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Impact of the Hydro-Meteorological Disasters in the Upper Beas Basin in the Kullu Valley, Himachal Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An investigation exploring the people perception about the impact of the hydro-meteorological events was executed in the upper Beas basin of Kullu district using a semi-structured questionnaire. The selection of the study area was made after conducting preliminary studies, revealing that the region experienced property losses amounting to Rs. 18.61 Cr as a result of disasters occurring between 2017 and 2019.. In the past few decades, the occurrence of the

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extreme weather events of cloud bursts, flashfloods and heavy rainfall in the Beas Basin has affected the livelihood of the local inhabitants. Therefore the current research is designed for the identification the existing disaster related issues of the inhabitants of the Himalayan region. To assess the community perception towards the disaster events, the one third households of the most prone villages of the region were studied i.e. 251 respondents. To find the community perception , the respondents were enquired about the information regarding the past events of the disaster in their area and perception about the probable causes of such events. It was analyzed that the disasters events has affected the agriculture, water supply, infrastructure, tourism and allied businesses in the region. It was found from the insights of the research that 70.18% respondents agree that hydro- meteorological disasters occurs each year furthermore 75.2% of the respondents believe that among the all types of disasters, the flash floods are the most common type of disaster to the area. In addition to this, the 38.40% and 30.02% respondents believed that impact of disaster has increased due to the climate change and the practices of deforestation respectively. The collected statistical data was further evaluated using Pearson's Chi Square test and it was noticed that the responses such as anthropogenic role in the increased intensty of disasters and the effect of disasters on this tourism dominated area had a significant association at the 95% confidence interval with the respondents having different educational qualification, gender and age groups. It was examined from the investigation that the activities such as deforestation, over grazing and illegal extraction of medicinal plants in the high altitude areas are the precursors behind the increased impact of the disaster events. The outcomes of this study will assist the policy makers and scientific community for the better understanding of the disasters and planning the risk management strategies for the region.

Keywords: Climate change; hydro- meteorological disasters; flash flood; risk management; people's perception.

1. INTRODUCTION

Over the last several decades, the climate change has simulated the pressure on the environmental ecological services. It was noticed that the global temperature has increased 0.74 degree Celsius in past 100 years and the present gas emission if unchanged, will raise global temperatures by 5 degree Celsius by 2080 [1]. The change in global climate has increased the events of the disasters such as floods, droughts, heat waves and many more [2]. The word disaster particularly is defined as a sum of the hazard, vulnerability and potential risk from such events. The disasters are also categorized in the form of natural, man-made disasters and combination of both. The natural disasters are caused due to the disruption in the natural phenomena of the earth such as cyclones, tsunamis, earthquake and volcanic eruption. Man-made disasters are those which are completely caused by the anthropogenic impact such as explosion, pollution, dam failure, etc. Then there are few disasters such as flood, draught, landslides, fires those have both natural and anthropogenic in their origin. Steffen [3] found that the anthropogenic activities has significant role in the process of the climate change. Also, it was observed by Eriksson et al. [4] that there has been increase in the events of flash flood and cloud burst in the Indian Himalayan Region due to the climate change. The term flash flood is defined as the flooding that begins within 6 hours of heavy rainfall (USNWS 2021) and the cloud burst defined as the precipitation of >100 mm per hour over the geographical region of 20-30 Km^2. These both are dependent on the intensity of the rainfall, land use, topography, vegetation type, soil type, and soil-water interaction. It often causes destruction to the side lying area along the channels of the river. The floods originate in the geographical region when any of its dependent factors are troubled [5]. During the year of 1947-1981, it was observed that the total number of 554 hydrological disasters took place, comprising of floods and cyclones [6]. It was also discovered that during the 20^{th} century, the floods took around 8 million lives worldwide [7]. A report published by CRED (2018) investigated that in the year 2017, out of the 335 natural disasters occurred over the earth, 126 were reported due to floods. The continent of Asia was found to be most prone to the occurrence of such water induced disasters as this continent contains 44% of the all disaster events, 58% of the total deaths and 70% of the total people affected. It was observed that out of the total deaths of 9697 people on the earth in the year 2017, the 3331 people died only due to floods. Out of the 55

million affected people due to flood, 26.9 million were from India, Nepal and Bangladesh and 12.0 million were from China. Around the world, the floods in the year 2017 caused the economic loss of around $20.3 Billion [8]. According to the Human Development Report [9] the natural hazards have increased to 75% in past 2 decades. In past 20 years, 4 billion people were affected claiming 1.23 million lives and economic loss of $3 Trillion due to these disasters.

India is also vulnerable due to its proximity to geo-dynamic nature. As per the report of NIDM (2018) it is among the ten most disaster prone countries of the world. Out of its 36 states and UTs, 27 are vulnerable to the disasters. It has around 58.6% of landmass prone to earthquakes; 12% landmass prone to floods and river erosion; 75% coastal area prone to cyclones and tsunamis; 68% of the cultivable land area vulnerable to draught and mountainous regions at risk of avalanches and landslides. In the year 2018, the total numbers of 23.9 million people were affected due to the events of the disaster. The Indian Himalayan Region has also encountered numerous disaster events such as earthquake, landslides, cloud burst, avalanches, Glacier Lake Outburst Floods (GLOFs) and flash floods. The IHR covers an area of 5 Lakh sq. km i.e. 16.2% of the total geographical area of the country. These new fold mountains embodies snow fed rivers, ground water resources, flora, fauna, clean air, fertile land and many other valuable services. The event of the disasters in the fragile ecosystem of the Himalayan region has affected the livelihood of the inhabitants in an adverse manner [10-12].

The main purpose of the present study is to assess the impact of the hydro-meteorological disasters on the livelihood of the mountainous peoples. It was found from the secondary data that the frequency and intensity of the disasters in the state of Himachal Pradesh has increased manifold. The state has seen numerous floods, cloud bursts, earthquakes, landslides and avalanches in past several decades. The Kullu district of the state due to its dynamic geographical environment is prone to the occurrence of floods, cloud bursts and landslides. The district of Kullu has total area of 5503 sq. km out of which the area of 5401 sq. Km prone to the landslides. This landslide prone area has 1820 sq. km area under risk of severe to very high risk and 3512 sq. km area under high risk zone [13]. It was observed that in the state of Himachal Pradesh 14 cloud burst event occurred during monsoon of 2022 while among these events a majority of 5 events occurred only in the Kullu district [14]. In these disaster events, the body of 18 people is still reported to be missing. It has caused the enormous economic loss and damage to the government and private property in the region [15].

Therefore, the problem needs an attention from the scientific perspective as to look for the reason behind the increase in the frequency of such disasters and the extensive impact due to these disasters.

2. RESEARCH METHODOLOGY

2.1 Study Area

The study area falls along the Beas river valley that is situated in the Kullu District of Himachal Pradesh located in the Indian Himalayan Region. The total area of the district is 5,503 sq. kms which is 9.88% of the total area of the state. It geographically lies between the lesser and Greater Himalayas. The district is situated between 31°20’25” to 32°25’0” North latitude and 76°56’30” to 77°52’20” East longitude. It is bounded by the districts of the Lahual & Spiti, Kinnaur, Shimla, Mandi and Kangra. The altitude varies from 1,089 metres to over 6,632 metres from the mean sea level. The district has some important glaciers such as Beas Kund, Saraomaga, Parvati, Dibbi and Mantalai in its periphery. These have length from 3 to 16 kms, and width 500 to 800 metres. The most regions are covered with densely forest except western part of the district. The forest contain species like Chir, Kail, Silver fir, Walnut, Horse chestnut, Oak and Deodar. The geology of the region is comprised of the middle Proterozoic formations. The phyllite, slate, quartzite, limestone, schist and granite rock types are found in the district. The district of Kullu has 4 tehsils and 2 sub-tehsils containing the total number of 326 villages. Also, the district is sub-divided into the 5 developmental blocks namely Naggar, Kullu, Banjar, Ani and Nirmand. The population of the district was 4.38 lakhs during census of 2011 with the decadal population growth of 14.8%. The 90.54% population of the district resides in the rural areas [16]. The economy of the district is mainly dependent on the agriculture and tourism. The region is famous for the large number of the tourist footfall around the places such as Kullu, Manali and Manikaran. Also, the district has number of hydropower project within its boundary due to presence of rivers Beas, Parvati, Malana, Sainj, Tirthan, Sarvari etc.

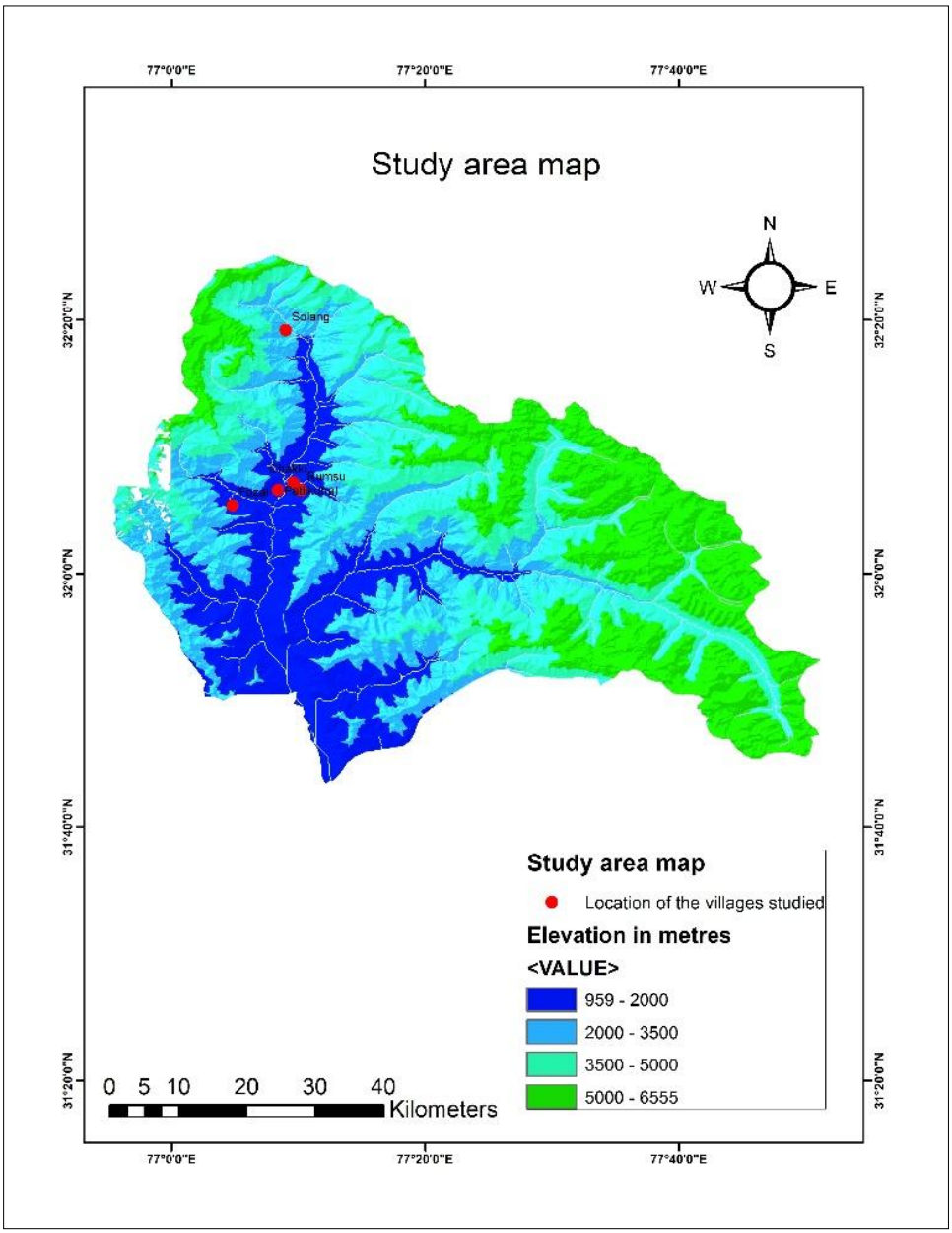


Fig. 1. Study area map

The purpose to choose the area for the study of disaster events is that the region is vulnerable to the disasters such as earthquakes, landslides, floods, cloud bursts, avalanches and others. The State Disaster Management Authority in its report states the degree of disaster vulnerability of the area. The district falls under the seismic Zone V that is at risk of disastrous earthquakes. On February 1906 it has experienced the earthquake with intensity of 6.4 magnitudes in the Karshing area of Kullu. Also, the landslides event of September 1995 took live of 65 persons in the area of Luggar Bhatti (DDMA 2022). Also, the sub-division of Anni, Banjar and Manali are vulnerable to the frequency and intensity of floods in the area. These disasters often damage the roads, houses, horticultural crops and also take human lives along with economical loss to the property. The other disaster events common to the district area are cloud bursts, snow avalanches, forest fires, draughts and wind storms. In this regard, to know the people's perception a questionnaire survey was carried out in the study area. The primary data was collected for the 5 villages along the watershed area of the river Beas (Fig.1). The details for the location of the villages are mentioned in Table 1.

Table 1. The location of the village studied

S. No.	Name of the village	Latitude	Longitude	Elevation (in metres)	Total No. of households as per census 2011	No. of households surveyed
1.	Solang	32°19.393'N	77°9.397'E	2570	127	38
2.	Patlikuhal	32°6.982'N	77°8.821'E	1474	180	54
3.	Fozal	32°5.657'N	77°5.311'E	1760	102	32
4.	Chhakki	32°7.247'N	77°9.939'E	1645	209	62
5.	Rumsu	32°6.847'N	77°10.743'E	2062	226	65

It was found in the preliminary study that these villages are affected from the frequent disaster events such as flash floods, landslides and cloud bursts. The disaster events in these villages have resulted in human, economic and environmental loss to the region in the past. To find the people perception about the various components of the disaster and its effects, the preliminary study was carried out in the area.

3. RESULTS AND DISCUSSION

3.1 Data Collection

The primary data was collected to find the people perception about the climate change and disaster events. The responses for the people perception was collected from the village households using pre designed semi-structured questionnaire prepared in the bilingual language i.e. Hindi and English. A questionnaire survey was personalized using open-ended questions such as types of disaster common to area, frequency of such disaster, effect on water supply, most affected sectors due to disaster and effect of disaster on the tourism industry. The study area was chosen on the basis of secondary data collected for the previous disaster from the District Disaster Management Authority, Kullu. It was found that in the year 1994, property around the water stream in village Fozal was completely destroyed; the town of Patlikuhal was inundated in 1995 after a cloud burst induced flash flood resulted residents to left their home for around 7-8 weeks; the disaster events of the year 2017, 2018 and 2019 in the district has caused the accumulated financial loss of around Rs. 1861.26 lakh to the property. The responses were collected from the 1/3rd of the total households from the each village using the random sampling technique. 30% of the total households (N=251) were surveyed from January, 2021 to March, 2022 at the villages of Solang, Fozal, Chhakki, Patlikuhal and Rumsu.

3.2 Sample

It was observed that, among the respondents highest participation was from the male i.e. 66.9% (168) respondents were male and 33.06% (83) were female (Fig. 2). It was found that out of the 251 responses, 11.9% (30) respondents were from age group of 15-30 years, 26.29% (66) respondents from 31-40 years age group, 39.04% (98) from 41-60 age group and 22.70% (57) were from the age group of above 60. The maximum percentage of the respondents was from the age group of 41-60 years. It was also observed that the 54.98% (138) respondents had educational qualification above the matriculation. It can be summarized that the data was provided by the well-educated and experienced citizens of the village. The responses were noted and analyzed for the suitable output.

3.3 Data Analysis

The respondents were enquired about the questions such as the type of the disaster, frequency of the occurrence, intensity and damage caused due to the disasters. The results for the Pearson's chi-square test were also developed to find the relationship between the community perception with respect to the variables such as age, gender and educational qualification. The results are discussed below:

3.3.1 Community perception on the disasters

3.3.1.1 The type of hydro-meteorological disasters common to the area

The respondents were asked about the type of the frequent hydro-meteorological disasters common to the area. It was found from the analyzed responses that the area is prone to the flash floods as it was observed that 67.37% (169) respondents believe that flash flood are more common to area while 23% (58) and 9.87% (25) respondents believed that cloud bursts and landslides respectively are more common. It was found from the field survey and questionnaire

analysis that that respondents from the villages near the river Beas are affected due to flash floods i.e. Patlikuhal and Solang while the villages at higher altitudes are more prone to cloud bursts and landslides i.e. Rumsu, Chhakki and Fozal which sometimes evolve into flash flood in the low-lying areas. It was observed that as the village of Patlikuhal and Solang fall along the river Beas so the 94.40% (51) respondents from Patlikuhal and 84.21% (32) respondents from Solang responded that flash floods are more common while the villages of Rumsu, Chakki and Fozal are located on higher elevations, therefore respondents stated that the area is more prone to problem of cloud bursts (Fig. 3).

3.3.1.2 The frequency of the occurrence of the disasters

The respondents were asked to provide the information about the frequency of the occurrence of the disasters in the area. Majority of the respondents told that such type of disasters occurs each and every year while some stated that it happens after the cycle of few years. 89.47% (34), 70.37% (38), 31.25% (10), 70.97% (44) and 86.15% (56) respondents from the villages of Solang, Patlikuhal, Fozal, Chhakki and Rumsu respectively believe that these disasters occurs each year while 25% respondents from the Fozal believe that it occurs after the cycle of 5-10 years (Fig. 4).

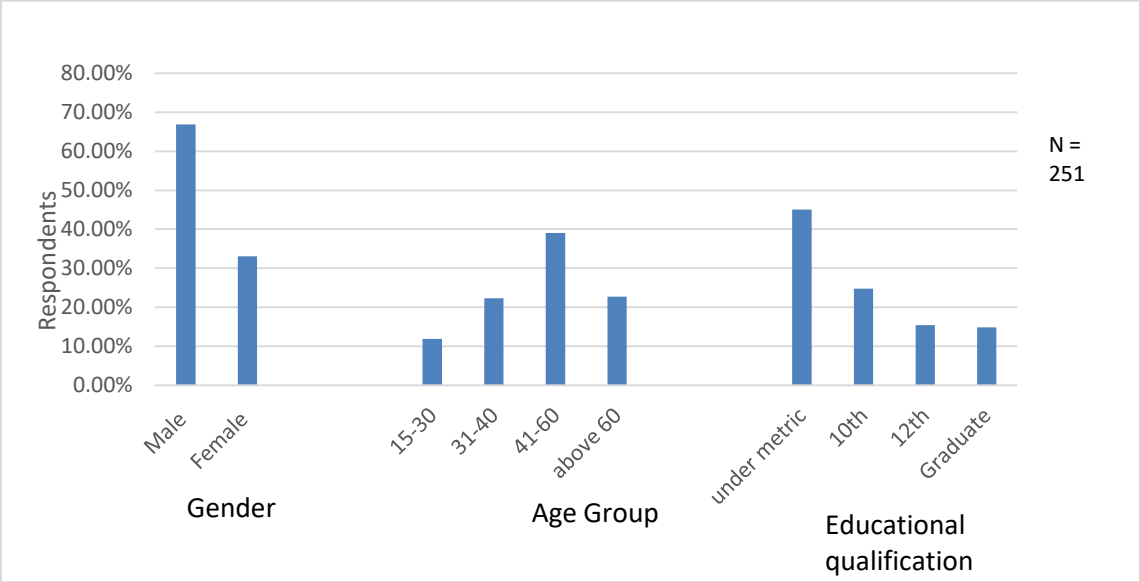
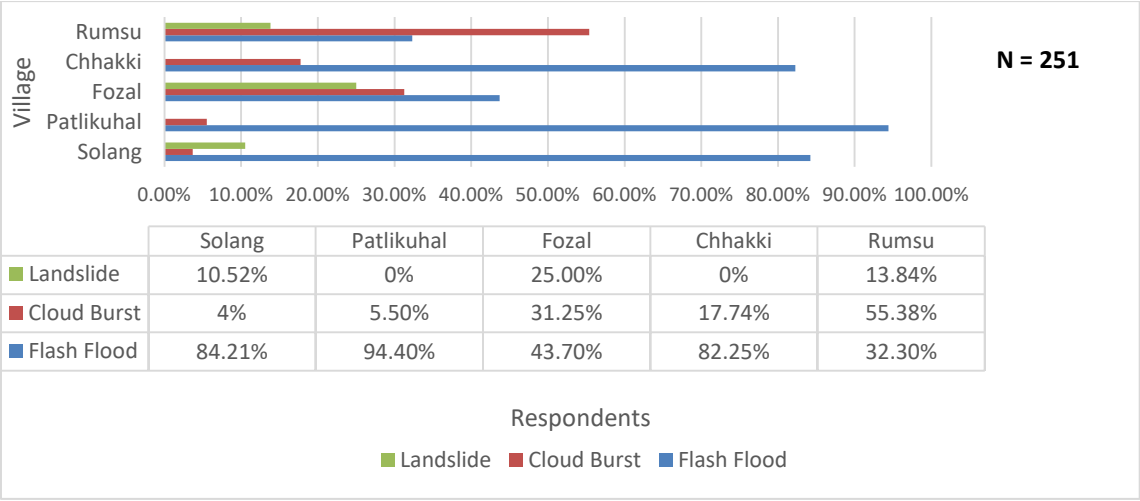


Fig. 2. Particulars of the respondents



	Solang	Patlikuhal	Fozal	Chhakki	Rumsu
Landslide	10.52%	0%	25.00%	0%	13.84%
Cloud Burst	4%	5.50%	31.25%	17.74%	55.38%
Flash Flood	84.21%	94.40%	43.70%	82.25%	32.30%

Fig. 3. The type of hydro-meteorological disasters common to the area

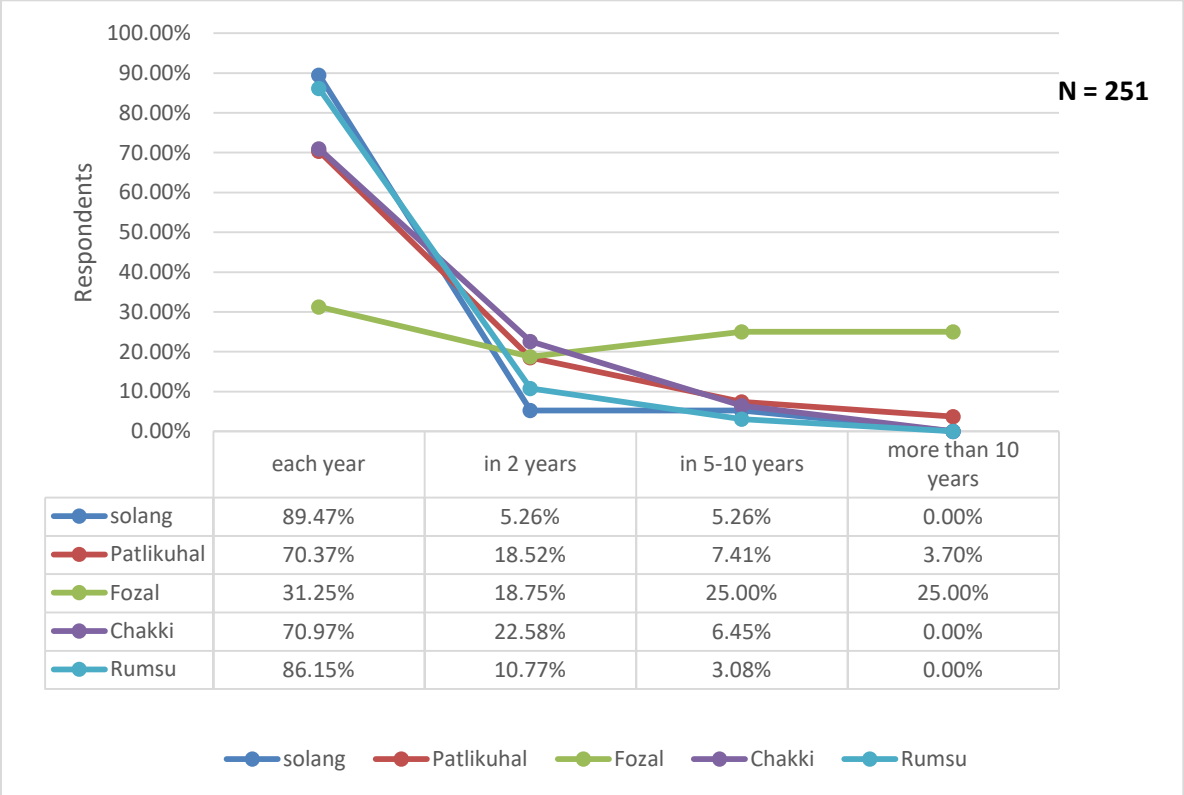


Fig. 4. The frequency of occurrence of disasters

3.3.1.3 Effect of the disasters on the drinking water supply

The Sustainable Development Goal number 6 focuses on the quality and sustainability of water resources. According to the annual reports of the HPSDMA (2016; 2017; 2018; 2019; 2020), it was found that in the state of Himachal Pradesh, the disasters during the year 2016-2020 led to loss of around Rs. 1421.84 Cr. to the water supply and irrigation schemes. The residents were asked about their perception on the impact of the disasters on the water supply. Only 26.7% (67) respondents agreed that such event leads to water deterioration while 73.3% (184) of the respondent's stated that these disasters do not affect the available water resources directly. However, it was found that in the past the spring water resources were either damaged or degraded due to these disaster events. It was observed from the different studies that the disasters deteriorate the quality of water [17,18] but in the study area it has not affected the water supply as the government has provided the storage tanks for the water which treat the water and supply it in the potable condition to the residents.

3.3.1.4 Damage to the property due to the disasters

The secondary data from the District Disaster Management Authority was collected for the household affected due to the occurrence of disasters. It was found from the data that in the year 2017, 2018 and 2019 the disasters such as flash floods, cloud bursts and landslides in the district Kullu took lives of 17 people and 130 cattle's, 14 people were injured and economic loss of Rs. 18.61 Cr to the government. Therefore, the respondents were enquired about the damage to the property due to the disaster in the past. It was found that out of total respondents around 64.27% (161) of the respondents agreed that the property loss has occurred to their land and infrastructure due to the disasters. The property included the loss to human lives, livestock loss, damage to cultivable land and houses. 94.73% (36) respondents from village Solang and 68.51% (37) respondents from Patlikuhal agreed that their property has been destroyed due to the occurrence of the disaster in the area (Fig. 5). The most of the damage was reported due to the event of the landslide in the area.

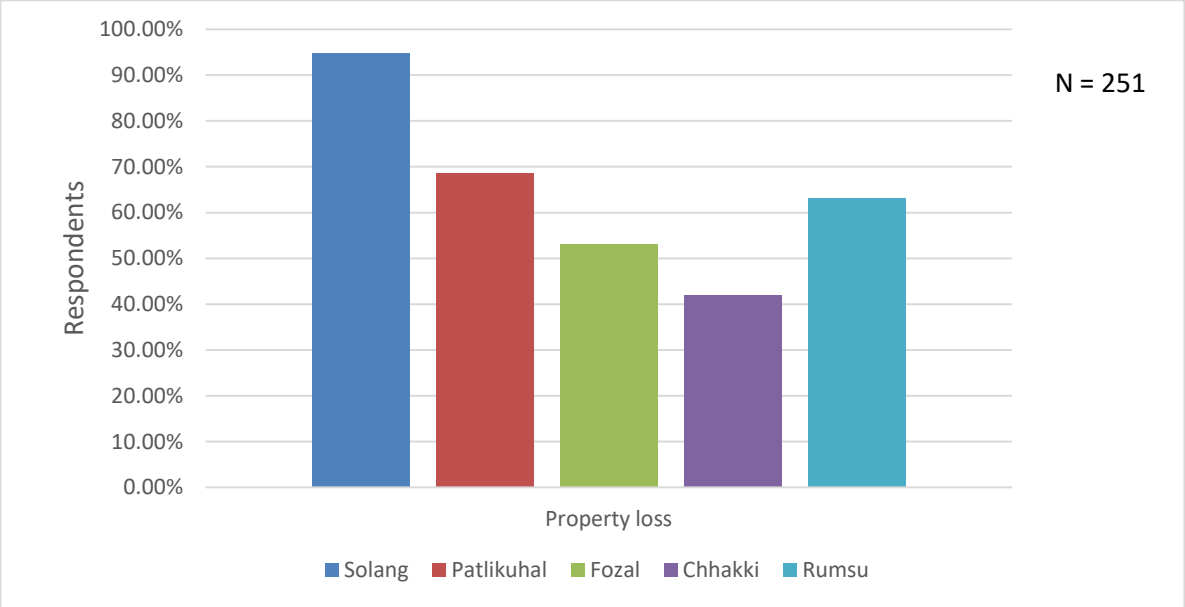
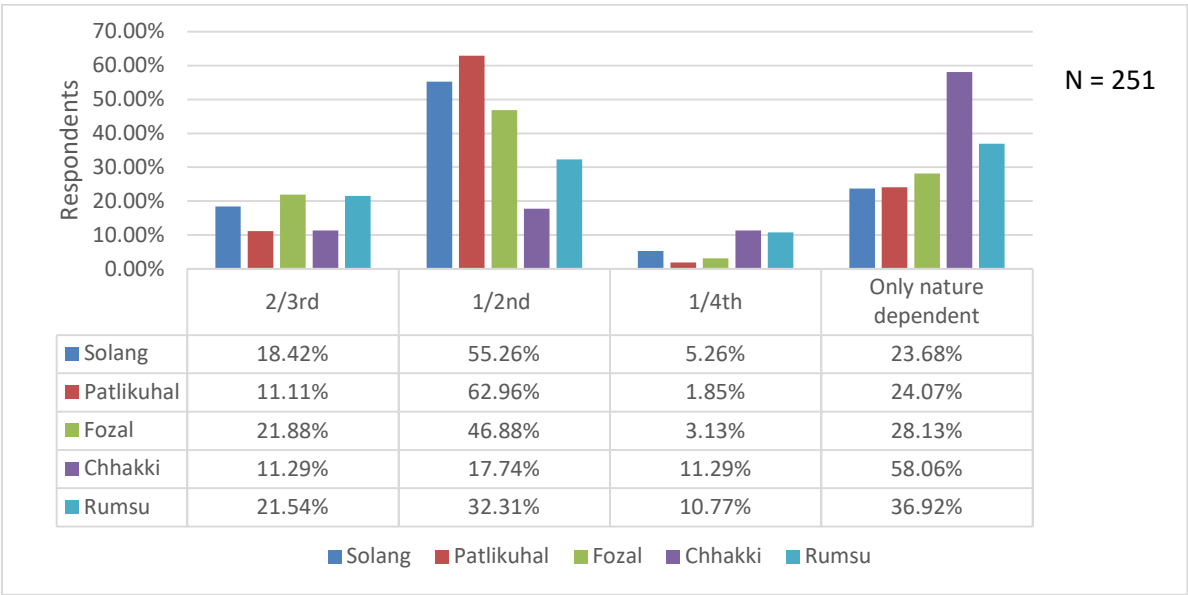


Fig. 5. Damage to the property due to the disasters



	2/3rd	1/2nd	1/4th	Only nature dependent
Solang	18.42%	55.26%	5.26%	23.68%
Patlikuhal	11.11%	62.96%	1.85%	24.07%
Fozal	21.88%	46.88%	3.13%	28.13%
Chhakki	11.29%	17.74%	11.29%	58.06%
Rumsu	21.54%	32.31%	10.77%	36.92%

Fig. 6. Anthropogenic role in the disasters

3.3.1.5 Perception about the anthropogenic role in the high impact of disasters

The increase in the population over the globe has led to the change in the land use and land cover. This change in response sometimes increases the impact of the disasters. The settlements on the mountain ridges are more susceptible to the landslides while the settlements around the embankments of the streams and river area are often prone to the flash floods. The change in the cropping pattern also increase the soil erosion that followed by the event of heavy rainfall causes huge destruction to the region. The respondents were asked about their perceptions on the anthropogenic role in the high impact disasters in the region. 42.58% (107) respondents out of the 251 respondents believe that the reason behind occurrence of these disasters is both natural as well as anthropogenic (Fig. 6). While 34.17% (86) respondents of the total respondents believed that these disaster events occurs naturally.

3.3.1.6 The factors responsible for the disasters

It has been observed that the responsible factors for the disasters are climate change, deforestation, excess development and many more. The respondents were asked about their perception about the factors those increase the destruction due to the disasters. 38.18% (92) respondents believe that the increased impact of disasters is due to the climate change (Fig. 7). It indicates that most people are aware of the term of the climate change and its consequences. Some of them also indicated the reason to be excess development and hydropower projects in the area. The deforestation was also believed to be reason for the excess destruction by the 30.26% (87) respondents. Whereas, 78.46% (51) people surveyed in the village of Rumsu believe that the increased destruction due to the disasters is solely due to the practice of the deforestation in the upper reaches of the forest (Fig. 7). It was found from the in depth analysis that the deforestation practices, extraction of medicinal herbs and over grazing in the higher altitudes is responsible for the increased impact of the landslides and floods during the rainy seasons which affect the low lying areas.

3.3.1.7 The most affected components due to the disasters

It was observed that the disasters in the past has caused destruction to the forest and agricultural products and also affected the roads and infrastructure in the area. To find the perspective of the residents about the destruction, the people from the 5 villages were asked about the components those get most affected due to the disasters. 20.48% (49) and 32.12% (77) respondents out of all the respondents believed that forest and agricultural products respectively is mostly affected primarily due to occurrence of disasters while 31.54% (81) respondents and 14.06% (39) of all respondents believe the infrastructure and business respectively to be most affected areas (Fig. 8). Patlikuhal did not had any agricultural and horticultural land therefore the only 2.40% (1) respondents from the region believed that the disaster do not affect the agricultural component while the 38.89% (21) respondents from the area believe the most affected component to be business due to the occurrence of the disasters [19-21].

3.3.1.8 The effect of tourism on the disaster

Kullu district is among the leading tourist destination in the country. In the report by Tourism Department of Himachal Pradesh it was found that in the year 2015, 2016 and 2017 a total number of 3.3, 3.5 and 3.7 million tourists respectively visited Kullu district that comprised of 3.18 million domestic and 0.12 million foreign tourists. Therefore, the region has its importance in the tourism sector that can be affected due to the occurrence of the high impact disasters. The tourism includes the activities such as river rafting, site seeing, trekking, hiking etc. The large population of the area solely depends on the tourism. But the disasters such as flash flood, cloud burst and landslides induce the fear among the tourist mainly during the rainy seasons. 49% (123) respondents agreed that the disasters affect the tourism while 34.26% (86) disagreed, which may be due to the lack of awareness among these respondents. It was found that each year number of tourist casualties and economical loss to the tourism properties happen due to the events of heavy rainfall and landslides so the effect of disaster on the tourism need to be explored [22-24].

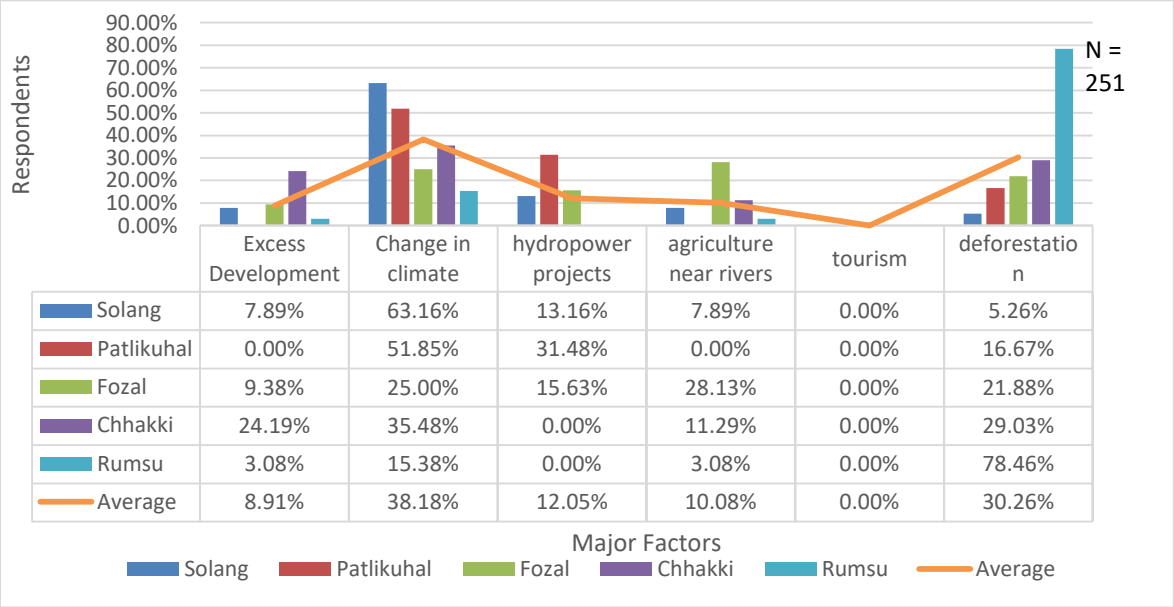
3.3.2 Relationship between the people perception and variables such as age, gender and educational qualification

To find the relationship between the people responses and variables, Chi-square test was performed using the Statistical Package for the Social Sciences (SPSS) (Table 2). It was used to find the perception of the people on the basis of age, gender and educational qualification.

Table 2. Results for the Pearson's chi-square test

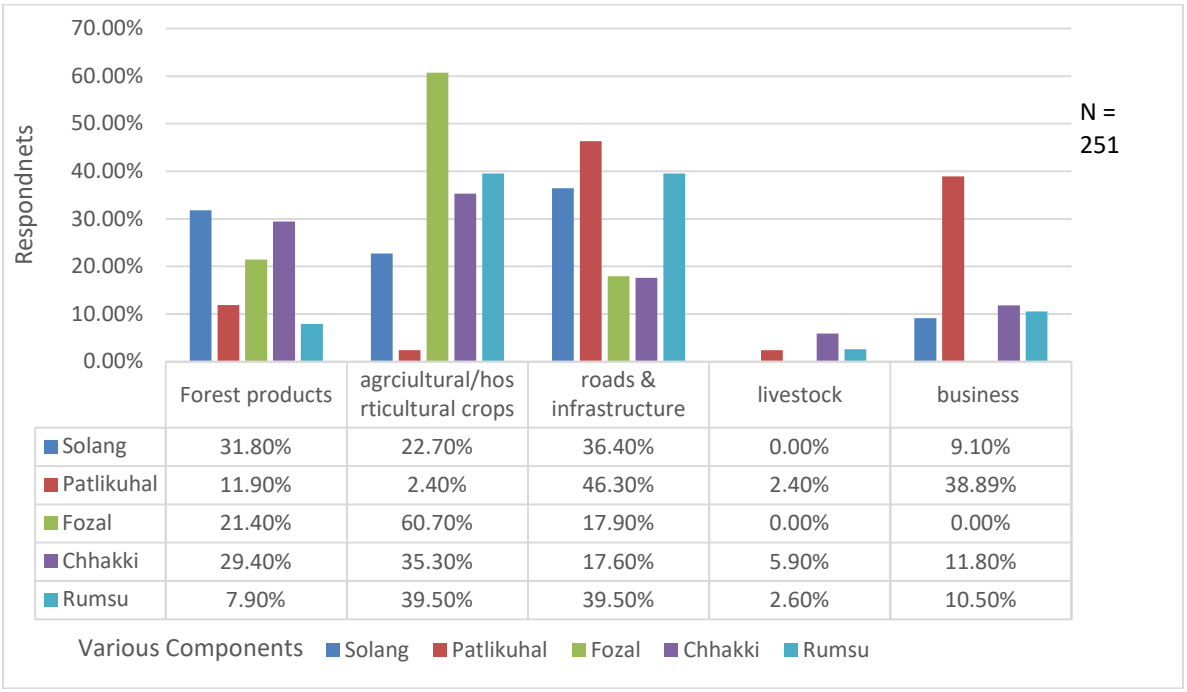
S. No.	People Perception	Significance value (at 95% confidence interval)		
		Gender	Age group	Educational qualification
1.	Perception about the anthropogenic role in the high impact disasters	0.62	0.027*	0.008*
2.	The factors responsible for the disasters	0.082	0.324	0.229
3.	The most affected components due to the disasters	0.761	0.422	0.261
4.	Effect of the disaster on the tourism	0.008*	0.838	0.283

** Significance = $p < 0.05$*



	Excess Development	Change in climate	hydropower projects	agriculture near rivers	tourism	deforestation
Solang	7.89%	63.16%	13.16%	7.89%	0.00%	5.26%
Patlikuhal	0.00%	51.85%	31.48%	0.00%	0.00%	16.67%
Fozal	9.38%	25.00%	15.63%	28.13%	0.00%	21.88%
Chhakki	24.19%	35.48%	0.00%	11.29%	0.00%	29.03%
Rumsu	3.08%	15.38%	0.00%	3.08%	0.00%	78.46%
Average	8.91%	38.18%	12.05%	10.08%	0.00%	30.26%

Fig. 7. The factors responsible for the disasters



	Forest products	agrciultural/horticultural crops	roads & infrastructure	livestock	business
Solang	31.80%	22.70%	36.40%	0.00%	9.10%
Patlikuhal	11.90%	2.40%	46.30%	2.40%	38.89%
Fozal	21.40%	60.70%	17.90%	0.00%	0.00%
Chhakki	29.40%	35.30%	17.60%	5.90%	11.80%
Rumsu	7.90%	39.50%	39.50%	2.60%	10.50%

Fig. 8. The most affected components due to the disasters

The Pearson's chi square test is used to determine if there is any relationship between two variables. The above variables were tested for relationship at the confidence interval of 95% (significance of 0.05). It was found that the age group and educational qualification was significantly related to the people's perception on the anthropogenic role on the disasters while the gender class did not responded similarly. It implies that age group and educational qualification has impact on the people perception about the anthropogenic role on the disasters. Further, it was observed that there is no significant relationship between the responses of people on the factors responsible for disasters and most affected component due to disasters and the variable studied. It was further found that only the gender

variable was significantly related to the people perception on the effect of the disaster on the tourism. This concludes that the people responses on the effect of disaster on the tourism were better understood in the gender class.

4. CONCLUSION AND RECOMMENDATION

Present study observed that the region of the Kullu is affected due to the high impact weather events like cloud bursts, flash flood and landslides. The main income sources of the local residents were found to be from the agriculture and tourism that often gets affected due to these disaster events. Therefore, the destruction caused due to the disasters in the region substantially affects the livelihood of the people of the region. The lack of the proper infrastructure in the mountainous regions for the mitigation of the disaster events often led to the human casualties and the property loss. The hill terrains in the region also make the living difficult in the area in term of the disaster. It was analyzed that the region often experience cloud bursts followed by landslides and flash floods. Also it was observed that these events occur each year in the region studied. These disasters cause the enormous damage to the property. It was agreed by 64% (157) of the respondents that the damage has been caused by the disaster to their property. The damage to property such as cowsheds, houses, human lives and cultivable land was noticed during the study. It was also observed that damage to the water channels and sources has been caused due to the disaster that can burden the water availability to the region in the future. The analysis of the available water should be carried out in the area to find out the impact of the disaster on the water quality and quantity. The study also found that people are also aware that climate change has increased the intensity of these disasters in the area. The respondents agreed that the anthropogenic activities may increase the occurrence and intensity of these disasters while some believed that these have only natural origin. So, awareness seminars at village and school level can help in sharing the knowledge about the practices that can help in mitigating the impact of the disasters. Overgrazing and illegal extraction of medicinal plants in the higher altitudes of the forest area was reported to be the leading cause for the landslides followed by heavy rainfall in the region. The disaster events have also affected the farmers of the region adversely. The loss to the roads and infrastructure during these rainy days bring loss to the agriculture crops due to the lack of connectivity. Also, the lack of the connectivity to the town and cities can give rise to the problem of availability of medical facilities, school, business etc. The region due to its disaster vulnerability needs an attention of the administration and scientific community to work towards the preparedness and mitigation of the disaster events in the region. The frequency of the occurrence of high impact weather events in the region needs an immediate attention for the development of a disaster management policy. On the basis of concluded investigation the following policy recommendation are suggested:

- ✓ The administration shall develop a preparedness and mitigation plan for the disasters specific to this region such as landslides and flashfloods. It is also suggested that scientific knowledge should be incorporated to assess the vulnerability of the area with respect to these disasters.
- ✓ The stringent laws shall be introduced on the construction and developmental activities in disaster prone areas, practices such as deforestation, over grazing and illegal medicinal plants extraction as these activities often increase the impact of the disaster events.
- ✓ The local residents shall be made aware about the factors responsible for the climate change and its consequences. Also, the local residents should be trained for the preparedness and mitigation techniques for disaster management plan.
- ✓ The administration should work on the permanent solution for the loss to the roads and infrastructure during disaster events. The all-weather roads can provide a solution to the problem of the connectivity issue among the local residents.
- ✓ The scientific community should work on the effective early warning systems for disaster events and knowledge dissemination to reduce the impact of the disasters. The plan should incorporate the traditional knowledge along with scientific advancement to achieve the solution.
- ✓ The integrated disaster management plan can save human lives and also assist in reducing the economic loss to the government.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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