current understanding of

risk perception. Originally, geographic research focused on comprehending human behaviour in natural hazard contexts, but it has since broadened to encompass technological hazards as well (Beckinsale, 1979). Sociological and anthropological investigations (Douglas & Wildavsky, 1982) have emphasized the role of social and cultural factors in shaping risk perception and acceptance. An essential step in defining the risk management process is identifying the factors that expose individuals to flood risks. Frequently, susceptibility to flooding is associated with a lack of awareness about one's natural surroundings (Mondino et al., 2020a). The examination of risk perception entails delving into individuals' awareness, emotional responses, and behavioural tendencies toward hazards. Originating from the nuclear discourse of the 1960s (Sowby, 1965; Starr, 1969), this field of study has expanded into various domains, including flood risk management (Messner & Meyer, n.d.). Understanding the factors contributing to individuals' vulnerability to flooding is essential for informing effective risk management strategies, with flood vulnerability often linked to a lack of awareness regarding one's natural surroundings (Mondino et al., 2020b). In the literature on natural hazards, risk awareness and risk perception are frequently used interchangeably across diverse disciplines such as psychology, geography, medicine, sociology, anthropology, and political science (Bera & Dank, 2018). However, while closely related, these terms possess subtle distinctions. Risk awareness pertains to the acknowledgment of a risk's existence, whereas risk perception encompasses a broader concept of "intuitive risk judgment" (Slovic, 1987). Consequently, while interconnected, the level of awareness and the perception of a hazard are not interchangeable. Risk perception emerges as a crucial factor in determining individual or societal vulnerability to environmental hazards (Neil, 1999).

4.4 Risk Perception and Risk Awareness

The perception of risk holds significant sway over residents directly affected by flooding (Rahimizadeh et al., 2024), influencing their awareness, knowledge, and understanding of the associated hazards (Lara et al., 2017). The majority of respondents (78%) living near rivers have experienced flooding firsthand, yet none anticipated a flood of the magnitude witnessed in 2010, which caused extensive damage to both lives and properties. Notably, individuals' perception of their personal exposure to flooding assumes a pivotal role in shaping overall risk perception (Bosschaart et al.,

2013). Interestingly, when asked to explain cloudburst phenomena, all riverfront residents described clouds as akin to water-filled balloons that burst upon collision with mountains or sudden lightning strikes, releasing their contents. This perception highlights the local use of "cloudburst" and "cloud blast" interchangeably. And Regarding flood risk awareness, 62% of respondents acknowledged the vulnerability of their residences to flooding and the potential for functional damages, while 38% believed their properties to be immune to such consequences. Residing in close proximity to rivers, respondents displayed varied perceptions concerning the potential damage inflicted by flooding upon their residences. Specifically, 48% of respondents perceived flooding as a significant threat to their homes if it were to recur, whereas 38% regarded it as non-threatening. Additionally, 42% expressed uncertainty regarding the extent of potential damage. This divergence in viewpoints can be attributed to the spatial distribution of residences in relation to the river, with those situated closer to the riverbank exhibiting heightened concern compared to those positioned farther away. Analogously, respondents' overall sense of safety residing near rivers reflected a similar pattern. Notably, 46% of respondents conveyed feeling entirely unsafe, 42% expressed uncertainty, and only 12% reported feeling secure in their residential proximity to rivers. Moreover, residents within the village exhibited a cognizance regarding the elevated flood risk associated with residing near a river, along with an understanding that homes situated along the river's edge were particularly susceptible to flooding. This understanding was substantiated by the response of 88 percent of respondents who expressed a belief that a flood could significantly imperil the residences situated in close proximity to the village river. However, despite possessing pertinent knowledge or experiences conducive to heightened awareness, certain respondents disclosed a lack of personal concern regarding their own exposure to flood hazards. For instance, some participants acknowledged being well-versed in the flood risks prevalent in their vicinity, citing instances of familial or communal properties being repeatedly inundated. Nevertheless, they appeared to selectively discount this knowledge when assessing their individual vulnerability to flood risks (Burningham et al., 2008). As posited by (Thaler & Levin-Keitel, 2016) the absence of recent flood occurrences within a given region can potentially impede the cultivation of community participation in flood management initiatives. This hindrance may stem from a decline in individuals' awareness of flood threats and their corresponding interest in engaging with flood

management efforts. Furthermore, flood risk awareness is intricately linked with the collective human memory of past flood events. Consequently, the temporal gap since the last significant flood event may contribute to a decline in individuals' recollection of flood-related hazards. Consequently, this lapse in flood memory may inadvertently lead to the resettlement of individuals in flood-prone areas. Such resettlement actions, particularly evident in locales like the Choklamsar area, could precipitate substantial damage in the event of future flood occurrences.

4.5 Rural vs Urban Risk Perception, Awareness and Indigenous Knowledge

Differences in the inclination towards resettlement in flood-prone regions are observable between rural villages and urban centres within the Leh district (see Figure 4). In villages, inhabitants exhibit a heightened awareness of historical flood occurrences, often inheriting this knowledge through intergenerational transmission or discerning it from visible indicators such as flood marks, which dissuade them from establishing residences near rivers susceptible to inundation. In the Nubra Valley, villages are predominantly situated on alluvial fans, exposing residents to the frequent occurrence of flash floods. Take, for example, Hunder, the village with the largest catchment area in the Leh district spanning 527.3 square kilometres. Due to the considerable catchment

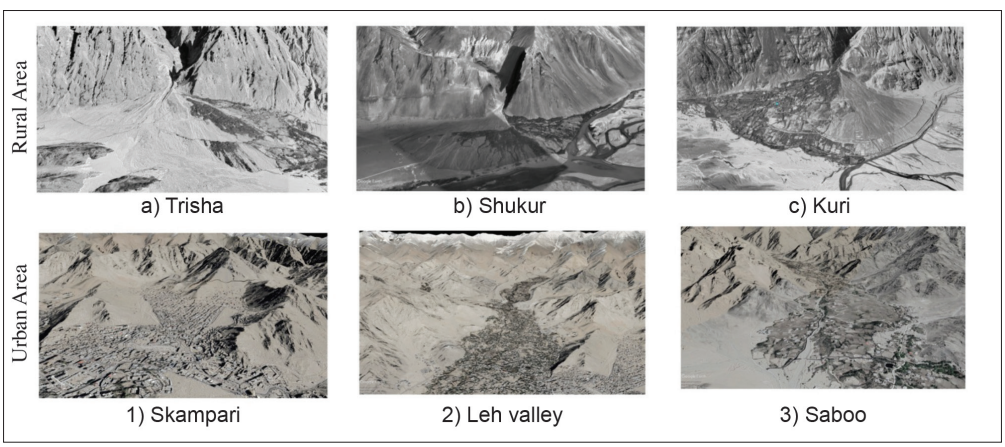

Figure 4 : Illustrating the spatial distribution of settlements influenced by environmental determinism and possibilism within rural and urban regions of Ladakh (source: google earth)

area and the heightened risk of flash floods in this region, inhabitants have strategically chosen to maintain a significant distance from the river. This settlement pattern reflects a broader phenomenon observed across all villages in the Nubra Valley, such as Tirith, Sumur, Tiricha, Kuri, Shukur, Taksha, Hundri, Skuru and Udmaru etc, illustrating the influence of environmental determinism on settlement practices. Conversely, urban areas witness a predominant demographic influx from rural locales, with settlers primarily driven by the pursuit of economical land acquisition, often disregarding the inherent risks of flooding. This pattern of settlement typifies the development of new urban sectors across Leh.

The entirety of the Skampari area, the vicinity surrounding the Nimoling bus station, the Army Hospital in Skara, and the CSD depot area near the airport have been densely populated within the expansive catchment area of the valley. Following the severe devastation caused by the 2010 cloudburst in the Nimoling bus station area, the Leh administration allocated land behind the existing housing colony for the relocation of affected individuals. Despite being designated as a high-risk zone by the administration, resettlement efforts led to the re-establishment of residences in this area. A similar scenario unfolds in Choklamsar, where dwellings are once again erected in close proximity to riverbanks. Moreover, the diminished level of risk awareness prevalent in urban settings is multifactorial, encompassing factors such as lower educational attainment, limited exposure to flood events, fading collective memory of past floods due to temporal distancing, insufficient engagement in risk awareness initiatives, unplanned urbanization, and the absence of comprehensive disaster risk mapping.

Additionally, the respondents advocate for proactive measures aimed at mitigating potential flood-related damages. These measures include: a) the clearance of riverbeds to enhance hydraulic conveyance, b) the construction and maintenance of robust riverbank defences to mitigate flood impacts, c) the implementation of effective warning and communication systems to alert residents to impending flood hazards, d) the enforcement of regulations prohibiting development within flood-prone zones or adjacent to river basins, and e) the implementation of surveys to monitor and regulate residential development within vulnerable areas. These initiatives are perceived as

essential preparatory measures to minimize the adverse consequences of flood events within the region. As articulated by (Newell & Wasson, 2002), there is a notable concern regarding the current flood mitigation practices in certain parts of Ladakh, particularly evident in the construction of small protective retention walls alongside streams such as Choglamsar's Sabu Stream. These measures, implemented in anticipation of future cloudbursts, may inadvertently instil a false sense of security among residents. This concern is corroborated by (Thayyen et al., 2013), who note the inadequacy of these diminutive protective walls in effectively mitigating flood risks. They highlight that during the 2010 flood event, which experienced depths of 2-3 meters in certain areas, the protective walls currently being constructed were significantly lower in height. Such findings underscore the urgent need for reassessment and enhancement of flood mitigation strategies in Ladakh to better align with the region's susceptibility to extreme flood events. The residents of Choklamsar in Ladakh have reported experiencing heightened apprehension during the summer months of July and August, characterized by a notable rise in water levels accompanied by ominous sounds, instilling fear of potential flooding throughout the night. Some individuals have reportedly evacuated their homes on such occasions, seeking refuge elsewhere as a precautionary measure. Furthermore, in the aftermath of the cloudburst event that occurred in Leh on August 6th, 2010, inhabitants of the Leh valley responded swiftly by relocating to the nearest elevated terrain, primarily the surrounding hills. These hillsides quickly became populated with makeshift tents, as residents opted to reside there for approximately a week to ensure their safety. Notable locations included the hills adjacent to Housing Colony, Shanti Stupa Hill, and Tsemo Hill. The decision to seek refuge on higher ground was influenced by indigenous knowledge passed down through generations, which led residents to perceive elevated areas as safer havens during periods of flood risk. Such adaptive measures underscore the Ladakhi people's ingrained indigenous knowledge of safety precautions, particularly evident in their practice of relocating to higher ground during flood-prone periods. This tradition reflects a longstanding cultural adaptation strategy tailored to the unique environmental challenges of Ladakh, where extreme weather events such as cloudbursts pose significant risks to local communities.

Figure 5 : The image displays a low flood protection wall along the Choklamsar River (captured by Tsering Dorjay in Sept, 2023)

4.6 Administration Preparedness

The consideration of public perception is paramount within the top-down communication framework between authorities and the lay population concerning the management of risks associated with natural hazards (Pagneux et al., 2011). The success of public participation in flood risk management is contingent upon the understanding, competence, and confidence of local stakeholders, as well as the transparency of governmental processes (Thaler & Levin-Keitel, 2016). (Pearce, 2003) emphasizes the importance of involving local communities in risk management

endeavours, as their engagement can significantly influence decision-making at the local governmental level, thus enhancing the likelihood of successful outcomes. All respondents expressed a willingness to actively participate in community-based programs aimed at reducing flood damage and recognized the significance of local public involvement in governmental flood risk management. For instance, governments in South and Southeast Asia have advocated for the establishment of flood management committees with clearly defined compositions, responsibilities, and tasks both pre- and post-disaster (Prasad, 2005). Urban communities in the Philippines have played an integral role in identifying and categorizing post-disaster aid, facilitating its distribution to affected areas (Carcellar et al., 2011). Similarly, in Cuttack, India, collaborative efforts between the community and government have been pivotal in conducting comprehensive risk assessments (Lara et al., 2017). Hence, community preparedness becomes imperative to furnish an efficient response to flooding, thereby attenuating its adverse consequences (Syarif et al., 2022).

According to Sub-section (2) of Section 30 of the Disaster Management Act of 2005, it is mandated that a Disaster Management Plan (DMP) be established for each district (DDMA, 2011). In the aftermath of the significant cloud-burst event of 2010 in the Leh district, which resulted in extensive property damage and loss of life, the Leh administration promptly issued its inaugural district disaster management plan (DDMP) in 2011. The DDMP (2011) outlined a commitment to annual updates; however, no subsequent disaster management plans have been observed since 2011. On October 31, 2019, Ladakh transitioned to a union territory status. Subsequently, the administration initiated the development of new disaster plans for the periods of 2019-20 and 2022-23. These plans remained in draft form according to administrative records. The 2023-24 plan is reported to be nearing completion in its final stages, as asserted by the administration. Oversight of Disaster Management, Relief, Rehabilitation, and Reconstruction (DMRRR), along with the union territory disaster rescue force (UTDRF), is led by the Deputy Commissioner of Leh, who heads the UT District Disaster Management Authority (UTDDMA). The DDMP adopts an integrated strategy that ensures the active participation of local communities, governmental agencies, the military, and various other relevant organizations.

5. Conclusion

This study examines local perceptions of flood risk, risk awareness, and the indigenous knowledge of communities residing in the valleys of the Trans - Himalayan Mountain range in the Leh district. It highlights historical flood events and their implications for settlements, underscoring the importance of these findings for the District Disaster Management Authority (DDMA) of Leh and the local planning department.

The findings indicate that individuals residing in close proximity to rivers are cognizant of their exposure to flood risk and acknowledge the potential for significant functional damage. Despite this awareness, they express feelings of insecurity about residing in these areas. Conversely, those residing farther away from rivers perceive lower levels of risk and feel safer, yet recognize the vulnerability of homes situated on the riverbank. The indigenous practice of seeking refuge on higher ground during floods is observed to be highly effective, particularly in mountainous regions of Leh, where villages are situated in the floodplain of river valleys.

Rural villages demonstrate a stronger awareness of historical flood risks, leading to more cautious settlement patterns, such as avoiding flood-prone areas near rivers. In contrast, urban centers, driven by economic factors, see increasing resettlement in high-risk zones despite the dangers. This contrast underscores the importance of integrating indigenous knowledge into urban planning to mitigate flood risks effectively. Addressing the growing urban vulnerability requires improved risk awareness and land-use management. The months of July and August pose heightened flood threats to communities residing near rivers, a pattern evident across various villages such as Choklamsar, Saboo, Timosgang, Nymoo, Ney, Sakti, Igoo, Shara, Domkhar, and Tykshi, where settlements lie within 20 meters of the riverbanks.

Given the increased frequency of floods since the significant event in 1999, which has been linked to climate change, there is an urgent need for the administration to conduct targeted flood risk awareness campaigns directed at vulnerable communities (Bogdan et al., 2024). Furthermore, it is recommended that the planning department establish a policy prohibiting new settlements within a 20-meter buffer zone along riverbanks. Such measures are essential for reducing potential flood damage and avoiding unnecessary expenditures in the aftermath of flood events. Additionally,

strengthening collaborative efforts between the planning department and the DDMA is crucial for minimizing disaster-related damage and loss of life, ultimately enhancing the resilience of communities facing climate-induced flooding.

References

1. Beckinsale, R. P. (1979). Book reviews: Burton, I., Kates, R. W. and White, G. F. 1978: The environment as hazard. New York: Oxford University Press. xvi+240 pp. £5.00 cloth; £2.95 paper. Waltham, T. 1978: Catastrophe: the violent earth. London: Macmillan. vi + 170 pp. £5.95. *Progress in Physical Geography: Earth and Environment*, 3(4), 600–603. https://doi.org/10.1177/030913337900300408
2. Bera, M. K., & Daněk, P. (2018). The perception of risk in the flood-prone area: a case study from the Czech municipality. *Disaster Prevention and Management*, 27(1), 2–14. https://doi.org/10.1108/DPM-01-2017-0004
3. Bogdan, E., Krueger, R., Wright, J., Woods, K., & Cottar, S. (2024). Disaster Awareness and Preparedness Among Older Adults in Canada Regarding Floods, Wildfires, and Earthquakes. *International Journal of Disaster Risk Science*, 15(2), 198–212. https://doi.org/10.1007/s13753-024-00555-9
4. Bosschaart, A., Kuiper, W., van der Schee, J., & Schoonenboom, J. (2013). The role of knowledge in students' flood-risk perception. *Natural Hazards*, 69(3), 1661–1680. https://doi.org/10.1007/s11069-013-0774-z
5. Burningham, K., Fielding, J., & Thrush, D. (2008). 'It'll never happen to me': understanding public awareness of local flood risk. *Disasters*, 32(2), 216–238. https://doi.org/10.1111/j.1467-7717.2007.01036.x
6. Carcellar, N., Co, J. C. R., & Hipolito, Z. O. (2011). Addressing disaster risk reduction through community-rooted interventions in the Philippines: experience of the Homeless People's Federation of the Philippines. *Environment and Urbanization*, 23(2), 365–381. https://doi.org/10.1177/0956247811415581
7. Chang, H., Franczyk, J., & Kim, C. (2009). What is responsible for increasing flood risks? The case of Gangwon Province, Korea. *Natural Hazards*, 48(3), 339–354. https://doi.org/10.1007/s11069-008-9266-y
8. Cœur, D., & Lang, M. (2008). Use of documentary sources on past flood events for flood risk management and land planning. *ComptesRendus Geoscience*, 340(9–10), 644–650. https://doi.org/10.1016/j.crte.2008.03.00
9. Dame, J., Schmidt, S., Müller, J., & Nüsser, M. (2019). Urbanisation and socio-ecological challenges in high mountain towns: Insights from Leh (Ladakh), India. *Landscape and Urban Planning, 189*, 189–199. https://doi.org/10.1016/j.landurbplan.2019.04.017
10. DDMA. (2011). Disaster management Plan Leh district. In *UT Ladakh Administration* (Vol. 1). DDMA.
11. Douglas, M., &Wildavsky, A. (1982). *Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers* (1st ed.). University of California Press. http://www.jstor.org/stable/10.1525/j.ctt7zw3mr
12. Filatova, T., Mulder, J. P. M., & van der Veen, A. (2011). Coastal risk management: How to motivate individual economic decisions to lower flood risk? *Ocean & Coastal Management*, 54(2), 164–172. https://doi.org/10.1016/j.ocecoaman.2010.10.028
13. Ikeda, N., Narama, C., & Gyalson, S. (2016). Knowledge Sharing for Disaster Risk Reduction: Insights from a Glacier Lake Workshop in the Ladakh Region, Indian Himalayas. *Mountain Research and Development*, 36(1), 31–40. https://doi.org/10.1659/MRD-JOURNAL-D-15-00035.1
14. Jalis, Z, & Abbasi, T. (2016). Disaster mitigation measures (flood) for the river Indus and nallahs in Leh town, J&K. *International Journal of Advance Research in Science and Engineering*.
15. Jest, C., & Sanday, J. (1983). The Palace of Leh in Ladakh: An example of Himalayan Architecture in need of Preservation. *Tourism Recreation Research*, 8(2), 23–30. https://doi.org/10.1080/02508281.1983.11015161
16. Khattri, N. (2012). A Case Study on the Flash Flood in Leh, Ladakh, J/K: Crisis and Rehabilitation. *Issues of Journalistic Ethics and Freedom in the Contemporary Age of Digital Media*.
17. Lara, A., Garcia, X., Bucci, F., &Ribas, A. (2017). What do people think about the flood risk? An experience with the residents of Talcahuano city, Chile. *Natural Hazards, 85*(3), 1557–1575. https://doi.org/10.1007/s11069-016-2644-y
18. Messner, F., & Meyer, V. (2006). Flood damage, vulnerability and risk perception–challenges for flood damage research. In *Flood Risk Management: Hazards, Vulnerability and Mitigation Measures* (pp. 149–167). Springer Netherlands. https://doi.org/10.1007/978-1-4020-4598-1_13
19. Mileti, D. S. (1980). Human Adjustment to the Risk Environmental Extremes. *Sociology and Social Research, 64(3)*, 327–347. https://cir.nii.ac.jp/crid/1570572699590027648.bib?lang=en

20. Mir, A. R., Dar, F. A., & Ahmad, M. Z. (2023). Characteristics of Geosites for Promotion and Development of Geotourism in Ladakh, India. *Geoheritage, 15*(3), 105. https://doi.org/10.1007/s12371-023-00866-1
21. Mondino, E., Scolobig, A., Borga, M., & Di Baldassarre, G. (2020a). The Role of Experience and Different Sources of Knowledge in Shaping Flood Risk Awareness. *Water, 12*(8), 2130. https://doi.org/10.3390/w12082130
22. Mondino, E., Scolobig, A., Borga, M., & Di Baldassarre, G. (2020b). The Role of Experience and Different Sources of Knowledge in Shaping Flood Risk Awareness. Water, 12(8), 2130. https://doi.org/10.3390/w12082130
23. Morup, tashi, & Chodon, rigzin. (2018). The Old Town Leh, Ladakh. In *Sahapedia*. Sahapedia.
24. Narama, C., Tadono, T., Yatagai, A., & Ikeda, N. (2011). Current State of the Glacier Lakes and Related Outburst Floods in the Domkhar Valley, Ladakh Range, Indian Himalayas. *Himalayan Journal*.
25. Neil, A. W. (1999). Social Vulnerability to Climate Change and Extremes in Coastal Vietnam. *World Development*, 27(2), 249–269. https://doi.org/10.1016/S0305-750X(98)00136-3
26. Newell, B., & Wasson, R. (2002). social system vs solar system: why policy makers need history. In *IHP-VI; Technical Documents in Hydrology (TDH)*. UNESCO.
27. Owen, L. A., Caffee, M. W., Bovard, K. R., Finkel, R. C., & Sharma, M. C. (2006). Terrestrial cosmogenic nuclide surface exposure dating of the oldest glacial successions in the Himalayan orogen: Ladakh Range, northern India. *Geological Society of America Bulletin, 118*(3–4), 383–392. https://doi.org/10.1130/B25750.1
28. Pagneux, E., Gísladóttir, G., & Jónsdóttir, S. (2011). Public perception of flood hazard and flood risk in Iceland: a case study in a watershed prone to ice-jam floods. *Natural Hazards*, 58(1), 269–287. https://doi.org/10.1007/s11069-010-9665-8
29. Pearce, L. (2003). Disaster Management and Community Planning, and Public Participation: How to Achieve Sustainable Hazard Mitigation. *Natural Hazards*, 28(2/3), 211–228. https://doi.org/10.1023/A:1022917721797
30. Prasad, K. (2005). Community Approach to flood Management in India. *The Associated Programme on Flood Management*.
31. Rahimizadeh, A., Fallah-Aliabadi, S., Vaezi, A., & Heydari, A. (2024). Designing and Psychometric Evaluation of a Questionnaire for Assessing Society's Perception of Flash Flood Risk. *Health Scope, 13*(2). https://doi.org/10.5812/healthscope-146111
32. Schanze, J. (2007). *A Conceptual Framework for Flood Risk Management Research* (pp. 1–10).
33. Sharma, S., Rawal, R., Pande, R., Phunsog, C., Sultan, M., & Raina, P. (2020). Disasters and Ladakh Action Points for Management and Mitigation. In *G.B. Pant National Institute of Himalayan Environment (NIHE)*. GBPNIHE & Administration of Ladakh UT.
34. Shen X. (2010). *Flood risk perception and communication within risk management in different cultural contexts*. nited Nations University Institute for Environment and Human Security (UNU-EHS).
35. Slovic, P. (1987). Perception of Risk. *Science*, 236(4799), 280–285. https://doi.org/10.1126/science.3563507
36. Sowby, F. D. (1965). Radiation and Other Risks. *Health Physics*, 11(9), 879–887. https://doi.org/10.1097/00004032-196509000-00008
37. Spate, O. H. K., Learmonth, A. T. A., & Farmer, B. H. (1976). *India, Pakistan and Ceylon* (2nd revised edition). Methuen and Co., Ltd.
38. Starr, C. (1969). Social Benefit versus Technological Risk. *Science*, 165(3899), 1232–1238. https://doi.org/10.1126/science.165.3899.1232
39. Suri, K. (2018a). Understanding historical, cultural and religious frameworks of mountain communities and disasters in Nubra valley of Ladakh. *International Journal of Disaster Risk Reduction*, 31, 504–513. https://doi.org/10.1016/j.ijdrr.2018.06.004
40. Suri, K. (2018b). Understanding historical, cultural and religious frameworks of mountain communities and disasters in Nubra valley of Ladakh. *International Journal of Disaster Risk Reduction*, 31, 504–513. https://doi.org/10.1016/j.ijdrr.2018.06.004
41. Syarif, E., Maddatuang, M., Hasriyanti, H., & Saputro, A. (2022). Exploration of Knowledge and Community Preparedness in Flood Disaster Mitigation. *Geosfera Indonesia*, 7(3), 277. https://doi.org/10.19184/geosi.v7i3.35066
42. Thaler, T., & Levin-Keitel, M. (2016). Multi-level stakeholder engagement in flood risk management—A question of roles and power: Lessons from England. *Environmental Science & Policy*, 55, 292–301. https://doi.org/10.1016/j.envsci.2015.04.007
43. Thayyen, R. J., Dimri, A. P., Kumar, P., & Agnihotri, G. (2013). Study of cloudburst and flash floods around Leh, India, during August 4–6, 2010. *Natural Hazards*, 65(3), 2175–2204. https://doi.org/10.1007/s11069-012-0464-2
44. Whyte, A. (1986). From hazard perception to human ecology. In *In Kates RW, Burton I (eds) Geography, resources and environment* (Vol. 2). themes from the work of Gilbert F. White. University of Chicago Press.
45. Ziegler, A. D., Cantarero, S. I., Wasson, R. J., Srivastava, P., Spalzin, S., Chow, W. T. L., & Gillen, J. (2016). A clear and present danger: Ladakh's increasing vulnerability to flash floods and debris flows. *Hydrological Processes*, 30(22), 4214–4223. https://doi.org/10.1002/hyp.10919

Challenges of Development-Induced Hazards on Tribal Livelihood in Singrauli, Madhya Pradesh: An Empirical Study

Shreyash Dwivedi[1], Roosen Kumar[2] and Anamika Sharma[3]

Abstract

Energy generation has been the cornerstone of the human socio-technical system since the inception of civilization. Thermal Energy generated from coal is the most abundantly used means of energy generation and the process of development as historically defined is largely tied with coal-based fossil fuel energy generation. The study explores the various hazards and livelihood challenges associated with coal mining on the local population. The study area is rich in coal reserves and has witnessed extensive mining operations by various companies, leading to significant disruptions in the lives of local tribal populations. The selected population is mainly tribal and they reside in the forest. These forest dwelling communities are culturally, economically and socially tied to the forest land and its endowments for survival, existence and identity assertion. Due to mining activities, the population goes through numerous unseen challenges such as, health risks from coal dust, structural damage from mine blasting, water scarcity by groundwater depletion, reduced agricultural productivity due to soil contamination and many more. This research paper delves into the few clearly visible hazards and challenges faced by tribal communities in Singrauli District, Madhya Pradesh, due to coal mining activities. The paper also discusses the marginalization of local tribal communities in the labor market, and lack of skill development opportunities. Lastly, the paper proposes strategies to enhance tribal livelihoods, including agricultural interventions, skill development initiatives, and advocacy for fair labor practices. By addressing these challenges and promoting sustainable development practices, the paper advocates for the holistic advancement of tribal communities in coal mining regions.

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Keywords: *Coal mining, Environmental Hazards, Development, Livelihood, Socio-economic Impacts, Local Resources, Tribal People, Energy Demand*

1. Introduction

Energy generation has been the cornerstone of the human socio-technical system since the inception of civilization. Thermal Energy generated from coal is the most abundantly used means of energy generation and the process of development as historically defined is largely tied with coal-based fossil fuel energy generation. Modern energy services are a powerful engine of economic and social development. As a fast-growing country India also has a large demand of energy in various fields for rapid growth. India is the third largest country in terms of power generation and consumption as well as the second largest coal producing country in the world[1], which is the major source of Indian thermal energy. About 57% of the electricity consumed in India is generated by thermal power plants in which 50% is generated through coal. (CEA 2023). Energy consumption of the country has multiplied since the year 2000 and despite government emphasis on renewables, thermal energy produced by coal will play the most important role and is expected to grow by 6-7% annually in the next few years to reach about 1.5 billion tons in 2029-30.[2] (PIB, 2023)

Singrauli, comprises one of the most important coalfields in India both in terms of reserves and productions. Large scale mining activities have generated a great deal of environmental stress not only on the Land use, Land Cover but also on ecosystems in this region (Greenpeace 2008; Singh et al. 1997). Mining sites, primarily located in forest areas inhabited by tribal families for decades. It poses complex challenges of livelihood and displacement. Singrauli emerges as a battleground between land oustees and proposed projects. (Singh, 2009) Due to an increase in mining activities, social networks of local communities get disturbed and have a negative impact on health. Agricultural production and forest areas are decreasing day by day. Ultimately, local communities have to leave their lands and move to other places. However, most of the time the socio-economic, cultural and environmental costs are ignored while discussing mining. It is observed that the poor had closer livelihood and consumption linkages with environmental resources (Niti Aayog, 2000). There are few major issues associated with

[1] www.statista.com/statistics/265638/distribution-of-coal-production-worldwide/
[2] Ministry of Coal, Enhanced Coal Demand & Production Posted On: 18 DEC 2023 5:13PM by PIB Delhi

the context of coal mining impacts such as, how does it force indigenous people to leave their own, cultural and traditional way of living? To what extent it impacts the livelihoods and what impact does it have on the health of vulnerable populations especially women and children? With these questions in mind, the present a Study of Hazards and Challenges of Coal Mining on Tribal Livelihoods in Singrauli District of Madhya Pradesh.

2. Study Area

District Singrauli extends between latitude 23° 49' and 24° 42' North and longitudes 81° 18' and 82° 48' East in the north eastern part of Madhya Pradesh. Total geographical area of the district is 5675 sq. Km and it ranked 28th in the state. The district is divided into 3 Tehsil (Deosar, Chitrangi and Singrauli) and 3 development blocks (Deosar, Chitangi and Waidhan). The area is covered with many opencast coal mines operated by various companies like - NTPC, Reliance, Essar, DB Power etc. Only Northern Coal Limited (NCL) operates more than 10 coal mines alone in that area. Population share of Schedule Tribes (ST) in Singrauli is 32.6% of the total population of the district, which has increased by 0.3% from the previous 2001 census. The major tribes of the district are Baiga, Kol, Gond, Pal, and Agriya. [3]The 80-90 % population belongs to the ST community who live inside the forest and majorly depend on them for daily survival.

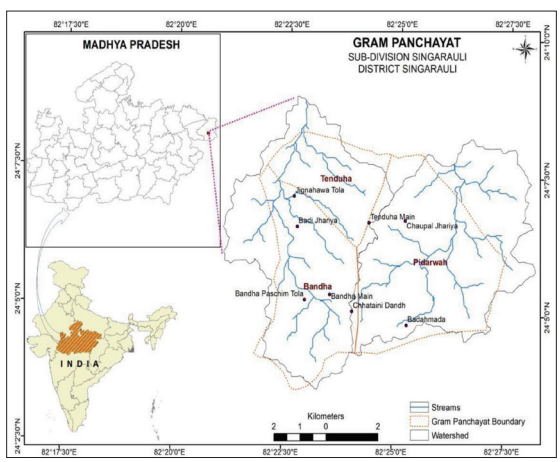

Figure 1 : Study Area (Prepared by Author)

[3] www.statista.com/statistics/265638/distribution-of-coal-production

3. Methodology

This study is based on empirical data collected through field visits conducted by the author in two panchayats, "Tendhua" and "Bandha," encompassing nine villages. A total of 114 samples were selected for the study. Data collection employed a combination of methods, including questionnaires, interviews, and focus group discussions, allowing for a comprehensive understanding of how mining activities have impacted the livelihoods and well-being of local tribal communities. The challenges were observed and documented. A mixed-method approach was used for analysis. The quantitative component draws from both primary and secondary sources, including censuses, government portals, annual reports from various ministries, and data gathered through questionnaires, interviews, focus group discussions, and participatory rural appraisals (PRAs). This provided a detailed factual overview. The qualitative component focuses on understanding the behavioral and psychological effects of mining on the tribal communities, particularly in terms of the loss of livelihoods and exposure to hazardous activities.

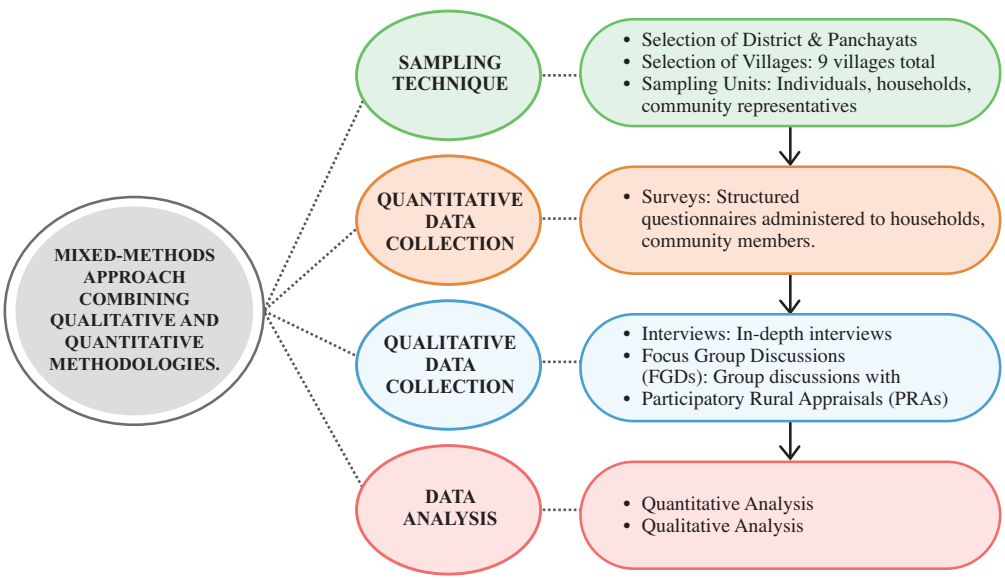

Figure 2 : Methodology and framework (Prepared by Author)

4. Results and Discussion

In the name of development, massive challenges of livelihood and sustainability are being imposed on the tribal populations, who have traditionally been dependent upon their local ecosystems for survival. In the energy capital of India (Singh et al., 1997), while energy production is crucial for the country's growth, it also raises significant concerns. These include environmental degradation, health issues, reduced agricultural productivity, groundwater depletion, accidents, and the impact on the survival of tribal communities.

Singrauli is home to several prominent coal mining blocks, serving as vital sources of fuel for the region's thermal power projects. Notable among these are the NCL Coal Mines, supplying coal to NTPC's Shaktinagar plant established in 1977 with a capacity of 2000 MW, and the Nigahi mines, providing coal to NTPC's Vindhyachal plant established in 1987, boasting a capacity of 4760 MW.

Table 1 : Coal Mining Fields in Singrauli District, Singrauli District

S.No.	Company Name / Coal Field		Year of Allocation	Area	Coal Production
1	Northern Coalfields Limited				
	a.	Jhingurda Project	1965	235 Ha.	22.66 MT (Last 5 year)
	b.	Dudhichua Opencast mine	1975	2400 Ha.	15.500 MT (2017-18)
	c.	Block – B	2004	1339 Ha.	4.475 MT (2014-15)
	d.	Amalhori	1982	9.28 Km.^{2}	11.105 MT (2017-18)
	e.	Jayant	1976-77	3.8 Km.^{2}	11.850 MT (2014-15)
	f.	Kakari	1982-83	-	2.8 MT (2017-18)
	g.	Nigahi	1980	-	15.52 MT (2016-17)
2	Mahan Coal Block		De-allocated		
3	M.P. Jaypee Minerals		2006	729 Ha.	250 MT Reserve

	a.	Amelia			4.2 MTPA (Peak Cap.)
	b.	Dongarital			
4	THDC India Ltd. (Amelia)		2016 (Allocated)	1905 Ha.	393.59 (Net Geological Reserve)

*Source - NCL Website, Coal Ministry Report, Jaypee Group and THDC India Ltd.

** MT – Metric tonnes , MTPA – metric tonnes per annum

These coal mining blocks play a major role in defining the geographical and sociological characteristics of the region. Various hazards and challenges directly or indirectly associated with the coal mining in the region is discussed below:

5. Hazards and Challenges:

a. Coal Dust

The dust caused by an explosion in mines and the transportation of coal has a negative effect on human health, arable land and crops etc. (Figure 3). Particles smaller than 2.5 microns go into human lungs and become the cause of deadly diseases like lung cancer. The dust from coal mines spreads on agricultural land and affects its fertilizer capacity and water storage capacity. Other than this, dust settled on crops and trees restrict their growth and also hinders the process of photosynthesis, which ultimately affects the production capacity.

Figure 3 : Dust on Road

Figure 4 : Mining Site

b. Blasting at Mines

Daily blasting for coal extraction in the mines creates vibrations akin to earthquakes in the surrounding areas. The majority of residents in these coal mining zones are tribal communities, often dwelling in mud houses nestled within forested regions, their roofs covered with makeshift materials. These vibrations cause structural damage, roof breakage and in severe cases complete collapse, endangering lives and exacerbating property loss.

Figure 5 : Effects of blasting in the region

Figure 6 : Broken leg

c. Water Issues (Quality, Availability & Groundwater Depletion)

Deep mining operations exacerbate groundwater depletion, as subterranean water channels through the mines, leading to a significant decline in the local groundwater table. Consequently, a substantial portion of the district grapples with acute water scarcity during the summer months, amplifying the challenges faced by these communities. Mining activities also trigger a series of interconnected challenges for the affected communities. The displacement of borewells due to blasting in coal mines disrupts access to essential water sources, compounding the already acute water scarcity issue. Additionally, seepage of groundwater from open-cast mine sites further exacerbates the problem, diminishing the available water resources in the vicinity. Moreover, the presence of coal dust layers reduces groundwater porosity, hampering

natural filtration processes and further limiting water availability. Consequently, water quality deteriorates as the depletion of water levels creates open ponds contaminated with coal dust, posing health risks and exacerbating the challenges faced by these communities.

Figure 7 : Wells are not in use

Figure 8 : Rust due to poor quality of water

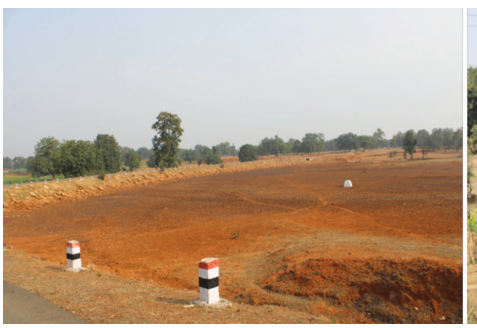

Figure 9 : Dried pond

Figure 10 : Water to home

d. Agriculture Productivity

Limited groundwater and coal dust on crops make **agricultural activities** difficult. There's not enough water for irrigation, and when crops are harvested, they get dirty with coal dust, which lowers their quality and value. Also, farmers struggle because they don't have modern tools, good seeds, or fertilizers, and they can't afford to buy them. **In addition**, the area doesn't get much rain. All these things together make it tough for farmers to grow enough food and make a good income.

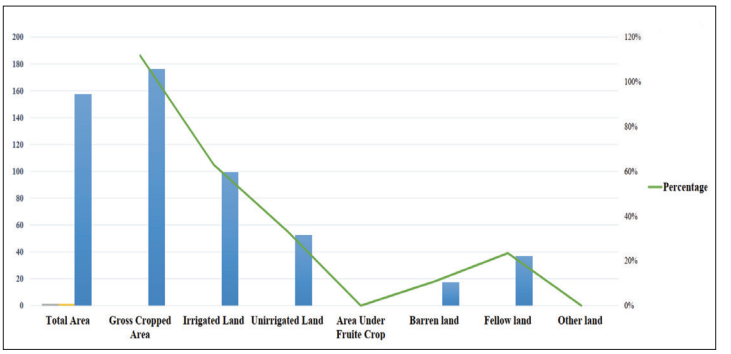

Figure 11 : Agricultural land use

e. Forest as Major Livelihood Source

Local population mostly relies on the forests for their sustenance and livelihoods. They depend on a variety of resources found within the forest, including essentials like Mahua, Tendu Leaves, Honey, Fuel, Fodder, and Medicines. Of these, Mahua fruits and tendu leaves are particularly crucial as they serve as key sources of income for the community. Tendu leaves, for instance, are used in bidi making, providing a significant source of revenue. Additionally, firewood collected from the forests serves as a vital source of fuel for cooking and heating needs.

Figure 12 : Tendu leave

Figure 13 : Mahua leave

Figure 14 : Firewood

The forests also serve as important grazing fields for their livestock, ensuring their animals have access to food and sustenance. Moreover, the forests also offer opportunities for small-scale activities such as mining of White Stone for mud house painting and honey collection, further contributing to the community's economic well-being. In essence, the forest plays a central role in meeting the diverse needs of the tribal community, serving as both a source of sustenance and economic opportunity.

f. Other Livelihood Sources

Opencast mining takes up a lot of land. It clears away the top layer of land, including forests. This affects tribal people because they often rely on the forest for their livelihoods. Since many tribal people lack extra skills, technology knowledge, or education, they struggle when the forest is destroyed. They lose their jobs and struggle to survive. Local people often work in jobs like making furniture, which relies on materials from the forest. But when the forest is cleared, these jobs disappear too. It's ironic that in mining areas, most of the workers actually come from places like Bihar or Chhattisgarh, not from the local tribal communities.

The local tribal groups usually have less education and skills for higher-paying jobs, so they end up doing labor work. But even in these jobs, they often don't get hired much, they have a high competition with migrant laborers from other neighboring states. There's a big problem with the low number of local people working in the mines. In many coal mining areas, laborers are hired through brokers. These brokers take a big cut of the wages, leaving the workers with very little. This means they don't get the fair wages they deserve.

With the above analysis and findings, it is clear that the mining activities can have a number of negative socio-economic and ecological impacts. The mining associate hazard and challenges are very high for the tribals living in surrounding areas.

Figure 15 : Furniture work

Figure 16 : Brick work

Table 2 : Major Hazards and Associated Impacts in the Study Area

Coal mining Associated Hazard	Impact on Life
Mine Blasting	Damages in Houses (both in kutcha & pucca), Displacement of borewell machine, Accidents and Loss of life.
Coal dust	Causes respiratory problems such as chronic obstructive pulmonary disease (COPD), silicosis, and pneumoconiosis (black lung illness), Decreased agricultural productivity due to dust settlement on soil and leaves. Open ponds also get polluted.
Groundwater Depletion	Due to excessive and deep mining water continuously starts flowing from mining and it impacts the ground water level of the surrounding area.
Loss of livelihood	Loss of essential resources such as fuel, fodder, timber, fruit, and other commercial products that tribal communities rely on for their livelihoods and have honed specialized skills to utilize.
Degradation of environment	Ecological disbalance, human wildlife conflict, loss of species and biodiversity.
Failure of agriculture	When coal dust falls on crops, it harms crop health, and reduces agricultural output. Mining-related chemical spills pollute water and soil, making land unusable and damaging crops and livestock.

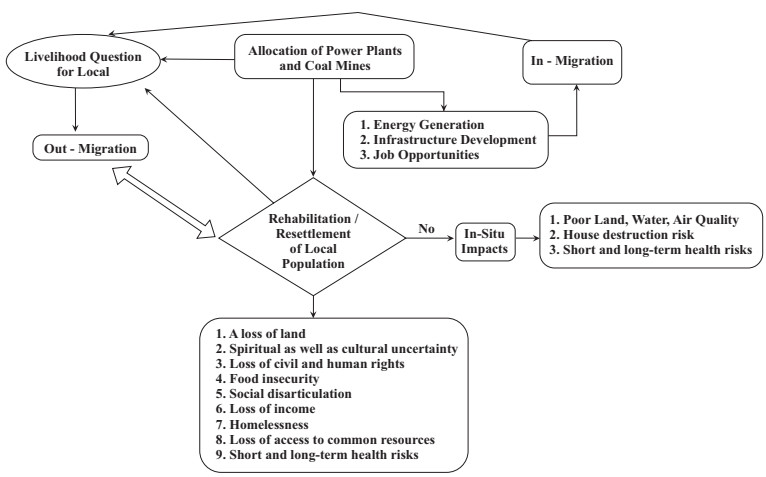

Figure 17 : Framework of mining induced issues and their interconnectivity (Prepared by Author)

6. Conclusion

The study showcased that coal mining in Singrauli, Madhya Pradesh, has caused serious problems for the tribal communities living in the area. These issues include environmental damage, health risks and the loss of their traditional ways of making a living. While coal mining is important for India's energy production, the negative effects on these vulnerable communities cannot be overlooked.

The tribal people in Singrauli depend heavily on the forest and natural resources for their livelihood. Creating sustainable livelihood options is key to helping these communities. This could include offering skill development programs and promoting eco-friendly farming practices. It is also important to involve the local people in decision-making, especially when it comes to mining operations and their rehabilitation.

Protecting the environment is equally important. Mining companies should be held accountable for reducing pollution, managing water resources properly, and helping restore agricultural land. In conclusion, solving the challenges faced by the tribal communities in Singrauli requires a balanced approach. We need to rethink current policies, support the local people in finding new ways to earn a living, and ensure that economic growth doesn't come at the cost of their well-being and environment. By doing so, we can achieve sustainable development that benefits everyone.

References

1. (2009) Census of India | Office of the Registrar General & Census Commissioner, India. India.
2. Bjureby, E., Britten, M., Cheng, I. (2008). The True Cost of Coal: How people and the planet are paying the price for the world's dirtiest fuel. *Greenpeace International*. Amsterdam The Netherlands
3. Guha, A. (2014). Book Review: Hari Mohan Mathur, Displacement and Resettlement in India: The Human Cost of Development, *Institute of Development Studies Kolkata*.
4. Khanna, A. (2013). Governance in Coal Mining: Issues and Challenges, *The Energy and Resources Institute* (TERI).
5. Mandal, S. (2017). Tribal dispossession through land acquisition: a study of open cast mines in west Bengal, *Journal of Rural Development*, Vol. 36, No.2, pp. 181-202, NIRD&PR, Hyderabad.
6. Mehar, R. (2007). Globalization, Displacement and the Livelihood Issues of Tribal and Agriculture Dependent Poor People, *Journal of Developing Societies*, Vol. 25, No. 4, pp. 457–480.
7. Mishra N. (2015). Coal Mining, Displacement and Rural Livelihoods: A Study in Mahanadi Coalfield Odisha, Department of Humanities and Social Sciences, National Institute of Technology (NIT) Rourkela, Odisha.
8. Sharma, R.N. 2009. Singh, S.R., Displacement in Singrauli Region: Entitlements and Rehabilitation, Economic and Political Weekly, Vol. 44, No. 51, pp. 62-69.
9. Siddiqui, K. (2018). Development induced displacement of rural communities in India: A critical review, *Turkish Economic Review*, Vol 5, No. 2.
10. Terminski, B. (2012). Mining induced displacement and resettlement: Social problem and Human Rights issue (A Global Perspective), *SSRN Electronic Journal*. http://dx.doi.org/10.2139/ssrn.2028490. Global Perspective), SSRN Electronic Journal. http://dx.doi.org/10.2139/ssrn.2028490.

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