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Disaster & Development
National Institute of Disaster Management
Ministry of Home Affairs
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Editor-in-Chief

The disasters causing loss and damages to life, ecological imbalances and adversely affecting economy of the country are increasing. The concern over impact of climate change and extreme weather events are also rising globally. In the year 2023, India faced hydro-meteorological events of landslides and flash floods in Himachal Pradesh, Glacial Lake Outburst Floods (GLOF) in Sikkim, cyclone Biparjoy and cyclone Michaung hit the coastal regions of Gujarat, Tamil Nadu and Andhra Pradesh. Although, the country is focusing more on disaster risk reduction approach by incorporating nature-based solutions to reduce the impact of disasters, yet it is imperative to increase the resilience of the systems through the application of state of art technologies along with socio-cultural changes amongst people to enhance their coping capacities to deal with disaster related situations.

National Institute of Disaster Management (NIDM) under the aegis of the Ministry of Home Affairs, Government of India is mandated to promote a disaster resilient India through training, research, documentation and publications along with academic assistance in planning, policy, guidelines and procedures for disaster risk reduction and resilience. This issue of the journal collates and compiles the original and innovative research works on various aspects of disasters management and developmental practices.

I sincerely thank everyone who has helped the journal flourish over the years, including readers who share the goal of building disaster-resilient communities, authors from a wide range of disciplines who have contributed, reviewers who have generously devoted their time and knowledge, committed editorial board members, hardworking and conscientious editorial team.

Shri Rajendra Ratnoo, IAS

Editorial Note

With great pleasure, NIDM presents Journal on "Disaster & Development", Volume 12, Issue 02, July–December 2023, published by the institute.

The journal consistently receives outstanding feedback from all of the distinguished writers and readers, which is very encouraging and motivates the team to keep improving the services being offered, to make it easier for authors to publish with this prestigious journal with high-quality research, and disseminating it in free of cost and simple to understand the use of best practices for Disaster Risk Reduction and Resilience (DRR & R) for readers to access.

The journal also aims to motivate writers to generate excellent research that will help readers, academicians and practitioners to concentrate on different facets of catastrophe risk reduction and disaster safe development initiatives.

Finally, the editor would like to thank and convey gratitude to all the authors, reviewers, publication team (especially Dr. Ravinder Singh, Shri S. K. Tiwari, Shri Shubham Badola and Ms Karanpreet Kaur Sodhi), and readers for keeping their faith on the journal and associating with at over the years to make this periodical a successful blind peer-reviewed open access UGC CARE listed journal. The editorial team expects continuous support and cooperation in the coming years as well.

Surya Parkash, Ph.D.

The Impact of COVID-19 Pandemic on the Livelihood of Informal Sector Workers in Kerala

Anjana N C[1] and Sheeja S R[2]

Abstract

The global economy has been facing severe challenges in recent years, primarily due to the sudden outbreak of the COVID-19 pandemic. The COVID-19 pandemic triggered a deeper and more widespread economic and social disaster than any other pandemic since the 1900s, impacting virtually every sector of the economy and its workforce. The situation was particularly alarming for low-paid and semi-skilled informal workers, as the informal sector has become one of the hardest-hit sectors. With the emergence of the pandemic and consequent social distancing norms and containment measures, informal workers were deprived of their livelihood options. In this context, the present study aims to examine the impact of COVID-19 pandemic on the livelihood of informal workers in Kerala. The study employed a descriptive research design. The sample size and study area were determined with the assistance of the E-Shram registration. The present study is based on data collected from 150 informal workers in the Chelakkara Grama Panchayat in Thrissur Kerala. The fifty samples were randomly selected from each category of workers and sample includes three categories of vulnerable informal workers: home-based domestic workers, daily wage construction workers, and workers in small-scale manufacturing establishments. The COVID-19 pandemic has brought significant changes to the lives and livelihoods of workers in the informal sector in Chelakkara. Many workers faced challenges in reaching their workplaces due to the lack of transportation facilities, leading to changes in consumption patterns, income levels, and employment patterns. Strong government intervention is necessary to mitigate the crisis caused by the pandemic.

Keywords: *COVID-19 pandemic, Kerala, Informal workers, Livelihood, Vulnerability.*

[1] **Anjana N C,** Research Scholar, Department of Economics, University of Kerala.
[2] **Sheeja S R,** Professor & Head, Department of Economics, University of Kerala.

1. Introduction

The global economy has been facing severe challenges in recent years, primarily due to the sudden outbreak of the COVID-19 pandemic. The disease was first reported in December 2019 in Wuhan, China, and began to impact the global economy (Kesar et al., 2021). In India, the first case of COVID-19 was reported on January 30th, 2020, in Thrissur district of Kerala. In order to control the rapid spread of the coronavirus, the central government enforced a nationwide lockdown (Janatha curfew) as a mass safety measure on March 25th, 2019. Initiatives such as physical distancing, mask-wearing, and hand sanitization were strictly implemented within the country as precautionary measures. The pandemic triggered a deeper and more widespread economic and social disaster than any other pandemic since the 1900s, impacting virtually every sector of the economy and its workforce. Although it started as a health crisis, it turned out to be an economic crisis and humanitarian crisis.

Owing to the containment measures associated with the pandemic, many workers were compelled to work from home, especially those in the formal or organized sectors (Hodder, 2020). However, the situation for informal sector workers was markedly different, with many losing their daily income. In low- and middle-income countries, where a large proportion of these workers, comprising 61% of the global workforce, are employed, social protection or safety nets are inadequate. The situation was particularly alarming for low-paid and semi-skilled informal workers, as the informal sector has become one of the hardest-hit sectors. Nearly 2 million individuals constituting around 62 percent of total workers across the globe are relying on the informal economy. Informal work accounts for 90% of overall employment in low-income nations and 67% in middle-income countries.

According to the National Commission for Enterprises in the Unorganized Sector (2007), "the informal sector consists of those working outside the formal sector or household, excluding regular employment with social security benefits provided by employers and workers in the formal sector without any employment and social security benefits provided by employers." Employment in the informal sector is characterized by low wages, unsafe work environment, lack of social protection and excessive dependence on daily earnings for survival. Self-employed people and casual labourers are some important categories of informal workers. Indian economy's high dependence

on informality and absence of adequate social security net exacerbated the scale and intensity of the crisis. More than 90 percent of working population in India depends on the informal sector for their livelihood.

Any interruption of economic activities in a region instantaneously disrupts employment and earnings of those who are employed in the informal sector. Migrant labourers, particularly those who were unskilled or semi-skilled, were among the worst affected by the pandemic. Since many of these migrants worked in the informal sector, they were at risk of losing their jobs much sooner than their counterparts in the formal sector (Khanna, 2020). Many studies (Desphande and Ramachandran, 2020; Abraham, Basole, and Kesar, 2021) have pointed out the people with pre-existing vulnerabilities were worst affected by the pandemic.

In Kerala, the southernmost state in India, 37.8 percent of total workforces of 127 lakh (GOK, 2022) are self-employed and 27.7 percent were casual workers indicating that 65.5 percent of the total workforce in Kerala still works in the informal sector for their livelihood. As in the case of Indian economy, largest share of workers in the informal economy are self-employed and 90 percent of firms in Kerala come under the category of own account enterprises. Majority of the casual workers are working in small establishments without having adequate facilities. Gig and platform workers constitute an emerging segment of the informal labour market in the state. In comparison with the workforce employed in the formal sector, informal workers enjoy less privileges and protection. The COVID-19 has severely restricted informal workers' mobility from their dwellings. This situation adversely affected the activities of informal workers who worked in long distance places. Kerala lost three times as many manufacturing jobs as the rest of India, and the recovery rate has been the slowest (Kakarlapudi, 2022). The lockdown had the most severe impact on self-employed and casual workers across all sectors of the Kerala economy. Due to a curfew-like circumstances, practically all informal sector activity were halted, with the exception of essential trading and agricultural operations. A significant number of people who had regular employment in the private sector lost their jobs (Prakash, 2020). With the emergence of the pandemic and consequent physical distancing norms and containment measures, informal workers were deprived of their livelihood options. The Covid has affected all sections of people, including street vendors, waste pickers, load workers, gig and platform

workers, construction workers, vegetable vendors etc in many ways. COVID has become a threat not only to their jobs but also to their lives and livelihood. People were unable to manage all the important aspects of life, such as children's education and marriage. The social life of the people of Kerala came to a standstill. It's not just the loss of jobs, it's the loss of quality of life. In this context, the present study aims to examine the impact of COVID-19 pandemic on the livelihood of informal workers in Kerala.

2. Objectives and Hypothesis of the Study

The important objectives of the study are as follows:

1. To examine the impact of the COVID-19 pandemic on the lives and livelihoods of informal sector workers.
2. To explore how far the government programmes have been successful in alleviating challenges faced by the informal worker during the pandemic.

The study is based on the following hypotheses:

- There is an association between employment loss during the pandemic and reduction in income.
- There is an association between employment loss during the pandemic and reduction in consumption.
- There are gender-wise differences in the impact of COVID-19 on employment.
- There is an association between the educational qualification of respondents and awareness about government support.

3. Data and Methodology

3.1 Field Survey

The study employed a descriptive research design. The sample size and study area were determined with the assistance of The E-Shram registration, which is the National Database of Unorganized Workers developed by the Ministry of Labour and Employment. Among various districts in Kerala, Thrissur district where COVID appeared for the first time in India was selected for a detailed study. Thrissur ranked 4th in E-Shram registration. Within the district, since around 5000 informal workers are registered in the E-Shram portal from the Chelakkara Grama panchayat, it was selected as the study area. Chelakkara Grama Panchayat is one of the ten most populous panchayats in Thrissur district. Chelakkara, comprising 22 wards, comes second in the

list of panchayats with the highest number of wards. Due to the restrictions imposed to contain the spread of COVID-19 and the lack of travel facilities, the researcher had to choose the nearby Chelakkara Grama Panchayat since it was convenient for the researcher to gather information from the informal workers. Among these 5000 workers a sample of 150 workers constituting 3 percent were selected for an in depth analysis. Hence, the present study is based on data collected from 150 informal workers in the Chelakkara Grama Panchayat.

The sample includes three categories of vulnerable informal workers: home-based domestic workers, daily wage construction workers, and workers in small-scale manufacturing establishments. Field surveys were conducted to gather primary data from respondents, and an interview schedule was developed by the researcher to collect the necessary data from workers. 50 samples were randomly selected from each category of workers. The researcher visited three small scale manufacturing industries in the area and collected information from a randomly selected sample of 50 workers. Relevant information was collected from a randomly selected sample of 50 construction workers from five working sites in Chelakkara Panchayat. In order to identify 50 home based domestic workers for data collection the researcher visited 20 higher income families who were employing home based workers and also approached the agents who assigned the domestic workers for the needy. Thus, the primary data collected from a sample of 150 informal workers belonging to the above mentioned three groups in the study area was used to examine the impact of COVID-19 on their livelihood. The period of field survey is from January to March 2022.

3.2 Model

Descriptive methods, including cross-tabulation, tabular and graphical presentations, were employed to understand the impact of COVID-19 on livelihood of the informal workers. The variables used were meaningfully correlated to infer findings, utilizing frequency distribution and percentage analysis. Analytical methods like Likert scale analysis, chi-square test, Kruskal-Wallis H test, Mann-Whitney U test, and Spearman rank correlation were utilized. These analytical tools were employed to delve deeper into the data and extract meaningful insights regarding the effects of COVID-19 on the livelihoods of informal workers.

Table 1: Ranking of likert scale

Description-1	Description-2	Ranking
Never	Not at all	1
Rarely	A little	2
Sometimes	Moderately	3
Often	Very much	4
Always	Extremely	5

The scale was developed following manner. To determine the minimum and the maximum of the likert scale, the scale range was calculated by (5-4)/5. By this method we get the least value of the scale that is 4/5=0.80. The 0.80 is considered as the minimum value in the scale. By adding one in to this least value on the scale we get the range. Thus the scale structured as follows.

Table 2: Interval class for likert scale

Score	Interval Class	Difference
1	1.00-1.80	0.80
2	1.81-2.60	0.80
3	2.61-3.40	0.80
4	3.41-4.20	0.80
5	4.21-5.00	0.80

4. Limitation of the Study

This study on the impact of COVID-19 on the livelihood of the informal sector workers in Kerala has some limitations. One is the sample comprising 150 respondents is limited due to time constraints. The selected sample is limited only to the rural area because of the survey on Chelakkara Grama Panchayat. The survey could not be carried out in the municipalities or corporations in Thrissur district due to time constraints and restrictions imposed to curb the COVID-19 outbreak. Since the responses and challenges faced by informal sector workers may vary across the regions, we cannot do a general review based on the study conducted in only one Panchayat.

5. Results and Discussion

5.1 Socio-Economic and Demographic Characteristics of the Respondents

The data collected from a sample of 150 workers were used for analysis. In both construction and small-scale manufacturing, the proportion of females is lower, with female participation being lowest among workers in small-scale manufacturing industries (SSMI). Among the age groups, the highest number of individuals, representing 36% of the sample, falls within the age group of 35-45 years. Additionally, fifty-two people, comprising around 34.7% of respondents, are aged between 25 and 35. Interestingly, approximately 70% of the respondents are young people between the ages of 25 and 45, while only 29% of the sample population is above 45 years old. Regarding marital status, out of the total workers (N=150), out of the total respondents 17.33% were single, 73.3% were married, 3.33% were divorced, and 6% were widowers or widows. Among the single workers, 10 were home-based domestic workers, 9 were construction workers, and 7 were workers in small-scale industries. Out of the three groups of workers, 9.3% individuals are informal workers who are living a single life after marriage.

In terms of religious classification, the data show that 58.7% of workers belong to the Hindu religion, 18.7% belong to Christianity, and 22.7% are from the Muslim community. The figure indicates that the highest number of respondents belong to the Hindu religion, followed by the Christian and Muslim religions. The majority of informal workers are from the Hindu religion, with the remaining being from the minority community (41.3%). Regarding educational levels, the data reveals that 16% are illiterate or have not yet attended school, while 38.7% have completed only primary schooling. Additionally, 7.3% of respondents have completed high school, 12.7% have completed upper secondary education, and only 9.3% have attained a bachelor's degree. Approximately 71.3% of the respondents have only upper primary education or lower educational qualifications. In terms of family status, 60.6% of the respondents live in a nuclear family system, while 39.3% live in a joint family system. The nuclear family system is the most common among the informal sector workers surveyed.

5.2 Impact of COVID-19 on the Livelihood of the Informal Sector Workers

The major focus of the present study is on the impact of COVID-19 on variables like employment, consumption, saving, borrowing and wellbeing etc.

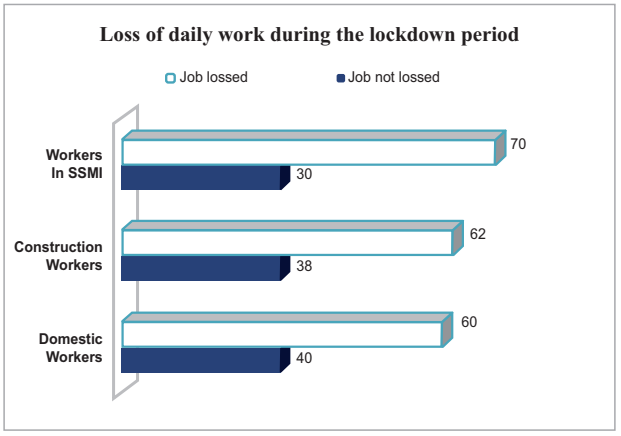

Figure 1: Loss of Daily Work During the Lockdown Period

Source: Field Survey (2022)

According to the survey out of the total workers, 64% respondents had lost their job during the period of the pandemic, and 36% respondents said they had no job loss in the time of the lock down. They revealed that lack of transportation facilities were the major reason for the loss of work during the COVID-19 lockdown. They trapped in the curfew and unable do the daily work and this would again lead to the reduction in income, consumption and their daily savings. Out of the total workers job loss was high in workers in the small scale manufacturing sector (70%) and less in domestic workers. From this, we can understand that there is less job loss among people doing domestic work and there is less job loss among other workers during the pandemic because it less risk of job loss as compared to other works.

Table 3: Association Between Job Loss and Reduction in Income (Cross Tabulation)

Employment loss	Reduction in Income		Total	χ 2 (P value)
	Income not reduced	Income reduced		
No loss of job	30 (20.00)	24 (16.00)	54 (36.00)	12.964
Loss of job	25 (16.70)	71 (47.30)	96 (64.00)	(0.000)
Total	**55 (36.70)**	**95 (63.30)**	**150 (100.00)**	

P*<0.05, P<0.01**

Source: Field survey (2022)

The above table shows the impact of employment loss brought by the pandemic and subsequent lock down towards income reduction among the respondents. Around 63 percent of the respondents revealed that their income was reduced due to the lockdown. Rest of the respondents said that there is no income reduction. According to the test result, the p-value is <0.05, which is statistically significant. Hence, the null hypothesis shows that there is no association between employment loss and reduction in income is rejected. So, there is an association between the employment loss during the pandemic and the reduction in income.

Table 4: Association Between Employment Loss and Reduction in Consumption

Loss of employment	Reduction in Consumption		Total	χ 2 (P value)
	Consumption Not reduced	Consumption reduced		
No loss of job	29 (19.30)	25 (16.70)	54 (36.00)	12.462
Job loss occurred	24 (16.00)	72 (48.00)	96 (64.00)	
Total	**53 (35.30)**	**97 (64.70)**	**150 (100.00)**	(0.00)

Source: Field Survey (2022)

The association of employment loss due to the pandemic and the consumption of the respondents is depicted in above table 4. According to the test result, the p value is <0.05 which is statistically significant. Therefore, the null hypothesis is rejected. Hence, the results reveal that there is an association between the employment loss during the pandemic and the reduction in consumption of the respondents.

Table 5: Patterns of Income Changes in Lockdown Period

Pattern of Change in income in Lockdown period	Job Type			Total
	Domestic Workers	Construction Workers	Workers In SSMI	
No change	12 (24%)	8 (16%)	10 (20%)	30 (20%)
Increased	9 (18%)	7 (14%)	8 (16%)	24 (16%)
Decreased	29 (58%)	35 (70%)	32 (64%)	96 (64%)
Total	**50**	**50**	**50**	**150 (100%)**

Source: Field Survey (2022)

The Table 5 depicts the pattern of income changes in the lockdown period. 20% of respondents said they didn't have any change in their income from employment. 64% of the individuals indicated their income declined while the lockdown was in effect. Only 16% participants said they had noticed the increase. Within the group highest income reduction is experienced by construction workers. As compared to other workers low income reduction for domestic workers, explanation that given for this minor increment was they have engaged in additional income generating activities such as animal husbandry and other agricultural-related activities.

Table 6: Frequency of savings before and after lockdown

Frequency of savings before lockdown	Domestic Workers	Construction Workers	Workers in SSMI	Total
Daily	8 (16)	5 (10)	10 (20)	23 (15.3)
Weekly	30 (60)	20 (40)	24 (48)	74 (49.3)
Monthly	12 (8.00)	25 (50)	16 (32)	53 (35.3)
Total	**50 (100)**	**50 (100)**	**50 (100)**	**150 (100)**
Frequency of savings after lockdown	**Domestic Workers**	**Construction Workers**	**Workers in SSMI**	**Total**
Daily	0	1 (2)	3 (6)	4 (2.7)
Weekly	10 (20)	11 (22)	13 (26)	34 (22.7)
Monthly	40 (80)	38 (76)	34 (68)	112 (74.7)
Total	**50 (100)**	**50 (100)**	**50 (100)**	**150 (100)**

Source: Field Survey (2022)

The above table represents the frequency of savings of the respondents. The frequency of savings is categorized into pre-pandemic and post-lockdown periods. Out of 150 respondents in the pre-COVID period, the majority of 74 (49.3 percent) respondents save weekly, followed by 53 (35.3 percent) respondents monthly and 23 (15.3 percent save daily. In the post-COVID period, the majority of the 112 (74.7 percent) respondents saved monthly, followed by 34 (22.7 percent) weekly, and only four (2.7 percent) daily. It found that savings of the workers declined post lockdown period.

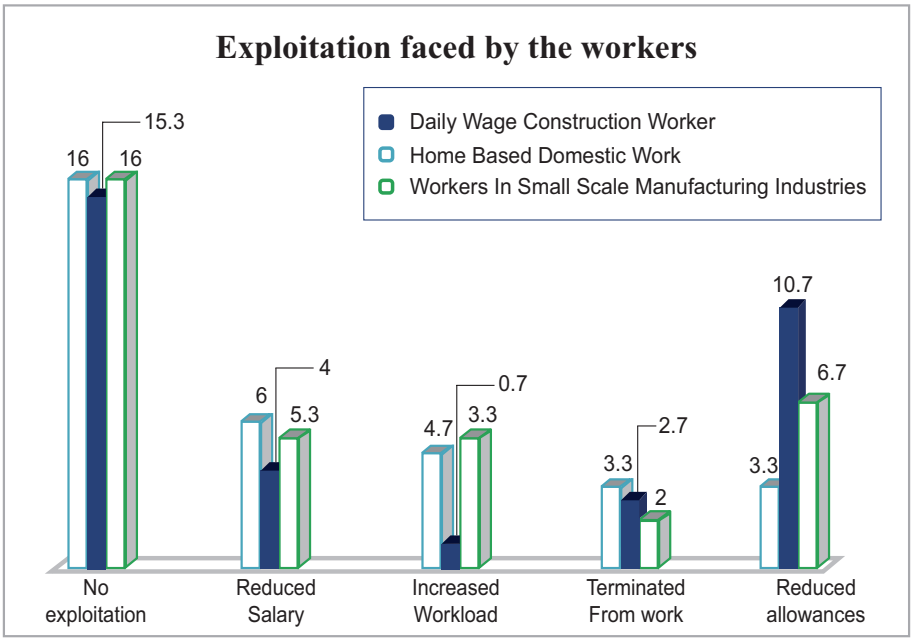

Figure 2: Exploitation Faced by the Workers During Lockdown

Source: Field Survey (2022)

The Figure 2 illustrates the type of exploitation practiced by employers on their employees during the pandemic. For understanding the level of employers' exploitation, several factors are considered (Bogoeski 2022). The employer's exploitation during the pandemic was measured on the basis of four factors - salary reduction, over workload, termination from work, reduction in the employment allowances. As compared to other 2 group of workers, construction workers faced the highest level of exploitation from the employer in terms of low pay and workload increment. Out of the total respondents, 56.7% reported facing various kinds of exploitation from their employer, while 71 individuals (47.30%) stated that they did not experience any form of exploitation from their employer. Specifically, during the pandemic, 15.30% of workers had their salaries reduced, and 8.70% were overworked. Additionally, the employment of 8.00% of workers was terminated by their employer. Moreover, 31 respondents (20.70%) experienced a reduction in the amount paid by their employers during the pandemic.

Table 7: Impacts of pandemic on daily life

Sl. No.	Statements	Responses in percentage					Mean	Description
		NA	AL	M	VM	E		
1	Time spend on watching TV increased	4.0	7.3	16.7	29.3	42.7	3.99	Very much
2	Time spend on social media networks increased	14.0	9.3	10.7	36.0	30.0	3.59	Very much
3	Time spend on sleeping Increased the	6.0	6.7	4.2	31.3	14.0	3.41	Very much
4	Food intake increased	25.3	32.0	24.7	10.7	7.3	2.43	A little
5	Time spend on family increased	9.3	12.0	32.0	33.3	13.3	3.29	Moderately
6	Time spend on child care increased	8.0	9.3	18.0	26.7	38.0	2.19	A little
7	Stress in marital relationships increased	32	34.0	20.7	9.3	4.0	3.28	Moderately
8	Household workload increased	8.7	12.0	10.0	34.7	34.7	3.75	Very much
9	Life style diseases increased	10.7	8.7	39.3	24.7	16.7	3.53	Very much
10	Usage of Alcohol and tobacco products	68.0	18.0	9.3	2.7	2.00	1.53	A little
11	Job insecurity feelings increased	8.6	10.0	26.7	28.0	26.7	4.41	Extremely
12	Financial insecurity feelings increased	8.0	10.0	34.7	27.3	20.0	3.75	Very much
Over all mean score							3.18	Moderately

Note: NA-Not at all, AL-A little, M-Moderately, V-Very much, E-Extremely

Source: Field Survey (2022)

The Table 7 presents the impact of the pandemic on the daily lives of the respondents, analyzed using a five-point Likert scale. The responses are classified using

the following discriptions such as “not at all”, “a little”, “moderately”, “very much”, and “extremely”. Each discrptions are ranked between 1 to 5. To determine the minimum and the maximum of the likert scale, the scale range was calculated by (5-4)/5. By this method we got the least value of the scale that is 4/5=0.80. The 0.80 is considered as the minimum value in the scale. We obtain the range by adding one to this least value on the scale. The mean values of each of the responses were calculated to get the overall opinion of the workers. We can rank the statements on the basis of the mean values. Eleven statements were formulated regarding the daily routines of the respondents. The findings reveal that approximately 96% of respondents believe that the COVID-19 disease and related lockdown have increased their time spent watching television, with a mean score of 3.99. About 86% of the respondents felt that there was an increase in usage of social media networks such as Facebook, WhatsApp, Instagram, etc. (M = 3.59). Additionally, around 74.7% responded that their food intake had increased (M = 2.43). Spending time with family members increased, reported by 90.6% of respondents (M = 3.29).

Moreover, approximately 92% of the respondents (M = 2.19) opined that time spent on child care increased during the lockdown period, and 91.4% (M = 3.75) revealed that household workload increased during the lockdown period. Around 68% (M = 3.28) reported an increase in stress in marital relationships. Increased lifestyle diseases were reported by approximately 89.4% of respondents, with a mean score of 3.53. However, only 32% of those polled predicted an increase in alcohol and tobacco use. Almost 91.4% (M = 4.41) believe job insecurity has increased, while 92% (M = 3.75) believe financial insecurity has increased. The overall mean score is (M = 3.1828), indicating a moderate influence. Therefore, it can be concluded that respondents also believed that COVID-19 and related lockdowns moderately influenced the daily lives of the workers.

Table 8: Financial difficulties during the lock down

Financial difficulties	Domestic Workers	Construction Worker	Workers In SSMI	Total
No	23(46)	22(44)	15(30)	60(40.0)
Yes	27(54)	28(56)	35(70)	90(59.3)
Total	50(100)	50(100)	50(100)	150(100)

Source: Field Survey (2022)

The Table 8 displays the responses regarding the financial difficulties faced by workers during the nationwide lockdown. It indicates that families affected by COVID-19 or those having a member with disability or special needs. Forty percent of respondents reported not encountering any financial difficulties during the COVID-19 outbreak. Conversely, 59.3% of workers disclosed experiencing significant financial distress during the pandemic period.

5.3. Gendered Impact of COVID-19 Pandemic

Table 9: Gender and work during Lockdown

	Financial difficulties in lockdown	Lose of job	Difficulties in work due to social distance	Employer exploitation during lock down
Mann-Whitney U	2708.000	1912.500	2775.000	2325.000
Z	-.131	-4.069	-3.110	-2.119
Asymp. Sig. (2-tailed)	.896	.000	.002	.034
a. Grouping Variable: Gender				

P*<0.05, P<0.01**

Source: Field Survey (2022)

The above table 9 shows the impact COVID-19 on employment variable. According to the survey the result shows that the employment situation during COVID-19 is different between men and women. The field survey revealed that loss of job among was higher among men as compared to women. Male workers suffered more job loss as compared to their female counterparts. This result is supported by the study of Kakarlapudi (2022). Their study also found that male employment fell from January to April 2020, whereas female employment fell by only four percentage points. Male employment in Kerala has fallen much more when compared to both low- and high-income states.

Table 10: Gender and Household workload during COVID-19 lock down

Gender	N	Mean Rank	Sum of ranks	U	Sig
Male	75	46.50	3487.50	637.500	0.000
Female	75	104.50	7837.50		
Total	**150**				

P*<0.05, P<0.01**

Source: Field Survey (2022)

The Table 10 depicts the situation of household workload among male and female workers. The result of the U test indicates significance, suggesting that the burden of household workload falls primarily on women. These findings are supported with the works of Aslam & Adam (2022), Chauhan (2022) and Del Boca et.al (2020). With all family members staying together throughout the day in congested living conditions, there is an increase in workload, conflicts, and privacy issues within the household, particularly impacting women. Additionally, the responsibility of caring for children who remain at home all day becomes an added concern for many women. The household responsibilities also increase for women workers in the informal sector. All the women surveyed reported a deterioration in their quality of life, characterized by reduced time available for rest and recreation, as well as decreased social interaction. Leisure activities derived from conversations with friends or neighbors have also diminished, compromising their social life.

Table 11: Reachability of Services among workers provided by the government.

Sl. No.	Services	Responses in percentages					Mean	Description
		N	R	S	O	A		
1	Additional Pension	35.3	0.0	0.7	12.00	52.0	3.46	Often
2	Financial assistance Rs.1000 for BPL families	28.0	0.7	0.7	38.0	32.7	3.47	Often
3	Free food kit	0.0	0.0	0.0	0.0	100.0	5.00	Always
4	Free rice and cereals	7.3	1.3	9.3	38.0	44.0	4.10	Often
5	Free COVID test	12.7	18.0	16.0	26.0	27.3	3.37	Sometimes
6	Tele medical support e sanjeevani	29.3	26.0	18.7	13.3	12.7	2.56	Rarely
7	Free medicine	19.3	14.7	20.0	24.0	22.0	3.14	Sometimes
8	Community kitchen	36.0	31.3	13.3	11.3	8.0	2.60	Sometimes
9	Government quarantine and treatment	24.0	30.0	19.3	15.3	11.3	2.24	Rarely
Overall Mean Score							3.3274	

***Note; N-Never, R-Rarely, S-Sometimes, O-Often, A-Always**

Source: Field survey (2022)

The Table 11 illustrates the accessibility of services among respondents provided by government authorities during the lockdown period due to the spread of the COVID-19 disease. It was analyzed using five point the Likert scale. The responses are classified

using the following descriptions such as “never”, “rarely”, “sometimes”, “often” and “always”. Each descriptions are ranked between 1 to 5. To determine the minimum and the maximum of the Likert scale, the scale range was calculated by (5-4)/5. By this method we got the least value of the scale that is 4/5=0.80. The 0.80 is considered as the minimum value in the scale. By adding one to this least value on the scale, we get the range. The mean values of the each responses were calculated to get the overall responses of the workers. Notably, 52% of respondents reported always using the government's additional pension. The free commodity kit was always available to each respondent in the survey without any restrictions. While 28% of people did not receive financial assistance, 32% reported receiving it every month. Among those who did not receive financial assistance, 28% were in the non-BPL category. Approximately 7.30% of the population did not receive free rice provided by the government through the public distribution system every month. Only 44% of those who received free rice on a regular basis used it every month. It is observed that very few people have access to the telemedical system implemented by the government.

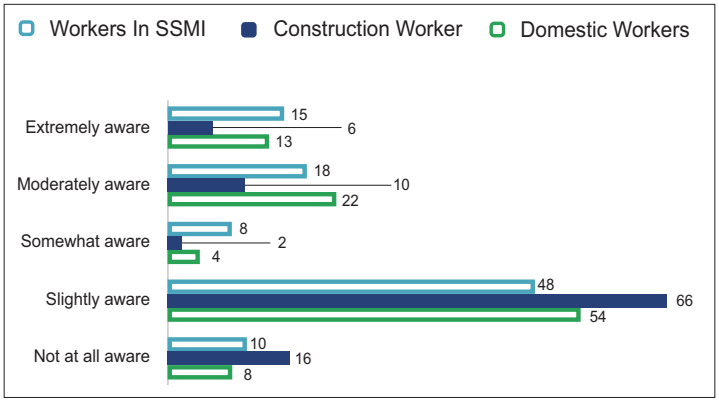

Figure 3: Awareness of government support and services during the period of COVID-19 lockdown

Source: Field Survey (2022)

The Figure 3 depicts the awareness of the respondents regarding government services provided during the pandemic. Government support is crucial in overcoming the effects of the pandemic. Out of the total informal sector workers surveyed, 56 percent of the workers indicated that they were slightly aware of the government initiatives. Specifically, construction workers showed a higher awareness level at

66 percent. Additionally, 16.70 percent revealed that they were moderately aware. Only 11.30 percent expressed being "extremely" or "not at all" aware. About 4.70 percent stated that they were somewhat aware of the services.

Table 12: Spearman rank correlation coefficient between Educational qualification and awareness of the respondents regarding government support and services during the period of Pandemic lockdown

	Educational qualification	Awareness
Educational qualification	1	.769
Awareness	.769	1

Note: Correlation is significant at the 0.01 level (2-tailed)

Source: Field Survey (2022)

The association between educational background and awareness of various government initiatives in lockdown was examined using Spearman rank correlation. The results revealed a strong positive correlation ($r = 0.769$, $N = 150$, $p = 0.01$), indicating a statistically significant relationship. This suggests that individuals with higher educational qualifications tend to have a higher level of awareness regarding government policy initiatives, while those with lower educational qualifications have lower awareness levels. Therefore, it can be concluded that awareness levels increase with higher educational qualifications. These findings are consistent with a study conducted by Sudha & Murugesan (2021), which also found that awareness levels are higher among individuals with higher educational qualifications.

6. Conclusion and Policy Suggestion

In conclusion, the COVID-19 pandemic has brought significant changes to the lives and livelihoods of workers in the informal sector in Chelakkara. Many workers faced challenges in reaching their workplaces due to the lack of transportation facilities during the pandemic, leading to changes in consumption patterns, income levels, and employment patterns. The hypothesis testing suggested that there is an association between employment loss during the pandemic and the reduction in income, savings and consumption of the respondents. So, from this we can come to the preliminary conclusion that the loss of employment due to the lockdown due to COVID-19 diseases

has reduced the income of the workers. This income loss again turned into reduction in consumption and savings. The household workload also increased during the lockdown period among the women workers. It found that there is gender gap in the household workload, the present study revealed that loss of job was higher among men as compared to women. Male workers suffered more job loss as compared to their female counterparts. This result supported by the study of Kakarlapudi (2022). Their study also found that male employment fell from January to April 2020, whereas female employment fell by only four percentage points. Male employment in Kerala has fallen much more than in both low- and high-income states. The household responsibilities are also greater for women workers in the informal sector. All the women surveyed reported deterioration in their quality of life, characterized by reduced time available for rest and recreation, as well as decreased social interaction. Leisure activities such as conversations with friends or neighbors have also diminished, compromising their social life. Women are suffering the double burden of work. Strong government intervention is necessary to mitigate the crisis caused by the pandemic. This study on the impact of COVID-19 on the livelihood of the informal sector workers in Kerala has some limitations. One is the sample comprising 150 respondents is limited due to time constraints. The selected sample is limited only to the rural area because of the survey on Chelakkara Grama Panchayat. The survey could not be carried out in the municipalities or corporations in Thrissur district due to time constraints and restrictions imposed to curb the COVID-19 outbreak. Since the responses and challenges faced by informal sector workers may vary across the regions, we cannot do a general review based on the study conducted in only one Panchayat. The size of the sample is an another limitation of the study. It is limited to only 150 workers in the study area because of the restrictions imposed to curb the spread of COVID-19 and lack of available time for field study.

The results of the present study has the following policy implications: Carefully designed policy intervention from state and local governments are essential for mitigating the adverse impact of the crisis caused by the COVID-19 pandemic on the vulnerable sections of the society. Firstly, the government and employer should provide transportation facilities to the labours when there is an outbreak of the pandemic. Loss of employment of informal labour is considered as a financial loss because this group contributes significantly to income generating activities. Secondly, enhancement of income and maintenance of consumption and savings of the workers

are very important. For that, the government should give food vouchers, targeted cash transfers or universal one-time cash payments to informal workers who could not work due to pandemic shock. Assisting the working poor with loan repayment, rent, and utility bills by integrating social protection measures in a package of measures including health and hygiene assistance is desirable. Third, government should adopt the gender sensitive programmes in the informal sector. In order to improve women's labour market outcomes, policymakers have to adopt a comprehensive strategy that includes expanding access to education and training programmes, developing skills, facilitating child care access, maternity protection in worksites, providing safe and accessible transportation, and promoting a pattern of growth that also generates more employment opportunities to women. Ensuring proper basic infrastructure facilities such as clean water, sanitation, healthy food and accommodation for the informal workers is also important. Additionally the work of the informal sector should be recognised via the proper application of social protection and legislation, accelerating and speeding up the steps to formalise the informal sector workers will help their job security in future. Hence, the government should ensure that all workers are registered on the E-shram portal and provide adequate facilities to ease the registration process.

India's informal sector, which comprises approximately 93% of the country's overall employment, has been particularly hard hit by the pandemic. While the formal sector has shown signs of recovery, the informal sector continues to struggle. It is crucial to recognize the efforts of informal sector workers through the proper application of social protection legislation. Every loss of informal labor represents a financial setback, as this group significantly contributes to the economy. Addressing the vulnerabilities and poverty faced by informal workers requires integrated and concerted government efforts. Political disenfranchisement among informal workers must also be addressed to remedy the injustices they faced during the pandemic. Unfortunately, informal workers continue to be an underserved group. The government must prioritize addressing their issues and ensure that the entire policy framework is equitable and justifiable. Only through comprehensive and inclusive policies can the challenges faced by informal sector workers be effectively addressed.

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Climate, Disasters and Infrastructure Development in Nepal

Achyut Tiwari[1] and Sanjev Dhakal[2]

Abstract

Nepal is well known for its climatic and topographic variation, which furnishes the unique biodiversity in the central Himalaya. However, Nepal is also prone to bigger disasters such as earthquake, flood and landslide. The rapidly changing climate in mountain topography has further intensified disaster risk in one of the poorest nations in the world. The higher rate of migration towards urban areas and massive population increase has enhanced infrastructure development in these areas, and urban planning has been very poorly designed. The major disaster events in Nepal and their risks have been analyzed in this communication with the published literatures. It is concluded that, Nepal is highly vulnerable to disasters related to climate and poorly designed infrastructure development. Although there have been considerable efforts in disaster risk reduction in Nepal, we shall critically analyze rapidly changing climate and our infrastructure development to condense disaster risks in Nepal.

Keywords: *Disaster risk, Urban infrastructure, Climate, Mountain, Extreme events.*

1. Introduction

Nepal comprises a great variation of altitude ranging from 60 meters to a maximum of 8,849 meters (Mt. Everest) forming the nation extraordinarily rich in regional climate and topography. The Himalayan range, extending about 885 km long (East to West) and 193 km wide (North to south) in the greater Himalaya range is the major source of freshwater, important drivers of regional and global climate. The Himalaya mountains represent an important component of mountain ecosystem providing ecosystem services for mountain people and people living downstream. The great variety of topography and the diversity of weather and climate simultaneously not only have

[1] **Achyut Tiwari,** Central Department of Botany, Tribhuvan University Kirtipur Kathmandu, Nepal.
[2] **Sanjev Dhakal,** Institute of Tibetan plateau research, Chinese Academy of Sciences.

resulted unique biodiversity in the region but also possesses various climate induced hazards and challenges in the mountainous country (Eckstein et al. 2021).

The evolution of Himalaya is an important geologic event to regulate global climate pattern, that contributed to establish active South Asian Monsoon (Boos and Kuang, 2010; Molnar et al., 2010) and to form relatively dry region in Tibet (Ding et al., 2017). The upraised Himalaya formed a physical barrier to the summer monsoon winds coming from the Indian Ocean and the cold winds coming from Siberia in winter, forming cold dry climate in Tibet and higher precipitation to the south in Himalaya. Also, the mountain topography is a sensitive indicator of climate change (Nijssen et al., 2001; Neupane et al., 2018) as this region constitutes higher frequency of flood related disasters in the summer season, which of course influences infrastructure development and sustainability in the southern slope of the Himalayan region. Nepal is highly vulnerable to many natural disasters such as floods, landslides, snow avalanches, Glacial Lake Outburst Floods (GLOF), drought, cold waves, hailstorms, thunderstorms, hot waves, epidemics and earthquakes. Majority of areas in Nepal; 49 districts out of 77 districts are highly vulnerable to floods and/or landslides, 23 to wildfires, and one to windstorms. Moreover, 64 districts out of 77 are at risk of potential disasters of some type (MOHA, 2017). Similarly, Nepal's biological resources, including its mountain forests, are highly vulnerable to the impacts of climate change (Eckstein et al. 2021). Younger and fragile geomorphology of landscape, evolving extreme climatic events and incapability of mitigation and adaptation for rapidly changing climate are intensifying disaster related risks in Nepal. In this regard, the present paper aims to evaluate the general climatic trend, typology of disasters, extreme climate events and explore the types of disasters risks in infrastructure development and preparedness in Nepal.

2. Materials and Methods

Nepal is situated between latitudes 26°22'N and 30°27'N, and longitudes 80°04'E and 88°12'E. The country is divided into five physiographic regions based on its geology and geomorphology (Figure 1); namely Tarai, Chure, Middle mountains, High mountains and High Himalaya (LMRP, 1986). We analyzed general climate and climatic trends for whole Nepal by using the meteorological data from Department of Hydrology and meteorology Nepal (DHM, 2015). Different published articles/reports (2000-2018 AD) including country reports and peer reviewed literatures on disasters, extreme climate

events, adaptation measures and Nepal's preparedness on disaster risk reduction were analyzed. were. The occurrence of disaster events and the casualty from those events were compiled from open data source from Ministry of Human Affairs Nepal (MoHA, 2015; 2017). The data were analyzed in Microsoft Excel.

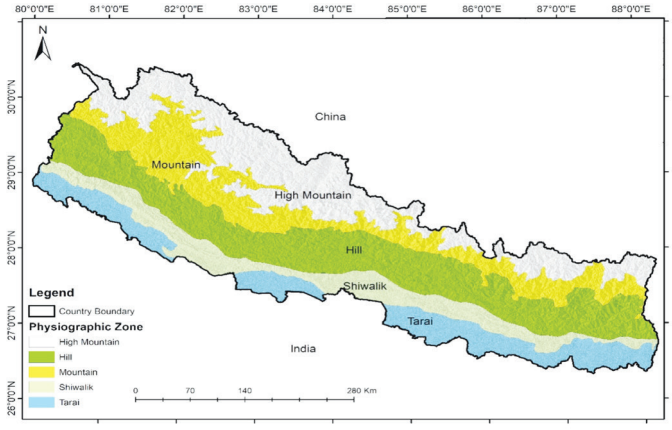

Figure 1 : Location and physiographic zones of Nepal

3. Results

3.1 Topography and Climate

The changing/emerging type, magnitude and the nature of disaster in Nepal is mainly due to its complex physiography and climate. The regional climate patterns are quite diverse in Nepal due to its varied topography and altitude (Karki et al., 2016). It is essential to have good prediction capability of impact of rapidly changing climate and topographic structure to establish any infrastructure development plan that will reduce risks by disasters. There has been a substantial road construction in the recent decades in Nepal, however, their stability and service ability against natural disasters and rapidly changing climate remains a challenge. For instance, larger part of Local Road Network (68%) in Nepal are unpaved and they remain apparently non-passable due to higher rainfall during summer season (June to September) as the country receives more than 80% of annual rainfall. Fatal road accidents are more frequent with huge loss of life and property, and huge budget is drained in restoring and renovation of such roads. Nepal government has taken several initiatives including the investment in the road

networks to reduce transportation risks and disasters to meet the increasing demands of transportation (GON, 2017).

According to the statement from the World Bank (2012), Nepal is ranked as the 4th most climate vulnerable country in the world as per the climate change vulnerability index. Consequently, there has been considerable increase in climate induced disaster risks in Nepal. Increased fire incidence in Nepal is associated with prolonged drought due to alteration in weather patterns. Fire is another common and frequently happening disaster in Nepal as the main driver for deforestation and loss of biodiversity thereby ruining national economy, environmental condition, and land properties. Hence, climate change due to global warming has been categorized as the important factor for disasters in Nepal in the recent years.

3.2 Climate Change Scenario and Impact in Nepal

The rate of warming is more than twice in high elevation areas in comparison to the remaining part of the world (Pepin et al., 2015), and similar trends have been reported in Himalaya which showed an average rate of 0.74°C in the last century. It was observed that the average trend of mean annual day temperature over Nepal is 0.04°C/year, and the minimum temperature trend is only 0.01°C/year (1971-2012, DHM Nepal) (Table 1). The maximum warming rate was recorded from the mid mountains and this region is likely to grow warmer and drier in the non-monsoon seasons (NCVST, 2009). However, the trend of mean annual minimum temperature is higher in low altitude regions (southern plane) and lower in high mountain areas. And there is a reverse trend pattern in mean annual maximum temperature (higher in high altitude and lower in low altitude). In high mountain areas of Himalayas, the warming rate is as high as 0.6 0C to 1°C decade -1 (Shrestha et al. 1999). The spatial analysis of temperature trends in the Himalaya since 1989 showed that the winter warming trends are up to +0.8°C per decade. And the pre-monsoon (March-May) warming was also increasing in the entire Himalayan region. Consequently, the frost days were decreased (up to -17 days per decade) in the Nepal Himalaya, with higher increase of day temperature in the southern slopes of Himalaya within altitude between 2000 and 3500 m asl (Gerlitz et al. 2014).

The meteorological data of Department of Hydrology Meteorology Nepal, of 1971-2012 indicated that the average trend of rainfall is positive for eastern, central western and far western development regions. However, there has been higher spatial heterogeneity such as increasing trend of 30 mm/year and decreasing trend of 40mm/

year in annual precipitation in some regions of Nepal. Overall, the annual precipitation trend was declining in most parts of the mid-western regions. These trends coincide with decreasing annual precipitation (up to 20 % for the last century) in the western Himalaya (Duan et al. 2006; Bhutiyani et al. 2010; Jain et al. 2013). It is particularly mentioned that the trends were based on only existing meteorological data, and stations could not capture some isolated regional climatic zones in Himalayan Mountains in Nepal. Himalayan mountain system is represented by a strong topographic; hence, the regional pattern of temperature and rainfall greatly vary even over close by regions (Schickhoff 2005, Tiwari et al. 2017a).

Table 1 : Summary of general trend of maximum minimum temperature and rainfall in Nepal in different physiographic zones (region wise) (DHM, 2015)

Region	Tmax			Tmin			Precipitation		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Tarai	-0.02	0.05	0.02	-0.01	0.04	0.02	-14.9	19.8	-1.3
Siwalik	-0.02	0.07	0.02	-0.03	**0.05**	0.01	-16.3	26.8	0.6
Mid Mountain	-0.01	**0.11**	0.04	-0.04	**0.05**	0.02	-35	28.7	-2.3
High Mountain	0.02	0.07	**0.05**	-0.03	**0.05**	0.01	**-42.5**	**31.1**	0.2
High Himalaya	0.04	0.06	**0.05**	-0.01	0.02	0.01	-6.1	17.2	**6.6**
Country	**-0.02**	**0.11**	**0.04**	**-0.04**	**0.05**	**0.01**	**-23**	**24.7**	**0.7**

Nepal Himalaya represents the typical monsoon climate, in which heavy precipitation is caused by a southwesterly flow from the Bay of Bengal, leading to summer season rainfall up to 3500 mm in windward mountain slopes in central and eastern Nepal. In contrary, the climate in the winter is determined by the westerly flow leading to higher precipitation in the western Nepal that decreases while going from west to east (Böhner 2006; Maussion et al. 2013). Consequently, about 80% of the annual precipitation is received by the eastern Himalaya during summer, and about 50% of the annual precipitation is received for western parts during winter season (Figure 2). However, the transition season in Himalayan region is mainly dry despite intermittent convective rainfall in the southern slopes (Romatschke et al. 2010).

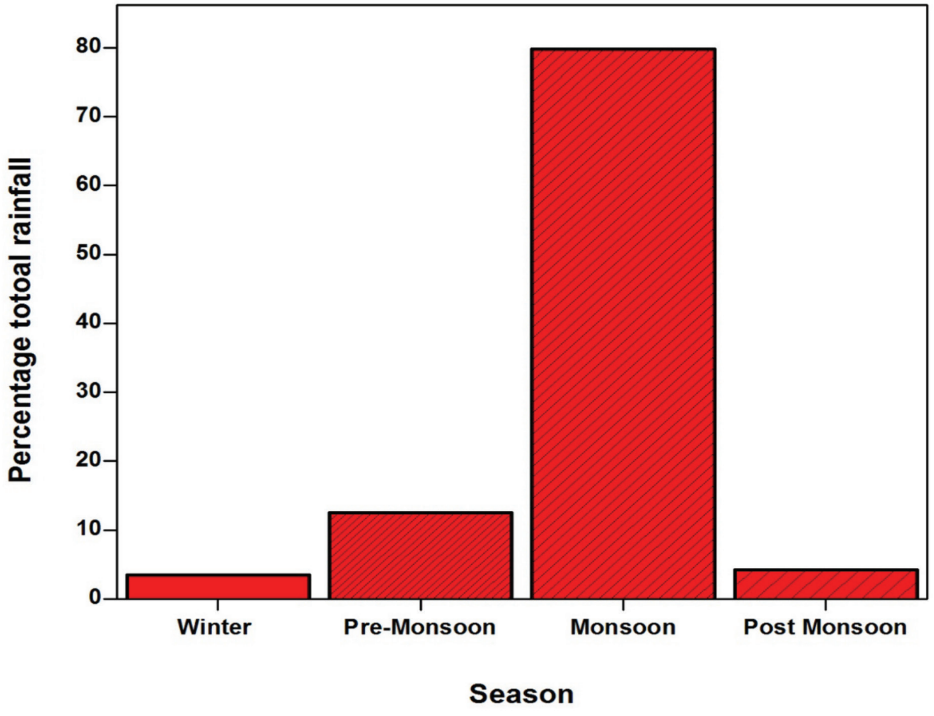

Figure 2: Seasonal Rainfall Pattern in Nepal (DHM, 2015)

3.3 Typology of Disasters in Nepal

Nepal is highly one of the highly vulnerable countries in terms of its exposures to various types of disasters because of its location in the central of the Himalayan range, and due to its extreme topography and climate. Every year the county is facing numbers of natural disasters, resulting tremendous loss both economic and life. The higher levels of disaster risks and hazards in Nepal are responsible for the huge economic loss that disrupts human lives and properties, infrastructure development, and economic development (NCTAD, 2014). The nation wise natural disasters and human death toll is summarized in Figures 3 and 4. Some of the common disasters happening in Nepal are listed and discussed below:

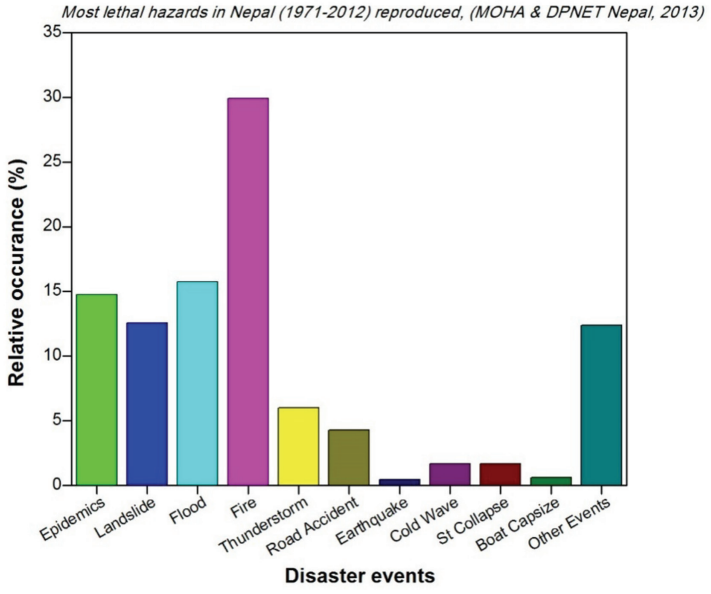

Figure 3 : Most common hazards in Nepal reproduced (MOHA, DPNET Nepal, 2013)

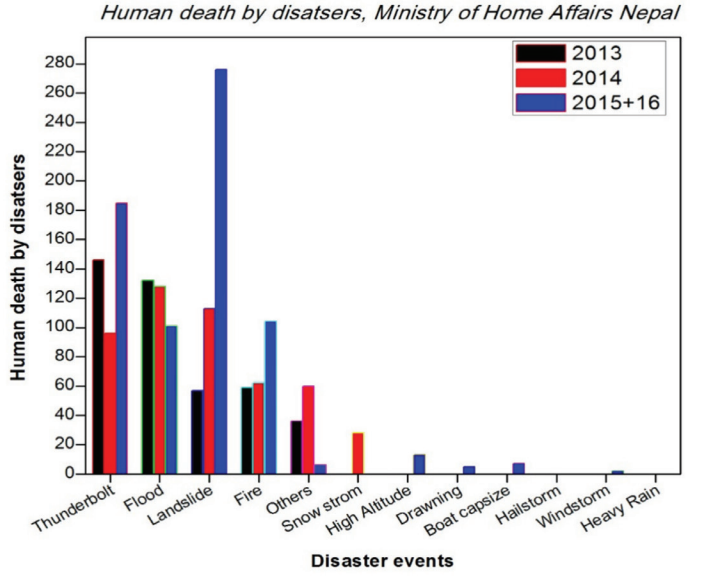

Figure 4 : Human fatalities due to disasters in Nepal 2013-2016 (MOHA)

a. Landslide

Landslide is quite common natural hazards in mountain regions of Nepal. Landslides mostly occur due to higher intensity of rainfall in summer monsoon season, which is associated with physiographic factors such as steep slopes, fragile geology, as well as due to unplanned human settlements. The risk of landslide is further exacerbated in the mountain belts by human activities such as improper land use practice, encroachment into vulnerable landforms and poorly planned development activities including road construction, irrigation canals and settlement practice. Beside the Tarai plain area, rest of the land area possess higher risk of Landslide due to its steep topography and fragile ecosystems.

b. Flood

Flood is the most frequent, highly damaging, and widespread water-induced disaster in Nepal natural hazard in Nepal, which is most common during monsoon season (DWIDP, 2013). Nepal has more than 6,000 small and large rivers that flow from north to south, and all of them are potential for flood, that make Nepal the second highest country in South Asia at the risk of floods (UNDP, 2009). During summer season (June-September), the volume of water in these rivers increases and cause flood damage to the settlement areas, agriculture lands and livestock. The rapid warming in high Himalaya, an unpredictable rainfall patterns especially the emerging heavy rainfall in short period of time, river encroachment and unplanned urban settlements all are intensifying flood related disasters in Nepal (UNDP, 2009; DWIDP, 2013).

c. Glacial Lake Outburst Floods (GLOFs)

Nepal Himalaya harbors more than 2,315 glacial lakes that are in the high elevation areas in the foothills of High Mountain (Mool et al., 2001). These lakes were formed due to damming by rapidly deposited moraines and consist of huge volume of water generated by melting of glacier. The stored water may outbreak resulting in flood, which is known as glacial lake outburst flood (GLOF). More specifically the glacial lakes in the eastern Nepal (Spata Koshi River Basin) are potentially dangerous for GLOFs (Mool et al., 2001). GLOF holds a substantial capacity that can bring catastrophic events towards its downstream. It was recorded that 15 glacial lakes are found potentially dangerous in Nepal and already we faced 14 GLOFs between the year 1935 and 1991.

d. Earthquake

Nepal Himalaya, one of the youngest mountains in the world, is geologically active and constitutes the potential risk of bigger earthquake due to the major active faults in

east-west alignment. The temporal trend of historical and modern seismological studies has also indicated that Nepal Himalaya is prone to earthquake because of its geographical position in the active seismic zone. The seismic pattern in Nepal has been divided into three clusters of events: eastern, central and western. Historical data showed that, there were four major earthquakes in 20th century namely the1934 Bihar-Nepal earthquake (Mw 8.1-8.2), 1980 Chainpur earthquake (Mw 6.5), 1988 Udayapur earthquake (Mw 6.8) and a recent 2015 Mw 7.8 Gorkha Earthquake. The recent 2015 Gorkha earthquake affected more than 14 districts with more than 9000 fatalities and a huge loss economic in Nepal (Adhikari et al., 2015; Dhakal et al., 2019). It was recorded that there were over 1600 seismic events in Nepal during 2017 and 2018, out of which 55 events were bigger than 4 Richter magnitude. Such higher seismic activities rank Nepal as the 11th risky nation in terms of earthquake the world (Nepal Disaster Report 2019).

e. Fire

Both anthropogenic and wildfires are common in Nepal as a potential disaster. More than 75% of the total households of the country rely on agriculture. Similarly, about 86 percent of the population lives in the houses made of earthen wire, stone and wood in rural areas of Nepal, and these residential houses are often built-in cluster. These settlements, especially in the dry season are more susceptible to catching and spreading fire. Wildfire is another common natural disaster in Nepal during dry season, especially in the mid hills and lower plains of Tarai region. With warming temperatures and prolonged drought until monsoon season, the prevalence of fire has been found increasing as a major disaster in Nepal.

f. Drought

Drought represents one of the frequently happening hazards in Nepal, and it is associated with uneven, irregular, and low monsoon rainfall. Overall, in Nepal Himalaya the highest trend has been observed in warming of day temperature (Tmax), which exacerbates drought intensity. In Nepal, some parts of Tarai, mid-land and Trans-Himalayan belts are prone to drought, especially during winter season (March-May). The seasonal drought causes huge loss of crops production and causes shortage of food, and this is mainly due to inadequate irrigation facilities. Major drought events recorded in Nepal were of 1972, 1979, 1994. The historical climate patterns also indicated that the western Nepal is getting drier in the recent times in comparison to rest part of country as indicated by Panthi et al. (2018).

g. Avalanches

Avalanches are quite a common hazard in high mountains, which are snow covered and are highly steep; these include a rapid movement of snow and debris flowing down

through the mountains. Avalanches occur by natural factors like slopes, thickness of snow or anthropogenic warming that influences temperature trend, snow accumulation and melting. Avalanches carry huge masses of snow and debris making them highly destructive hazards. The high Himalayan region in Nepal is highly susceptible to avalanche because of the rugged and steep slopes. Since the high Himalayan Mountain includes many north-south passing rivers and streams upstream, the avalanches may block the river channels intensifying the disasters. Several highly destructive avalanche have been reported in Nepal, one of recent avalanche is Seti River Flood of 5th May 2012 in central Nepal (Kaski).

Apart from the abovementioned common disasters in Nepal there many more including epidemics, road accidents, building collapse, hailstorm, thunderstorm, boat capsize etc. The following table summarized the overall hazards in Nepal (Table 2).

Table 2 : Types of Disaster Related Hazards in Nepal (Government of Nepal 2017)

Types of Hazards	Occurrence
Natural Hazards	
Earthquake	All Nepal
Flood	Tarai, Mid Hills
Landslide and landslide dam breaks	Hills, Mountains
Debris Flow	Hills and Mountain, more intense in areas of high altitude greater than 1700 m (glacial deposits)
Glacier Lakes Outburst Floods (GLOF)	Higher Himalayas (origin at the tongue of glaciers)
Avalanche	High Himalayan region
Fire (forest)	Tarai and Mid hills
Drought	All Nepal
Windstorms	All Nepal
Hailstorm	Hills
Lightening / Thunderbolt	All Nepal
Human-Induced Hazard	
Epidemics	Tarai and Hills, also in lower parts of Mountain region
Fire (settlements)	Mostly in Tarai, also in mid-Hill region
Road Accidents	Urban areas, along road network
Industrial/Technological Hazards	Urban / industrial areas
Soil erosion	Hills
Social Disruptions	Follows disaster-affected areas and politically disturbed areas

3.4 Extreme Climate Events in Nepal

The higher potential of disasters in Nepal is mainly attributed to higher precipitation events during the monsoon season, which induces natural hazards including floods, landslides, slope failures and flash floods. The overall climate station data revealed that the number of monsoon days is slightly increasing (Figure 5), this could be positive to cope with the influence of warming temperature but equally hazardous in terms of monsoon related disasters. The highly intense settlement with heavy encroachment of river system has posed great threat to urban sustainability. The poor water recharge in concrete town is the cause of urban flood which is taking lives of people in the heart of the town. Time has already come to re-estimate drainage management to prepare ourselves against highly intense rainfall in monsoon. There is lack of the policy implementation of lay/regulation which can control riverbank encroachment, which has created a huge problem of urban flood. Recently, the river turned into settlement area (personal observation 2018, Bhaktapur Nepal) causing enormous loss of life as well as infrastructures and farmland.

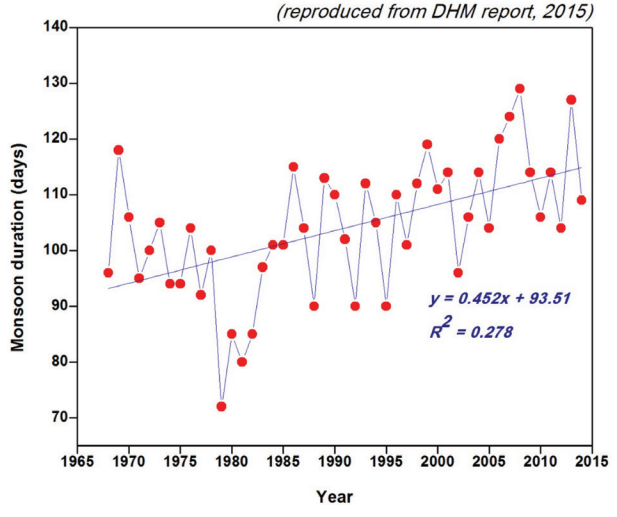

Figure 5 : Monsoon duration in Nepal, reproduced from DHM (2015)

The vulnerability to climate-related extremes and natural hazards are mainly to inadequate public awareness, lack in preparedness, lack of coordination among inter-government agencies, and due to financial constraints. Similarly, the weaker technical knowledge and inadequate mitigation skills of natural disasters have increased the vulnerability related to climate change and hazards in Nepal.

3.5 Climate Related Hazards in Transportation Sector

The per capita emission of Carbon Dioxide (CO_2) in Nepal is very low but emission rate is increasing day by day, globally the transport sector only contributes up to 45% of the per capita emission produced in the country (IPCC, 2014). Nepal is experiencing early impacts of climate change in the recent decades resulting in heavy rainfall, massive floods, and intensifying drought. Nepal exceeds global temperature trend with a rise in the maximum temperature by 1.8°C between 1975 and 2006, which has caused rapid glacier retreats in many regions (Fujita et al., 2009). The heavy rains followed by flooding in 1974, 1981, 1993, 2004, 2018 that caused a great destruction to the road network including bridge collapse in different parts of the nation. On the other hand, regional drought is an emerging weather extreme in Nepal, which is associated with warming temperatures. Seven districts have already been listed as highly vulnerable to drought.

The mountain topography of Nepal highly vulnerable to landslides, rock-falls, and debris flow. Basically, due to high rainfall. In the Tarai region, the increase in the temperature promotes cracks on the roads and heavy rainfall leads to potholes. The poor roadways are susceptible to the chances of accidents, delay the transportation system and increase the fuel consumption. Most of the road networks in the rural areas are just graveled or even not, the heavy rain causes serious damage to those roads, causing floods and landslides.

Figure 6 : Heavy Flash Flood in the Melamchi Bazaar, central Nepal (June 2021) While Cutting off Road Access to Several Villages Around Melamchi.

3.6 Disasters on Agricultural System

Agriculture is the main economic activity in Nepal; that provides employment to over 65 percent of the population, with only 21.88 percent of cultivable land and another 44.4 forested area (FRTC, 2009). The Tarai plains only constitute 43 percent of the total cultivated land in Nepal, however, most of the farmers rely on rain feed agriculture, as there are not adequate irrigation facilities. Approximately, more than 65 percent of the cultivated land is rainfed (CBS, 2013), showing the highly monsoon dependent agriculture in Nepal. Increasing climate natural hazards ruin agricultural productivity resulting poverty and insecurity of food. In recent decades, extreme climate events such as changes in magnitude of seasonal rainfall, droughts, floods, heat and cold waves as well as pest and diseases (IDS-Nepal, PAC and GCAP, 2014).

Although the calculated future impacts of climate change on agricultural production suggested an initial increase up to 2050 due to carbon fertilization effect then a decline by 2080 by 4.8 percent (Cline, 2007). Although these figures do not reflect the most likely negative impacts of natural disasters on agricultural production, the rapidly changing climate in Nepal could intensify uncertainties in agricultural production. Studies indicated the possibilities of more frequent and less predictable monsoon flooding, making mitigation and adaptation measures more complicated. In recent decades Tarai and mid-hill region in Nepal are experiencing more extreme events including severe 'cold waves' and cause huge damage to winter vegetable crops (Table 3).

Table 3 : Loss of agricultural and cropland by climate related hazards in Nepal (1971–2007) (Government of Nepal 2017)

Events	Loss of agricultural land	Loss of agricultural crops
Drought	329	332
Flooding	196	977
Hailstorm	117	518
Heavy Rainfall	54	895
Wind	23	239
Cold waves	21	794
Other (Epidemics, snow avalanche, fire, storm, thunderstorm, plague etc.,)	83	336
Total	**847 Hectare**	**648 Hectare**

4. Discussion

4.1 Topography and Climate

Nepal has diverse physiographic structure and regional climate, which divided into five physiographic zones: Tarai, Chure (Siwalik mountains), the Mid-hills, High Mountains and the High Himalayas. The Tarai region is the southern flat plain of Himalaya occupying 13.7% of Nepal's total land area (LRMP, 1986) with flat plains with highly fertile alluvial soil comprising some dense forests and protected areas including national parks, wildlife reserves and conservation areas. Agriculture and livestock are the main activities in Tarai region of Nepal. Churia region lies just north of the Tarai, running the entire length of southern Nepal occupies about 12.8% of the total land area of the country. Similarly middle mountains (29.2% of total land) and high mountains (20.4% of total land) lie towards the northern part of Nepal, the mountains are characterized by rugged landscape and very steep slopes (DoS, 2001). The mid-hills several mountains and valleys such as Kathmandu, Pokhara, Hetaunda, Dang, Surkhet etc., with large human settlements. In the higher altitudes there are rugged mountains and people are mainly involved in livestock, agriculture, medicinal plant collection and cottage industries. The Mountainous region varies from 4,878 - 8,848 m asl comprising more than 250 peaks and most of them are in the eastern and central Nepal. The snowline in the region is at about 5,000 meters, and above which there is no vegetation and human settlement. Most part of the high Himalaya consists of metamorphic and sedimentary rocks (Upreti, 1999).

Nepal shows slightly negative but not statistically significant long-term trends of winter precipitation (Bhutiyani et al. 2010). However, Nepal is experiencing enhanced frequency of winter and pre-monsoon drought events since the early 1980s particularly in the western Nepal Himalaya (Wang et al. 2013; Panthi et al. 2017). There is no significant change in annual precipitation in the eastern Himalaya (Jain et al. 2013). By in large the warming in high mountains in the central Himalaya is mainly due to the rise of day temperature (Tmax), although areas have shown decreasing trend of mean minimum temperature (Tmin) (Tiwari et al. 2017b; Rana et al. 2017). The warming temperatures and decrease of rainfall are likely to intensify drought stress, particularly in the spring season (March-May) in the Himalayas (Liang et al. 2014; Tiwari et al. 2017b; Panthi et al. 2017). Some regions have already shown warming induced growth decline in high mountain forests, and the reduced growth may eventually lead to poor reproductive

performance and regeneration of forests (Tiwari et al., 2017b). There has been a significant progress on regional evidences of warming despite the fact that IPCC's 2007 Fourth Assessment Report designated Hindukush-Himalayan region including Nepal as a "white spot' because of the limited number science based evidences on impacts of climate change in Himalaya (IPCC, 2007).

Studies revealed that local-scale precipitation patterns are mainly driven by wind- and leeward positions of the topography and regional circulation patterns (Gerlitz, 2014). It is expected that the future warming trend at mid-latitude will be enhanced at higher altitude than the surrounding areas at the same latitude (Rangwala et al. 2013; Pepin et al. 2015). Therefore, high mountain areas are particularly more sensitive to climate change, and this would have far-reaching consequences beyond the immediate mountain regions, mainly to the hydroclimatic balance because as Himalayan mountains are 'water towers' serving as the main source of fresh water to which the large populations in downstream rely on which is highly critical to people and ecosystems (Christensen et al. 2007).

4.2 Climate and Infrastructure Development

Infrastructure development in Nepal must be planned according to physiographic features (plains, middle mountains and high mountains). The prospect of infrastructure development in Nepal is different in denser settlement valleys (urban-sub urban areas) and sparsely populated mountainous regions. The development activities are heavily centralized in urban areas where the population density is quite high. The increasing difference in development activities in plains (valleys) and mountains has created the disparity not only in lifestyle and national economy but also in the potential hazards and disasters in the region. We see strikingly different challenges of disasters in urban and rural areas. In the rural areas floods, landslides, epidemics, seasonal drought, obstruction of road networks are major challenges, whereas urban areas constitute shortage of water, urban flood, building collapse, epidemics, landslide, flood, road accidents etc.

The cost of road infrastructure building and maintenance is high in Nepal as compared to other region due extreme terrain which is highly subjected to frequent disasters leading to premature land failures (MoHA, 2015; 2017). Hence, special consideration is needed while designing transport infrastructures to overcome such

adverse conditions and disasters. These infrastructures need to be emphasized in a way to operate and maintain in a cost-effective way.

Nepal is also engaged in a debate on the model of infrastructure development and its consequences to environment and disaster reductions. The environment and biodiversity management leaders also opine that the mega projects would not be sustainable in fragile topography that is equally prone to seismic hazards. Similarly, investments in road networks in highly steep areas is often questioned, as we are not only losing the investments, but also losing hundreds and thousands of lives every year in road accidents. On the other hand, infrastructure development is an urge to provide basic services to people. In capital city Kathmandu, the department of roads has recently made roads wider reducing the footpath for pedestrian, however, the narrow footpath is increasing hazards to people who could barely walk on it as they are much narrow and covered by numbers of extended outlets of stores. However, it is essential to understand the concept of pedestrian needs for a safe and comfortable walking environment in cities (Bivina, 2019). Similarly, the proposed construction of a second international airport in eastern Tarai is also under debate, as the airport needs clearing of big chunk of highly dense forests. The climate related hazards not only ruin human lives but also causes huge damage in infrastructure projects in mountain topography like Nepal, the Melamchi water supply project in Nepal was severely damaged by 2021 June heavy flash flood in the Melamchi Bazaar while cutting off road access to several villages (ICIMOD, 2021) (Figure 6). The environmental advocates have warned of the negative impact of clearing forests as the region already getting drier due to warming temperature and unpredictable precipitation.

4.3 Adaptation Measures

a. Infrastructure Development

Nepal has prepared the "Climate Resilient Planning – A Tool for Long-term Climate Adaptation" along with the National Adaptation Programme of Action (NAPA) and Local Adaptation Plans for Action (LAPA) in 2011. These adaptation plans were formulated for the effective preparation of resilient infrastructure development and to benefit in making the people and the environment able to adapt to the hostile impacts of rapidly changing climate. Similarly, Nepal has also made Climate Change Vulnerability

Mapping under NAPA as a tool to categorize the highly vulnerable areas of various hazards and disasters in Nepal.

Bioengineering tool has been initiated in Nepal as an effort to reduce landslides for road stability in the recent decades. However, less is known about specific designs to make climate proofing for roads. It is extremely important for the country to identify locations for extreme climate conditions, estimate risk analysis of roadways and design the infrastructure accordingly. Which will contribute not only to adapt extreme climate conditions, but also help in reducing maintenance and repairing cost of the road networks in Nepal.

There has been a huge surge in vehicle ownership (13% every year), and it has been a high time to switch to cleaner fuels for minimizing GHG emissions in Nepal. Promotion of clean energy-based transport, promoting bicycle lanes, walkway facilities and advocacy of non-motorized transport and public awareness about decreasing GHG emissions and air pollution are highly critical in Nepal in order to save the environment and minimize the disaster risks.

b. Nepal Preparedness

With increasing both natural and human induced hazards, Nepal is also developing its strategies in order to cope with them. The Central Natural Disaster Relief Committee (CNDRC) in Nepal is mainly dedicated to work for disaster relief, under the Chairpersonship of the home minister. It includes 27 ministries, security agencies and various voluntary organizations like Nepal Red Cross Society (NRCS) (MoHA, 2015). CNDRC is the major coordinator for looking after government agencies and stakeholders to coordinate at the time of emergency. It provides relief package arrangement and coordinates different sectors under the Natural Calamities (Relief) Act, 1982. It organizes necessary meetings annually or in case of emergency for making pre-monsoon preparation and to address possible natural or non-natural hazards. The following are some resource links of the institutional bodies that are working on disaster reduction in Nepal:

- Risk Profile in Nepal http://www.drrportal.gov.np/risk-profile-of-nepal
- Nepal Disaster Risk Reduction Portal: http://www.drrportal.gov.np/home

- DRR Strategic Action Plan - Nepali final version 2018
- National Disaster Risk Reduction Policy 2018.
- Integrated Action Plan for Post-Earthquakes Response & Recovery-2072: http://drrportal.gov.np/uploads/document/170.pdf
- National Adaptation Programme of Action (NAPA)
- http://adaptation-undp.org/resources/assessments-and-background-documents/nepal-national-adaptation-programme-action-napa

5. Conclusions

It has been quite clear that all physiographic zones of Nepal have shown warming temperature in recent decades although there are some regional anomalies. The meteorological data indicated that total annual rainfall does not show any significant trend for whole Nepal although eastern Nepal and some inner valleys are experiencing more rainfall and western Nepal is getting drier. Landslide, earthquake, fire, drought, and avalanche are most threatening disasters in Nepal, although flood and landslide have been found more frequent. We could predict that climate related disasters are increasing as the increase in extreme events in Himalayan region. We should pay greater attention in urban planning and developing infrastructure in Nepal, as they are more vulnerable in highly fragile geomorphology in Nepal. Although we have good legislature and policy framework for disaster risk reduction in Nepal, their implementation is critically important to reduce disaster risks in Nepal. And, it is very critical to characterize climate induced disasters in Nepal to benefit from Loss and Damage Fund, which has been recently operationalized from COP28 (UAE consensus).

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Hazard Assessment and Emerging Constraints for Disaster Risk Reduction in Higher Educational Institutions (HEIs) in Delhi

Abhay Shankar Prasad[1], Rajesh Kumar Abhay[1], Swati Thakur[1]
Anushka Garg[2], Amit Kant Awasthi[3] and Arvind Kumar[4]

Abstract

Disaster education plays a vital role in raising awareness for preventing and implementing conscious disaster risk management and mitigation measure under disaster risk reduction. It is stature to enhance the capacity of resilience and ensuring sustainable development pathways for disaster management. The betterment of higher education institutions in their national as well as local communities has progressed from providers to active participants in the creation, diffusion, and transfer of knowledge pertaining to the disaster management. This paper uses primary data collected from different higher educational institutions of Delhi based on questionnaire, field observation, interview (formal-informal), interactions, and discussions with students, teachers, and non-teaching staff. The study aims to assess the extent of understanding of disaster knowledge among students and staff to help in awareness about the concept of disaster, and disaster preparedness plans in higher educational institutions. The paper objective is to focus on the student developing a conceptual understanding of risk, vulnerability, and disaster management. This study aims to assess the present situation to address better implementation strategies for disaster risk reduction and management in higher education institutions.

Keywords: *Higher Education Institutions, Vulnerability, Preparedness Plan, Disaster Risk Reduction*

[1] **Abhay Shankar Prasad, Rajesh Kumar Abhay, Swati Thakur,** Department of Geography, Dyal Singh College, University of Delhi, New Delhi-110 003 (India)
[2] **Anushka Garg,** School of Disaster Management, Tata Institute of Social Sciences, Mumbai (India)
[3] **Amit Kant Awasthi,** Environmental Studies, Dyal Singh College, University of Delhi, New Delhi-110 003 (India)
[4] **Arvind Kumar,** PhD Research Scholar, Department of Geography, Delhi School of Economics, University of Delhi-110007 (India)

1. Introduction

Among the mass of disaster-prone countries in the world, India is one of them. Due to its location, topography, and geographical features, it is prone to several natural hazards, including drought, cyclones, floods, earthquakes, fires, landslides, and avalanches etc. The relationship of mankind with nature has progressed through several stages, setting with survival issues in primitive times, through a period of rapid mastery over nature since the industrial age (Boyles, 2012). With the rapid development of society, the vulnerability to natural disasters is reduced. In the 20th century, many groups are more vulnerable to disaster due to the material-intensive growth pattern. Hazards are threat to human progress. But hazard could become disaster when affects humans lives and property. Disaster has been defined in several ways. It is considered as a sudden event, catastrophe mishap arising from natural or human-induced and with a magnitude beyond the coping capacity of community and results into loss of life and property (UNISDR, 2007; NDMA, 2022; Atkinson, 2023). Disaster management is an approach to systematically managing the responsibilities of disaster prevention, preparedness, mitigation, response, and recovery. It is an effective process that prepares for and responds to disasters. Strategically organizing the resources to lessen the damage and loss that disasters cause is part of disaster management. (Rajesh et.al. 2011, Prasad, et.al. 2023).

Disaster preparedness refers to actions which can minimize the effects of disasters. That is, to predict and where possible prevent the disasters, mitigate their impacts on unprotected populations and respond effectively to their repercussions. Disaster preparedness solely is not a result of a distinct sectoral activity by itself, rather is a ceaseless and coherent process resulting from a wide range of activities and resources. It requires the contribution of many different areas ranging from training and logistics to health care and institutional development (Singh, 2005). Preparedness focuses on plans to respond to a disaster threat or occurrence. It considers the estimation of emergency necessities and identifies the resources to satisfy these necessities. It conjointly involves the preparation of well-designed plans to structure the undivided post-disaster response and acquaint the stakeholders, significantly the communities through information, education, communication, and good practices. Preparedness must be supported by the necessary legislation. Which enables them to handle disaster or similar emergencies that cannot be avoided (Joshi, 2014). Disaster Management

efforts are geared toward disaster risk reduction. Disaster Risk Management "implies the systematic process of using administrative decisions, organization, operational skills, capacities to implement policies, strategies, and coping capacities of society and communities to reduce the impact of natural hazards and related environmental and technological disasters (Roy and Pandey, 2016; UNESCO, 2013). These comprise all forms of activities including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects to hazards".

Many nations are educating their people about hazards and disasters to contribute to the manner of disaster risk reduction and sustainability to minimize potential damage and loss of life through awareness and safety measures for disaster management (Adiyoso and Kanegae, 2012; Chadderton, 2015). Due to a lack of awareness about hazards and disasters, today's conditions are not adequately able to deal with disasters, leading to numerous losses of lives and property. Individuals trained at HEIs and properly educated against disasters can prevent the consequences that risk their lives and property (Shiwaku, 2011). Undoubtedly, disaster preparedness is a priority in all parts of the world. Therefore, education against disasters to increase awareness is of vital importance for people and countries, particularly among young students at the HEIs levels (Tsai et al., 2020; Selby and Kagawa, 2014). When the studies on disaster education were evaluated, it was determined that they focus on students' awareness and knowledge levels related to disaster management for disaster risk reduction, disaster education programs in HEIs and how these issues are portrayed in the media, attitudes, and perspectives on disasters, education on disasters, planning and intervention for disasters, and student and teacher opinions on disaster education (Zhu and Zhang 2017). It is believed that disaster preparedness levels of teachers who are the resource persons under education can be determined with this study. It is significant as it will allow existing disaster education implementations at the HEIs level to be structured in a better manner by determining their deficiencies including the opinions of teachers (Avci, 2022; Bulut, 2020). The idea that teachers' level of preparedness for disasters will affect their students' gaining accurate knowledge, awareness, and experience about disasters is thought to be another indicator of the importance of the research.

NCT-Delhi has experienced many disasters in the past and is vulnerable to disaster-related damages in the future. Delhi is highly prone to multi-hazards like

earthquakes, floods, fires, building collapses, and epidemics. Surrounded by the river Yamuna and its tributary River Hindon, which lurk at the 204.63 m mark it lies in the seismic IV zone (Walling and Mohanty 2009). While East Delhi has problems of being submerged due to massive floods, and all the districts of Delhi are highly susceptible to major fires (Kumar and Bhaduri 2018). In Delhi, villages have been engulfed in the process of urbanization and rural villages are transformed into sub-urban areas. This process has increased the possibility of fire hazards in the capital city.

The increasing population, high urbanization rate, environmental degradation, development of unsustainable houses all have increased Delhi's vulnerability to disasters. This phenomenon has attracted many researchers to study the preparedness level, vulnerability, management, and knowledge of risk reduction in the Higher Educational Institutes (HEIs) of Delhi. Disaster education is aimed not only at implementing HEIs disaster management plans but also at developing an ambiance for preparedness and safety at HEIs. State governments will also ensure the inclusion of disaster management curricula through HEIs (Sharpe and Kelman, 2011). The education content should be designed to inculcate vocational training, emotional well-being, and qualities of leadership (Gangalal et al., 2014). In HEIs for disaster management-related work, the role of the NCC and boys, is also important and also encouraged.

2. The Study Area

The study area selected for the study is HEIs located in the National Capital Territory of Delhi. Delhi is a burgeoning metropolis with a population of 16.7 million and an education hub centre (Census of India, 2011). Delhi is located in northern India and bounded between the latitudes of 28°17' N - 28°00' N and longitudes of 76°24' E - 77°37' E. The capital of India, Delhi shares its borders with the states of Uttar Pradesh and Haryana covering a geographical area of 1,483 Sq Km. There are 9 districts in Delhi such as Northwest Delhi, North Delhi, South Delhi, Central Delhi, Southwest Delhi, West Delhi, New Delhi, East Delhi, and North-East Delhi (Figure 1). The district administration of Delhi exercises supervisory powers over numerous functionaries of the government and is the enforcement department for all kinds of the Government of Delhi's policies.

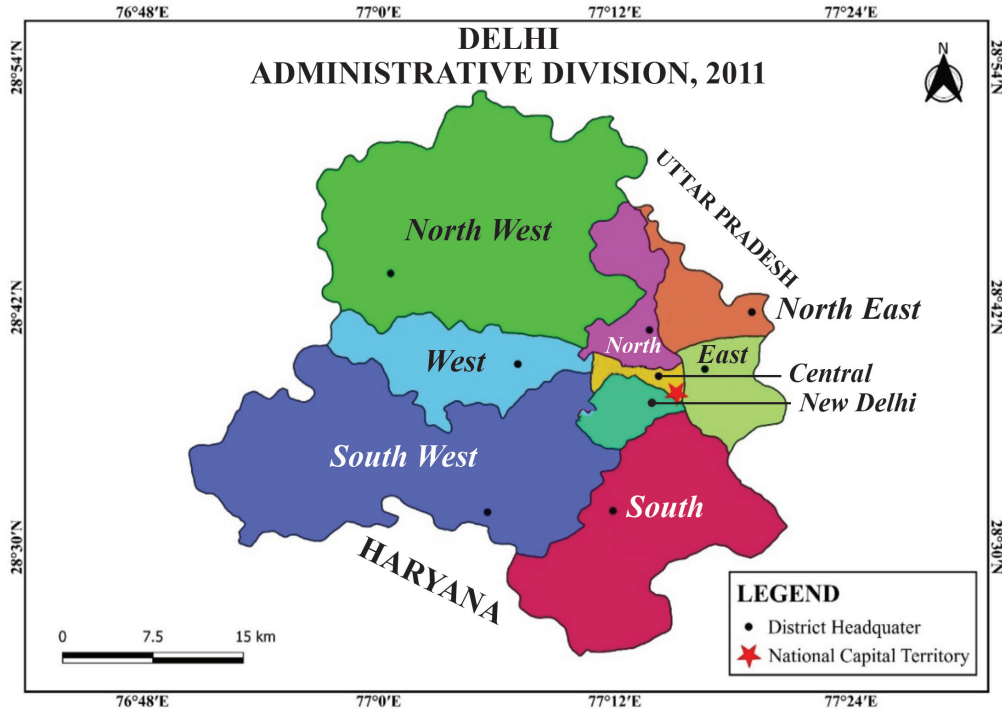

Figure 1: Study Area, Delhi

Source: Prepared by Authors

The selected HEIs in Delhi are the different colleges of Delhi University, like Dyal Singh College, Shaheed Bhagat Singh College, Swami Shraddhanand College, Kiroli Mal College, Maitreyi College, Kamala Nehru College etc. and the different Universities like University of Delhi, Indraprastha University, Jawaharlal Nehru University, Jamia Millia Islamia, Amity University, Noida, etc (Figure 2). The HEIs are selected in a way that they cover maximum part of Delhi. In some places, a higher concentration of institutions can be seen, mainly in the North Delhi district. In the rest of the places, institutions are spaced apart rationally. The metro network has also been represented in Figure 2 to show the connectivity with Delhi Metro.

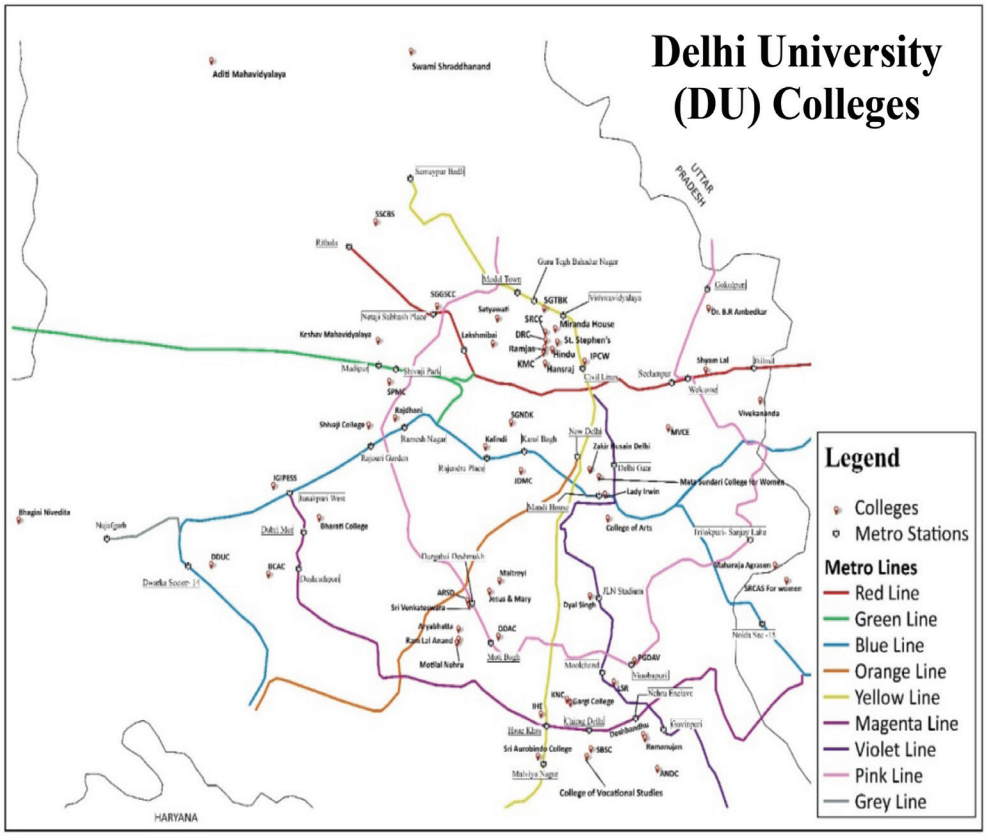

Figure 2: Location of Higher Educational Institutions in Delhi

Source: Based on DMRC Data and Primary Survey (2021-2022)

3. Objectives

To understand the above issues the present study tries to achieve certain objectives, which are below. The study aims: (i) to examine the risk of hazards and hazard prone areas in selected HEIs of Delhi, (ii) to examine the existing level of preparedness plans in HEIs, (iii) to evaluate the role of academic institutions in disaster risk reduction, and (iv) to recommend the management strategies for disaster risk reduction in HEIs of Delhi.

4. Database and Research Methodology

The study is based on both primary and secondary sources of data. The secondary

data has been used to collect basic information. The data has been collected from the Census of India, Delhi Metro Rail Corporation (DMRC), and Google maps for locating the HEIs on the map. For the Primary Data collection, an online survey was conducted through Google Forms conducted during 2021-22. A sample size of 200 people has been taken. The data have been analyzed and processed with the help of statistical techniques. Geospatial techniques (Q-GIS) and MS Excel have been used to represent the data through diagrams such as pie and bar diagrams. Based on the objectives of the study and the questionnaire the data have been analyzed. Primary data have been collected through simple random sampling. Here the samples were the respondents of HEIs of different colleges mentioned above. It includes students, teachers, and the non-teaching staff of HEIs.

The survey was in the form of a structured questionnaire with close-ended and open-ended questions. The questionnaire included questions related to awareness among the three subsets of the population about disasters and disaster management includes students, teachers, and non-teaching staff. Next, the questionnaire contained questions relating to the vulnerability assessment of the Higher Educational Institution of Delhi, and lastly, the questionnaire addressed the questions relating to the disaster preparedness and mitigation plan that exists in the Higher Educational Institution of Delhi. A structured questionnaire was prepared to obtain answers to some of the questions and hypotheses that were made before taking up the research by the researcher. The questionnaire and interview were conducted in three ways: Personal Interview, Telephonic Interview, and Online Interview. This technique helped to get a better insight into people's perspectives about their awareness of the disaster management plans, the preparedness level their HEIs has, and how they are prepared if any disaster occurs.

Linkert scale was used to analyze the exposure and vulnerability of different areas like classrooms, open grounds etc to different disasters. A Linkert scale is a unidimensio nal scale that researchers use to collect respondents' attitudes and opinions. The collected responses are calculated in a range of values. A range of possible responses to a specific question or statement is given to the subjects typically including "strongly agree", "agree", "neutral", "disagree", and "strongly disagree". Often, the categories of response are coded numerically, in which case the numerical values must be defined for that specific study, such as 1 = strongly agree, 2 = agree, and so on.

5. Results and Discussions

5.1 Assessment of Risk and Hazard Prone areas

According to people's perceptions, the study analyzed the hazards to which the HEIs were most prone. For this, the respondents were asked to choose one option out of 7 options, viz: fire hazard, chemical hazard, earthquake, stampede, flood, building collapse, and biological (COVID-19) hazard(Table 1). According to the Linkert scale, these response percentages need to be now categorized into three categories: highly prone (more than 60%), moderately prone (30% to 60%), and least prone (less than 30%) (Table 2). Segregation of the above table needs to be done, on to which scale the percentage of respondents has agreed that this disaster might occur in their institution. This will help to determine to which hazard they are more vulnerable.

Table 1: Different Hazards in HEIs of Delhi

S. No.	Hazard	Responses (%)
1	Fire Hazard	72
2	Chemical Hazard	43
3	Earthquake	62
4	Stampede	14
5	Flood	4
6	Building Collapse	1
7	Biological Hazard	1

Source: Primary Survey (2021-22)

HEIs in Delhi are most susceptible to fire hazards and earthquakes (Table 2). Institutions are moderately prone to chemical hazards and least prone to all the other hazards. While there are several HEIs close to the Yamuna River, the risk of flooding is far less than other hazards, especially fire, chemicals, and earthquakes. This is because, the schools are not located in low-lying areas, and even if some of them are, the river does not carry water there throughout the year and only has a high water level during the rainy season, which occurs infrequently.

Table 2: Susceptible to Hazards in HEIs

Disaster	Least Prone (Less than 30 %)	Moderately Prone (30 % to 60 %)	Highly Prone (More than 60%)
1. Fire Hazard			
2. Chemical Hazard			
3. Earthquake			
4. Stampede			
5. Flood			
6. Building Collapse			
7. Biological Hazard			

Source: Primary Survey (2021-22)

Institutions that are prone to flooding, lie in very close proximity to the river, and hence might be affected by the over-flooding of the Yamuna Bank, otherwise not. The maps in the next section explain the reasons for the high risk of fire hazards and earthquakes, moderate risk of Chemical Hazards, and least risk of flood (Table 3). Using the weighted average method, vulnerable zones in the HEIs were identified. A list of around 10 places was given to respondents, that are common to all the HEIs, and then they were asked to rate them out of 10, 1 is rated as the safest zone and 10 is rated as the most vulnerable zone. After conducting the survey, the data were tabulated as per Table 3. The rating that was given to a place by the maximum number of respondents was taken as its final rating, e.g., most of the respondents rated the basement vulnerability as 10 (most vulnerable), hence basement was put under the Highly Vulnerable Zone.

Susceptible to hazards in higher institutions, under this heading overall risk assessment of the HEIs is done to each of the hazards, as to how prone the college is to a particular disaster, whereas in this table physical vulnerability of specific areas is analyzed to the overall risk factor that is existing.

Table 3: Vulnerable Areas in the HEIs of Delhi

ZONE	Rating (1-3) Low Vulnerable Zone	Rating (3-6) Medium Vulnerable Zone	Rating (More Than 6) Highly Vulnerable Zone
1. Temporary Rooms			9
2. Basement			10
3. Bamboo Rooms			8
4. Football Field	2		
5. Basketball Court	3		
6. Department		5	
7. Canteen			7
8. Library		6	
9. Parking Lot	2		
10. Others		4	

Source: Primary Survey (2021-22)

The rating is out of 10 where 1 is rated as the safest and 10 is rated as the most vulnerable zone during a disaster. The areas taken into consideration are temporary rooms, basement, bamboo rooms, football field, basketball court, department, canteen library, and parking lot. The rates given by the respondents are categorized into three categories i.e., low, medium, and highly vulnerable zones. Areas like football grounds, basketball courts, and parking lots are less vulnerable to a disaster, due to their openness and larger space area so that people can easily gather up if any disaster takes place. The areas are away from the buildings and are safe as parts like windows, and facades from a nearby building which can easily collapse during a disaster.

Areas like the department of the respondents, library, and other areas are moderately vulnerable to any disaster as it depends on the structure and location of the areas. The chemistry department and other science departments can be more vulnerable as compared to the English or history department. Areas such as temporary rooms, basements, bamboo rooms, and canteen are rated as highly vulnerable zones to a disaster. The location and structure of temporary rooms in most HEIs are congested with fewer escape routes making them vulnerable. The basements are also rated the

highest vulnerable zone as if a disaster such as an earthquake occurs the building can collapse leading to no escape routes for the basement people. Similarly, bamboo rooms are made up of weak structures that can collapse and can easily catch fire. Though the structure of canteens is strong due to its prime role, there is always a chance of over-crowdedness which not only increases the risk during a disaster but is also seen as a vulnerable zone to a disaster.

Except for a low ridge as an extension of the Aravalli hills of Rajasthan, the terrain of Delhi is generally flat. The seismicity in and around Delhi is associated with the Delhi-Haridwar Ridge which coexists with the extension of Aravalli Mountain below the Ganga plain to Delhi's northeast towards the Himalayan Mountain. According to the intensity of damage or earthquake occurrence frequency the country has been classified into different zones. Through these zoning maps, the seismic coefficient can be adopted to design buildings in different parts of the country. With the movement of tectonic plates and ground motion, the zoning of earthquakes and landslides in a country is revised. Delhi is located in zone IV. Thus, Delhi comes under a high-risk zone area. In the past, five earthquakes of Richer Magnitude 5.5 to 6.7 are known to have occurred in the UT of Delhi (DDMA, 2024). Two major lineaments namely the Delhi-Haridwar ridge and Delhi-Moradabad faults pass through the territory, both having the potential to generate earthquakes of magnitude up to MSK VIII which is quite probable in the Delhi territory (Figure 3).

Since Delhi has a high seismicity (located in zone IV), there is a general occurrence of earthquakes, and it becomes mandatory to analyze whether the HEIs in Delhi are prone to earthquakes or not. This map shows the micro-seismic zonation map of Delhi. Based on the parameters such as – geological condition, subsurface and bedrock arrangements of ridge and basin, relief and geomorphology, and groundwater conditions, the seismic micro zonation map of NCT Delhi has been prepared (Kumar, 2006). The hazard level of each unit is as follows: (1) weathered rock zone: moderate hazard due to weathering-induced pronounced ground response (2) Chhatarpur basin: high hazard due to basin effect (3) Central Delhi: Moderate hazard due to basin effect (4) Newer Alluvium proximal to Yamuna River: high hazard due to liquefaction potential (5) Zone of basin margin effect west of Delhi ridge: high hazard

(6) South Najafgarh: moderate hazard due to high amplification in liquefaction (7) Northwest Delhi plains: Moderate hazard due to thick, soft sediments (8) Layer of impedance contrast at shallow depth: moderate hazard shown in light yellow colour (9), Ridge ambiance of exposed rock: low hazard shown in grey colour (Figure 3).

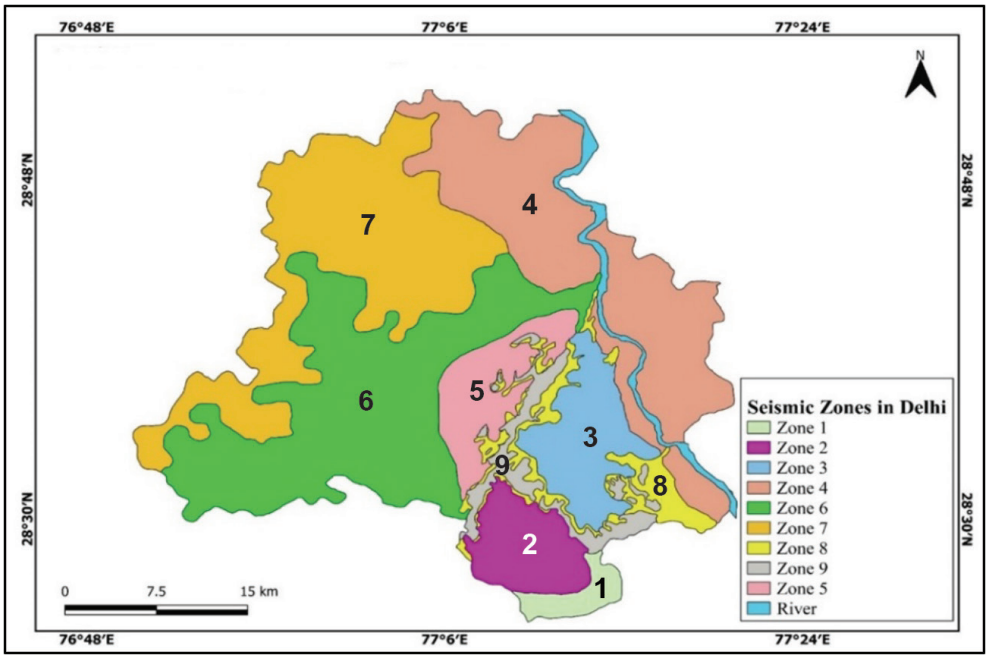

Figure 3: Seismic Level Micro Zonation Map

Source: Prepared by Authors based on Shukla, et.al, 2022

Location of petrol pumps has been used to evaluate the risk of fire hazards in HEIs. The locations of petrol pumps in Delhi located near the HEIs have been found nearby of about 2-3km. Having a petrol pump, in such proximity, of about 200-500 metres makes HEIs highly vulnerable to fire hazards like Dyal Singh College, Indraprastha College for Women, and some HEIs of the North Campus of Delhi University (Figure. 4).

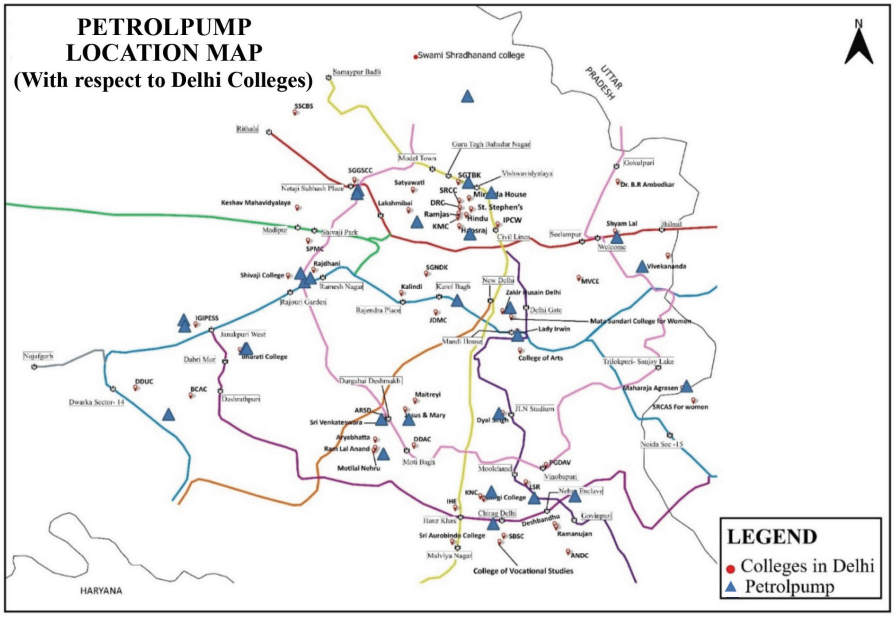

Figure 4: Location of Petrol Pumps in Close Proximity to HEIs

Source: Prepared by Authors using Primary Data (2021-22)

5.2 Level of Preparedness in HEIs

The primary data revealed that most of the respondents are familiar with the term hazard or disaster, while less than 10% of them have experienced a disaster in their respective HEIs. Most of them who did experience were the ones who caught COVID-19 while coming to college, recently. The rest of the disasters like fire, chemical, earthquakes etc were rarely experienced by the respondents in person, though they did think that their institution are prone to these disasters. However, some respondents also mentioned that sometimes they have also felts shocks of earthquakes.

It has been found that most of the HEIs were well-equipped with safety measures and equipment required fire hazards, like fire extinguishers, fire alarms, smoke detectors, etc. On the other hand, all HEIs are found to be not so well equipped to prevent or to reduce the destruction or casualty may be caused by occurrence of earthquakes, floods, or biological hazards. The HEIs showed that they had moderately wide corridors to escape for the people and had a considerable number of exit gates, to manage the large crowd at the same point time during a crisis if the actions were taken rationally.

Hospitals play a crucial role in saving lives and treating people, reducing their suffering during and after a disaster and hence, had a huge role in DRR. It has been found that in most of HEIs the medical rooms were available. However, at the same time, respondents added that they are not well maintained and only had the basic first-aid kit and are not capable of supporting a mass casualty situation which can be caused by an occurrence of a disaster. Though almost all the HEIs are in very close proximity to a big hospital, which makes the institutions a little less vulnerable to the risks of disaster, as the time crisis, medical facilities could be accessed easily, and the negative factor of distance to medical facilities will not make the situation worst (Figure 5). It shows that most of the HEIs have a hospital in a radius of 5 to 10 km.

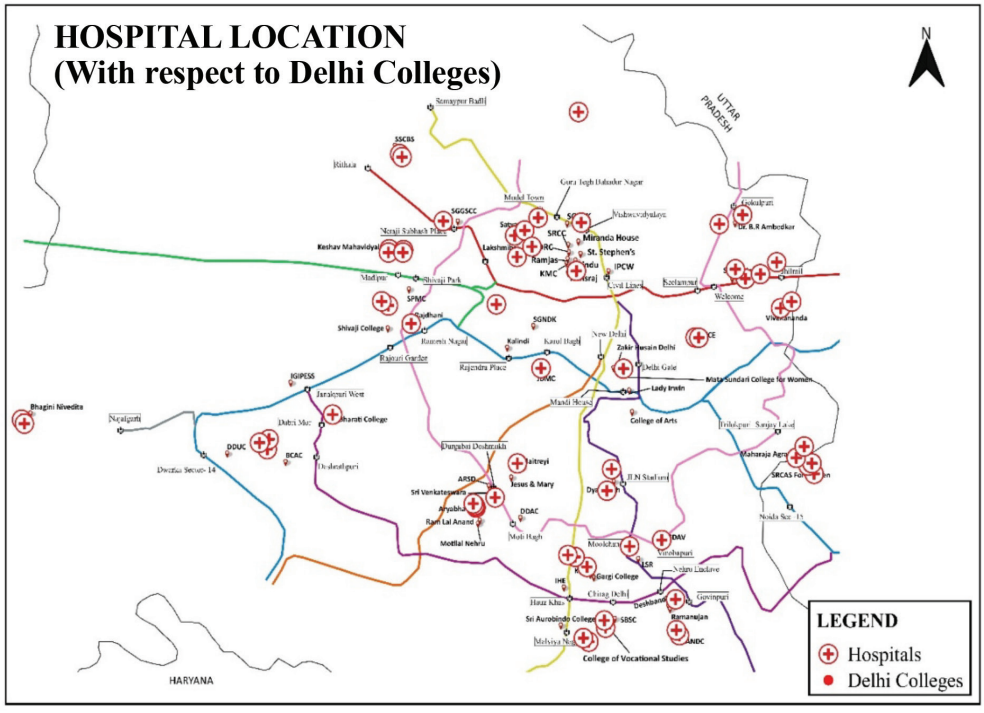

Figure 5: Location of Hospitals and HEIs

Source: Prepared by Authors using Primary Data (2021-22)

5.3 Role of Academic Institutions in DRR

The HEI role is important in all phases of the disaster management cycle. It is

necessarily involved in the phases as it is assigned with the mission of contributing to society. The HEIs helps in mobilizing funds and provide emergency voluntary support. These also help in various other aspects such as academic, awareness, education about the disaster, policies, being part of the reconstruction phase after the disaster, and establishing NGOs and other aids.

Disaster reduction can be achieved by various programs to identify and evaluate the physical characteristics of a disaster, implement strategies for its mitigation, and anticipate its impact while planning response action. However, it has been identified that most of the HEIs did not conduct any mock drills to prepare their stakeholders for a disaster situation, and even if they had the mock drills, most of the respondents of the institution did not participate in it. It was also seen that very few HEIs had proper committee to look after disaster management plans for the institutions. This is the aspect of disaster management cycle where most of the HEIs are lacking. A comprehensive disaster management program or educational curriculum for the community must be developed by HEIs for the purpose of DRR in HEIs. The programs organized by the HEIs should be simple, understandable, high quality, and of lower cost. These programs should be conducted on regular basis by the people actively involved in the preparedness plans of institutions and to provide precise and scientific preparations for the disaster management.

5.4 Management Strategies for Disaster Risk Reduction in the HEIs of Delhi

Most of the respondents were aware of what actions their institution should take to bring about awareness among the stakeholders regarding the escape plans and the actions to be taken during the time of disaster crisis. Most of them even knew about the emergency numbers to call during times of fire hazards, and earthquake while they lacked knowledge of flood management. The most challenging part is responding to a disaster because it requires critical decisions that must be made rapidly in the most critical situation.

Quick and timely emotional responses are needed during a disaster, but quick decision-making is not always correct as it can lack flexibility. In most cases-controlled cognition is better than a quick rational intuition, this can be reasonable but also inefficient. When asked about their first reaction, to a crisis, the majority of them find an escape route and call for the emergency that would restore a sense of control and overcome feelings of hopelessness and helplessness and is a mix of rationalized intuition and intuitive response based on emotions.

The close proximity to Yamuna river explains the risk caused due flooding (Figure 6). It shows a 1 km buffer zone to river Yamuna, with a relative location of the HEIs in Delhi. It is clear that no HEI is in this proximity to the river and are located at quite a considerable distance. It clarifies that overflowing of water during the rainy season would not cause any major flooding situation for the institutions located nearby like IPCW, College of Vocational Arts etc. Hence, it is concluded that the HEIs in Delhi are least prone to flood (Figure 6).

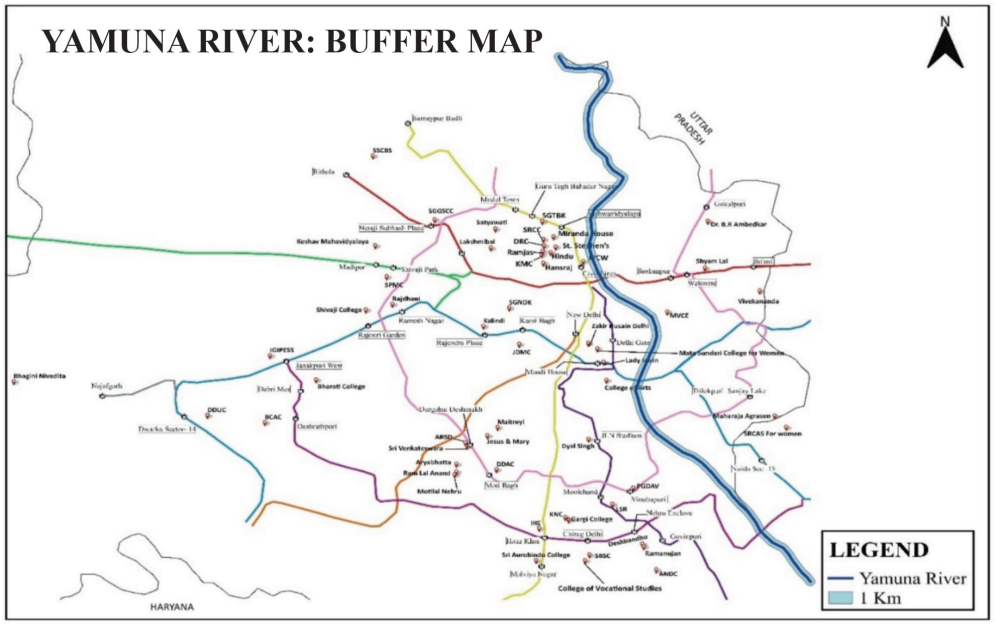

Figure 6: Proximity to Yamuna River using Buffer

Source: Prepared by Authors using Primary Data (2021-22)

If the HEIs of Delhi were well equipped for a disaster, respondents were asked to choose the equipment that was there in college, to which we got the response (Figure 7). 86.2% of the respondents were positive that their institution had fire extinguishers installed at different locations throughout the campus, and 64.7% of the respondents were positive about the presence of fire alarms in their institutions. According to 37.9% of the respondents, their institutions also had smoke detectors installed and 34.5% of the respondents said that their institution was equipped with safety equipment like shoes, helmets, jackets, anti-fog goggles, etc. Though none of

the institutions had prepared themselves for the biological hazard, none were equipped with RT-PCR kits for COVID testing. Some respondents added some remarks to the preparedness level of their institutions, and it can be analyzed that most of the HEIs were prepared for a fire-related disaster, as can be seen from above also, very few institutions had regular mock drills, and even fewer institutions were resistant to earthquakes. Most of the institutions according to the respondents had many open spaces, that provided the inhabitants of the institutions with a proper safe place, in times of disaster. Further, the respondents were asked if the institution had proper exit gates, and wide enough corridors, as exit gates and exit routes during a disaster are as important as the presence of safety equipment and the number of exit gates. The width of corridors through which the escape plans would be executed plays and important role in the formulation of a proper evacuation plan to be executed in times of disastrous situations, and their importance cannot be ignored in an area, especially where a large number of populations tends to be present. The moderately broad corridors will cause a problem only in a situation when the people escaping from the passage, do not properly follow the protocols and take irrational steps causing a situation of chaos and panic among other people as well.

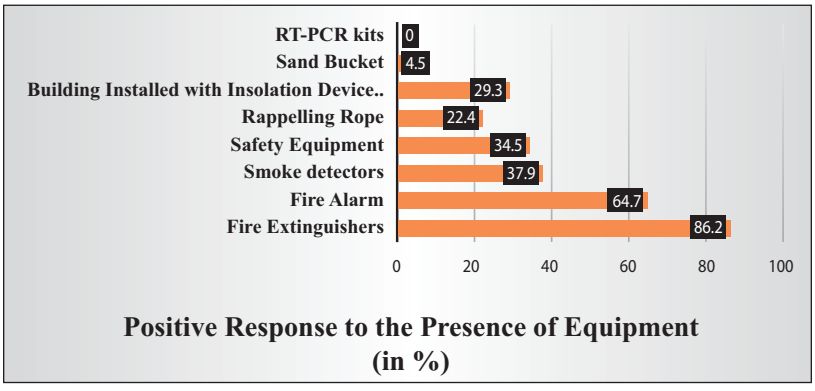

Figure 7: Capacity Building for Disaster Management in Higher Institutions

Source: Primary Survey (2021-22)

The majority of the HEIs show sufficient number of exit gates, ranges from 2 to 5. This is a considerable number of exit gates and will be helpful in times of emergency. Very few institutions had less than two exit gates, Like Shivaji College, Kalindi College,

and New Delhi Institute of Management. Further, when asked if their respective departments had proper exit gates and escape plans or not, and most of the respondent's reaction to it was moderate, that is the exit routes are planned in individual departments of the institutions, but when seen with respect to escape of a large number of populations, those plans might fail or might cause some problem, during a disastrous situation, if the actions are not taken rationally.

A preparedness plan for any disaster not only comprises of installation of equipment at different places for different disasters and having proper escape plans and exit routes to be used during the time of the disaster, but the HEIs also must be aware of its stakeholders about such escape routes, exit gates, and how in the time of emergency one should use the safety equipment. For this awareness among the stakeholders, the organization of proper mock drill sessions at regular intervals is very necessary, in the presence of a committee that overlooks such mock drill sessions and awareness programs, in the institution. So, to analyze, whether the HEIs of Delhi has such regular mock drills or not, or if they at least had a committee or society for making people aware of disasters and their management plans, to which their response was as follows.

As per Figure 7, the majority of the stakeholders don't know, if their respective HEI has regular mock drill sessions or not and whether the college has a committee or society for making people aware about disasters and had a management plan for the same. This means that both things are not so prominent in the HEIs of Delhi and they lack the aspect of preparedness from the disaster management cycle. Once actions for prevention, mitigation, and preparedness plan are taken, the disaster management cycle towards, managing the crisis caused after the disaster has occurred. This process includes a response, relief, and rehabilitation for which the presence of proper medical services is an important aspect. To analyze whether the inhabitants of the HEIs in Delhi had proper access to medical services during the crisis period, some questions related to college proximity to hospitals and the presence of a medical room in the institution were asked, to which the response was as follows. Almost all the HEIs of Delhi have quite a good proximity to the hospitals outside their campus, as no respondent said that the nearest hospital is more than 10 km away from the institution, and most of the HEIs have hospitals in around the 2-5 km range. 97% of the respondents said yes to the presence of a medical room in college and only 3% disagreed with it. But when asked about the condition of the medical room, and whether they could support a

disaster crisis, most of the respondents were susceptible to this and disagreed that the HEI medical room could support a crisis caused after the occurrence of a disaster, as at almost all times the basic first-aid kit is also not available (Figure 8).

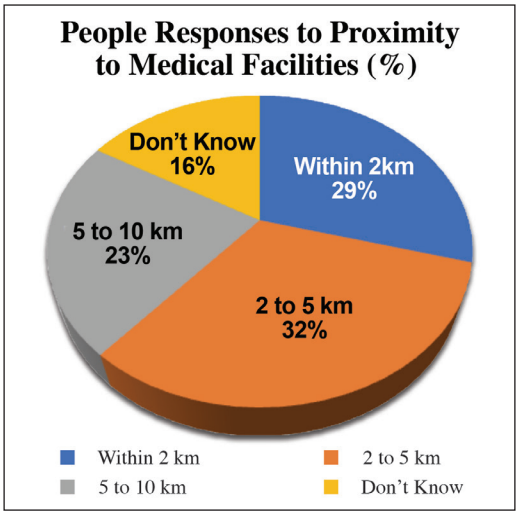

Figure 8: Responses to Medical Facilities Availability

Source: Prepared by Authors using Primary Data (2021-22)

5.4.1 General Awareness among the Stakeholders Regarding Disaster Management

Once all the planning is done for disaster management, equipment being installed, escape routes, being properly planned out, and mock drill sessions being done, it's the stakeholders of the institution who need to take action at the time of crisis. Actions related to calling for an emergency, properly executing the escape plans, and showing the presence of mind during a time of crisis are the duties of a stakeholder of that institution. To fulfill such a duty, one needs to be aware of certain things like the emergency numbers to call, in different disaster situations or the knowledge about the exit gates in HEI is important because without that knowledge one cannot execute escape plans, etc.

5.4.2 Awareness among the Stakeholders

After asking the respondents, about the preparedness plan of their HEI, they were asked what steps should be taken by the HEI, to mitigate the effects of the disaster.

This question was asked specifically to plan future developments in the institution regarding disaster management preparedness. There is a demand of the stakeholders of the institution to prepare the plan for disaster management, and by which action, the majority of the stakeholders will be in a good position to execute the management plans during the time crisis.

The majority of the stakeholders are in opinion of organizing the awareness programs as well as there is a need for a disaster management committee in the institution. This clears the picture that, to bring about awareness among the stakeholders, the role of the institution becomes very important by organizing regular mock drills and forming a committee that looks into the disaster management preparedness strategies for the institutions. Even the majority of the stakeholders want the same because awareness about the escape routes of the place knowing the placement of safety equipment in the college, knowledge about the exit gates, etc can only be made available by the institution itself (Figure 9).

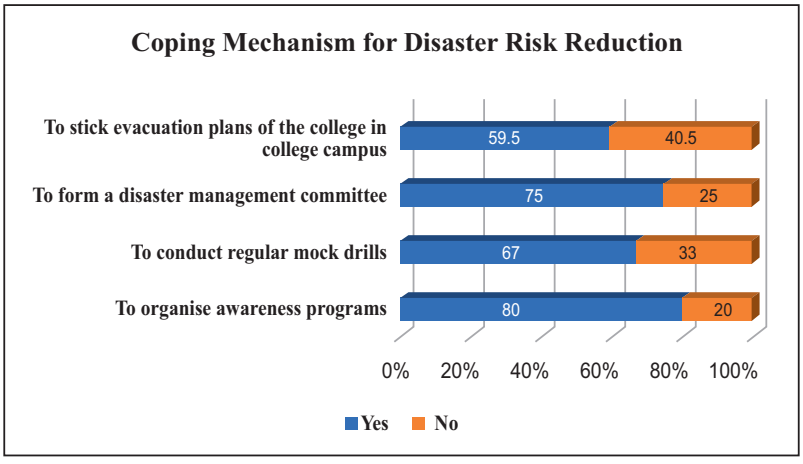

Figure 9: Responses for Coping Mechanism for DRR in Selected HEIs

Source: Based on Primary Survey (2021-22)

Further, after understanding the escape routes or the management plan to be undertaken in times of crisis, the individual's action matters then, as to whether he/she takes the decision rationally or not. After taking the stakeholders' perspectives about the steps to be taken, HEIs should take their reaction during the time of crisis.

6. Conclusion

Educational institutions are expected to plan and formulate mitigation plans 'pre-disaster' situation. They can only educate and inform the people and can implement the basic measures before a disaster to reduce the vulnerability of the stakeholders. Institutions need to develop preparedness mechanisms and strategies to strengthen and increase the effectiveness of the emergency response. These include the development or formation of such types of structure and non-structural safety precautions as evacuation procedures (including how to disseminate these procedures to the public), search and rescue teams (including plans for training them), assessment teams (including plans for training them), an assessment process and information priorities for an emergency response measures for the disaster risk reduction.

Natural disasters do not have any social or economic considerations nor do they have any coherent administration. There have been several disasters in Delhi in the past, and it is highly vulnerable to multi-hazards such as earthquakes, floods, fire accidents, as well as epidemics. In this study, HEIs across Delhi were analyzed to determine their proneness to disasters, preparedness, management, and risk reduction knowledge. It can be concluded that most of the students are aware of the term disaster and know their college and its location well. Disaster management occupies an influential place in the policy framework as it helps prevent and mitigate disasters. With this study, the importance of education in promoting and enabling DRR has already been identified in many institutions. The study has also established that to accelerate the assessment of disaster risk management, many strategies can be adopted like awareness campaigns, mock drills, disaster management societies, capacity-building programs, etc. can be done. Thus, HEIs play an instrumental role in influencing younger minds to develop adequate values and reflexes against disasters.

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Unfolding the Success Story of NDRF at Siang River Crisis Management: Strategic Planning and Deployment

Umesh Kumar Thapliyal[1] and Kaushalendra Pratap Singh[2]

Abstract

Disaster management involves the development of strategic plans and procedures aimed at safeguarding vital infrastructures from significant harm caused by natural or man-made calamities and catastrophic events. Disaster management is a comprehensive and ongoing process that involves the careful planning and implementation of actions to minimize harm to both people and property. This paper presents a case study on the deployment of the National Disaster Response Force (NDRF) during the Siang River Crisis caused by a landslip that obstructed the mainline of the Brahmaputra River in the Tibet autonomous area, resulting in the formation of a barrier lake. The presence of this temporary lake constituted a threat to the downstream Indian region, since there was a possibility of an abrupt discharge of water. This discharge had the potential to cause flooding in the catchment area of the Brahmaputra River in India. Hence, the study aims to elucidate the Siang River Crisis and the swift reaction of NDRF 12th Battalion (Bn) in terms of strategic planning and deployment. The credit for crafting the narrative during this crisis should be attributed to none other than the NDRF officials and staff, as well as the HQR NDRF in New Delhi, for promptly and punctually disseminating the information.

Keywords: *Siang River, Crisis, Management, NDRF, Strategic Planning, Deployment.*

1. Introduction

On the morning of October 19, 2018, the 12th Battalion (Bn) of the National Disaster Response Force (NDRF), located at the foothills of Doimukh village in Arunachal

[1] **Umesh Kumar Thapliyal,** DIG, SSB and Former Commandant, 12 Bn NDRF, Arunachal Pradesh, India
[2] **Kaushalendra Pratap Singh,** Associate Professor, Department of Social Work, Rajiv Gandhi University (A Central University), Rono Hills, Doimukh, Arunachal Pradesh, India

Pradesh, around 20 kilometres from the state capital Itanagar, was celebrating Durga Puja at a temporary residence. The personnel of the National Disaster Response Force (NDRF) were occupied with finalising the preparations for the last day of the religious ceremony and organising the process of submerging the idol of Goddess Durga. However, before the festivities could come to an end, the obligation to fulfill one's duty arose. The immersion programme had to be abbreviated and expedited. Amidst the blaring siren, the NDRF personnel swiftly moved, clutching their vibrant Orange bags, and formed a neat queue. Shortly thereafter, individuals carrying orange bags were observed departing through the gate in loud automobiles. The message was intended for the determined rescuers who are dedicated to preserving the lives of individuals.

The story commenced when the Department of International Cooperation and Technology of the Ministry of Water Resources of the People's Republic of China transmitted three facsimiles to the Central Water Commission (CWC), Government of India, regarding a landslip obstructing the primary flow of the Brahmaputra River at the Milin Section, situated 70 kilometres downstream from the Nuxia hydrological observation station. The approximate volume of water storage blocked was estimated to be around 62 subsequently, the water began to exceed the capacity of the barrier caused by the landslip, resulting in a discharge of around 18000 m^3/s. The anticipated volume of water flow, taking into account multiple contributing streams, was projected to arrive at Tuting about 9-10 pm on October 19, 2018, and at Pasighat between 4-5 am the following day. Anticipated at both of these stations was an extraordinary volume of water. The relevant domestic departments in India were instructed to carefully consider the supplied information in order to prevent any panic situation. They were advised to take appropriate precautionary measures to relocate people to safer locations. Following the aforementioned information, all relevant authorities in the region were placed in a state of heightened vigilance, and the Central Water Commission (CWC), a government agency in India, issued an advise regarding the situation.

On 19/10/18 at 1000 Hrs, the Commandant of NDRF 12th Bn received information from NDRF HQ New Delhi via telephone and fax. The information stated that NDRF teams needed to be pre-positioned in District East Siang and Upper Siang of Arunachal Pradesh, as well as Dibrugarh and Dhemaji of Assam. This was due to the formation of an artificial lake in the Milin province of China, caused by a large landslip upstream of the Siang River. The exact location of the lake is unknown.

Figure 1: Deployment of NDRF Personnel

Later that day, the Commandant received another telephone request from the Chief Secretary to the Government of Arunachal Pradesh regarding the ongoing worrying situation caused by the issue with the Siang River. Later that day, at 1200 Hrs, the Secretary of Disaster Management in Arunachal Pradesh provided information about an emergency meeting scheduled for 1300 Hrs in the Chief Secretary Conference room. The purpose of the meeting is to discuss the emergency situation caused by the formation of an artificial lake in River Siang and to participate in a Video Conference with Cabinet Secretary of New Delhi. Subsequently, the Commandant and his team of officers participated in an Emergency Meeting at the Chief Secretary Conference room. They also engaged in a Video Conference with the Cabinet Secretary of the Government of India in New Delhi on 19/10/18 at 1300 Hrs. It was discovered that a flood was imminent due to the accumulation of water and the creation of an artificial lake caused by a landslip and blockage in the River Siang. It was suggested that if the blockage was overcome, the water level of Siang would increase and impact the population residing along the river's banks.

The Ministry of Water Resources of China reported that landslides obstructed the Milin section of the main stream of the Brahmaputra river/Siang/Yarlung Zangbo river (located 80 kilometres downstream from Yarlung Zangbo River to the Nuxia Hydrological Station for flood reporting in India) from the late hours of October 16th

to the early morning of October 17th, 2018. This obstruction was anticipated to affect the water conditions in the lower parts of the Yarlung Zangbo River. The Chinese government was instructed to maintain a vigilant focus on the obstruction of the Yarlung Zangbo River. If any additional information becomes available, the Indian side will be promptly contacted.

The National Disaster Response Force (NDRF), guided by its slogan "Apda Seva Sadaiv" (meaning "An Ever-Ready Commitment to Service during Disaster Situations"), deployed teams from the 12th Battalion on 19/10/18 as per the need. The first team was mobilised at 1430 Hrs on 19/10/18. Until the early hour of 20/10/18, eight teams from the unit had been deployed at different locations in Assam and Arunachal Pradesh. Therefore, the present document tries to unfold the success story as a Case Study on the timely Deployment of Resilient Saviour i.e. NDRF on Fury Siang River Crisis in Arunachal Pradesh along with essential lessons learnt for the future humanitarian interventions.

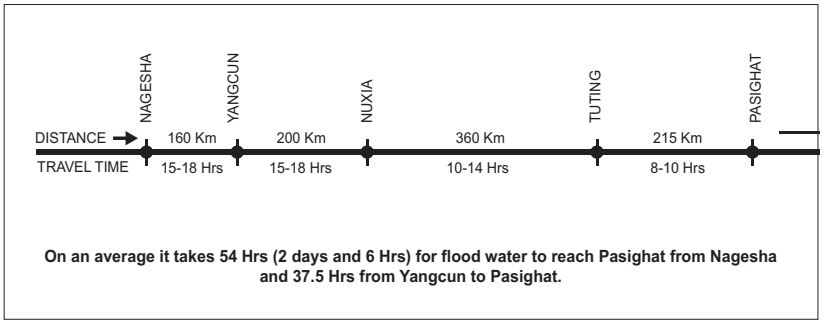

Figure 2: River Line Diagram from Nagesha (CHINA) to Pasighat (INDIA)

Source: Information Received by 12th Bn NDRF from NDRF HQ New Delhi

2. Objectives

This paper tries to unfold the success story of NDRF at Fury Siang River Crisis Management along with spreading awareness of the prompt and timely response by NDRF among different stakeholders.

3. Research Methodology

The nature of the study is qualitative and adopts a descriptive research design based on firsthand knowledge gathered by the author during the Siang River Crisis.

4. National Disaster Response Force (NDRF)

The succession of severe natural calamities in India and the International environment made it critical to press for, the need of a comprehensive disaster management plan. In this regard, on 23rd December, 2005, Disaster Management Act was enacted. The National Disaster Management Authority (NDMA) was constituted for disaster management.

The Disaster Management Act has statutory provisions for constitution of National Disaster Response Force (NDRF) for the purpose of specialized response to natural and man-made disasters. Accordingly, in 2006 NDRF was constituted with 8 Battalions. However, presently NDRF has strength of Sixteen (16) Battalions, Four (4) Bn each from BSF & ITBP, Three (3) Bn from CRPF, Two (2) Bn each from CISF & SSB, and One (1) from Assam Rifles. All the 16 battalions of NDRF are equipped and trained to respond in any situation (https://ndrf.gov.in/).

12th Bn NDRF

12th Bn NDRF with HQ at Doimukh in Arunachal Pradesh, is looking after Disaster Management in the States of Arunachal Pradesh, Manipur, Nagaland, and Upper Assam. It is originally a SSB Battalion.

5. Recent Deadliest Disasters in the Region

The region is affected by several natural disasters such as floods, earthquakes, and landslides (Pal & Shaw, 2017; Hindustan Times, 15 July 2017). The North Eastern area of India has experienced significant progress, including the inauguration of India's longest bridge, the 'Dhola Sadiya Bridge', and the announcement of the upgrade of Guwahati airport to an international airport (The Hindu, 2024). Despite the significant accomplishments, the 'Seven Sisters' are annually shaken by natural disasters as the northeastern region (NER) of India lies in seismic zone-V as per IS 1893 (2002) in the country and is considered one of the most seismically active zones in the world. As per, North Eastern Regional Node for Disaster Risk Reduction of North Eastern Space Applications Centre (NESAC) northeast has a very complex tectonics and geological setup (https://nerdrr.gov.in).

6. NDRF De-induction

Upon receiving a warning, the Search and Rescue (SAR) teams from the NDRF 12th Bn were dispatched to the region affected by the tragedy. This phase of activity is quite important since the teams are disbanded. The decision of the Deputy Commissioner

was intimated to the Commandant 12th Bn NDRF and the plan for de-induction of troops was sorted out accordingly – Three teams of 12th Bn NDRF pre-positioned at Mebo, East Siang after obtaining fuel from the state authorities were de-inducted on 21/10/18 at 1645 Hrs and reached NDRF location Dhemaji at 2030 Hrs and made night halt enroute. The teams further moved at 0500 Hrs on 22/10/18 and reached unit headquarters on 22/10/18 at 0930 Hrs. Two teams of 12th Bn NDRF pre-positioned at Yinkiong district after obtaining fuel were de-inducted at 0430 Hrs on 22/10/18 and reached their unit headquarters at 1730 Hrs on 22/10/18.

Meanwhile, the process of transporting the 08 teams of NDRF 3rd Bn via train for their de-induction was underway. Train services were unavailable in Pasighat, East Siang. As a result, alternative arrangements had to be made from the nearest Railway station, 'Morkongselek', located in Jonai, District Dhemaji, Assam, which is around 45 kilometres distant from Pasighat. Due to its tiny size, Morkongselek Railway station only has one Express train that operates between Morkongselek and Guwahati, Assam. This train lacks sufficient waggon capacity to convey the equipment and supplies for all eight teams. Consequently, other plans were necessary to convey equipment and supplies by road to Guwahati, Assam.

Due to its remote location, Pasighat and the neighbouring territories of Assam and Arunachal Pradesh faced difficulties in quickly locating trucks, as it was a small-town distance from the city centre. The district administration secured two trucks to move stocks and equipment from their site to New Guwahati yard in Assam, which is around 600 kilometres away. The hunt for these trucks took a long time and they were finally arranged on 22/10/18. On 22/10/18 at 1930 Hrs, SOs-02 and ORs-02 successfully transported stores and equipment from Pasighat via road. A bandh was announced in Assam by certain organisations on October 23, 2018. As a result, the trucks were unable to move on that day and had to stop near Banderdewa, which is around 17 kilometres away from the headquarters of the 12th Battalion of the National Disaster Response Force (NDRF). The Commandant, perceiving the issue caused by the bandh, provided an escort for the vehicles to ensure their safe stoppage at the unit headquarters. The trucks proceeded towards Guwahati around 1900 Hrs on 23/10/18 and arrived at New Guwahati yard on 24/10/18 at approximately 0830 Hrs to load additional supplies and equipment into the reserved waggon. The waggon was loaded at approximately 1530 Hrs on 24/10/18 with assistance from the manpower given by NDRF 1st Bn in Guwahati.

The remaining teams embarked on the Lachit Express train on 24/10/18 at 1915 Hrs from Morkongselek and arrived at Kamakhya on 25/10/18 at 0730 Hrs. The entire crew embarked on the Kamakhya-Puri Express train from Kamakhya on 25/10/18 at 2345 Hrs and arrived at the 3rd Bn HQ Mundli on 27/10/18 at 1300 Hrs.

On October 24, 2018, six teams from the NDRF 2nd Bn were de-inducted. On 24/10/18 at 0230 Hrs, four teams stationed at Jonai and one team stationed at Lakhimpur departed for Dibrugarh. They travelled to Dibrugarh Railway Station using vehicles provided by the local officials and arrived at 0730 Hrs. Transportation for their movement was organised via train. On October 24, 2018, at 1825 Hrs, the six teams of the NDRF 2nd Battalion in Kolkata boarded the Kamrup Express train from Dibrugarh and safely arrived at their unit location at the RRB Campus in Haringhata, Mohanpur, Nadia District, West Bengal on 26 October, 2018, at 1030 Hrs.

7. Strategic Planning and Deployment

Good plan can accelerate response and significantly reduce of danger. Therefore, teams were deployed as per the strategic planning. A team of D' Coy 12th Bn NDRF Hollangi under the command Insp/GD Indra Singh Bist equipped with Flood and Rope Rescue equipments was dispatched at 1430 Hrs on 19/10/18 and reached Yingkiong at 1400 Hrs on 20/10/18 and pre-positioned at Yinkiong District of Arunachal Pradesh. They were accommodated at Multipurpose Hall Yingkiong. A team of F' Coy 12th Bn NDRF Hollangi under the command Insp/GD Thang Joseph equipped with Flood and Rope Rescue Equipment was dispatched at 1630 Hrs on 19/10/18 and reached Yingkiong at 1400 Hrs on 20/10/18 and pre-positioned at Yinkiong District of Arunachal Pradesh. They were accommodated at Multipurpose Hall Yingkiong. A team of B' Coy 12th Bn NDRF Doimukh under the command Insp/GD Rakesh Kumar equipped with Flood and Rope Rescue Equipment was dispatched at 1830 Hrs on 19/10/18 for pre-positioning at East Siang District of Arunachal Pradesh and reached the location on 20/10/18 at 0845 Hrs and accommodated at Govt. Secondary School, Kiyit Pasighat, District East Siang. A team of E' Coy 12th Bn NDRF Itanagar under the command Insp/GD Mintu Sonowal equipped with Flood and Rope Rescue equipments was dispatched at 1830 Hrs on 19/10/18 and reached for pre-positioning at East Siang District of Arunachal Pradesh on 20/10/18 at 0825 Hrs and accommodated at Mebo Pasighat East Siang. A team of

A' Coy 12th Bn NDRF Doimukh under the command SI/GD Diwakar Yadav equipped with Flood and Rope Rescue equipments was dispatched at 2210 Hrs on 19/10/18 for pre-positioning at East Siang District of Arunachal Pradesh. The team reached Pasighat at 0345 Hrs on 20/10/18 and later was pre- positioned at Kiyit, Mebo in East Siang. A team of C' Coy 12th Bn NDRF Dhemaji under the command Insp/GD Sunil Kumar Yadav equipped with Flood and Rope Rescue equipments was dispatched at 0230 Hrs on 20/10/18 and reached the assigned location on 20/10/18 at 0435 Hrs at Gali GPO Jonai under Dhemaji District of Assam. Two more teams of C' Coy 12th Bn NDRF Dhemaji were pre-positioned at Coy Location, Dhemaji, Assam with Flood rescue equipments under the command of SI/GD Sushil Kumar and SI/GD Ranbir Singh Pathania respectively.

Teams on pre-Monsoon deployment in the Districts of Sibsagar, Tinsukia and Jorhat of Assam were kept on high alert to meet any kind of eventuality. In the meantime six teams of 2nd Bn NDRF, Kolkata led by Sh. Yogesh Singh Sengar Dy. Commandant were Airlifted at 0030 Hrs on 20/10/18 and landed at Airport, Dibrugarh at 0130 Hrs on 20/10/18 to be pre-positioned in the district of Dibrugarh, Dhemaji and North Lakhimpur. The three teams were accommodated at Town Hall Jonai – Dhemaji, one team at Gali GPO Jonai- Dhemaji, one team at Mancutti CRPF camp Dibrugarh and one team at Circuit House Dhakuakhana – Lakhimpur. In total eight teams of 3rd Bn NDRF Mundli, Odisha equipped with Flood Rescue equipments under the command of Sh. B. K. Das Dy. Commandant were also airlifted from Bhubaneswar Airport at 0330 Hrs on 20/10/18 and landed at Pasighat, Airport at 0535 Hrs on 20/10/18 and pre-positioned in the district of East Siang. Five teams were accommodated at Pasighat Stadium, one team at Kiyit Govt School Pasighat, one team at Seram Primary School at Pasighat and one team at Panchayat Hall at Namting Pasighat.

Shri Pranab Daimari, the Deputy Commandant, and Shri Vimal Gupta, the Assistant Commandant/General Duty, of the 12th Battalion of the National Disaster Response Force (NDRF), Doimukh, departed from the Battalion Headquarters at 1900 Hrs on 19/10/18. They are heading to Pasighat in the East Siang District and Yingkiong District in Arunachal Pradesh, respectively. Shri Pranab Daimari, the Deputy Commandant, was assigned the role of a liaison officer to oversee the deployment of NDRF personnel and supervise operations during a disaster. At 0230 Hrs on 20/10/18, he arrived in Pasighat and met with the teams from 3rd Bn NDRF Mundli. He then strategically placed the

teams at several sites in the East Siang District. Shri Vimal Gupta, an Assistant Commissioner in the General Duty cadre, relocated to Yingkiong. He assumed the role of leader and supervisor for both teams in Yingkiong.

The case study of deployment highlighted the need of Emergency Response as a necessary requirement for proactive involvement in situations that endanger the well-being of human resources. The success of the 12th Battalion of the National Disaster Response Force (NDRF) should not be measured based on any tangible results. However, the emergency response strategy mentioned above demonstrates the characteristic of a highly prepared NDRF team, whose motto, as indicated earlier, is "aapda seva sadaiv". The NDRF has been entrusted with the crucial role of "saving lives and beyond". This demands its personnel to be constantly prepared. The Fury Siang River Deployment Strategy, as mentioned earlier, is a testament to their dedication and diligence.

8. Rapid Response, Resilience, and Reflections

The outflow of water from the manmade lake created by a large landslip in Tibet was extremely severe. The early assessment of the area was hindered due to the gradual breach of water. Nevertheless, a person was successfully rescued at approximately 1900 hours on October 20, 2018, after being choked on the opposite side of the surging waters of the Siang River. A specialised unit consisting of members from the 3rd Battalion of the National Disaster Response Force (NDRF) effectively carried out the operations. Two inflatable boats equipped with outboard motors (OBM) were utilised during the activities. The utilisation of Lighting Towers and Torch lights was crucial in facilitating illumination and signaling during the activities.

The induction of teams on such a big scale with such little notice had not been previously experienced. The learning experience was highly beneficial for all members of the 12th Battalion of the National Disaster Response Force (NDRF). The troops have acquired valuable knowledge and gained the opportunity to learn the art of crisis management during operations. The major reflections may be highlighted as below:

a) Planning is the key component of all crisis management. If the planning is executed effectively, the outcomes will be favourable.
b) The hierarchical structure and prompt communication of instructions are also essential components of crisis management.

c) The multi-disciplinary team of 12th Bn NDRF Team and their knowledge, performance and operational response quality during this operation was exceptional.

d) Optimal resource utilization took place in terms of Appropriate Utilization of man power and equipment of National Disaster Response Force.

e) Smooth 'coordination' and exchange of information with local administration is critical.

f) It has been learnt from this exercise that NDRF teams should be prepared always to jump into response during such types of disaster.

g) Mobilization of various NDRF Teams from different parts of the country in a short notice and induction in the affected area within a stipulated time period that too in coordinated manner was exemplary which as primarily due to frequent exposure of the force for all such type of contingencies.

h) In case of any critical situation 'coordination' among various government departments and agencies and integration of various resources available with different governmental and non-governmental organizations is the key of success.

i) Role of Indian Air Force for lifting of NDRF Teams from different locations and deploying them in the affected area was significant.

j) Induction of teams in such a large scale within short notice wasn't experienced until then. It was a very good learning experience for all ranks of 12th Bn NDRF to be prepared for an unplanned and emergent action.

k) During the flood in river Siang both the states i.e. Arunachal Pradesh and Assam get affected and both the states should respond in proper and coordinated manner in future as well.

l) There should be proper resource mapping and timely updating of that i.e. earth movers, civil bus, privet transporter, dumper, local wooden boat. SDMA of both states require proper sharing of information.

m) Mock drill based on flood in River Siang should be planned every year by the SDMA of both the states and other stake holders.

n) Early Warning System & Relief Centre to be earmarked in advance and proper action plan should be worked out and distributed to all stakeholders so that all should know what action has to be taken during the emergency.

9. Conclusion

History has its lessons to offer, to ignore which is to risk repeating them with tragic consequence. After the intervention of NDRF the water logged has been gradually breached out therefore the danger of creating flood didn't arise anymore. It was because of strategic planning, timely deployment and response of NDRF personnel. Therefore, on 21/10/18 at 1300 Hrs Deputy Commissioner of East Siang district called a meeting and called off the Ops and asked DDMO East Siang to withdraw the NDRF teams to their respective units. Therefore, the rapid response of NDRF 12th Bn in terms of Strategic Planning and Deployment could prevent a major probable damage due to Siang River crisis situation. Being located at a state as remote as Arunachal Pradesh and having responsibility to look after the high hazard zone as North East India, it is imperative for NDRF forces to have an approach for continuous quality enhancement with an uncompromising zeal for service towards humanity.

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Geospatial Analysis of Seismic Zone and Infrastructure Development Challenge in Himachal Pradesh

Manoj Kumar[1], Krishna Kumar[2]
Manjit Singh[3] and Garima Aggarwal[4]

Abstract

Himachal Pradesh is vulnerable to a wide range of man-made and natural disasters. Draughts, dam failures, landslides, flash floods, snowstorms, avalanches and forest fire are among the main threats. The biggest hazard to the state, however, is the possibility of earthquakes. On the basis of previous data, there have been more than eighty earthquakes of a magnitude greater than 4. Examining the spatial relationship between seismic zones and the development of the studied area's infrastructure was the primary goal of the article. The primary source of secondary data for the study is the Indian Geological Survey, Indian Census, Department of Health, Department of Education, and Department of Road and Transport, among other departments. An index of infrastructure development has been computed, with a normalized scale ranging from 0 to 1, where 1 denotes a high level of infrastructure development. The Geographical Information System (GIS) platform used to perform earthquake zonation. The findings of the study have showed that highly vulnerable seismic zones of the state have high level of infrastructural development.

Keywords: *Seismic Zone, Earthquakes, Geographical Information System, Infrastructure Development.*

[1] **Manoj Kumar,** Ph. D Research Scholar, Geography Department, Indira Gandhi National Open University (India).
[2] **Krishna Kumar,** Assistant Professor, Discipline of Geography, School of Sciences, Indira Gandhi National Open University, New Delhi (India).
[3] **Manjit Singh,** Assistant Professor, Department of Geography, School of Earth, Biological and Environmental Sciences, Central University of South Bihar (India).
[4] **Garima Aggarwal,** Senior Consultant, Resilient Infrastructure Division, National Institute of Disaster Management, MHA, Govt. of India.

1. Introduction

A notable correlation exists between the idea of disaster management, the development of facilities and the quality of infrastructure, design, and construction techniques. Scholars in different academic fields have not yet investigated this connection. In terms of regulations and codes, many researchers have proposed that modifications to planning and development policies typically incorporate the lessons learnt from post-disaster evaluations. However, it is still to be implemented that the risk-based approach to infrastructure development and planning is not evident at this level. Socio-economic infrastructural development affects the spatial distribution of economic activities and therefore it is important to understand the spatial profile of future development, which can take place in more or less disaster-prone locations.

According to Hall et al. (1992), a hazard is an occurrence or activity that could cause harm or adverse outcomes to persons or property. The magnitude of a hazard is the amount of harm and the severity of the consequences resulting from that hazard (De Rodes and Deneen, 1994). Out of the hundred most deadly and hundred most expensive natural disasters of the 20th century, 25 and 15 events respectively were due to earthquakes (EM-DAT 2006). Human population growth has made people more susceptible to future earthquake disasters, even though seismic intensity and magnitude might not have increased over time (Kolars, 1982). Early work (Liu and Hsieh, 1981; Scawthorn et al., 1981) centered around identifying damage/loss pattern from existing earthquakes data and predicting it for future earthquakes.

Estimating the consequences of building damage, such as casualties and economic losses, is also assisted by earthquake zonation and vulnerability assessment (Coburn and Spence, 2002). Planning for land use can be a very effective strategy for minimizing damage from natural disasters. According to Morrow (1999), social and economic processes dominate in risk mapping and management, impact and response, and even research. Planning initiatives influence both the location and the manner in which development occurs (Godschalk et al., 1998) and aid in building a constituency of informed citizens who support hazard mitigation measures (Burby and May, 1998). Planning initiatives minimize the possibility of catastrophic harm by redesigning places that are without risk (Burby, 1999). The use of GIS in vulnerability analysis is advantageous as it introduces a technology intended to facilitate spatial

decision-making into a field that requires it immediately to address many important spatial decisions (Cova and Church, 1997).

Infrastructural development is a significant component of overall development of any developing society. Due to rapid population growth and poverty leads to haphazard infrastructural construction and low quality of standard. Highly vulnerable seismic zone area needs proper adaption of earthquake resistant constructions. However, in the present paper we are trying to highlights spatial relationship between infrastructural development and seismic vulnerability.

2. Review of Literatures

How can various building structures be made more resilient against earthquakes through using the technique of seismic design? According to Haseeb (2011), the study offers some recommendations for how Pakistani building structures should be constructed to increase their seismic resistance and reduce damage. Shiwua (2013) aims to restate the importance of designing earthquake-resistant structures in Nigeria, taking into account the nation's history of earthquake activity as well as our clear understanding of the earth's dynamism. Nevertheless, creating a built environment that is resilient to disasters is a difficult process that involves numerous obstacles. As a result, the study's goal is to investigate the difficulties in creating a built environment that is resilient to disasters (Malalgoda, C. et al. 2014). To incorporate disaster risk reduction measures in the planning process, an effort has been made to identify gaps in the planning processes, stakeholder incentives, and the enabling environment processes involved in the development of major infrastructure projects (Jain, 2015). For modern, resilient societies, the focus of seismic design for infrastructure and buildings should shift from life-saving to business continuity. According to Takagi and Wada (2019), after a significant earthquake, structures should be built to be easily and affordably restored to full operation. Dube 2020 has concluded that build-back-better promotes sustainable development and reconstruction by fostering resilient and resilient communities and stronger infrastructure. Accurate performance results are supported by the design tools that support performance estimation based on structural testing. In the Indian context, this study highlights the difference between expected and actual performance (Raisinghani at al 2021). Another study recommended incorporating traditional authorities into the development processes, putting in place

an environmental framework with integrated waste management plans and policies for disaster management, and creating cutting-edge technology initiatives that offer the most recent data on spatial planning to provide infrastructure in unincorporated areas that reduces the risk of disasters (Akola et al 2022).

The aforementioned discusses make clear that obstacles to developing a built environment that is resilient to disasters include a lack of regulatory frameworks, unplanned development practices, outdated, vulnerable building structures and infrastructure, unapproved structures, institutional arrangements, insufficient funding, and a shortage of qualified human resources (Palliyaguru and Amaratunga 2008).

The studies mentioned above explicitly show that the issue of disaster risk reduction and infrastructure development received little attention from Indian intellectuals in general or from those in the Himachal Pradesh context in particular. A few foreign geographers have conducted some solitary studies on this topic. It was crucial to conduct a study on seismic vulnerability in light of the state of infrastructure development.

3. Objectives of the Study

The present study tends to examine the following objectives:

- To identify and examine the earthquake zone and level of infrastructural development of Himachal Pradesh.
- To study the spatial relationship between earthquake hazards zone and level of infrastructural development of the study area.

4. Methodology

The study is entirely based on secondary data collected from various departments e.g. Geological Survey of India, Census of India, Health Department, Educational Department, Road and Transport Department (Figure 1). Earthquake zonation has been done by using GIS platform. Infrastructure development has been examined through normalized between 0 and 1 scale where 1 indicates for high degree of development. However, at the district level, in order to include the relative gap in available infrastructure i.e. education, transport network, social infrastructure and health indicator has also been included. Based on the objective to identify the intra-state disparity in the infrastructure developmental together indicators are selected

for main components of development i.e. demographic, educational development, health and basic amenities and infrastructure.

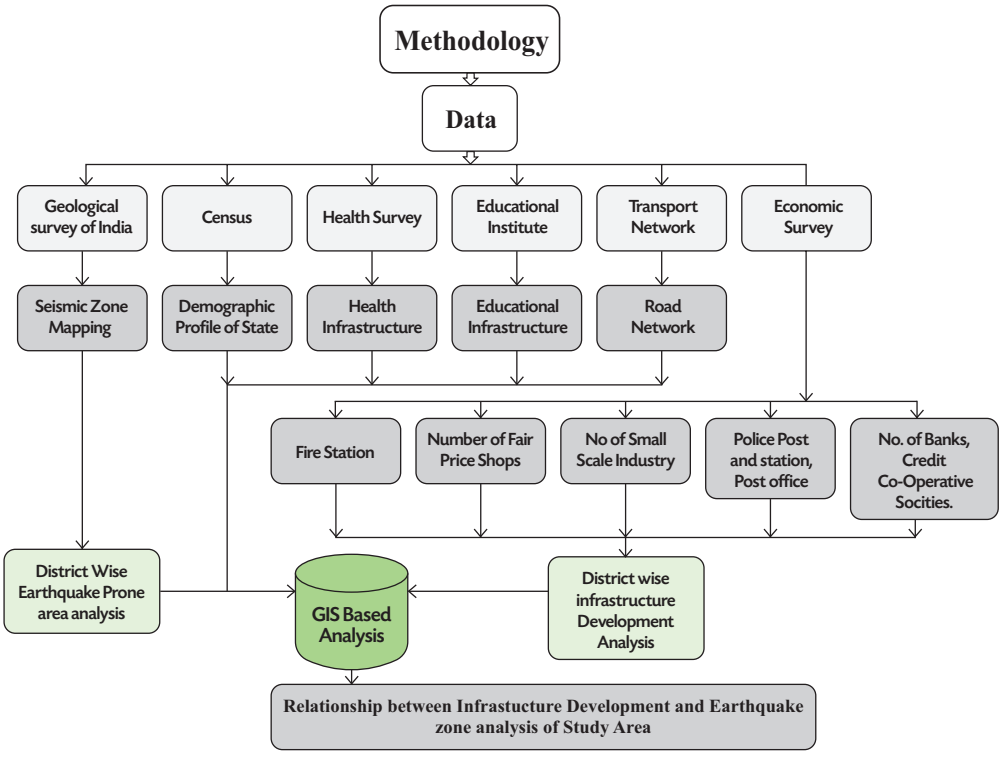


Figure 1: Flow Chart of Methodology

The present study is entirely reliant on secondary data that was gathered from various agencies, including the Department of Education, the Department of Health, the Department of Road and Transport, and the Geological Survey of India and the Census of India (Figure 1). Geographic Information Systems (GIS) has been utilized for earthquake zonation. Applying a normalized scale that ranges from 0 to 1, where 1 denotes a high degree of development, infrastructure development has been examined. But, the district level has also included a health indicator in order to account for the relative gaps in the infrastructure that is currently available, such as in the areas of social infrastructure, education, transportation, and health. Indicators are chosen for

the primary development components - demographics, educational progress, health, and basic infrastructure - based on the goal of identifying intra-state disparities in infrastructure development.

4.1 Infrastructural Variable

Surface Road Kms, Hospital / Dispensaries/ CHC/ RH / PHC, Education institute High School/ Secondary / UG College / PG College, Employment Exchange, Fire Station, Police Post and Station, Post office, No of Banks, Credit Co-Operative Societies, Number of Fair Price Shops. Bakshi et al., (2015) also mentioned three criteria used for selecting the indicators after data collection: correlation, sensitivity, and data source criteria. Only indications that have been gathered using a reliable methodology and by reputable sources meet the first requirement. It is implied by the second sensitivity criterion that any variable chosen must have the ability to distinguish between developed and less developed regions. Within this framework, it is possible to mention attempts may be tried to use indicators in a manner that is adversely connected with the district's development of infrastructure. Third, the correlation criteria is a significant one, meaning the variable chosen should ideally have correlation coefficients between 0.30 and 0.90 that are neither uncorrelated nor so tightly correlated Normalization of Indicators.

The indicators have different units of measurement and thus aggregating them without making scale free will lead to weird index. Normalize and scale free data by using following formula:

X new = (X — X min) / (X max — X min) (after Fahrenbach at el. 2019)

4.2 Weighting and Aggregation

The infrastructure development index is calculated using an equal-weight linear summation method. Every component that is thus produced can be normalized on a scale of 0 to 1, with 1 denoting a high level of infrastructure development. As mentioned in GoI (2013), it is essential to make sure that no component has an excessively large weight in the overall index.

5. Study Area

Geographically, the study area is bounded by the great Himalayan range on the north, the Dhauladhar and Pirpanjal ranges on the northwest, and the Shiwalik ranges on the

west to southwest. The northern and eastern boundaries are defined by the Zanskar Range. With a land area of 55,673 square kilometers, Himachal Pradesh is situated between latitudes 30° 22'44" north to 33° 12'44" north and longitudes 75° 45'44" east to 79° 04'20" east. Approximately 0.57% of India's population and 1.69% of the country's total area are included, according to the 2011 Census. Twelve districts—Bilaspur, Chamba, Hamirpur, Kangra, Kinnaur, Kullu, Lahaul-Spiti, Mandi, Shimla, Sirmaur, Solan, and Una—make up the study area (Figure 1). The Shiwalik Hills divide the hilly and mountainous state of Himachal Pradesh to plains of Punjab. Himachal Pradesh has unique landmass represented by mountainous ranges, hills and valleys.

5.1 Earthquake Hazards Zonation of Himachal Pradesh

The North West Himalayas in the state of Himachal Pradesh are extremely sensitive from a seismicity perspective. Table No. 1 indicates that the state has experienced numerous small and large earthquakes over the past century. The state, along with the neighboring regions of Punjab, Uttar Pradesh, Jammu Kashmir, and Ladakh, has been hit by several powerful earthquakes. A few of the notable earthquakes that rocked the state were the one in Kangra in 1905 (M=8.0), which claimed the lives of 18,815 people; the one in Kinnaur in 1975 (M=6.7), which claimed the lives of 60 people; and the one in Dharamshala in 1986 (M5.7).

Table 1: Most Severe earthquakes in Himachal Pradesh

Date	Locations Affected	Magnitude	Damage
4th April 1905	Kangra	7.8	20,000 people died 53,000 domestic animals perished 1,00,000 houses destroyed Economic cost of recovery 2.9 million rupees
1st June 1945	Chamba	6.5	NA
19th January, 1975	Kinnaur	6.8	60 people died 100 badly injured 2000 dwellings devastated 2500 people rendered homeless

26th April 1986	Dharamshala	5.5	6 people died, Extensive damage to buildings Loss estimated at 65 crores
1st April 1994	Chamba	4.5	NA
24th March 1995	Chamba	4.9	Fearsome shaking More than 70% houses developed cracks
29th July 1997	Sundernagar	5	Damage to about 1000 houses

Source: Himachal Pradesh State Disaster Management Authority

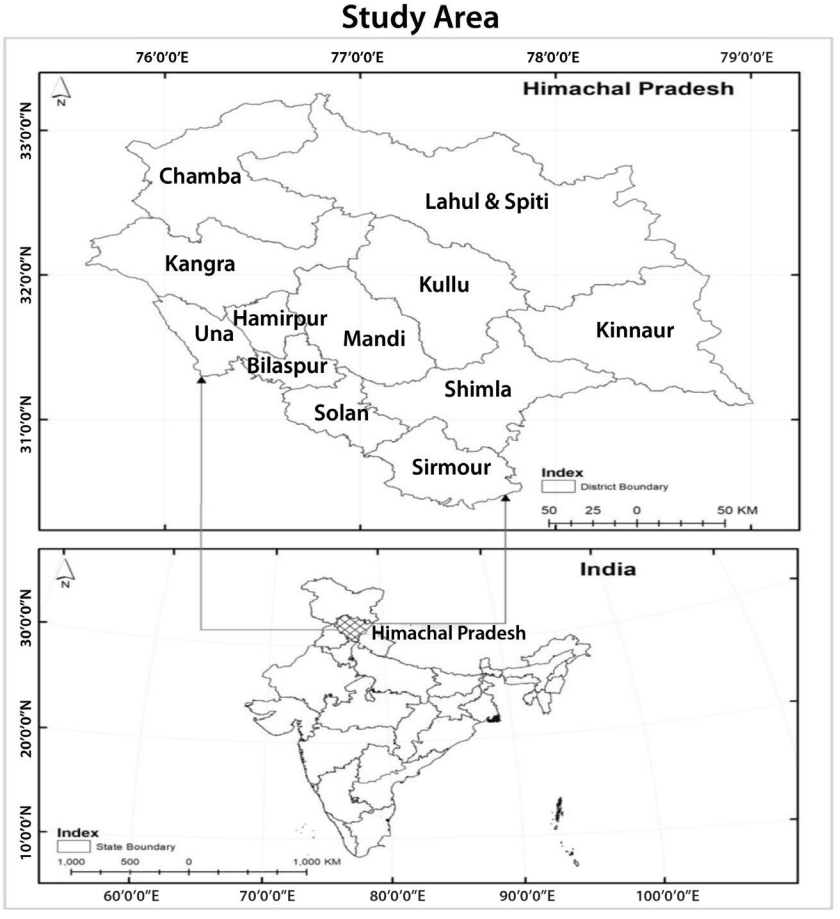


Figure 2: Study Area

It is evident from the Figure 3 that all the districts of Himachal Pradesh came under to the high (zone IV) and very high risk zone (zone V). However, the four districts namely Kangra, Mandi, Hamirpur and Bilaspur have entire area under very high risk seismic zone. About 50 percent area of districts Chamba, Kullu, Una and Solan came under the very high risk zone (zone V). The Figure 3 further revealed that the Kinnaur and Sirmaur districts have about 100 percent area under high-risk seismic zone (zone IV). Although Shimla district has 75 percent area under high risks zone and remaining 25 percent area under very high seismic zone. It is also evident from the above discussion that about 40 percent area of the study area under the very high risk zone and 60 percent came under the high risk zone respectively.

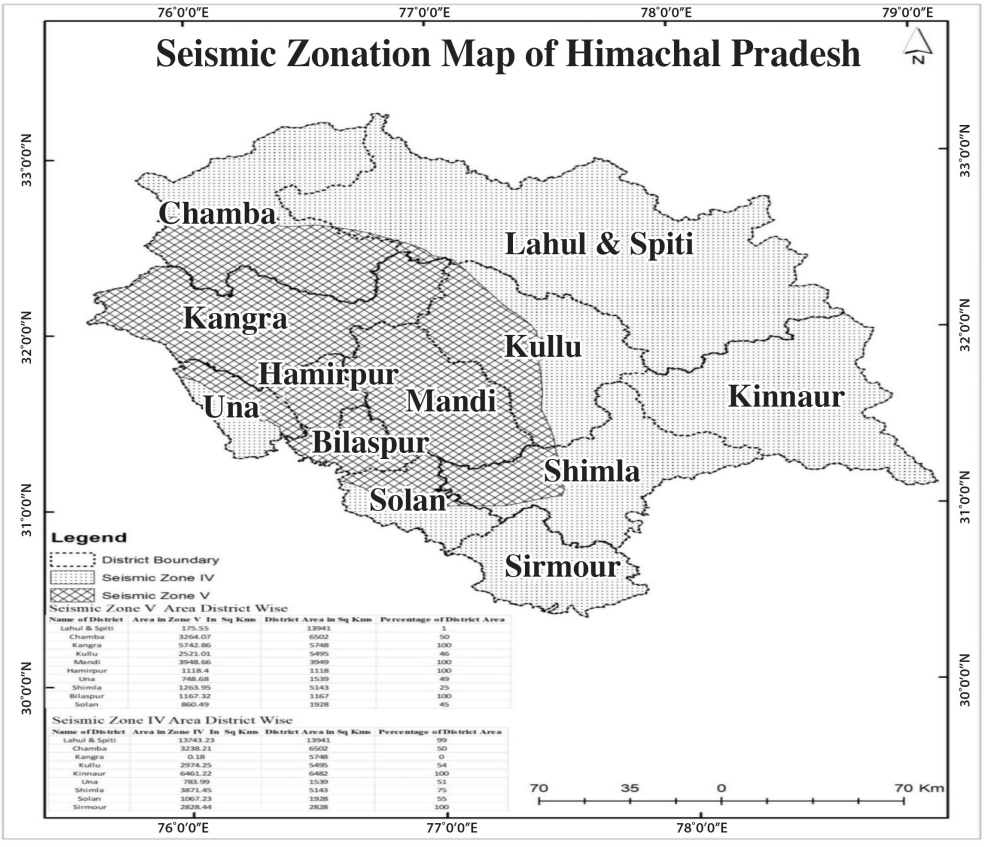


Figure 3: Seismic Zonation Map of Himachal Pradesh

Source: Bureau of Indian Standards (BIS)

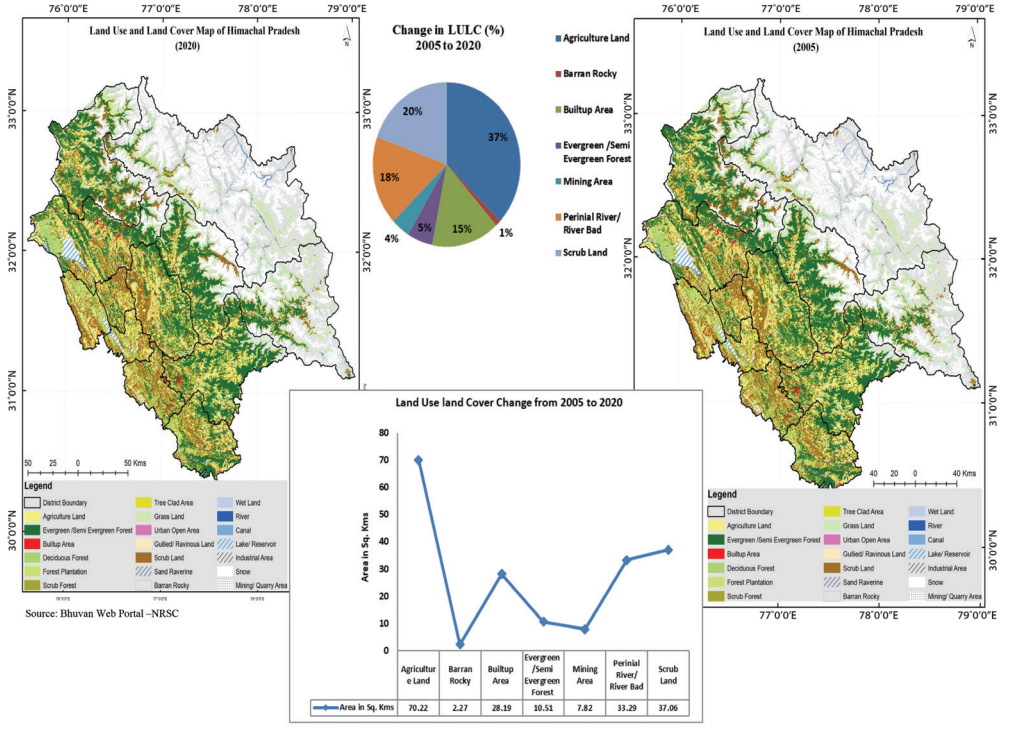


Figure 4: Land Use and Land Cover of Himachal Pradesh

5.2 Land Use and Land Cover Status

It is evident from figure 4 highest changes have been found in agricultural land followed by scrubland, river bed, built-up area and evergreen semi-evergreen forests. The lowest change has been found in the barren rocky and mining area. Rest land use categories changes have been found less than 1 percent.

5.3 Infrastructure Development in the Study Area

Development in its essence is a multi-dimensional process involving change in social infrastructure, institutions in consonance with the cultural heritage of the people, as well as the acceleration of productivity and production, reduction of regional and inter-personal inequalities and eradication of poverty. The public investments in various socio-economic sectors determine the role of overall development in different sections of society by providing opportunities. The education of the impoverished, and consequently their income and welfare, is positively impacted by increasing the

quantity and quality of basic infrastructure services available to them in developing nations (Leipziger et al., 2003:7). According to numerous studies, one of the main obstacles to economic development is poor infrastructure (McRae, 2015:36). Moreover, research has demonstrated a robust positive correlation between economic growth and infrastructure development (De la Fuente & Estache, 2004:5; Foster & Briceño-Garmendia, 2009:10).

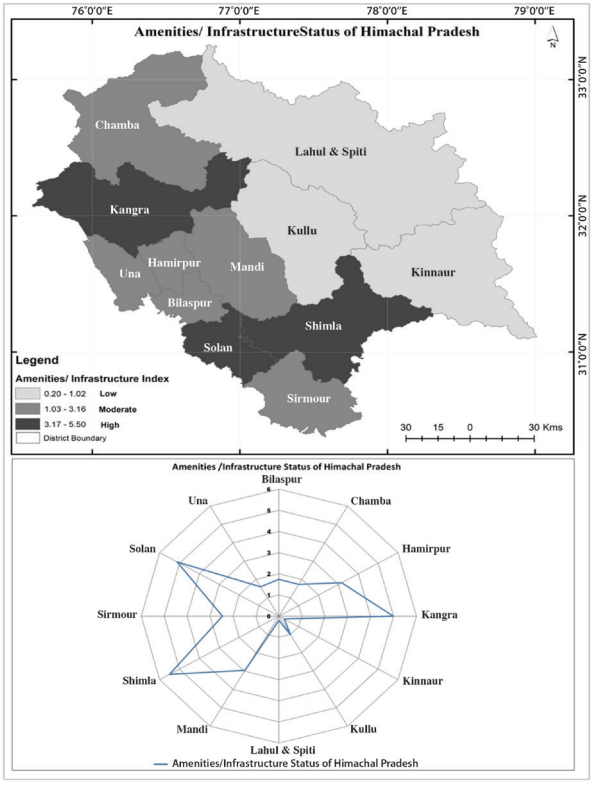


Figure 5: Infrastructure Status of Himachal Pradesh

It is evident from the Figure 5 that infrastructural development is not equal distributed in the study area significant spatial variations can be noticed in this regard. Only three districts namely Shimla, Solan and Kangra of the state have high level of infrastructural development. Six districts, Chamba, Mandi, Una, Bilaspur, Hamipur and Sirmaur have moderate level of Infrastructural development in the study area. Remaining, three districts out of which two are tribal region having low level of Infrastructural

development in the study area. The Figure 5 further reveals that Shimla district has highest level of development; it may be because of capital district of the state. However, Lahual-Spiti has lowest infrastructural development due to its hard topography, difficult climatic conditions and sparsely distributed population.

Spatial Relationship of Earthquake Zone and Infrastructure Development:

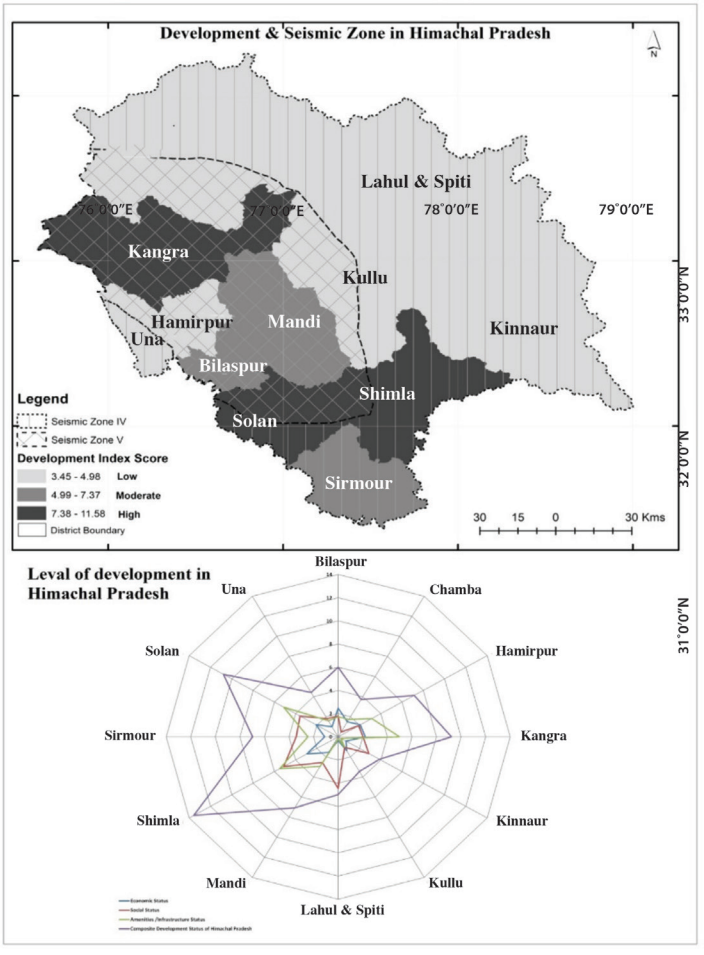


Figure 6: Development and Seismic Zone in Himachal Pradesh

It is evident from Figure 6 that only three districts of the state have overall high infrastructural development. However, these districts are located mainly in very

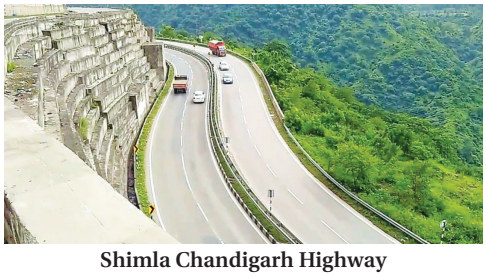
high and high vulnerable earthquake zone of the state. Construction activity has been uncontrolled, and it has largely ignored the hazards posed by seismicity. The seismically sensitive zones comprising Chamba, Shimla, Kullu-Manali, Kinnaur and northern Kangra receive a very heavy arrival of tourists throughout the year

Chamera Dam – Reservoir, Chamba, Himachal Pradesh
Latitude:32°28'23.89"N
Longitude:76°15'14.69"E

Karcham Dam, Kinnaur, Himachal Pradesh
Latitude:31°30'0.26"N
Longitude:78°10'39.54"E

Atal Tunnel, Rohtang Pass, Himachal Pradesh
Latitude:32°23'59.37"N
Longitude:77°8'54.77"E

Indira Gandhi Medical College & Hospital, Shimla Himachal Pradesh
Latitude:31°6'23.36"N
Longitude:77°10'56.11"E



Shimla Chandigarh Highway Near parwanoo, Solan HP
Latitude: 30°50'13.01"N
Longitude: 76°58'30.93"E

Atal Bihari Vajpayee Govt. Degree College Takipur, Kangra, Himachal Pradesh
Latitude:32°2'29.47"N
Longitude:76°15'2.41"E

Figure 7: Infrastructure Development in Himachal Pradesh

Source: Field Survey (2022)

and level of development is also very high in these areas. These areas have emerged as major hydro-power generation zones where a number of power projects are in various stages of construction which increase the possibility of disaster induced loss in the future perspective. Recently, the example of Joshimath disaster is an important lesson for us regarding how unbalanced and unsustainable infrastructural and huge constructional can lead to manmade disaster.

Conclusions

Himachal Pradesh has historically been vulnerable to seismic hazards, as the discussion above makes clear. The zones of concentration for earthquakes today match the earthquake-prone areas mentioned in ancient Indian literature (Chandel and Barar, 2010). The level of development, population density, and tectonic characteristics of the state of Himachal Pradesh are closely related to these earthquake zones. Major earthquakes that have been recorded for the area have been observed to have happened before both the acceleration of development efforts and a significant increase in population. The state's seismic zone 5 has seen a sharp rise in constructional activities i.e., the development of infrastructure, tourism, associated building activities, and allied activities like roads and social infrastructure. Because of uneven and haphazard development activities, there is a very high risk of earthquake-related human population vulnerability and related economic losses. One step toward managing and reducing the seismic hazard is mapping the risk zones of high seismic activity and development level. An endeavor of this kind yields the data required to set planning priorities for earthquake safety.

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Smart Fire Detection System Using IoT

Subhankar Sarkar[1]

Abstract

Fire is a chemical process between heat, oxygen and fuel, every year fires cause environmental and human loss. Fire accidents are increasing every year around the world, and India is not out of it. Every year fire causes loss of life and property damage. Controlling fire is essential to reduce all these fire-related accidents. Therefore, proper fire control planning and the development of a fire detection system are required first. If the source of the fire is known in a very short time, it is possible to repair the damage. In this case, sensor technology-based fire alarms, Smoke detectors, and heat detectors can be used. The use of IoT technology can control fires more quickly even without being present in these cases. This paper will discuss the advantages of various sensors, fire alarms, and network techniques used in fire detection using IoT.

Keywords: *Internet of Things (IoT), Wireless Sensor Network, Fire Detection, Sensors, Alarm system, Future Works.*

1. Introduction

Fire is a chemical reaction that is made up of three elements oxygen, heat, and fuel respectively. I have tried to show in my research paper that if we can predict fire through sensor technology then it is possible to take measures to fight fire quickly. As essential as fire is to the advancement of human life, accidental fires are also very dangerous, fire accidents are increasing day by day even in a densely populated country like India. Every year many people and livestock die due to fire and a lot of property is damaged. According to National Crime Records Bureau report in the year 2019- Fire cases were registered at 11,037 and deaths at 10,915. In 2020 fire cases registered 9,329 and deaths 9,110. So, from these statistics, it can be said that around 50 people die every day in

[1] **Subhankar Sarkar,** Maulana Abul Kalam Azad University of Technology (Formerly known as W.B.U.T). Haringhata, Kalyani, Nadia, West Bengal.

India due to fire-related accidents. The fire spreads rapidly over time therefore, quick-fire detection is necessary to control the fire. Fire control can be done faster using a smart fire detection system and IoT.

The population in rural and urban areas is increasing day by day, as a result, new buildings are being constructed, resulting in increasing pressure on public transport, electricity, and food. Pressure on the environment is also increasing. In this situation, natural calamities are increasing, along with incidents like fire and loss of life. In old fire detection systems, there is a problem in detecting fires quickly. So smart fire detection system is required to avoid fire accidents. Some automatic sensor technology, Wireless sensor networks, electronic devices, software, and IoT devices are also required. Here the fire alarm system means when a situation like a hit or wash or fire is created in a place so that an alarm can be alerted. So that life can be saved from the fire. In earlier days, manpower was used for fire detection, but even today this system is used in several public places. In some areas old fire alarm was used. However, due to the introduction of many sensor device technologies, fire detection has become more convenient. I am going to show that in this paper, in the Internet of Things some smart devices, wireless sensor networks, and sensor technologies are connected to send a warning message to the user and take measures to quickly detect the fire. So that life and property can be saved along with vigilance. Here the user can know the situation of a building or place through SMS or Email, and can control if it is necessary. This message will be sent to the user at specified intervals. For pre-fire situation monitoring from a control room, I have tried to highlight in this paper, that I have shown the complete work on the online simulator platform using tinkercad.com. Also in this research paper, the concept of a control room is given.

2. Internet of Things (IoT)

The Internet of Things is one of the most used computer technologies today and Internet of Things technology has transformed today's ordinary life into a highly technological one. As a result of the use of this technology, as the standard of living has become modern and easier, it has also become possible to take control of a place from a distance with the help of a remote server. Using IoT to solve various industrial or common life problems or using this technology in common life has also led to technological changes in the use of electronic products. In the Internet of Things,

several sensor technologies are generally used that collect data from the ground level and send the valuable data to the cloud server storage through the microcontroller device, and finally, these data are sent to the user at a specified time interval. And the user can quickly make necessary decisions by looking at this processed data. The use of the Internet of Things has been seen in various areas such as the Industrial Sector, Agriculture, Fire Fighting, Health Monitoring, Smartphones, etc.

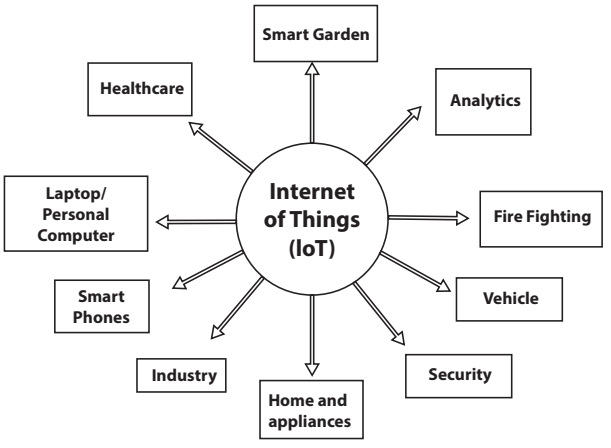


Figure 1 : Applications of the Internet of Things (IoT)

In this paper, I have shown that using IoT, various sensors can be used to obtain detailed information about pre- or post-fire conditions and analyze it to take further action. Here all sensor devices are connected to Wi-Fi internet Connection. Cloud databases are used for data collection storage and analysis and some smart fire fighting devices are used for the post-fire response.

3. Wireless Sensor Network

A wireless sensor network is collection of multiple sensor networks to monitor an activity. And this network approach is infrastructure less. Wireless sensor networks typically work as a unit with an onboard processor or with a microcontroller device. The function of a wireless sensor network is to exchange monitoring data from different base stations connected to a location. The use of this network can be seen in multiple sectors, including the Internet of Things, the security sector, the environmental sector various types of noise levels, and medical applications.

In my research paper, I have used a wireless sensor network to transmit the data received and stored from the other sensor devices and microcontroller devices to the user. or to send reports directly from the cloud server to the user in the form of email or SMS.

4. Related Work

Here we will discuss various methods used in fire detection:

I. Manaswini Parlikar, Shivkanya Angad Padole, Pratik shauttam rao sargar, Nikhil Vilas Jadhav, Mayur Anil Shinde on "IOT BASE FIRE EVACUATION SYSTEM 2022", this paper shows how to get information and take necessary action through a mobile application method. Here database cloud is used for data storage. Several sensors have been used which will send information to the user according to a specific level of fire or toxic gas or temperature rise, the alarm will sound necessary. For indoor positioning, location tracking and rescue wi-fi technique or wireless access point is used. Where in the case of a building (Fire case), the correct exit route can be found with the help of path navigation and mapping. Also, in this paper,a safe exit route and necessary instructions are given using the Ant colony optimization (ACO) algorithm.

II. IOT Based Fire Alarm Security System by Hari Varshini S, Boomika S, Sherene Amalia G, Leena R, 2022. This research paper shows the work on microcontroller units, the internet of things, and fire alarms with the help of ad hoc networks. The microcontroller unit used here is ESP 8266 Node MCU, also seen here is the use of an infrared flame sensor. Which can continuously detect the presence of fire in the surrounding area. After fire detection, the microcontroller unit with the information, and then that message is sent to the user in the form of SMS. Alarms are used as warnings. Here heat sensors, flame sensors, and smoke sensors are used as sensor devices and a buzzer is used for warning alarms. C programming language is used here for programming and SMTP or Simple Mail Transfer Protocol is used for sending email or SMS. Cloud applications are used for data storage using the Internet and LED lights and buzzers are used to sense alerts. Blynk apps interface is used to turn the whole system on and off.

III. Review on Fire Detection Techniques by Jasa Marin K and Amal S Kannan, Department of Electronics and Communication Engineering, 2021. This paper presented WSN (wireless sensor network) there is also Flat network architecture

through this network, the data reaches the base station through specific routing protocols by various sensor nodes. And Hierarchical network architecture Here, basically several sensor technologies combined are selected as powerful sensors. Not only that, but the rest of the sensor nodes here are usually referred to as cluster members, The main function of these devices is to send the sensed data to the cluster head, and this data is then sent back to the database station. This results in a larger area being covered. This paper also uses a Fire detection sub-system that is basically, here each sensor detects the CO_2 and temperature values through WSN technology and sends the data to the user at specified time intervals. Early Fire Detection Method Based on the Image Processing method used here, basically, fire detection is based on using color features of fire that are mainly RGB Colour models. Also using image processing techniques, that information is sent to the user according to the specific color of the fire. Convolutional Neural Networks Based Fire Detection in Surveillance Videos are also used. For some images, fire classes are divided according to pixel size. Analyzing all these musical matters, one can understand by looking at the picture it fire class or non-fire class.

IV. A study on IoT Technologies for Fire Safety Systems 2020, Brunda N, Chandan R, Lavanya N R, Prajwal G M, Panchami S V. In this IoT-related research paper, they have divided the fire safety controlling system into several parts which respectively are Sensors, Actuators, Gateway, and Servers. The case of sensors is shown Smoke sensors, LPG Sensors, Motion detectors (Sensors), Carbon dioxide detectors or sensors, and Tank Water Level Sensors. The smoke sensor mainly detects the smoke caused by the fire or the smoke released before the fire and sends the relevant information to the user or sounds the warning alarm if necessary. In the case of LPG Sensors, all types of flammable gas detection and subsequent fire accidents can be prevented. In case of a motion detector or sensor, it is used to detect the movement of a person or object and it will send detailed information directly to the user. The Carbon dioxide sensor or detector measures the amount of CO_2 in the air and is useful in locating the source of this flammable gas and is used for ventilation. Tank Water Level Sensors help to check the level of stored water for firefighting and inform through messages when water storage needs water. This research paper shows some relay nodes, pump control panels, and ventilation control panels in the field of Actuators, which are used to control the water pumps

during firefighting and extinguish the fire and use the ventilation control panel to release poisonous gas or smoke from the fire. And for gateway networks, wireless and wireless gateways are used as needed. In the case of servers, cloud databases are used primarily to store and transmit data. Also, within the server, we have seen the use of some mobile applications such as sharing information from the origin of the fire to the user through email or short messaging services and the ability to control the fire as needed to extinguish the fire by analyzing the information. From this research paper, it is understood that they mainly focus on the rapid detection of fire through various sensors and its rapid data collection to extinguish it quickly.

V. Forest Fire detection system using wireless sensor networks and machine learning by Udaya Dampage, Lumini Bandaranayake, Ridma Wanasinghe, Kishanga Kottahachchi & Bathiya Jayasanka Department of Electrical, Electronic and Telecommunication Engineering, In this paper, they mainly work on forest fires, using wireless sensor networks and machine learning. Here the paper initially warns about forest fires and explains the causes of forest fires and damages of forest fires. More emphasis is placed on early fire detection wireless sensor network is used here for fire detection. A machine learning regression model is proposed to optimize this fire detection process. Wireless sensor networks are used here to monitor the environmental conditions and transmit the data obtained through this network from one location to another. Where these data can be monitored and analyzed. Also, here a microcontroller transfer model unit is used and batteries and solar panels are used to supply power to other microcontroller devices and other sensor nodes. In this research paper first, the sensor nodes are installed in a garden and then the data is collected from there through a sensor device and wireless sensor network. And using the machine learning method here the data can be obtained in the form of graphs. Temperature ratio, humanity ratio, light intensity ratio, or carbon levels can be seen in graph form. By simply looking at this graphical output or other parameters, one can understand whether a fire situation has occurred.

5. Problem Statements

A smart fire detection system using IoT is the main objective of writing this paper, be aware of fire hazards and to know the situation just before the fire through online monitoring using sensor devices. Before writing this research paper, when I visited any place especially any shopping mall, hospital, railway station, metro station, or govt.

office buildings. I noticed that all those buildings have fire alarm systems installed for fire warning and extinguishers or in some cases, sprinklers are installed to put out the fire. Besides, being a volunteer member of civil defence, I have visited fire accident sites several times. I have observed several times in those incidents, that despite having adequate water storage or adequate firefighting system, huge damage has been caused by fire before it is known, only due to lack of adequate monitoring. So, I have tried to show, that if adequate monitoring can be done through various sensor devices sitting in a control room in all these cases, then We can take adequate measures to control the fire before it starts, where these data can be monitored and analysed.

6. System Requirements

A. Software Descriptions:

i. **Python**: Python is a high-level object-oriented programming language; python programming language is mainly used for rapid application development It is used as a scripting language to connect many components. Python is used as a support language for software developers.

ii. **Cloud Application Server**: A cloud application server basically refers to a method of storing data in a virtual way. Users can view the data, analyse it or use it for other purposes according to their needs in this research paper, the help of a cloud application server is taken, so that the required information is sent to the user through SMS or email.

iii. In addition to Python and Cloud Application Server mentioned in the above software, C++ Programming and Arduino Programming are used as programs to do the main work virtually.

B. Hardware Descriptions:

i. **Fire Alarm**: A fire alarm is a mechanical device that alerts people when a fire breaks out, or toxic gas, carbon monoxide, or a fire-related emergency is detected. It can be activated automatically or manually through a call point to alert people. In the case of a manual fire alarm, the switch of the alarm is covered by glass and the switch can be activated by breaking the glass if necessary. The sound level of the alarm system can be set and changed as needed depending on the importance of the situation. These devices are used for fire warning alarms. Such devices are used

in hospitals, metro stations, shopping malls, etc. However, in this research paper, I have demonstrated the use of buzzers for virtual warning alarms. The figures below introduce the fire alarm system, firstly automatic fire alarm system that sounds immediately upon fire or as an early warning signal, and secondly, a manual fire alarm system that is operated manually by breaking the glass and pressing a switch inside.

Figure 2 : (i) Fire Alarm System

Figure 2 : (ii) Manual Fire Alarm System

ii. **Breadboard**: A breadboard is a hardware device, which is commonly used for testing various types of electronic circuits.This device is divided into two parts, the upper and lower parts are connected side by side, and the middle part is connected up and down. This breadboard can be seen in computer architecture labs. Sometimes multiple breadboards are used when the circuit size is large. However, in my research paper, a breadboard has been used to create this circuit virtually.

iii. **Arduino board**: Arduino is an open-source platform that is easy to use, The Arduino device is a hardware device that is connected to various fire-related sensors, and it can read input data from all these fire sensors, And the data received from here can be sent to the user through output.

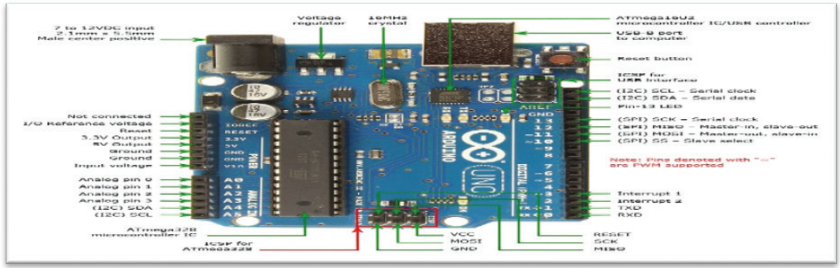


Figure 3 : Arduino Circuit Board

iv. **GSM Shiel**d: A GSM shield is a mobile communication hardware device that can send ground real information to the user with the help of the internet. This device is used to connect to the Internet and share information. So, in many cases, the use of a cloud server is not required. In this research paper of mine, the cloud server is used here, but later monitoring of fire is possible by using GSM Shield. A GSM shield has a SIM card installed so that SMS or email can be easily sent to the user using the SIM card.

v. **Temperature Sensor**: A temperature sensor is basically a type of electronic device that measures the temperature fluctuation of a place. If the temperature of any place is higher than normal, then the information about that temperature is sent to the user, so that the user can easily understand if there is any fire problem at that location.

Figure 4 : Temperature Sensor

From, where the temperature sensor is placed, it is connected to the Arduino microcontroller device, and temperature monitoring is done.

vi. **Smoke Sensors**: Before the fire, heat is first generated at that place and smoke is gradually generated from there, when the smoke reaches a certain level, fire is generated in the presence of fuel with the help of oxygen. Therefore, the detection of pre-fire smoke is essential. The smoke detection is done by the smoke sensor. In other words, smoke sensors usually detect small particles in the air. When particles are detected above a certain level, an alarm sounds. Generally, this Sensor works within 50 to 60 square meters of the place where the smoke sensor is installed. The range may be more or less depending on the category of smoke sensor. This device is connected to the microcontroller device through a wire.

Figure 5: Smoke Sensor

vii. **Gas Sensor**: It informs us if there is any toxic gas or LPG gas leakage in a residential building or industrial area or when a gas-related accident is likely to occur. This device is very important for fire safety. These gas sensor devices, from the air, can give readings between zero and five parts per million. Not only this, this device is also connected to the microcontroller device through a wire.

viii. **Buzzer**: Buzzer is a type of mechanical audio signaling device. This device essentially converts different types of signals into sound, this device is used for various types of alarm or warning signals. In this paper, I have shown the use of a virtual buzzer, usually the buzzer device is connected to various devices like temperature sensors, smoke sensors, or other sensors. So that any kind of fire situation can be known through the buzzer.

ix. **Motion Sensor**: A motion sensor is a hardware electronic device that is used to detect any kind of movement of animals or humans. In most cases, this device is used for security purposes. The device can detect the movement of anything within a distance of about 50 to 80 feet (approximately). The reason I mainly show the use of motion sensors in this paper is that when a fire breaks out in an enclosed space, the space is often filled with black smoke. At that time, it becomes difficult to identify and rescue any human or animal trapped in that place. I have tried to detect the movement of trapped animals or people by using this sensor and arrange for their quick rescue from that place.

Figure 6: Motion Sensor

x. **Water Level Sensors**: A water level sensor is mainly used to measure the level of stored water in a place. Water is mainly needed to fight the fire, so several lakh litres of water are stored in several buildings in populated areas or industrial areas for advanced fire fighting. This paper will provide an idea of the amount of water stored in water storage using water sensors. The reason why a water level sensor is mainly used here is that in most cases it is seen that despite having water storage we cannot know how much water is currently stored, through a water level sensor we can know how much water is stored in water storage for fire fighting.

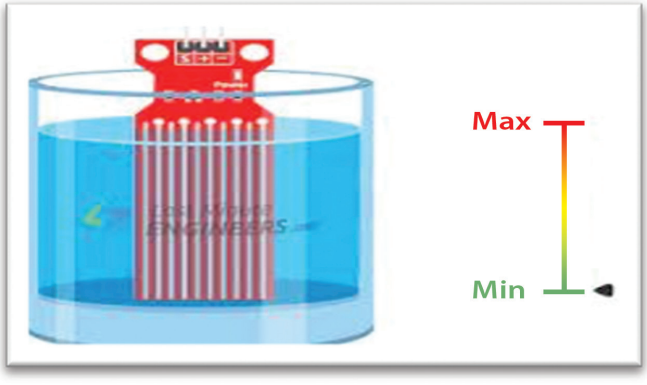


Figure 7: Water Level Sensor

xi. **Connecting Wires**: Connecting wires are required to connect the various sensor devices to the microcontroller device. For ease of understanding, different colored wires are used with each device.

xii. **Power Supply**: A power supply is required to operate the microcontroller device or Arduino board. A 5-voltDC power supply is used here.

7. Proposed System and System Functioning

In this paper, I want to show the huge amount of damage caused by a fire in a forest or township (city or village area). To avoid the dire situation of the fire first alerting and gathering speed information and giving early warning by alarm and send data to the user or control room. And, then the user inform the nearest fire station if necessary. Here mainly in the hardware part, it shows how to collect the fire data through sensors (Temperature, Gas, Water level, etc.) through a microcontroller board Arduino and send it to the user through a cloud database. The software part uses Python and C++ coding. The entire system is designed here for monitoring and using an online simulator platform (tinkercad.com).

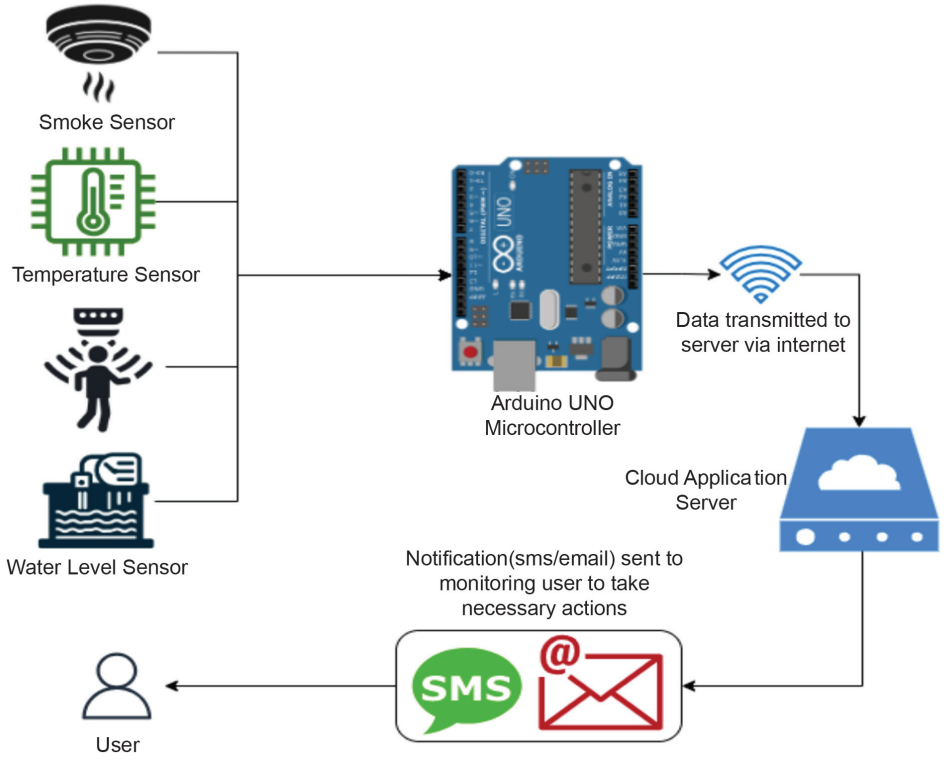


Figure 8: Detection, Transmit Data, Processing and Visualize System

8. Working Flowchart

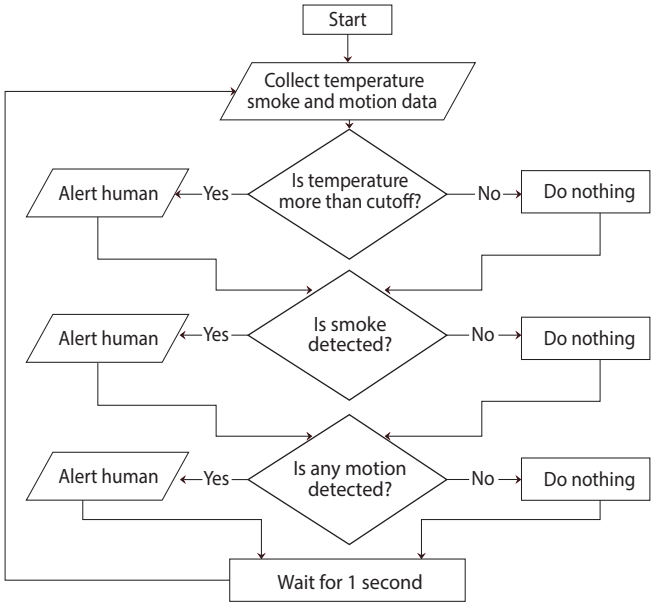
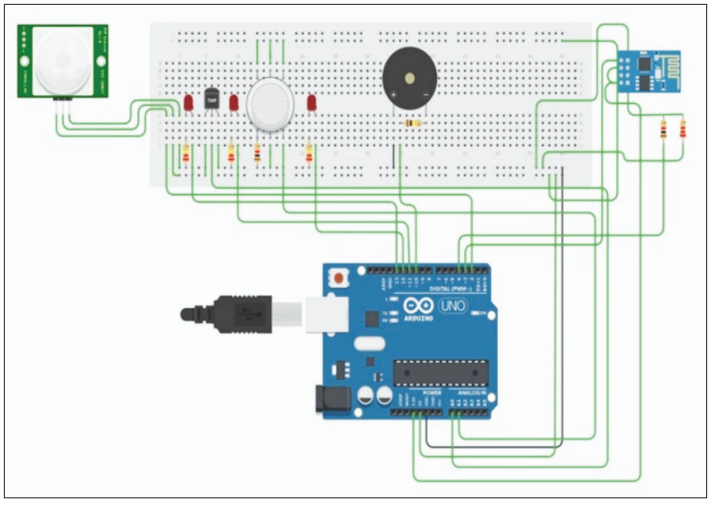


Figure 9: Smart Fire Detection System Flowchart

9. Circuit Diagram



Component

- Arduino Uno R3
- Red LED
- 220 kΩ Resistor
- Temperature Sensor [TMP36]
- Gas Sensor
- 21 kΩ Resistor
- Piezo
- 100 kΩ Resistor
- Wifi Module (ESP8266)
- 2.2 kΩ Resistor

Figure 10: Circuit Diagram with Components.

10. Result:

All OK!!
All OK!!
High Temperature - 50 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 50 Degrees celsius Smoke detected; Alert Adequate water
Motion detected;
High Temperature - 50 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 50 Degrees celsius Smoke detected; AlertAdequate water
Motion stopped!
High Temperature - 50 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 60 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 70 Degrees celsius Smoke detected; Alert Adequate wate
Motion detected;
High Temperature - 70 Degrees celsius Smoke detected; Alert Adequate water
Motion stopped!
High Temperature - 70 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 70 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 65 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 70 Degrees celsius Smoke detected; Alert Adequate water
High Temperature - 60 Degrees celsius Smoke detected; Alert Adequate water

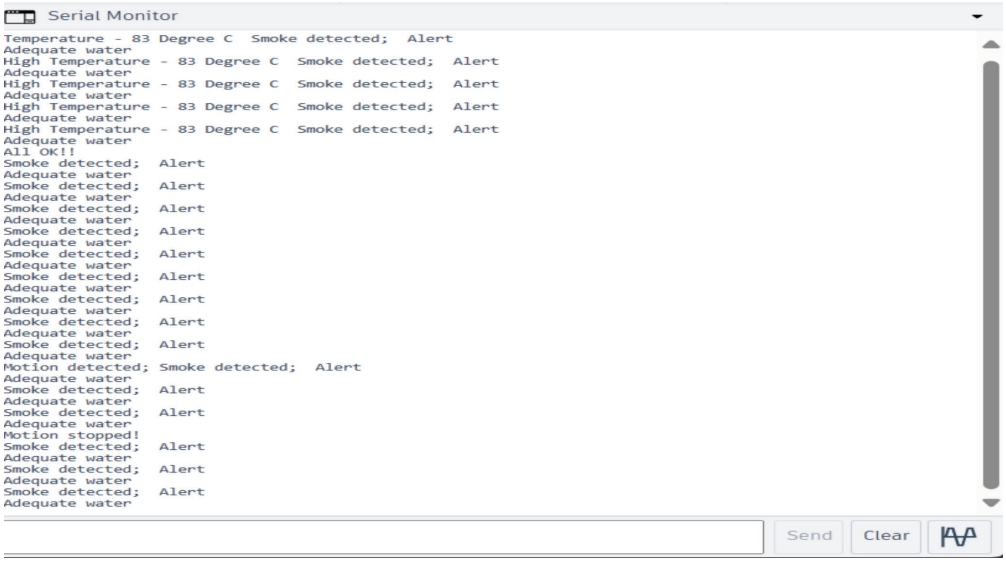


Figure 11: Monitor View

Figure 12: Email Alerts for Fire

In this research paper, after running the proposed fire detection model in the online simulator, the result of the fire detection system can be seen on the computer monitor. And will know it through email at a specified time interval. The results are shown here in Figure 11 and Figure 12.

11. Control Room:

Looking at the computer monitor from the fire control room desk, I can see the necessary information from the fire sensors. After seeing the details of fire-related sensors I can take necessary action from there and inform the local fire department. Early warning signals can prevent accidents. It is possible to sit in the control room and monitor fire-related issues through email or SMS through the Internet of Things, later on sitting in this control room, fire-related instructions can also be given. Necessary decisions about fire fighting can be taken from here by looking at fire-related monitoring reports.

Figure 13: (i) Fire Control Room

Figure 13: (ii) Fire Control Room

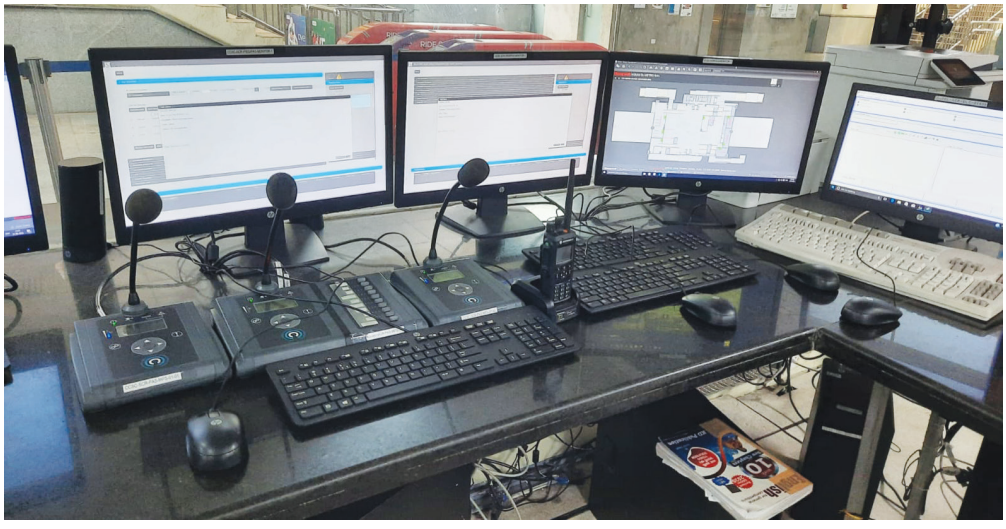


Figure 14: Control room desk from where necessary action is taken

12. Future Works: In this research paper, I tried to show the aspect of fire monitoring using IoT and sensor technology. Possible aspects to make fire monitoring smarter in the future are briefly discussed at some point below:

- **Application of Internet of Things and integration of smart systems**: If the Internet of Things and smart systems can be used jointly to detect fire, then automation will be allowed to control the fire, this can automatically shut off gas lines or electricity, turn on sprinkler system or alert emergency services remotely, sensing danger.
- **Remote monitoring and uses of mobile applications**: If a mobile application is developed, through which only the status of the fire detection system can be checked, the status of the fire detection system can be checked anytime remotely using just a smartphone or computer or Laptop. As a result, the user can know the status of the fire detection system from a remote location and take necessary action
- **Uses of Advanced fire detection system**: More emphasis should be placed on the fire detection system, and if necessary, the use of various types of advanced technology sensors as well as the use of infrared sensors, ultrasonic sensors, and artificial intelligence integration sensor technology should be increased.
- **Application of machine learning and data analysis in fire detection systems**: If machine learning algorithms and data analysis can be used in fire detection systems, then naturally we can predict fire before it occurs. This requires proper analysis of the data by searching for the cause of previous fire accidents. As a result of this fire disasters can be reduced as well as we can get a forecast before the fire starts.
- **Uses of multi-sensor fusion**: In this method, the data obtained from multiple sensors are combined and analysed for warning alarms or other responses to fires. The use of this system increases the reliability and proves the accuracy of the fire detection system. For the data to be accurate, fake alarms are also reduced here.
- **Fire regulatory compliance and standards**: For fire detection systems to gain widespread acceptance, there is a growing need to improve firefighting industry standards. In the future, research on fire fighting systems needs to be improved and more done while maintaining the expected standards.
- Apart from the above points which are more needed in future are making arrangements to study fire detection technology from school level. Widespread awareness about fire detection techniques among common people. As a result, fire detection techniques can be learned at the school level and protect oneself and the environment from fire-related accidents.

13. Conclusions

This research paper of mine has been prepared mainly to reduce fire accidents and reduce the severity of the fire. This paper shows that all the monitoring especially, detailed information about motion, temperature, gas, and water storage can be found in one place. If there is any warning in the information received then we can send the fire control unit from the control room. Alarms can also be sounded and people can be evacuated from dangerous places to safe places. Also, after receiving this alert, we know whether there is enough water for firefighting, so, if necessary, we can start early firefighting with our trained personnel for rescue operations and using stored water. As a result, we can save lives and reduce property losses and we don't need multiple computers, only the computer on which this system is installed, we can take action as needed by sitting in the control room and seeing the relevant information. It can also be said that accident prevention does not always require the monitoring of computers or other devices. All sensor devices are connected through an Arduino board and it sends data to the computer at regular intervals if there is any problem somewhere we can know it through an alarm or notification. By using this method, we can prevent fire or other fire-related accidents in places like multi-storage buildings hospitals, shopping malls, or metro stations. The result section contains information about fire alerts in the form of an email or SMS. Besides, the role of a control room in monitoring the fire detection system is also discussed. What else can be done with fire detection techniques in the future is also highlighted in this research paper. If the model of my research paper is implemented, the work of fire detection system of several public places will be easier.

14. Acknowledgement

First of all, I thank and gratitude to my respected parents, as they have given me encouragement and other support to write this paper. Secondly, I would like to thank the Department of Computer Science - Maulana Abul Kalam Azad University of Technology. Haringhata, Nadia, W.B, C.S.E - Department. And lastly thanks to the Department of Civil Defence and Disaster Management – Murshidabad, W.B. Govt. of West Bengal. And as a civil defence volunteer member, I visited several fire accident sites and observed fire detection systems and control rooms of several public places. That's why I tried to write and show this work of Smart Fire Detection System using Internet of Things paper. So fire monitoring can be done through a sensor device sitting in the control room and it can be known in the form of a report. Finally, if this work of mine is of any use in monitoring the country's fire fighting or monitoring, then I will consider my hard work worthwhile.

Figure 15: Fire fighting Training

15. Declaration

- Funding: Smart Fire Detection System Using IoT As the main work in this research paper is done virtually, no grant or funding money of any kind has been used or required for the preparation of this manuscript.
- Competing Interest: I have no financial or non-financial interest to publish the manuscript titled Smart Fire Detection System Using IoT.

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Climate Resilient Sustainable Livelihood Practices in Western Himalayas: A Case Study of Tehri Garhwal District of Uttarakhand

Pratyush Kumar Singh[1], Sakshi [2]
Mohan Lal Meena[3] and Shreyash Dwivedi[4]

Abstract

The following study attempts to outline the livelihood practices of communities living in the Tehri Garhwal District of Western Himalayas in trying to adapt and mitigate climate change related phenomenon employing their traditional knowledge to move towards sustainable models of survival. The region although nestled in acute isolation from the modern world has immense scope for development. The organic agriculture and naturally derived medicines are in high demand in the urban areas and the region can act as a cardinal hinterland for the purpose. The promotion of these traditional systems and their broader applicability in the wider world can pave the path for judicious, sustainable development and proper allocation of limited resources. The biological systems of the world have been deteriorated in the wake of illusionary development and their resilience is the need of the hour. The cooperation and collective action, intergenerational transfer of knowledge and concern for future generations are essential mechanisms adopted by locals. As over exploitation of natural resources happen in pursuit of livelihood, it is important to formulate livelihood options that are in harmony with the local milieu. Sound knowledge about inherent logic of the local customs and their rasion d'être would be critical for devising such strategy.

Keywords: *Traditional knowledge, Sustainable livelihoods, Natural resource management, Climate resilience.*

[1] **Pratyush Kumar Singh,** Research Scholar, Jawaharlal Nehru University
[2] **Sakshi,** Post Graduate Student, Jawaharlal Nehru University
[3] **Mohan Lal Meena,** Research Scholar, Jawaharlal Nehru University
[4] **Shreyash Dwivedi,** Resilient Infrastructure Division, National Institute of Disaster Management

1. Introduction

The concept of sustainable livelihoods was first introduced by the Brundtland Commission on Environment and Development (1983) as a way of linking socioeconomic and ecological considerations in a cohesive, policy-relevant structure. The 1992 United Nations Conference on Environment and Development (UNCED) stated that sustainable livelihoods could serve as 'an integrating factor that allows policies to address "development, sustainable resource management, and poverty eradication simultaneously."

The UN Declaration on Indigenous Peoples, endorsed by the UN Human Rights Council (2006) with a recommendation for the UN General Assembly to adopt it recognizes "that respect for indigenous knowledge, cultures and traditional practices contributes to sustainable and equitable development and proper management of the environment". The world is changing and people are again switching to nature-based commodities as well as other basic solutions. In the process enhancing or consolidating Indigenous Knowledge Systems can bring high economic potentials and scope to the poverty situation of traditional communities while engaging them in utilizing natural resources in a sustainable way. The following study attempts to outline the livelihood practices of communities living in the Tehri Garhwal District of Western Himalayas in trying to adapt and mitigate climate change related phenomenon employing their traditional knowledge to move towards sustainable models of survival.

2. Review of Literature

Rana et.al (2018) explained how the introduction of modern agro-technologies with rising intensity of climate change have replaced traditional practices which led to numerous issues including land degradation, pollution and most importantly the constant downfall in crop productivity. Further, the study tries to validate use of sustainable Indigenous Technical Knowledge (ITK) by farmers, especially the mountain ones which are more vulnerable and experiencing extremities of weather because of climate change, for managing plant diseases, pest control, protection of seeds and plethora of others, as a response and a way to adapting with changing nature.

Anthwal et. al. (2010) explains how forests have been a centre of civilisation, evolution and has a strong significance according to mythology of n number of religion present in the country. This importance of forests in cultural rituals and religion having

sacred sites influence human behaviour and relationship with nature and can be used as a tool to protect the environment.

Negi et.al. (2017) details about how local cultivators in Himalayan region have been using indigenous knowledge and strategies to mitigate and adapt with changing climate since millennia. Climate change has affected the species diversity, composition, rare occurrence, and endangered crop species which calls for conservation values for ecologically sensitive and most vulnerable zones such as Himalayan ecosystem, and ancestral knowledge of farmers for response incorporated with strategic planning and policy by bureaucrats which only can bring a solution to the same. As per IPCC Third Assessment Report (2001), adaptation, which is also a take of people in Himalayan region, is the most effective strategy to deal with the impacts of climate change. Farmers have altered cropping calendar for different climatic zones and tried to look for most suitable crops for rising climatic variability and extreme situations.

Uniyal et. al (2008) introduced women as a vital part in mountainous regions, holding immense knowledge and understanding of sustainable resource management in response and adaption to the changing climate. Women while having an awareness about natural resources management and biological diversity with power of indigenous knowledge can be trained and educated to generate income-oriented activities such as organic farming, medicinal plant cultivation and varied high value cash crops. The study concluded with proposing such programmes for training women with listing benefits from economy, decreasing migration rate and lastly environmentally sustainable life while adapting with changing climate.

S.C Rai (2007) gave a picture of the natural resource management system in highly diverse human societies of Northeast India where people are intertwined with their nature tightly. Northeast India has a rich biodiversity and abundance of natural resources with a variety of traditional human societies managing it with their indigenous knowledge and tools. Various reasons and purposes were listed for managing the natural ecosystems by communities including timber extraction for industrial purpose, routine products from forests for rural communities and a host of others. A very popular tribal group was introduced, the Apatains with their sustainable and economically vital agricultural practices in extensive valley lands. Water schedules and crops patterns are decided very cleverly by traditional

communities according to the soil fertility variation along the slope, as cultivating species of nutrient use efficient at the top while less efficient in the downslopes.

Vikrant Jaryan et. al. (2010)tried to explain the potentials and importance of sacred groves, the small forest patches which are conserved through the spiritual belief and faith of human, while presenting a beautiful example of traditional conservation practices. Religion beliefs has been the centre of the norms and management culture of sacred tree groves in country. But due to rapid socio-economic transformation and rising inclination of human towards the materialistic world, these vital groves are degrading drastically. Shivbari, due to pertaining this level of rare faunal diversity, act as a centre of eco-tourism and educational living laboratories. Rising economic oriented activities and commercialisation is keeping the environmental and climatic stability of this region at stake.

Kala et. al. (2004), gave an understanding of indigenous utilization of local medicinal plants in Uttaranchal. Globally, herbal medicines are getting priority in health care which makes it a necessity to preserve those valuable medicinal plants species. Himalayan region contains 350 out of 700 medicinal plants that are used for drug production in industries, showing a vast potential for herbal based pharmaceutical industry. Rural or local methods of cultivating these rare species should be promoted among local people for their socio-economic development and this will also reduce the pressure on wild resources.

Langton et. al. (2005) detailed the fundamental role of traditional and indigenous system for sustenance and biodiversity conservation in the remote and rural regions, as playing a major role in economic structure of developing countries such as Australia, Singapore, India and many other. Traditional methods and techniques are the base of food production and many other basic routine activities in these countries, making high portion of population rely on them for livelihood practices. Local community and indigenous people want to conserve this knowledge system not only for the sake of environment or biodiversity but more because of their sentimental connection with their ancestral lands, to hold their traditional livelihoods and most importantly local food security. International organisations and national authorities are also taking steps for capacity building and equipping traditional people for their socio-economic upliftment and optimum utilisation of their knowledge.

V.S Negi et. al. (2023) explains how modern lifestyle and healthcare systems, including daily food, beverages, medicines, cosmetic and plethora of other associated segments are somewhere a gift of a long history of Indigenous Knowledge System (IKSs) which passes from generation to generation and plays a major role in the sustainable management and conservation of biodiversity. The study demonstrates the importance of traditional and indigenous knowledge not only for relative communities but for entire modern world for human well-being and food security. Globally, it is accepted that there is a positive correlation between the IKS and sustainable development goals making the agenda of their perseverance a necessity to all, international political bodies to individual citizen.

R.K. Maikhuri et.al. (1997), indicates about traditional crops getting extinct at a faster rate in Central Himalayas which used to have a huge variety of indigenous crops and cultivars grown by native people for sustenance. These diversified indigenous crops have high tolerance level against unpredictable bad weather conditions and vital for local food security. These ecologically and economically important crops are moving towards extinction and demands for urgent consideration by government and policy makers.

Phukan & Gazdar (2014) discuss the importance of integrating climate change adaptation and disaster risk mitigation strategies to develop resilient livelihoods in the face of evolving climatic conditions. It highlights that both climate change and disasters can significantly impact vulnerable communities' ability to sustain their livelihoods, leading to increased poverty and vulnerability. The integration of these two approaches involves combining efforts to address the interrelated challenges posed by climate change and disasters. By doing so, communities can enhance their adaptive capacity, reduce vulnerabilities, and build resilience.

3. Objective of the Study

The research seeks to understand the livelihood pattern in the study area revolving around traditional knowledge and climate resilient practices in the community. It involves tracing linkages between the local resources and the community while identifying practices for capacity building.

4. Study Area and Methodology

The field visit was conducted in May 2014 in the Pratap Nagar Block, Tehri Garhwal, Uttarakhand. The survey was conducted in 11 villages in field area viz. Sera, Budkot, Beldogi, Maulya, Onal Gaon, Herwal Gaon, Deen Gaon, Ghandiyal Gaon, Mukhem, Pokhri and Sadad villages all placed in close geographical vicinity with each other. A sample of around 14 households from each village was selected through random sampling.

The questionnaire consisted of both open ended and close ended questions starting with personal details of the respondents followed by different sections pertaining to different subjects of agriculture, water management, resource management, health issues, livelihood patterns, housing structures and folk culture. Responses were also taken from public representatives like Gram Pradhan, President, and Treasurer of Mahila Mandal Dal. Study about the medicinal herbs was done with the help of experts and samples of these herbs were collected by the team from the forest in the vicinity. The interviews of local medicinal experts were taken and recorded.

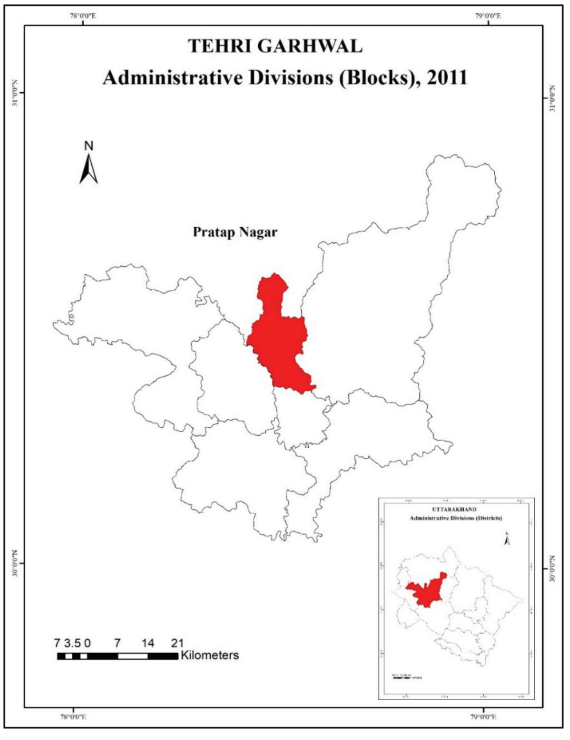

Figure 1: Location of Study Area- Pratap Nagar Block, Tehri Garhwal District

5. Summary of Findings

5.1 Socio-Economic Structure

Out of the total sample almost two-thirds (64 percent) fell under the age of 40 years while only 10 percent of the total sample was constituted by the elderly (60 years and above). The sex ratio of the sample was fairly equal with minimum variation in the proportion of women vis-à-vis men. Almost three-fourths (73 percent) of the total population were literate. There is a significant variation in the education level of the people among the 11 villages. Men have a higher percentage in education while there is widespread illiteracy among womenfolk in these hilly villages.

Agriculture is the major occupation of the community constituting almost three-fourths (76 percent) of the population followed by formal employment and private jobs (17 percent). A miniscule population identified as agricultural labour (3 percent) and manual labour (2 percent).

5.2 Agriculture

The major kharif crops cultivated in the area comprise of paddy, mandua, jhangora and chulai, while the major rabi crops consist of wheat, barley, potato, peas and vegetables. Most of the agriculture is rainfed and the crops are cultivated according to the variability of rainfall around the year. There is minimal commercialisation and most of the produce goes towards subsistence. Cropping patterns are simple and historic and the knowledge is passed down generations. The most striking agricultural feature of the region is optimum utilization of step farming or terrace farming and contour ploughing which allows for better irrigation, increases land under cultivation and reduces erosion. Mixed farming is the prominent cropping technique utilised over and above monoculture.

Most of the people use organic manure instead of chemical fertilizers to cultivate the crop unlike conventional agriculture where copious amounts of chemical fertilizers are used to get higher yield. This use provides the required motivation to pursue environmentally responsible farming, and the environmental knowledge served by the memory of farmers act as guidelines having a direct relationship with responsible environmental behaviour. Productivity in this area was low as compared to other parts of the state due to various reasons such as inadequate irrigation facilities, dependence on monsoon, occurrence of natural disasters and minimal use of technology and chemical

fertilisers. Livestock is an integral component of the agriculture sector in this region and it provides draught power, fertilizer, nutrition, and income for farm households. However, due to acute seasonal shortages of nutritious fodder, economic benefits from livestock as an occupation remain negligible. Traditional methods of livestock rearing are used. Fodder is confined to locally found species and the lack of fundamental animal health infrastructure and marketing facilities limits possibilities.

The demand for organic food in the urban areas must be cashed upon by providing adequate storage, transportation, and marketing facilities. The agricultural practices shall be chosen keeping in mind the agronomic condition of the area. The traditional system needs to be preserved, protected, and promoted.

Figure 2: Terrace Farming/Step Cultivation in Pratap Nagar

5.3 Watershed Management

This region is blessed with ample water resources with small streams criss crossing it abundantly. The major sources of water in this region are springs and river, which caters to the need of the people. The stream water is used for drinking and irrigation purposes. In case of scarcity or if water flow decreases in streams, people are dependent on natural springs. In recent times due to developmental works, today most of the houses are

fitted with tap facility. Women spend excessively in terms of time and labour to collect water manually. *Gharat* system is an innovative technique used for grinding wheat as well as generating electricity with the help of turbines. It is a sustainable technique that can be used on mass level.

As this region receives moderate rainfall, people construct small irrigation channels called *guls* and '*gadhera* to collect rain water. Water from the snow-fed streams is diverted by placing boulders in the bed of the streams into channels which run along the contours. During early dry summer months scarcity of water is felt and some streams go dry. Even drinking water is fetched from far off places. Nearby spring water or water supplied by *guls* is carefully utilized. Irrigation by wells is insignificant in the region. There are abundant water resources but they have not been tapped properly which creates acute shortage. The *Gharat* system can be used to produce hydro-electricity which can be used for off-grid electricity purposes. Construction of overhead tanks should be encouraged for saving the travelling time and labour of women which could reduce the burden of care labour they bear for the household.

5.4 Housing Structure

The houses in this region are constructed using silt, mud and wood, in which the inner wall is made with mud while the outer wall is made with cement. This unique technique helps to keep houses warm in winters and cool during summers. Houses generally consist of two floors, of which the family occupies the upper floor to avoid the excess heat and cold and the livestock are kept on the ground floor. The houses have sloping roofs so that rainwater and snow does not accumulate on the roofs. The sizes of the doors and windows are generally kept small in order to keep the house safe from harsh winds and heavy snowfalls. These traditional houses of wood and stone can survive natural hazards like earthquake and floods. This proves native intelligence is significant in disaster mitigation and preparedness.

5.5 Forestry

Plant life is influenced by altitude, exposure, and the amount of precipitation. In this region which receives heavy rainfall, dense forests with sal, haldu, tun and other tropical trees predominate below a height of 1075 meters. It serves as a cardinal physical and cultural resource, providing fuel wood, fodder, honey, fruits, tubers etc.

The *Van Chaukidar* is appointed to avoid encroachment and exploitation of the pious resource. Many customs, beliefs and rituals of the inhabitants are derived from the pious entity (Sem Nagraja Temple nestled in the womb of the forest and Sem Mukhem festival). People of this region have strong ecological ties to the forest. They travel approximately 3-8 kilometers to collect fodder, fuel wood, medicinal herbs, fruits, and other minor forest products.

The government should provide incentives and frame policies for optimum use and conservation of forests by locals. The locals should be made equal stakeholders along with the administration in regulating, facilitating, and augmenting the resource. Stringent laws and their proper implementation should be ensured to prevent misuse, abuse, and overuse of the forest resource. Poaching needs to controlled with a from hand and the endangered fauna of the region should be allowed to flourish in their natural environs.

Figure 3: Women collecting Minor Forest Produce in study area

5.6 Medicinal Herbs

This region is blessed with more than one hundred seventy different kinds of herbs but the new generation is completely unaware of the use of these herbs. The forest regime is a home to innumerable exotic and endemic species whose commercial and medicinal values are invaluable (Shankh Jadi, Rhododendron, Brahmi, Pasanved, Jhoola

Ghas, Kasturi Ghas).The locals use them for subsistence and very few are aware of their commercial potential. Few traders usually outsiders get licenses from government to trade in the medicines. Many herbs of high commercial value face illicit trafficking to China and abroad. People get to know about medicinal herbs mostly from their parents and grandparents. These herbs have high medicinal values as well as market value which ranges from twenty thousand to twenty lakhs per kilogram. The community needs to be made aware about the different herbs found in their vicinity and their uses so that they can use them for commercial purpose which will help in economic upliftment of the community. Raising awareness is also essential in order to minimise the role of middlemen and traders who garner huge profits by exploiting the lack of exposure of the community to the market for medicinal herbs. The community knowledge flowing down generations has suffered a major setback due to the dearth of interest by the youth in preserving the rich knowledge which is threatened to become extinct.

Research institutes need to be established to extract maximum information and medicinal properties of the herbs. The locals should be involved in the marketing and extraction of herbs so that the profits of these treasures goes to their truthful possessors

Figure 4 : *Jhula Ghas*, Medicinal Herb collected from study area

and stakeholders. Specialized training and awareness regarding herbs needs to be revitalized so that the legacy of this hidden treasure doesn't dissolve in the wake of changing times.

6. Conclusion

Traditional knowledge is essential for the sustainable use of resources and is instrumental in the human quest for sustainable livelihood. Traditional knowledge is deeply embedded in the cultural and historical context and is manifested through their practices. Knowledge of local communities regarding biodiversity, conservation of natural resources and maintenance of ecosystem have been significant adaptive management tools for sustainable livelihood.

The cooperation and collective action, intergenerational transfer of knowledge and concern for future generations are essential mechanisms adopted by locals. As over exploitation of natural resources happen in pursuit of livelihood, it is important to formulate livelihood options that are in harmony with the local milieu. Sound knowledge about inherent logic of the local customs and their rasion d'être would be critical for devising such strategy.

The area is rich in biodiversity and has a huge scope in the field of medicine and ayurvedic research. The traditional knowledge is diminishing in the wake of modernism and the new generation is not well informed about their ancestral practices due to lack of inter-generational transfer of knowledge. Changes in the cropping pattern of this area are affecting the health of the local community. Locals are opting to move out of the area into towns and cities because of the dearth of basic amenities, education, and health.

The region although nestled in acute isolation from the modern world has immense scope for development. The organic agriculture and naturally derived medicines are in high demand in the urban areas and the region can act as a cardinal hinterland for the purpose. The promotion of these traditional systems and their broader applicability in the wider world can pave the path for judicious, sustainable development and proper allocation of limited resources. The biological systems of the world have been deteriorated in the wake of illusionary development and their resilience is the need of the hour. We have a lot to learn and adopt from these pristine environs and tap

into their knowledge and customs which can be instrumental in their economic and societal progress leading to sustainable livelihood.

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Risk Communication and Community Engagement: Strategies for Informed Decision-Making and Community Resilience

Surya Parkash[1], Rajeev Sharma[2], Raju Thapa[3] and Harjeet Kaur[3]

Abstract

In both routine and emergency scenarios, effective risk communication and community engagement (RCCE) are critical. This paper delves into the significance of RCCE in enabling people to make knowledgeable decisions and encouraging modifications in behavior. It highlights that effective RCCE require trust, cultural awareness, and two-way communication. The manuscript also discusses the difficulties presented by false information and social issues and emphasizes how gender concerns are included into RCCE. In order to facilitate quick crisis communication, it presents the Crisis and Emergency Risk Communication (CERC) framework. The manuscript also explores the stages of crisis communication, emphasizing the values of respect, action, accuracy, empathy, and credibility.

Keywords: *Public Health Emergency and Disaster Management (PHEDM), Risk communication and community engagement, Crisis and Emergency Risk Communication, Community Outreach.*

1. Introduction

The term "risk communication" describes the instantaneous sharing of knowledge, suggestions, and viewpoints between professionals, authorities, and individuals who are at risk of losing their lives, becoming ill, or experiencing financial or social hardship. The ultimate goal is to empower everyone who may be impacted by a danger

[1] **Surya Parkash,** National Institute for Disaster Management, Ministry of Home Affairs, Government of India
[2] **Rajeev Sharma,** Division of Global Health Protection, Centers for Disease Control and Prevention, Country Office-India
[3] **Raju Thapa, Harjeet Kaur,** Emergency Management, VHS-CDC, India

or hazard to make educated decisions about how to lessen the impacts of the threat or hazard—like a disease outbreak—and to adopt preventative and defensive actions. The public can get real-time information, guidance, and expert opinion regarding the nature, importance, and control of risks through the successful two-way flow of communication (NCDC RCCE Strategy 2023).

Households, communities, and social groups are the target audiences for the systematic and well-organized RCCE process, which comprises of several interventions and activities. It deals with the perception, application, transmission, and understanding of information. Protection and the need to "do no harm" should be the cornerstones of preparedness and response strategies.

1.1 Necessity of RCCE:

Incorporating risk communication and community engagement (RCCE) into various fields and contexts is imperative for several compelling reasons.

The following key aspects of RCCE highlight its pivotal role in crisis communication and community engagement:

- Effective RCCE establishes trust and credibility between authorities and the public, particularly vital during crises to motivate adherence to recommended actions.
- RCCE fosters behavioural change by providing information for safer behaviours, such as vaccination during outbreaks or evacuations during disasters.
- RCCE ensures cultural sensitivity in conveying information, aligning messages with community values to enhance effectiveness.
- RCCE facilitates two-way communication, allowing authorities to understand community concerns, needs, and priorities, making decision-making community-centric.
- RCCE combats misinformation by disseminating accurate and timely information, and countering rumors.
- Gender integration is a crucial component of all RCCE programs, spanning all aspects of risk communication and community involvement;
- RCCE empowers communities by involving them in preparedness and mitigation activities, strengthening resilience to future hazards.

The efficacy of communication initiatives in risk reduction may be greatly increased by utilizing community-based networks, interacting with prominent individuals, and strengthening the capabilities of local organizations. In addition to establishing authority and trust, this strategy makes it possible to respond to emergencies more quickly.

Several steps have been taken by the Indian government to promote risk communication and community engagement (RCCE). The government launched a number of RCCE programs during COVID-19. Furthermore, all of the areas of the National Curriculum Framework for Foundational Stage—which was created in accordance with the National Education Policy (NEP) 2020—are covered by the National Curriculum for Early Childhood Care and Education (ECCE).

1.2 Integration of Gender as a Cross-Cutting Issue Across all RCCE Interventions:

Historical turning moments may be utilized to monitor the evolution of risk communication and community engagement (RCCE), such as the 1918 influenza pandemic, which is estimated to have killed 50–100 million people. This crisis demonstrated the need for a more thorough societal response to issues pertaining to health. Later, in the 1920s, governments embraced the concept of socialized medicine, and in 1924, the Soviet Union introduced the idea of physicians addressing socioeconomic concerns impacting illness prevention. In 1946, the formation of the World Health Organization (WHO) underscored the understanding that pandemics are social challenges, not just individual ones. As the COVID-19 pandemic deepens economic and social stress coupled with restricted movement and social isolation measures, gender-based violence is increasing exponentially. Many women are being forced to 'lockdown' at home with their abusers at the same time that services to support survivors are being disrupted or made inaccessible (UN, 2020). Public health emergencies can lead to a rise in domestic violence and sexual assault (Peterman et al. 2020). In response, RCCE gradually emerged as a critical component of pandemic response, emphasizing effective communication and community involvement in tackling health crises.

2. Crisis and Emergency Risk Communications (CERC)

Emergencies can strike communities suddenly. Whether it's floods, cyclones, chemical

incidents, earthquakes, or pandemics, these public health crises threaten communities at any time. When disaster hits, the first and sometimes only resource available to responders is information. Effective communication during these critical moments can significantly impact how our community responds and recovers.

'Crisis and Emergency Risk Communication (CERC)' plays a vital role in rapid crisis communication. It's about making informed decisions swiftly, even when faced with imperfect or incomplete information. Imagine being in an emergency situation where risks and actions need to be determined urgently. These choices may be irreversible, and the outcomes uncertain, yet they're crucial for community safety.

CERC integrates the imperative of conveying information regarding risks and advantages to your community within pressing time limitations. CERC serves as a tool to furnish guidance to individuals or entire communities, enabling them to make the most informed choices concerning their safety and well-being in emergency situations. Table 1 represents the Communication Matrix for Crisis and Emergency Management.

Key Elements:

Communicator: Expert who is impacted by outcomes

Time pressure: Urgent and unexpected

Message Purpose: Explain, persuade, and empower decision-making

Table 1: Communication Matrix for Crisis and Emergency Management

Communication Type	Crisis Communication	Issues Management Communication	Risk Communication	Crisis and Emergency Risk Communication
Communicator	Member of the Organization impacted by the crisis	Member of the organization impacted by the crisis	Expert who is not directly impacted by outcomes	Expert who is impacted by outcomes
Timing	Urgent and Unexpected	Anticipated; timing is somewhat controlled by the Communicator	Anticipated with little or no time pressure	Urgent and unexpected

Message Purpose	Explain and persuade	Explain and persuade	Empower decision-making	Explain, persuade, and empower decision making

2.1 Why is CERC Important?

When a crisis occurs, even if it was anticipated, it can take some time to mount a comprehensive response. Resources need to be allocated, the situation needs to be assessed, and attention must be paid to emerging or secondary threats. Additionally, logistical and safety obstacles may need to be overcome to ensure that people and supplies can reach the affected area.

However, individuals directly impacted and facing imminent risk are eager to take immediate action and require information about the situation and quick safety measures. In situations with tight time constraints, the CERC framework and its principles can be invaluable in providing the public with the information they need to make informed decisions and accept the reality of imperfect choices.

2.2 The Six Principles of CERC

Integrating CERC fully ensures that limited resources are effectively managed and contribute optimally to every phase of an emergency response. The six principles of effective emergency and risk communications are outlined as follows (see Figure 1):

- **Be First**: Time is of the essence during crises. Providing information promptly is vital. Often, the initial source of information becomes the most trusted for the public.
- **Be Right**: Accuracy builds credibility. Information should include what is known, what is uncertain, and efforts being made to fill in the gaps.
- **Be Credible**: Integrity and truthfulness must be maintained, even in the midst of crises.
- **Express Empathy**: Crises cause suffering, and it's important to acknowledge this in words. Addressing people's emotions and challenges fosters trust and connection.

- **Promote Action**: Offering practical steps for individuals to take helps alleviate anxiety, restore order, and in still a sense of control.
- **Show Respect**: Respectful communication is crucial, especially when people feel vulnerable. It fosters cooperation and trust.

Figure 1: Six Principles of CERC

2.3 Phases of a Crisis and the Communication Rhythm

Every emergency, disaster, or crisis unfolds in distinct stages, requiring communicators to adjust their strategies accordingly. These phases - preparation, initial response, maintenance, and recovery - allow communicators to anticipate the information needs of different stakeholders, including the media, government agencies, private organizations, and affected individuals. Tailored information is essential for each stage (see Figure 2).While communication tactics may differ across crisis phases, communicators must consistently prioritize three core objectives: fostering community engagement, enabling informed decision-making, and conducting ongoing evaluation. By dividing the crisis into these phases -preparation, initial, maintenance, and recovery - communicators can anticipate the information needs of the media, government organizations, private and public organizations, and the people in an affected area. For each of these phases, specific types of information need to be created CDC (2018).

2.3.1 Preparation

- Develop partnerships and build relationships with organizations and community stakeholders that you expect to work with in a response.
- Draft and test messages with different populations to make sure that the information is understandable and actionable in a crisis
- Prepare for the types of disasters you are especially likely to face.
- Create crisis communication plans.
- Select and train spokespersons.
- Determine the approval process for releasing information.
- Engage communities in preparedness planning.

2.3.2 Initial

- Express empathy
- Provide simple explanations of risk.
- Promote action.
- Establish your organization's credibility.

2.3.3 Maintenance

- Ensure community understands ongoing risks and actions they can take to reduce risk or harm.
- Provide more background information.
- Segment audiences - explain the different risks that exist for different people.
- Encourage public support and cooperation with response and recovery efforts.
- Address misunderstandings, rumors, and unclear facts

2.3.4 Resolution

- Motivate people to take action or remain vigilant. Promote community preparedness for possible future crises.

- Discuss, document, and share lessons learned from the response.
- Evaluate plans.

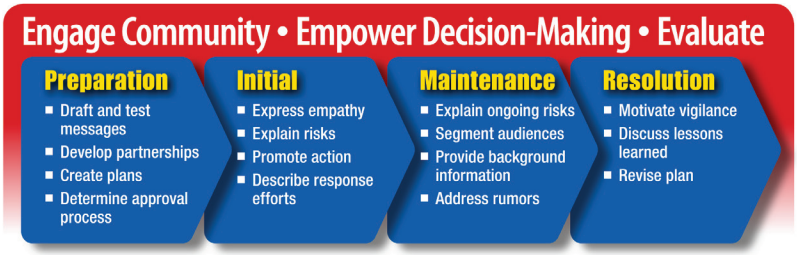

Figure 2: Crisis and Emergency Risk Communication (CERC) Rhythm

Source: https://emergency.cdc.gov/cerc/

3. Pitfalls of RCCE

There are a few things to watch out for in order to have crisis communication that works (Figure 3). Refrain from distributing contradictory information from several specialists since this might lead to misunderstandings and undermine confidence. It's critical to release information on time since doing so can impede public comprehension and reaction initiatives. Avoid taking on paternalistic views that impede the empowerment and involvement of the community. Actively dispel misconceptions and rumors in real time to stop misinformation from spreading. Ultimately, reduce public power struggles and misunderstandings by keeping lines of communication open and constant so that the community is educated and self-assured when faced with challenges.

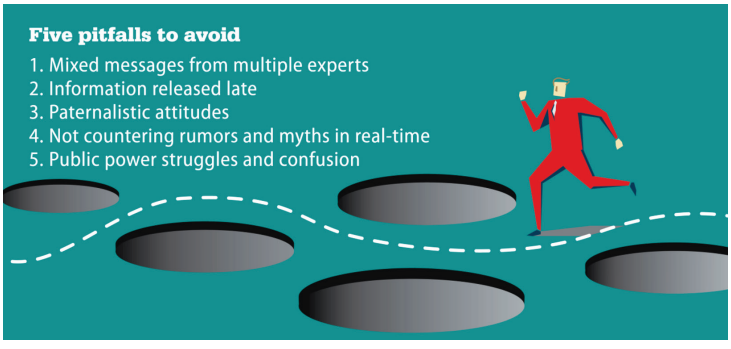

Figure 3: Five pitfalls to avoid

4. Planning Risk Communication and Community Engagement

A well-structured RCCE strategy is made up of two main parts: a communication plan that explores the nuances of communicating risk-related information and an action plan that outlines the tasks, accountable parties, and methodologies.

4.1 Components of the RCCE Action Plan

An action plan is a detailed document that provides a strategy framework and instructions on how to interact and connect with communities in an efficient manner during emergencies or times of crisis. This strategy provides a guide for how authorities and organizations will communicate with, involve, and enable communities to minimize risks, make informed choices, and collectively tackle challenges.

4.1.1 Endorsement

Clear leadership at the top is essential for effective systems. An authority individual should unambiguously approve the RCCE action plan. This might be the district magistrate at the district level, or it could be the chief secretary or another senior official at the state level whose approval or presence can encourage interdepartmental cooperation.

4.1.2 Teams and their Responsibilities

Establish distinct teams tasked with crafting RCCE communication strategies for the public, media, social media, and partners. Additionally, establish teams responsible for coordinating and reviewing these plans.

4.1.3 Clear Communication Processes

Define a well-defined process delineating the flow of communication, specifying which team or individual will release particular messages, the timing and frequency of these communications, and the necessary approvals. For example, in the context of a health emergency, identify the authority or official responsible for approving the technical aspects of communication.

4.1.4 Joint Information Centers

If there is a need to establish joint information centers (JIC) with partners or community-

based organizations, outline the partners involved and describe the coordination mechanisms within the action plan.

4.1.5 Designated Spokesperson

It is imperative to designate a spokesperson and clearly indicate their role in the action plan. This designation promotes consistency in communication and mitigates the risk of multiple information sources. In the event of an extended emergency, consider identifying more than one spokesperson and specify their roles and succession plan within the action plan.

4.1.6 Contact Details

Provide comprehensive contact information for all team members, partners, media personnel (both at the reporting and senior levels), including after-hours contact numbers and email addresses, to ensure 24/7 connectivity within the RCCE team.

4.1.7 Resource Plan

The final element of the RCCE action plan entails mapping available resources and projecting future requirements. This proactive approach facilitates the allocation of additional resources as needed in a timely manner.

4.1.8 Monitoring

Monitoring in the context of RCCE is essential to assess whether the communication objectives established for RCCE are being achieved. Within RCCE, the monitoring process serves the purpose of helping the risk communicator determine whether the intended target audiences are being reached, if they are comprehending the messages accurately, and if there is evidence of the desired behaviour change.

Monitoring and evaluation (M&E) are crucial for gauging the progress and success of all interventions, providing clear output and outcome measures. The RCCE plan includes an M&E framework that is devised at the country level, incorporating specific output and outcome indicators related to the communication activities outlined in the RCCE communication plan. It is imperative to systematically record the quality of the response and preparedness mechanisms, adhering to established standards. Monitoring and evaluation in various scenario contexts facilitate periodic analysis, reporting, and making necessary adjustments.

The aim of community engagement standards is to facilitate the implementation of high-quality, evidence-based community engagement on a broad scale, encompassing both development and emergency situations. An important objective of communication monitoring is to allow for mid-course corrections when needed.

The monitoring of communication adheres to a predefined monitoring plan, which is ideally structured into four key components:

- *Monitoring indicators* – Prior agreement on how communication elements will be 'assessed' or 'evaluated.'
- *Monitoring Frequency* – Specifies the frequency at which monitoring data will be gathered.
- *Operational Aspects of Monitoring* – Encompassing the who, how, and where of the monitoring process. This includes identifying who will collect the data, how it will be collected, and where it will be forwarded for analysis.
- *Utilization of Monitoring Data* – Outlines how the collected data will be employed for decision-making and the potential need for adjustments in the planning process.

5. Community Readiness Approach

Well-informed, actively involved, and empowered communities play a fundamental role in facilitating the introduction of public health emergency and risk new vaccines, treatments, and tests to mitigate the transmission of COVID-19 and ultimately safeguard lives.

According to the Collective Service which is a partnership between the International Federation of Red Cross and Red Crescent Societies (IFRC), United Nations Children's Fund (UNICEF), the World Health Organization (WHO) and the Global Outbreak Alert and Response Network (GOARN), and as well as key stakeholders from the public health and humanitarian sectors, the following 10 steps are well-established risk communication and community engagement (RCCE) principles that have proven their power. Collectively, they position communities as central figures in the process of implementing new vaccines, treatments, and tests, with the primary aim of fostering trust, a vital component for any community-driven action. Trust acts as the cornerstone upon which all community efforts hinge.

5.1 Make Decisions about the People, with the People

Consistently seeking and acting upon feedback from communities is a cornerstone for nurturing trust and enhancing the relationship between communities and public health authorities. To achieve this, it's vital to initiate meaningful discussions with these communities, delving into their sociocultural contexts and recognizing the power dynamics at play. Understanding community networks and identifying influential individuals within them is crucial for tailoring engagement interventions that are both safe and widely accepted. This thorough approach builds a strong connection between communities and public health efforts, leading to a more effective response overall.

5.2 Maintain and Strengthen Trust Through Formal and Informal Connections

Effective risk communication and community engagement (RCCE) relies on a coordinated and inclusive approach that brings together various stakeholders. Emphasizing trust as pivotal for community action and healthcare delivery, a whole-of-society approach is essential. To enhance health system readiness at all levels, RCCE coordination mechanisms should be activated or strengthened, utilizing existing health and response structures. Ensuring representation for civil society and vulnerable groups is crucial, acknowledging their unique needs and vulnerabilities.

5.3 Talk Less and Listen More

Seek out and address community comments regularly. Communities and public health and authorities have better relationships and mutual trust as a result. To encourage accountability and make sure that community opinions, queries, worries, and recommendations are taken into consideration, establish channels for community input. Direct the ongoing modification of the public health emergency reaction in a way that is safe, secure, nimble, and discreet.

5.4 Utilize Data to Make Informed Decisions and Adjust Course as Necessary

Social data provides a crucial viewpoint on the beliefs, behaviors, and knowledge gaps within a group. Knowing what motivates people's behavior is also essential to understanding why certain people follow social and public health regulations and others do not. An assortment of data sources is ideal for something as intricate as human behavior. For the fullest understanding of community knowledge gaps, opinions,

and behaviors, include survey data, social listening, community input, and polling. Apply this information to all levels of decision-making.

5.5 Engage in Collaborative Planning with the Community

Active community involvement in planning processes holds the potential to enhance service delivery, promote equity, and eliminate obstacles, particularly in the introduction of new tools such as vaccines, treatments, or novel testing methods. It's crucial to engage communities in the collaborative design of solutions, ensuring their perspectives are integrated into the planning phase. Employing social data analysis is essential to craft, consistently assess, and revise Risk Communication and Community Engagement (RCCE) action plans. Part of this comprehensive approach involves the development of crisis communication preparedness plans, all of which should actively involve the community to foster a more inclusive, responsive, and effective planning and implementation process.

5.6 Empower the Community to Measure Success

Extensive community engagement in monitoring and evaluation reinforces the endurance of programs, fostering shared responsibility and optimal resource utilization. Encouraging community involvement in shaping the monitoring and evaluation procedures is key.

Engaging civil society and community organizations in monitoring, reporting, and shared accountability initiatives increases the likelihood of broader community acceptance and ownership of new interventions.

5.7 Hire and Strengthen RCCE Expertise

The assistance provided through RCCE plays a vital role in linking communities with healthcare services, acting as a crucial bridge between them. This expertise is essential in supporting national authorities in preparing for and safeguarding individual and public health. It is crucial to strategically identify the areas where RCCE expertise is needed and promptly recruit the necessary personnel. Establishing RCCE leadership roles at all levels, with the authority to coordinate partnerships, is essential. Additionally, implementing and enforcing Standard Operating Procedures (SOPs) for RCCE, if not already in place, is vital. These SOPs serve as a central coordination mechanism and a tool for ensuring quality in RCCE efforts.

5.8 Enhance Skills and Capacities for PHEDM Adaptation

Offering training to the community workforce, including frontline workers, volunteers, disaster professionals, community leaders, and mobilizers from different civil society groups, on Public Health Emergency and Disaster Management (PHEDM) will help address local issues at the grassroots level. To enhance effectiveness, it's important to establish a continuous peer-to-peer support system for community mobilizers and networks.

5.9 Control the Spread of Misinformation

An Infodemic represents an excessive volume of both beneficial and harmful information that complicates individuals' health-related decision-making. The infodemic in Public Health Emergency and Disaster Management (PHEDM) can negatively impact the community. To address this, guarantee access to reliable information and efficiently handle misinformation and rumours. It is essential to activate or bolster national fact-checking and rumour-monitoring capabilities, recognizing the potential risks of rumors and misinformation, which can be as harmful as the challenges within Public Health Emergency and Disaster Management (PHEDM).

5.10 Consistent Two-way Engagement

Maintaining an ongoing, interactive dialogue, reinforced by information from reliable local sources, solidifies positive attitudes and spurs proactive responses. Swiftly establish and determine primary communication channels within communities. Whenever feasible, tailor scientific and health-related messages to better align with the diverse contexts present in these communities.

6. Conclusion

The foundation of well-informed decision-making, behavior modification, and community empowerment is effective risk communication and community engagement (RCCE).

Communication that can save lives is crucial. The goal of CERC is to help people make decisions that could save their lives by providing essential information when it's most needed. CERC also aids in the psychological support of those affected by a crisis, helping them to recover and manage stress. These guidelines provide a

framework and direction amidst uncertainty. When organizations communicate effectively, they are more likely to achieve their objectives, retain public trust, allocate resources wisely, and most importantly, prevent diseases and injuries. It's essential to adhere to these principles at every step of an effective response: respond swiftly, provide accurate information, build trust, show empathy, encourage action, and demonstrate respect.

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      ii. Larson, G. W., Ellis, D. C., & Rivers, P. C. (1984). Essentials of chemical dependency counseling. New York: Columbia University Press.
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Plot No. 15, Block B, Pocket 3, Sector 29, Rohini, Delhi 110042
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