

## Mapping Community Perceptions on Risks, Hazards, Vulnerability and Climate Change in the Selected Sites of Kullu district, Himachal Pradesh

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## **Major Highlights of the Study**

Study on mapping community perceptions on Risks, Hazards and Climate Change was conducted in Parbati Valley (1113 - 2650m, amsl) and Upper Beas Catchments (2000 - 2800 m, amsl). Perceptions of 791 respondents representing 31 villages and 370 households from Parbati Valley and 13 villages and 421 households from Upper Beas Catchment were taken through structured questionnaire. The structured questionnaire included detailed information on the Name of Village, Respondent, Family Members, Educational status, Occupation-Income, Migration, Agriculture, Horticulture, Vegetables, Communication means, Soil-types, Energy Sources, Land Use Patterns, Irrigation, Risks & Hazard Management, Biodiversity, Tourism, Factors affecting their common livelihoods, etc. The analysis and synthesis of information revealed that in agriculture sector the genetic erosion of the agriculture, Horticulture and vegetable crops is due to change in diversification of agriculture, change in life style and altitudinal shift of the high value cash crops. The major factors are rise in temperature, protracted rain fall, pest and diseases and decreasing intensity of snow fall. Maximum number of respondents revealed that glaciers are receding almost for last couple of decades and water bodies are drying up. The perennial water bodies are becoming seasonal and number of hand pumps has increased. Among the risks and disaster /hazards, drought, landslide, forest fire, cloud bursts, rock fall, debris flow, floods, construction of hydro-power projects, pests and diseases, avalanches, etc. were the prominent. The number of tourists has sharply increased during 1980 to 2014 in the Kullu Valley. Amongst different types of tourism, ecotourism is most prominent as revealed by the respondents. The biodiversity is decreasing fast due to high anthropogenic activities, natural calamities and climate change. 70.0% of the respondents believe that the weather is getting gradually warmer. Similarly 67.0 % respondents agreed that the onset of summer and monsoon has advanced during the last 10 years. Winter season has become shorter and warmer as revealed by 70% respondents. Overall, the inhabitants feel that the climate change has changed the life style of the inhabitants, and they have started adopting towards climate change.

## **Introduction**

The Indian Himalayan region occupies a special place in the mountain ecosystems of the world. It is the most complex and diversified among the global mountain system. The great variation in topogeographical features causes immense diversity in climate and habitat conditions within the region. These geo dynamically young mountains are not only important from the standpoint of climate and as a provider of life, giving water to a large part of the Indian subcontinent, but they also harbour a rich variety of flora, fauna, human communities and cultural diversity. Despite the abundance of natural resources, most of its people are marginalized and still live on subsistence level. The unscientific exploitation of natural resources is leading to increasing environmental degradation and aggravating the impact of natural hazards like cloudburst, flashflood, landslides, droughts, rock falls, debris flow, melting of glaciers, severe storms and change in vegetation pattern. Not only that but also reduced dense forest cover, accelerated soil erosion, increased silting of water bodies, drying up of springs, replacement and disappearance of several species and increased ratio of energy expended in fodder, fuel collection and agricultural activity that

increase drudgery of womenfolk are some of the tell-tale symptoms of environmental ill-health. There is a need to evolve new paradigm to restore balance between economic interest and ecological imperatives with due regards to socio-cultural principles.

Nestled and nurtured in the lap of the Himalaya, Kullu is a veritable jewel in the crown of Himachal Pradesh. The beauty of its marvelous landscapes, varied and rich biodiversity, colossal agriculture, tourism, lush green deep meadows, dazzling rivers, white capped snowy peaks and majestic hills covered with Pine and Deodar Forests and sprawling Apple Orchards are uncompetitive. But, this area is prone to several severe threats and global climate change. Environmental hazards have always been a part of vulnerable ecosystem. It covers all the rapid-onset events seismic, mass movements, atmospheric, hydrologic and technologic hazards which directly threatened human life on a larger scale. In the modern world there is a paradox between the outstanding achievements of science and the continuing destruction associated with the extreme of the nature. Misapplication and failure of technology have created recent emergence of threats and development oriented hazards. The valley is threatened not only from geophysical events but also from various anthropogenic activities as well as changing environmental conditions. In general throughout the globe, a large no of studies have been carried out on community perceptions covering various aspect of environment. However in India particularly in the Indian Himalayan Region studies on community perceptions are not available, therefor present study have been carried out in Parbati Valley and Upper Beas Catchment of kullu district to understand risks, hazards and climate change in kullu district and suggest the mitigation measures.

### **Aims and objectives**

- To map the community perceptions on risks, hazards and climate change in Kullu district of Himachal Pradesh

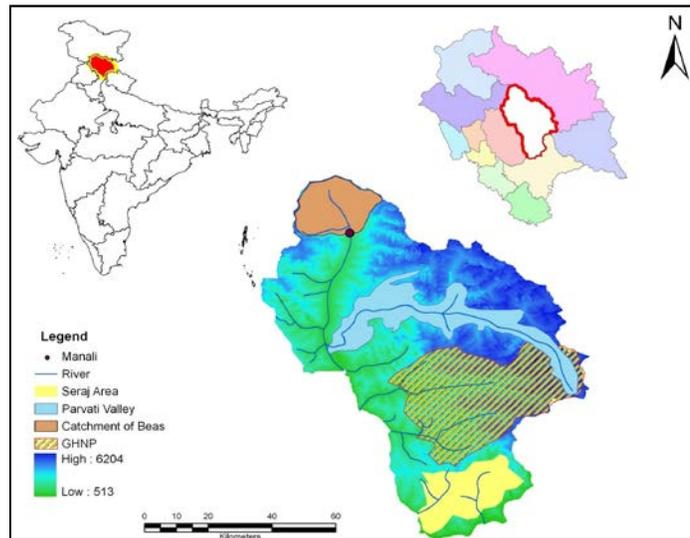
### **Review of Literature**

Review of literature indicated that in general, a very few studies have been carried out on climate change in Indian Himalaya (Vedwan & Rhoades, 2001, Sharma *et al.*, 2009; Chaudhury and Bawa, 2011, Chaudhury *et al.*, 2011; Negi *et al.*, 2012; Kumar & Dev, 2013; Devkota, 2014). However, in particular, in Himachal Pradesh study regarding the Community Perceptions on Climate change have been undertaken in Mid-Hill of Himachal Pradesh (Kimani & Bhardwaj 2015). Studies on Mapping Community Perception on risks, hazards and climate change have not been carried out so far. Therefore this is the initial step in the Indian Himalayan Region.

### **Study area**

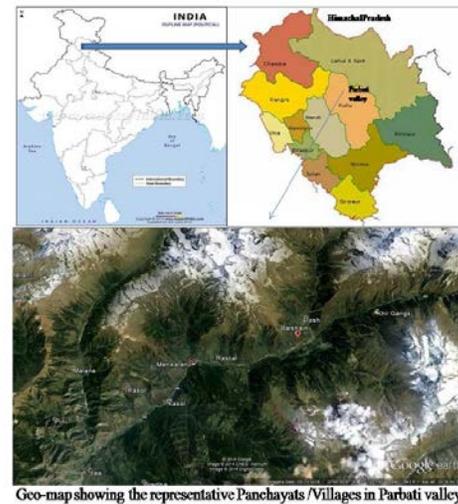
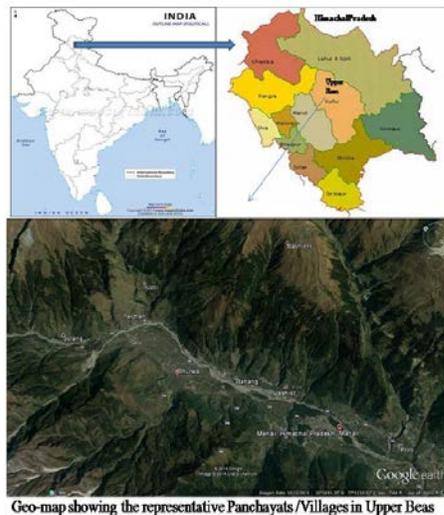
Out of the four selected sites in Kullu district (Table 1), the present study has been focused on Parbati valley (Latitude: 31°53' 48.41"-32° 04' 22.70" N and Longitude 77° 09' 01.81"-77° 18' 34.41" E) and Upper Beas Catchment (above Manali); (Latitude: 32°17'34.82"-32° 22' 15.61" N and Longitude 77° 10' 15.61"-77° 14' 41.49" E) of Kullu district.

Hemmed in by giant-pinnacled mountain peaks, the Parbati river of Parvati Valley, which twists west from the glaciers and snowfields on the Spiti border to meet the Beas at Bhuntar, is the Kullu Valley's longest tributary. It's a picturesque place, with quiet hamlets perching precariously on its sides amid lush terraces and old pine forests. The Parbati Valley has a large altitudinal range (1113 – 6,632m, amsl). The unique topography and some favorable climatic conditions support a large number of settlements. The area is rich in biodiversity and supports sub-tropical, temperate, sub-alpine and alpine vegetation. The inhabitants are largely dependent on natural resources for their sustenance. The area is prone to various risks, hazards and climate change. Much has been said than done on the detrimental effects of modern civilization on the environment. More so while referring to the effect on the biodiversity and wildlife. Human greed backed by an unabated pressure of human population is taking its toll on the green reserves of the valley at an astonishing pace. Endangered species protection efforts in the field are severely hampered by the high profitability of illegal wildlife trade. Consumption of endangered species products has become prevalent in India and many other countries, where greater affluence and buying power have not been matched by greater consumer awareness of the consequences of illegal wildlife trade. The villages directly depend upon the forest for fuel, timber, herb collection, charcoal and livestock grazing. Thus deforestation is again posing a serious threat to both flora and fauna in the Parbati valley. The past decade has seen a large amount of deforestation, which definitely is a cause of concern. As the population is growing, the need for construction has increased manifold. The timber required for the same is derived from the forests. This has led to massive deforestation and a severe threat to the valley. Due to various anthropogenic activities and natural calamities the area is under high vulnerability.



Upper Beas Catchment ranges from 2000-6001m, amsl. The typical topography and unfavorable climatic conditions does not support a good settlement. The area is also rich in biodiversity and supports temperate, sub-alpine and alpine vegetation. The area is highly prone to various risks, hazards and climate change. So far as the case study of upper Beas basin is concerned; the characteristics of hazards have been intensified in terms of frequency and severity. The environmental hazards are exposing the vulnerability of individuals and community in such a way that either their lives are directly threatened or sufficient harm is done to the economic structure. People in the valley are therefore, suffering as a result of both the natural disasters and the anthropogenic hazards as well. The complexity of the environmental problems in this valley has increased due to declining land-man ratio, non-availability of arable agricultural land, compulsion of increasing intensity of land use and careless developmental works. The geohydrological system of Upper Beas Catchment has become very sensitive to unsustainable and unadapted activities in the form of land use changes. The area shows a variety of mass movement processes, which were triggered by the heavy rains in September; the most

predominant being a series of slope failures on the outside of meander loops and bank erosion caused by turbulence of the overflowing Beas River.



### Base line dataset

- Database on perceptions of 791 respondents representing 31 villages and 370 households from Parbati Valley and 13 villages and 421 households from Upper Beas Catchment have been generated through a structured questionnaire.
- The structured questionnaire included detailed information on the Name of Village, Respondent, Family Members, Educational status, Occupation-Income, Migration, Agriculture and Horticulture, Vegetables, Communication means, Soil-types, Energy Sources, Land Use Patterns, Irrigation, Risks & Hazard Management, Biodiversity, Tourism, Factors affecting their common livelihoods, etc.

### Methodology

#### Mapping Community Perceptions

- A standard questionnaire was developed covering detailed information on the Name of Village, Respondents of the Family Members, their Education, Occupation-Income, Migration, Agriculture and Horticulture, Vegetables, Communication means, Soil-types, Energy Sources, Land Use Patterns, Irrigation, Hazard Managements, Biodiversity, Tourism, Factors affecting their common livelihoods, etc.
- For the Community Perception study in each site, representative panchayats/villages were selected along the topographical gradient. In Parbati valley panchayats/villages namely Jia, Shat, Kasol, Jallugran, Manikaran, Malana, Barshaini, Pulga, Tulga, Rasol, Pini etc. and in Upper Beas Catchment panchayats/villages namely Bhurwa, Manali, Ghoshal, Kulang, Solang, Majach, Bahang, Kothi, Matiyana, Vashisht, Shanag etc. were surveyed and sampled. In each village, 30% households were surveyed and sampled. Field information was updated in Microsoft Office Excel and analyzed for various parameters.
- Site-wise name of the Panchayats/Villages with number of households are based on census 2011 and interview of the local inhabitants were conducted.

## **Results:**

The community perception study carried out in Parbati valley and Upper Beas Catchment showed various opinions and suggestions on risks, hazards and climate change. The analysis and synthesis of data collected through a standard questionnaire have been presented as followed:

### **01. Family size and structure**

In Parbati Valley, amongst the households surveyed, 38.16% male and 32.00% females were of between 16-30 years age group; 30.13% males and 26.83% females were of between 31-60 years age group; below 30% of males and females were of under 15 years and a very few males and females were above 60 years (Fig. 1).

In Upper Beas Catchment, amongst the households surveyed 30.24% males and 32.39% females were of between 16-30 years age group; 31.23% males and 28.89% females were of between 31-60 years age group; below 26% of males and females were of under 15 years and almost near to 10% males and females were above 60 years (Fig. 2).

### **02. Education**

In Parbati Valley, 21.83% males and 27.95% females were illiterate. Educational qualification of maximum number of males and females were below matriculation. 22.59% of males and 20.27% females were matriculate; 20.56% males and 14.25% females were intermediate and a very few number of males and females were graduate and post graduate (Fig. 3).

In Upper Beas Catchment, percentage of male illiteracy is quite less than Parbati valley, 06.20% males and 25.62% females were illiterate. Educational qualifications of maximum number of males were intermediate and females were below matriculation. 08.33% of males and 20.25% females were matriculate and a very few number of males and females were graduate and post graduate (Fig. 4).

### **03. Occupation**

In Parbati Valley, the major occupation of the inhabitants was agriculture (77.03% males and 95.51% females), followed by business (8.12% males and 0.60% females). A very few people were in government services (Fig. 5).

In Upper Beas Catchment, the major occupation of the inhabitants is same as Parbati Valley; i.e. agriculture (58.76% males and 81.39. % females) followed by business (26.50% males and 10.39% females). A very few people were in government services (Fig. 6).

### **04. Energy sources**

Electricity, Kerosene, Liquid petroleum gas, Wood and Solar heater were the common and major energy sources in both the study sites.

In Parbati valley, use of electricity rapidly increased to 100% in 2000 from 44.3% of 1980s', all the villages were completely electrified. Use of kerosene oil decreased to 66.60% from 98.10% of 1980s'; rapid increase up to 89.90% in the use of liquid petroleum gas was found; use of wood remains more or less same; newly introduced solar heater's use were moderately increasing after 2009 (Fig. 7).

In Upper Beas Catchment, in 2010 and onwards all the villages were electrified; Uses of kerosene oil slightly decreased to 50.80% from 68.10% of 1980s'; rapid increase up to 92.00% in the use of liquid petroleum gas was found; use of wood remains more or less same; newly introduced solar heater's use were moderately increasing after 2007 (Fig. 8).

#### **05. Migration pattern**

In Parbati Valley, amongst the households surveyed, 26 families were immigrated from other valley or region, 14 families were emigrated to other valley or region. 121 families interchanged their settlements within the Parbati valley. Rest of the 209 families was permanent residents since their birth at their respective villages of the valley.

In Upper Beas Catchment, amongst the households surveyed, 53 families were immigrated from other valley or region, 42 families were emigrated to other valley or region. 138 families interchanged their settlements with in the Upper Beas Catchment. Rests of the 188 families were permanent residents since their birth at their respective villages of the valley.

#### **06. Livestock population**

In Parbati Valley, the major livestock were cow, bull, sheep, goat, horse, ass etc. But a trend of decreasing cattle population was found. Previously they had a numerous number of cattle but after 2001 the number has been decreased.

In Upper Beas Catchment, amongst the households surveyed, the major livestock were cow, bull, sheep, goat, horse and ass. But, the trend was same as in Parbati Valley, decreasing cattle population was found. Previously they had a numerous number of cattle but after 2004 the number has been decreased.

#### **07. Land use pattern**

In Parbati Valley, amongst the households surveyed, 48% land were used for agriculture, 29% land for horticulture, 9% land under settlements, 3.57% land barren and the rest under forest area, for business purpose and for other use.

In Upper Beas Catchment, amongst the households' surveyed 18.88% land were used for agriculture, 66.90% land used for horticulture, 11% area under settlements and the rest under forest area, for business purpose and for other use.

#### **08. House pattern**

In Parbati Valley, number of mud houses were decreasing day by day comparing the number of 1980s'. A sharp increase from 0.63% to 89.87% of cement-concrete houses was found; a decrease from 98.73% to 75.32% was found in the number of wood made houses in this valley (Fig. 9).

In Upper Beas Catchment, number of mud houses were decreasing rapidly comparing the number of 1980s'. A sharp increase from 5.88% to 95.38% of cement-concrete houses was found; a decrease from 76.47% to 31.93% was found in the number of wood made houses (Fig. 10).

#### **09. Agriculture**

The major agricultural crops of Parbati Valley were wheat, maize, paddy and barley. In Upper Beas Catchment, major agricultural crops were wheat, maize and paddy.

In Parbati valley, 37% of total agricultural land were used to cultivate wheat, 21% of total agricultural land were used to cultivate Rajmah, 17% of total agricultural land used to

cultivate maize and the rest used to cultivate other agricultural crops like barley, paddy etc. In this valley, maximum crop production was from wheat, followed by Rajmah and Maize. Rajmah provides maximum income generation for the inhabitants in this valley. In Upper Beas Catchment, 28% of total agricultural land were used to cultivate wheat, 31% of total agricultural land used to cultivate Rajmah, 19% of total agricultural land used to cultivate maize and the rest used to cultivate other agricultural crops like barley, paddy etc. In this valley maximum crop production was from Rajmah followed by wheat and Maize. Rajmah provides maximum income generation for the inhabitants in this valley.

#### **10. Genetic erosion of agricultural crops**

In few villages of Parbati Valley, genetic erosion was found in agricultural crops like kodra, kauni, cheeni, chankhu, etc. due to the changes in the lifestyle of the inhabitants, changes in their taste and the trend to shift in cash crops. Amongst the households surveyed, newly introduced agricultural crops was not found in the valley.

In some villages of Upper Beas Catchment, genetic erosion was found in agricultural crops like kodra, kauni, cheeni, etc. due to the changes in the lifestyle of the inhabitants, changes in their taste and the trend to shift in cash crops and horticultural crops. Amongst the households surveyed, newly introduced agricultural crops was not found in the valley.

#### **11. Factors affecting agricultural crops**

In Parbati valley, the agricultural crops were damaged due to several factors like irregular or heavy rainfall, massive snow fall, rising temperature, decreasing cattle population, forest degradation, pest attacks, plant diseases and many more unavoidable circumstances which resulted a severe loss to agricultural crops. Amongst the households surveyed, 71.85% inhabitants believed that rising temperature causes major loss in agricultural crop productivity, followed by irregular rainfall, pest attacks, diseases, snowfall, etc. (Fig. 11).

In Upper Beas Catchment, the agricultural crops were damaged due to several factors like massive snow fall, irregular or heavy rainfall, rising temperature, decreasing cattle population, forest degradation, pest attacks and plant diseases play a major role in low crop productivity. Amongst the households surveyed, 70.59% inhabitants believed that massive snow fall causes major loss in agricultural crop productivity followed by rising temperature, irregular rainfall, pest attacks, diseases, etc. (Fig. 12).

#### **12. Horticulture**

The major horticultural crops of Parbati Valley were apple, pear, pomegranate, peach, apricot, walnut, etc. In Upper Beas Catchment, major agricultural crops were apple, pear, pomegranate, peach, apricot, walnut, etc.

In Parbati valley, 68% of total horticultural land were used to cultivate apple, and rest were used to cultivate other horticultural crops like pear, pomegranate, peach, apricot, walnut etc. In this valley maximum crop production was from apple, followed by pear, peach and apricot. Apple provides maximum income generation for the inhabitants in this valley.

In Upper Beas Catchment, 81% of total horticultural land were used to cultivate apple, and rest were used to cultivate other horticultural crops like pear, pomegranate, peach, apricot, walnut, etc. In this valley, maximum crop production was from apple, followed

by pomegranate, pear, peach and apricot. Apple provides maximum income generation for the inhabitants in this valley.

### **13. Genetic erosion of horticultural crops**

In Parbati valley, amongst the households surveyed, genetic erosion of horticultural crop was not found. Pomegranate was a new introduction in this valley.

In Upper Beas Catchment, amongst the households surveyed, genetic erosion of horticultural crop was not found. Pomegranate was a new introduction in this valley too.

### **14. Factors affecting horticultural crops**

In Parbati valley, irregular and massive rainfall causes major damage to the horticultural crops, followed by rising temperature, snow fall, pest attacks and diseases (Fig. 13).

In Upper Beas Catchment, massive snowfall and rising temperature cause major damage to the horticultural crops, followed by irregular rainfall, pest attacks and diseases (Fig. 14).

### **15. Vegetables**

Major vegetables of Parbati Valley were cauliflower, cabbage, pea, tomato, potato, brinjal, ladiesfinger, bean, spinach, capsicum, etc. In Upper Beas Catchment, major vegetables were potato, tomato, cabbage, cauliflower, pea, brinjal and bean.

In Parbati Valley, amongst the households surveyed, 30.50% land were used to cultivate potato, 10.70% land used to cultivate tomato, 15.4% land used to cultivate cauliflower, 10.20% land used to cultivate cabbage, 20.30% land used to cultivate pea and rest used to cultivate other vegetables like ladiesfinger, brinjal, bean, spinach, capsicum, etc. In this valley maximum vegetables production was from potato, followed by pea and cauliflower. Potato provides maximum income generation for the inhabitants in this valley.

In Upper Beas Catchment, amongst the households surveyed, 17.20% land used to cultivate potato, 7.50% land used to cultivate tomato, 10% land used to cultivate cauliflower, 9.20% land used to cultivate cabbage, 25.4% land used to cultivate pea and rest used to cultivate other vegetables like ladiesfinger, brinjal, bean, spinach, capsicum, etc. In this valley maximum vegetables production was from potato, followed by pea and cauliflower. Potato provides maximum income generation for the inhabitants in this valley.

### **16. Genetic erosion of vegetables**

In Parbati Valley, amongst the households' surveyed, genetic erosion of vegetables like katthu was found. Vegetables like bean, tomato and capsicum were newly introduced vegetables in this valley.

In Upper Beas Catchment, amongst the households' surveyed, genetic erosion of vegetables like katthu was found. Vegetables like bean, lettuce and capsicum were newly introduced vegetables in this valley.

### **17. Factors affecting vegetables**

In Parbati Valley, rising temperature and irregular rainfall are the major factors for low vegetable productivity (Fig. 15).

In Upper Beas Catchment, massive snowfall and rising temperature causes major damage to the vegetables, followed by irregular rain fall and pest attacks & diseases (Fig. 16).

### **18. Spices**

In Parbati Valley, major spices were chili, coriander, garlic, turmeric, etc. In Upper Beas Catchment major spices were chili, coriander, garlic, turmeric, fenugreek, etc. In both the valleys mostly spices were cultivated for self-use.

In Parbati Valley, maximum land were used to cultivate garlic, followed by chili and coriander.

In Upper Beas Catchment, maximum land was used to cultivate garlic, followed by chili and coriander.

### **19. Genetic erosion of spices**

In Parbati valley, amongst the households surveyed, genetic erosion of spices was not found. New introduction of spices in this valley was also not found.

In Upper Beas Catchment, amongst the households surveyed, genetic erosion of spices was not found. New introduction of spices in this valley also was also not found.

### **20. Factors affecting spices**

In Parbati Valley, rising temperature and irregular rainfall are the major factors for low spices productivity.

In Upper Beas Catchment, massive snowfall and rising temperature cause major damage to the spices.

### **21. Soil type and soil degradation**

In Parbati Valley, major soil type was black-red, followed by black soil. In this valley, major causes of soil degradation were excessive use of chemical fertilizer and pesticides; low level of maintenance; landslides, etc.

In Upper Beas Catchment, major soil type was black, followed by black-red soil. In this valley, major causes of soil degradation were excessive use of chemical fertilizer and pesticides; low level of maintenance; landslides, etc.

### **22. Pesticides**

In both the valleys major pesticides used in agricultural crops, horticultural crops and vegetables were challenger (applied to cauliflower, tomato, pomegranate, etc.), dithane-bavistin (applied to pomegranate, apple, tomato, pea, cauliflower, etc.), monochrotophos (applied to pomegranate) and captan (applied to apple).

### **23. Water sources**

In Parbati Valley, major water sources were glacial water, water bodies, rivers, lakes, ponds and ground water. In Parbati Valley, maximum use of water bodies was found, up to 81.01%, gradual increase of ground water to 56.96% was found. Use of glacial water has been decreased from 87.97% to 65.82%. But use of other water sources like river water, lake or pond water remains more or less same (Fig. 17).

In Upper Beas Catchment, 63.87% inhabitants use ground water, 52.52% inhabitants use water bodies and use of glacial water has been decreased from 84.45% to 42.86%. But use of other water sources like river water, lake or pond water remains more or less same (Fig. 18).

#### **24. Potable water**

In Parbati Valley, major potable water were Stream (Kuhai), Spring (Talai), Well, Hand pump and Tap water. Use of stream by the inhabitants increased from 53.16% to 75.95%; whereas use of springs by the inhabitants decreased to 56.33% from 62.03%. Use of well-hand pump by the inhabitants jumps from 8.23% to 22.15%; interestingly the practice of using of tap water has a sharp increase up to 100% from 22.15% was found (Fig. 19).

In Upper Beas Catchment, major potable water were Stream (Kuhai), Spring (Talai), Well, Hand pump and Tap water. Use of stream by the inhabitants increased from 56.30% to 79.41%; whereas use of springs has been rapidly decreased to 38.24% from 60.92%. Use of well-hand pump has been increased from 8.40% to 21.01% and use of tap water by the inhabitant has been increased up to 95.38% from 17.23% (Fig. 20).

#### **25. Irrigation facilities**

In Parbati Valley, irrigation was done by Channels/Pipelines, Hydrams, Tanks and Rain water. The practice of using channel and pipe lines was maximum, 98.10% inhabitants prefer to irrigate by channels/pipelines, rain fed irrigation remains same and use of hydrams by the inhabitants was increased from 10.13% to 15.19% since 2007, use of tanks was a very new practice in this valley (Fig. 21).

In Upper Beas Catchment, irrigation was done by Channels/Pipelines, Hydrams, Tanks and Rain water. The practice of using channel and pipe lines was maximum, all the villagers irrigate with channels/pipelines, rain water irrigation has been decreased from 72.27% to 58.82% and use of hydrams has been increased from 15.13% to 18.07% since 2000, use of tanks are also a very new practice in this catchment too (Fig. 22).

#### **26. Factors responsible for the loss of water resources**

The entire households of both the valleys were dependent on glacial, river, lake, ponds and other water bodies for water until 2000. But, after 2000 mostly during 2010-2014 they have started using hand pumps for water. This clearly indicates the above perennial water sources have either dried or become seasonal. Overall, the water table is decreasing due to changing environmental conditions and human activities. Irregular rain fall and construction of hydro power projects were also the causes for the loss of water sources.

#### **27. Hydro power projects**

Amongst the households surveyed, Micro hydro power projects were absent in Parbati Valley, but number of Small hydro power projects has been increased up to 58.23% (Fig. 23).

In Upper Beas Catchment, large hydro power project was absent but there are some developing micro hydro power and small hydro power projects under construction (Fig. 24).

#### **28. Risks and disaster/hazards management and mitigation measures**

Water and climate induced disasters like floods, flash flood, cloud burst, cold wave, snow avalanches, droughts, soil erosion; geological disasters like landslides, rock fall, earth

quake; biological disasters like epidemics, pest attacks and plant diseases, cattle epidemic and several manmade anthropogenic threats were very common in both the valleys.

In Parbati Valley, water and climate induced disasters like floods were the major cause of hazards followed by soil erosion, snow avalanches and cloud bursts. Landslide was major disaster under geological disasters, accidental disasters like forest fire, village fire and biological disasters like epidemic and pest attacks were very common in this valley. Proper, satisfactory and confined mitigation measures were not found but some changes in the settlements of the inhabitants were found (Fig. 25).

In Upper Beas Catchment water and climate induced disasters like flood were the major cause of disaster, followed by snow avalanches, soil erosion, cloud bursts, droughts, etc. Landslide, debris flow, rock fall were major disasters under geological disasters; accidental disasters like forest fire, village fire and biological disasters like epidemic, pest attacks and forest fire were very common in this catchment too. Proper, satisfactory and confined mitigation measures were not found but some changes in the settlements of the inhabitants were found (Fig. 26).

## 29. Status of biodiversity

In Parbati Valley, the major forest/ecosystem types were of *Cedrus deodara*, *Pinus wallichiana*, *Picea smithiana*, *Abies pindrow*, *Quercus floribunda*, *Quercus semecarpifolia*, *Aesculus indica*, *Acer acuminatum*, *Betula utilis*, *Pinus roxburghii*, etc. The major causes of forest/ecosystem degradation were deforestation, forest fire, landslides, harsh environmental conditions, illegal trading of medicinal plants and several anthropogenic activities. Economically important medicinal plants were *Picorrhiza kurrooa*, *Trillium govanianum*, *Angelica glauca*, *Aconitum heterophyllum*, *Podophyllum hexandrum*, *Dioscorea deltoidea*, *Dactylorhiza hatagirea*, etc.; wild edibles were *Rubus ellipticus*, *Prunus cornuta*, *Rubus paniculatus*, *Rubus biflorus*, *Rosa brunonii*, *Rosa sericea*, *Rosa macrophylla*, *Morcella esculenta*, *Rhododendron arboreum*, *Fagopyrum dibotrys*, *Juglan regia*, etc.; common fuel plants were *Cedrus deodara*, *Pinus roxburghii*, *Quercus semecarpifolia*, *Quercus leucotricophora*, *Quercus floribunda*, *Cornus macrophylla*, *Picea smithiana*, *Pinus wallichiana*, *Aesculus indica*, *Acer cappadocicum*, etc.; major fodder plants were *Quercus semecarpifolia*, *Quercus floribunda*, *Quercus leucotricophora*, *Morus serrata*, *Salix acuminatum* etc; major fibre plant was *Cannabis sativa*, religious plants were *Punica granatum*, *Prinsepia utilis*, etc. Threatened plants of this valley were *Hypericum perforatum*, *Zanthoxylum armatum*, *Angelica glauca*, *Pleurospermum angelicoides*, *Valeriana jatamansi*, *Malaxis muscifera*, *Dioscorea deltoidea*, *Paris polyphylla*, etc. Forest fire, cutting of trees, trading of medicinal plants, fuel collection etc. were the major threats to biodiversity elements.

Common mammals like *Ursus thibetanus* (himalayan black bear), *Panthera uncia* (snow leopard), *Macaca fascicularis* (monkey), *Canis himalayensis* (himalayan wolf), *Pseudois nayaur* (himalayan blue sheep), *Erethizon dorsum* (porcupine), *Moschus chrysogaster* (musk deer), etc. were found. Birds like *Tragopan melanocephalus* (western tragopan), *Catreus wallichii* (cheer pheasant), *Aegithalos leucogenys* (white-cheeked tit), *Aegithalos niveogularis* (white-throated tit), *Phylloscopus subviridis* (brooks's leaf-warbler), *Sitta cashmirensis* (Kashmir nuthatch), *Ficedula subrubra* (Kashmir flycatcher), *Callacanthus burtoni* (spectacled finch), *Pyrrhula aurantiaca* (orange bullfinch), etc. was found. Trout fish was common and major fish in this valley. Insects like praying mantis, scorpion, spider, honey bee, beetles, grasshopper, ants, caterpillar, firefly, butterfly, and dragonfly were prominent. Amphibians like frog, reptiles like lizard, chameleon, snake and annelids

like earthworm were also found. Unfortunately hunting/poaching, forest fire, low genetic variation and scarcity of foods lead the fauna of this valley to a great danger. But, some conservative measures like general awareness programmes, sacred grooves forests, and reserve forest areas have been initiated in some selected places by the Forest Department. In Upper Beas Catchment, the major forest/ecosystem types were of *Cedrus deodara*, *Pinus wallichiana*, *Quercus semecarpifolia*, *Quercus floribunda*, *Acer cappadocicum*, *Acer caesium*, *Betula utilis*, *Populus ciliata*, *Salix daphnoides*, *Ulmus vilosa*, *Picea smithiana*, *Abies pindrow*, etc. The major causes of forest/ecosystem degradation were deforestation, rockfalls, debris flow, snow avalanches, forest fire, landslides, harsh environmental conditions, illegal trading of medicinal plants and several anthropogenic activities. Economically important medicinal plants were *Picorrhiza kurrooa*, *Pleurospermum angelicoides*, *Arisaema flavum*, *Artemisia roxburghiana*, *Trillium govianum*, *Angelica glauca*, *Ligularia amplexicaulis*, *Aconitum heterophyllum*, *Botrychium ternatum*, *Podophyllum hexandrum*, *Lyoina ovalifolia*, *Corydalis govianiana*, *Dioscorea deltoidea*, *Dactylorhiza hatagirea*, etc.; wild edibles were *Rubus ellipticus*, *Prunus cornuta*, *Rubus paniculatus*, *Rubus biflorus*, *Rosa brunonii*, *Rosa sericea*, *Rosa macrophylla*, *Morcella esculenta*, *Rubus ellipticus*, *Prunus cornuta*, *Juglan regia*, etc.; common fuel plants were *Cedrus deodara*, *Pinus roxburghii*, *Quercus semecarpifolia*, *Quercus leucotricophora*, *Quercus floribunda*, *Cornus macrophylla*, *Picea smithiana*, *Pinus wallichiana*, *Aesculus indica*, *Acer cappadocicum*, etc.; major fooder plants were *Quercus leucotricophora*, *Morus serrate*, *Salix acuminatum*, etc; major fibre plant was *Cannabis sativa*, religious plants were *Punica granatum*, *Prinsepia utilis*, etc. Threatened plants of this valley were *Podophyllum hexandrum*, *Meconopsis aculeata*, *Rhodiola heterodonta*, *Angelica glauca*, *Ferula jaeschkeana*, *Pleurospermum angelicoides*, *Valeriana jatamansi*, *Rhododendron anthopogon*, *Arnebia benthamii*, *Rheum australe*, *Bergenia stracheyi*, etc. Forest fire, cutting of trees, trading of medicinal plants, fuel collection etc. were the major threats to biodiversity elements.

Common mammals like *Ursus thibetanus* (himalayan black bear), *Panthera uncia* (snow leopard), *Macaca fascicularis* (monkey), *Canis himalayensis* (himalayan wolf), *Pseudois nayaur* (himalayan blue sheep), *Moschus chrysogaster* (musk deer), etc. were found. Birds like *Tragopan melanocephalus* (western tragopan), *Catreus wallichi* (cheer pheasant), *Aegithalos leucogenys* (white-cheeked tit), *Aegithalos niveogularis* (white-throated tit), *Sitta cashmirensis* (kashmir nuthatch), *Ficedula subrubra* (kashmir flycatcher), *Callacanthis burtoni* (spectacled finch), *Pyrrhula aurantiaca* (orange bullfinch), etc. was found. Trout fish was common and major fish in this valley. Insects like praying mantis, scorpion, spider, honey bee, beetles, grasshopper, ants, caterpillar, firefly, butterfly, and dragonfly were prominent. Amphibians like frog, reptiles like lizard, chameleon, snake, and annelids like earthworm were also found. Unfortunately hunting/poaching, forest fire, low genetic variation, scarcity of foods leads the fauna of this valley to a great danger. But some conservative measures like general awareness programmes, sacred grooves forests and reserve forest areas have been initiated in some selected places by the Forest Department.

### **30. Tourism**

In Parbati Valley, tourism has a great influence. Especially eco-tourism has been increased rapidly followed by adventure tourism, cultural tourism, rural tourism, wildlife tourism and sports tourism (Fig. 27).

In Upper Beas Catchment, eco-tourism; adventure tourism; cultural tourism; rural tourism; wildlife tourism and sports tourism were major. Eco-tourism has been increasing rapidly followed by adventure tourism, cultural tourism, rural tourism, wildlife tourism and sports tourism (Fig. 28).

### **Discussion**

Studies on Mapping Community Perceptions on risks, hazards and climate change have not been carried out so far in the Indian Himalayan Region. Therefore, this is the initial step in the Indian Himalayan Region. Based on the perceptions of households of Parbati Valley and Upper Beas Catchment present study indicated that options of energy from natural resources have heavily explored by the local community in the respective areas.

#### ***Family size and structure***

In both the valleys females between age group 16-30years were maximum; males between 16-30years age group in Parbati Valley and males between 31-60years age group in Upper Beas Catchment were maximum. Presently inhabitants between mid-age groups of both the valleys indicate sustainable and stable density of population, and this will lead them to a balanced and controlled population in future.

#### ***Education***

In Parbati Valley, maximum males and females were below matriculation, followed by illiterate peoples and in Upper Beas Catchment maximum males were intermediate and maximum females were below matric, followed by illiterate. This could be possibly because of the business oriented mind set in both the valleys, association with the agriculture, horticulture, distance of schools and colleges from the villages.

#### ***Occupation***

In both the valleys, horticulture as an occupation is maximum rather than agriculture, possibly to maintain their high livelihood status and high income generation. Some inhabitants of both the valleys were also choose business like motel & hotel, transportation, river rafting, adventure & trekking guide, snow games etc. as their occupation, this could be possibly because of good income generation as the valleys have a lot of tourists interests. Very few peoples are in Government services, this could possibly because of horticulture and business as an alternative source of more income generation.

#### ***Energy sources***

During 1980-1990 inhabitants of the valleys were mainly depended on Wood and Kerosene and small proportion of Electricity for energy requirements. Even until 2010 very small segment of group started to use LPG as energy option and Electricity, wood and Kerosene were also used by majority of people as a source of energy. Between 2010 and 2014 a larger segment of households were using electricity, LPG, wood and kerosene. In spite of availability of LPG, wood and kerosene, the people are continuing the use of fuel wood for various purposes.

#### ***Migration pattern***

All the emigration and immigration of the inhabitants in both the valleys mostly happened due to the work purposes of the inhabitants. Intra valley migrations of the inhabitants occurred due to accruing comfortable livelihood, better road and transport, business; avoid extreme environmental conditions in the upper hills, communication and infrastructural facilities. This clearly indicates that the inhabitants have started following adaptive measures towards climate change.

### ***Livestock population***

Number of live stocks of the inhabitants in both the valleys has been decreased due to changing life style, and the trend of shifting from agriculture to horticulture and business.

### ***Land use pattern***

Maximum land was used by the inhabitants of both the valleys to cultivate horticultural crops and other cash crops rather than traditional agricultural crops or vegetables. This could possibly due to the high income generation.

### ***House pattern***

The housing pattern is shifting from mud and wooden houses to cement houses and cement-wood mix houses. This could due to modernization as well decline in the timber species population. This clearly indicates that the inhabitants have started following adaptive measures towards climate change.

### ***Agriculture***

Most of the respondents from the study areas agreed that their agricultural crop productivity have been largely influenced by the irregular rainfall, rise in temperature and outbreaks of pests and diseases. Other factors such as less snowfall, forest degradation, decreasing cattle population, etc. are also playing role in low crop productivity. This clearly indicates that the inhabitants of the valleys have started following adaptive measures towards climate change.

### ***Horticulture***

Most of the people from the villages from the study areas agreed that their horticulture have been largely affected by irregular rainfall, rise in temperature and outbreaks of pests and diseases, less snowfall, forest degradation, decreasing cattle population, etc. The budburst and flowering of Apple has advanced 1-6 weeks in the area. This also clearly indicates that the inhabitants of the valleys have started following adaptive measures towards climate change.

### ***Vegetables***

Factors like irregular rain fall, snow fall, rising temperature, pest attack and diseases are the major causes for low vegetable yield in the valleys. This clearly indicates that the inhabitants have started following adaptive measures towards climate change.

### ***Spices***

Most of the respondents from the study areas agreed that spice productivity have been largely influenced by the irregular rainfall, rise in temperature and outbreaks of pests and diseases. Other factors such as less snowfall, forest degradation, decreasing cattle population, etc. are also playing role in low productivity. This clearly indicates that the

inhabitants of the valleys have started following adaptive measures towards climate change.

### ***Soil type and degradation***

Due to increasing temperature, insects and pests are gradually shifted upwards, therefore communities increased the use of chemical fertilizer, insecticides and pesticides which causes soil degradation and low fertility.

### ***Water sources***

The entire households were dependent on glacial, river, lake, ponds and other water bodies for water until 2000. But, after 2000 mostly during 2010-2014 they have started using hand pumps for water. This clearly indicates the above perennial water resources have either dried or become seasonal. Overall, the water table is decreasing due to changing environmental conditions.

### ***Potable water***

The inhabitants of both valleys were dependent on Spring/Talai until 2000; but, after that mostly during 2002-2010 they became dependent on Stream/Kuhai and after 2010 they were completely depended on tap water.

### ***Irrigation facilities***

The entire households were dependent on rain fed irrigation for until 2001. But, after 2001 mostly during 2005-2014 they have started using channels/pipelines for irrigation.

### ***Hydro power projects***

The study revealed that mainly large hydropower projects were constructed until 2010 in Kullu Valley. But, after 2010 construction of large hydropower projects have been declined sharply and construction of small hydropower projects have been promoted. This could be due to the decreasing volume of water in perennial streams which may be due to the consequence of environmental changes including climate.

### ***Risks and disaster/hazards management and mitigation measure***

Natural disaster like floods, cloud bursts, landslides, rock fall, debris flow, earthquake, GLOF's are very common in both the valleys. But, the inhabitants does not have or aware of proper mitigation measures. Analysis and synthesis of the responses of households indicated that gradually warming of weather happened since last two decades. Respondents agreed that the onset of summer and monsoon has advanced during the last 10 years. Winter season has become shorter and warmer as some respondents. According to them, the patterns of rainfall became totally unpredictable.

### ***Status of biodiversity***

According to the perceptions of communities indicated that the valleys are rich in biodiversity. Presently natural resources like wild edibles, fuel, fodder, water sources etc. are easily available and fulfill the requirements of the inhabitants. But natural calamities and anthropogenic calamities indicated rapid loss of biodiversity and they are not used sustainably. Due to over exploitation floras, faunas and habitats are in severe danger. Unusual climatic consequences has changed the phenology of many temperature sensitive species such *Rhododendron* spp., and most of the rosaceous species such as *Prunus*

*persica*, *Prunus domestica*, *Prunus armeniaca*, *Prunus cerasoides*, *Pyrus pashia*, *Pyrus communis* and *Malus pumila*. Thus, proper management and conservation is readily required.

### ***Tourism***

Considering the tourism, the pressure of tourist is more in Upper Beas Catchment than that of Parbati valley. A sharp increase in ecotourism is observed in both the valleys. The number of tourists has sharply increased during 1980 to 2014 in the Kullu Valley. Tourism like cultural, adventure, rural, wildlife and sports are increasing gradually in both valleys. This tourism has some positive impacts like income generation, cultural exchange for the inhabitants as well as negative impacts like air, water and noise pollution, forest degradation, unhygienic environment, chances of outbreaks of diseases, etc. This clearly indicates that the inhabitants of the valleys have started following adaptive measures towards climate change just to have high income generation from tourism business.

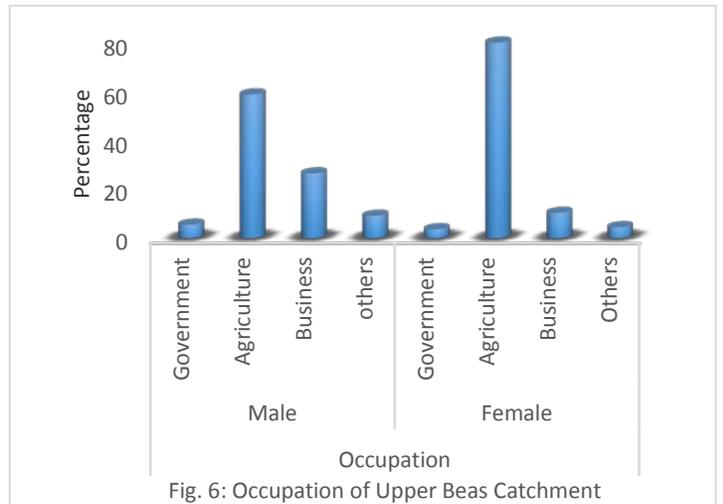
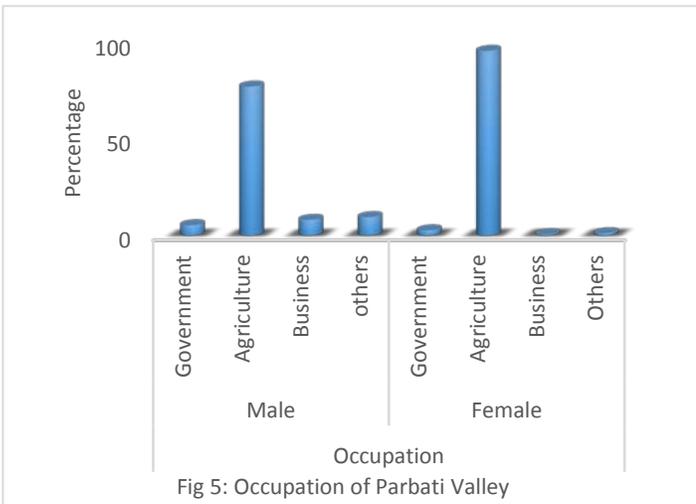
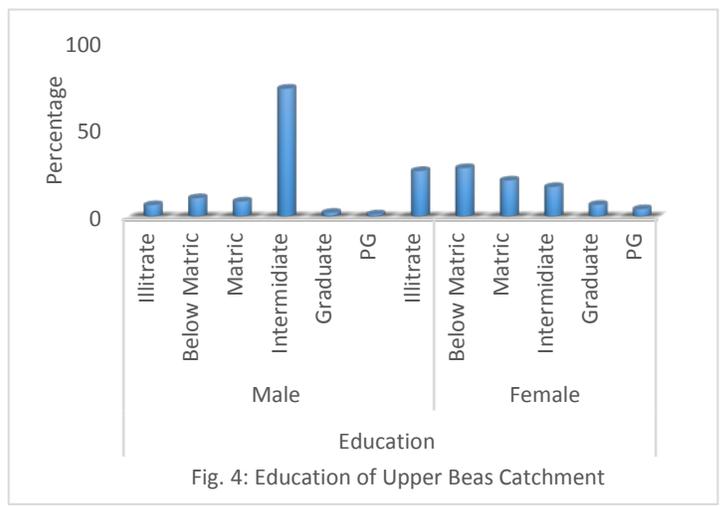
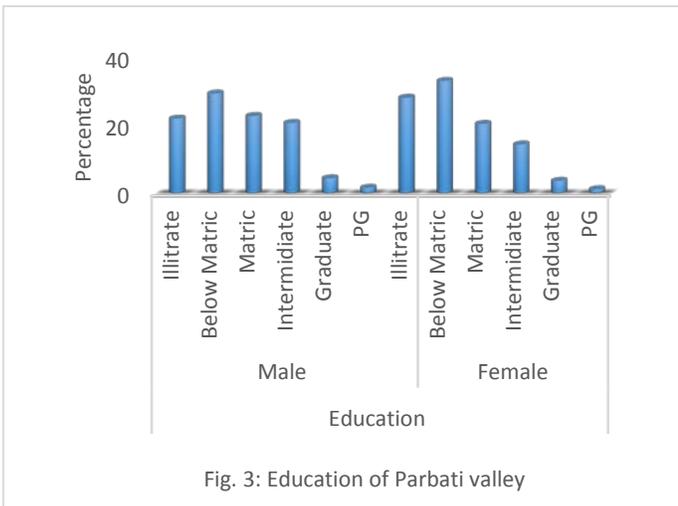
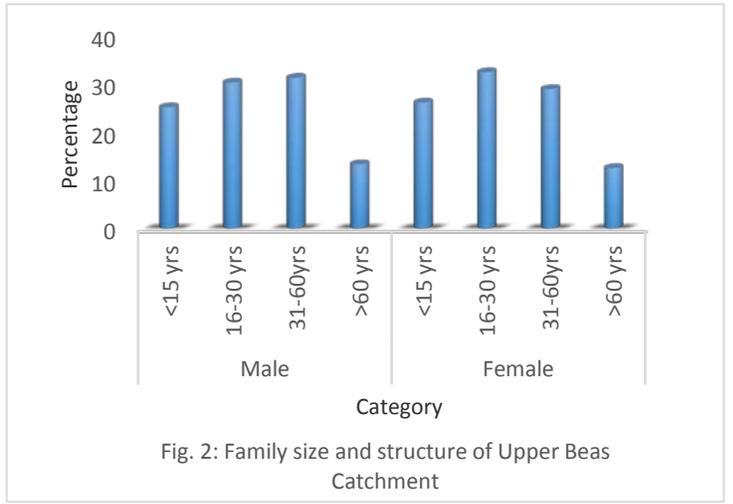
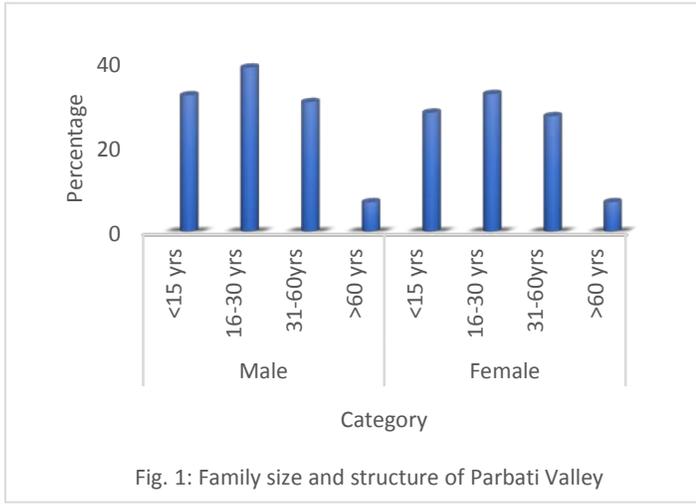
### **Work in progress**

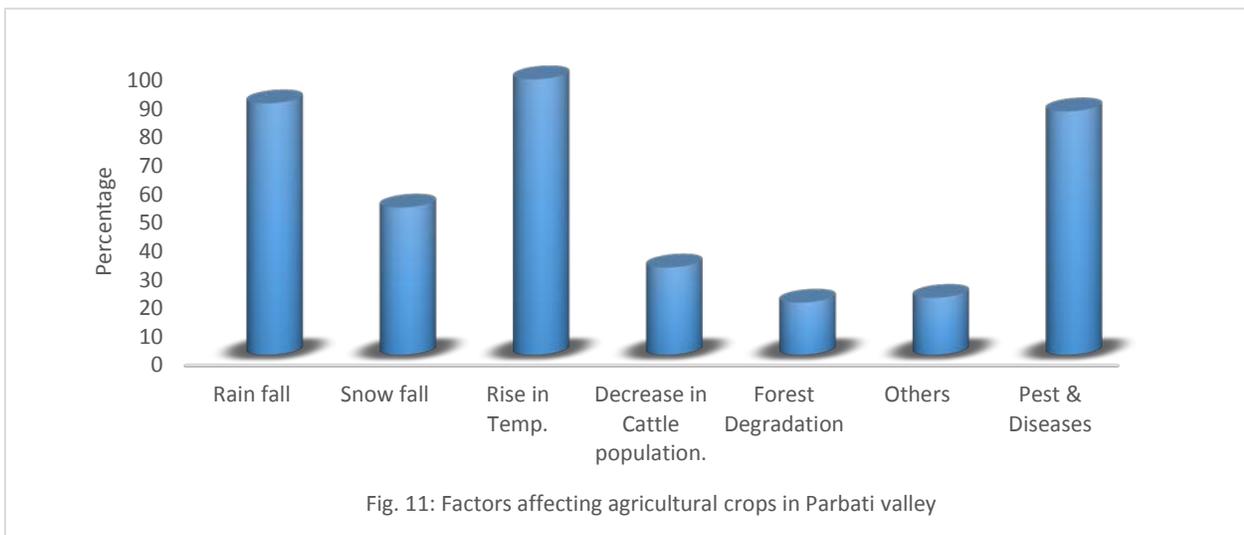
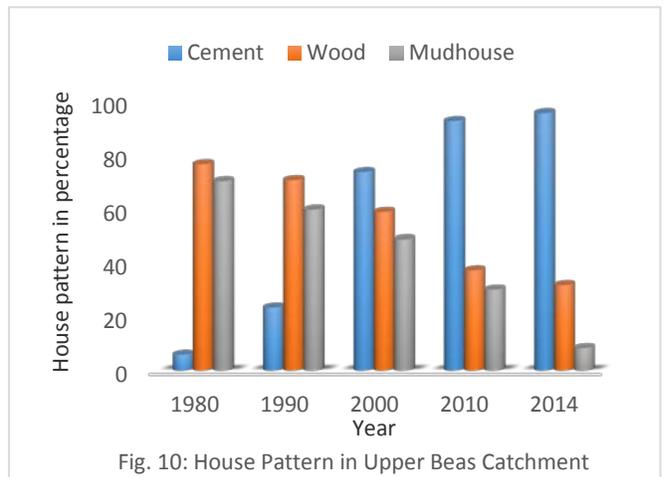
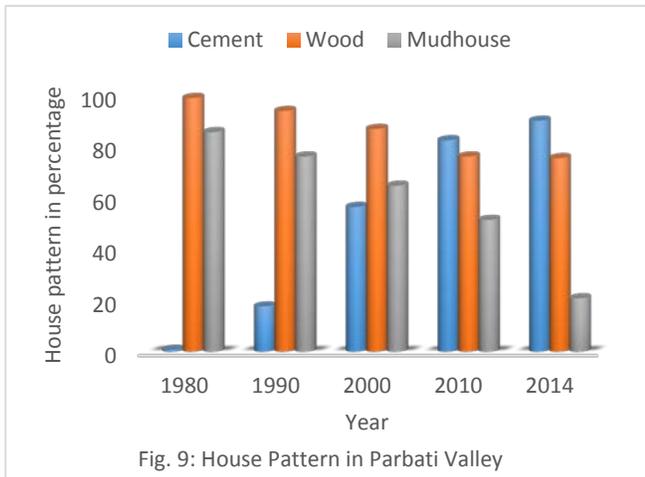
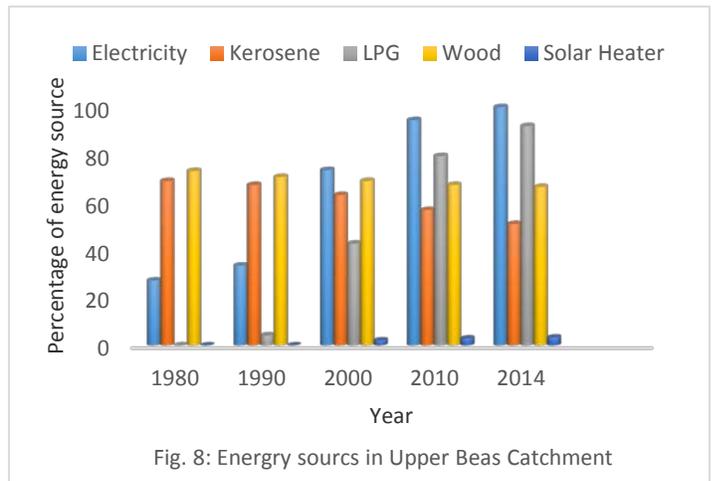
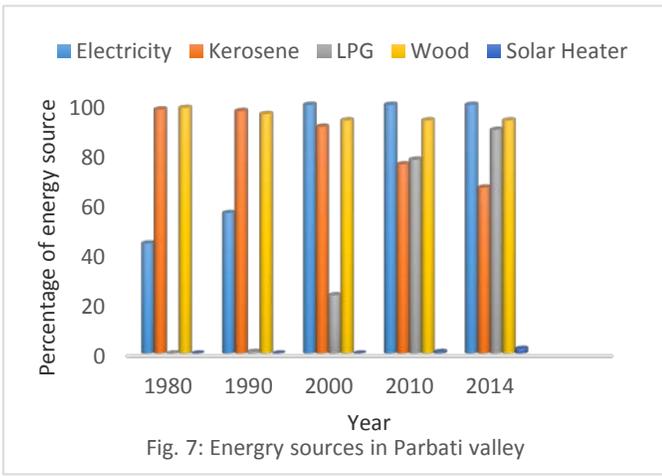
Further synthesis of data and documentation are in progress.

### **Perspectives for upscaling**

The present study has been conducted for the first time in the Indian Himalayan Region. The outcome of the study has helped in addressing various issues related to the Risks, hazards and climate change.

Therefore, replication of the study in Great Himalayan National Park, Sainj Valley and Anni Watershed in Seraj Division of Kullu district and other similar areas of Mandi, Chamba and Kinnaur districts would help in addressing the various issues related to the subject and developing appropriate management plan.





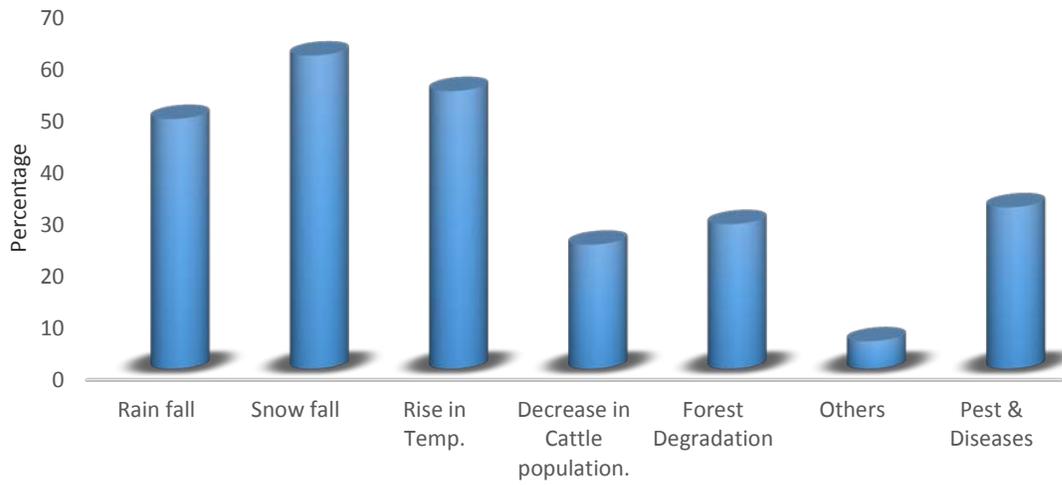


Fig. 12 Factors affecting agricultural crops in Upper Beas Catchment

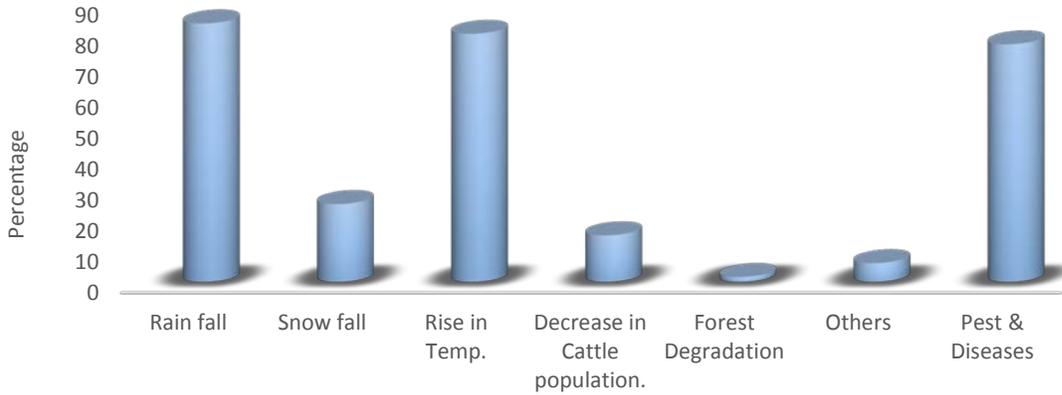


Fig. 13: Factors affecting horticultural crops in Parbati Valley

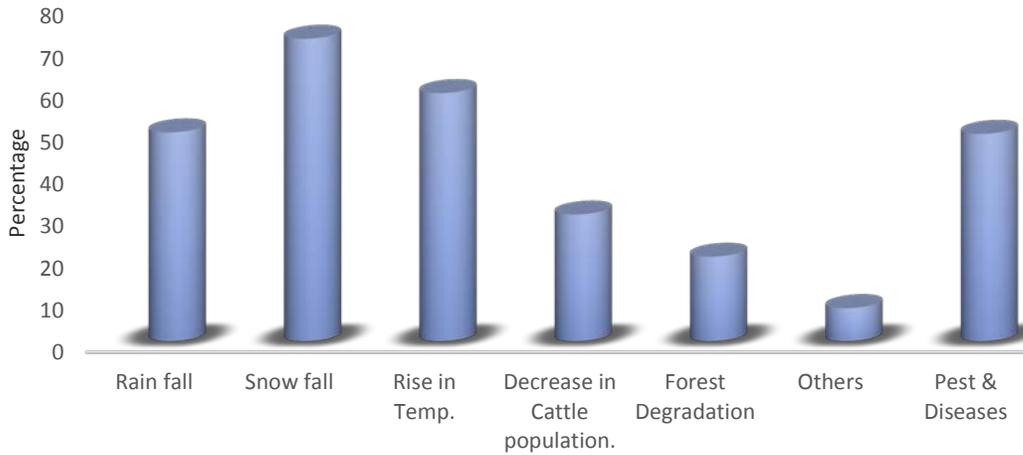


Fig. 14: Factors affecting horticultural crops in Upper Beas Catchment

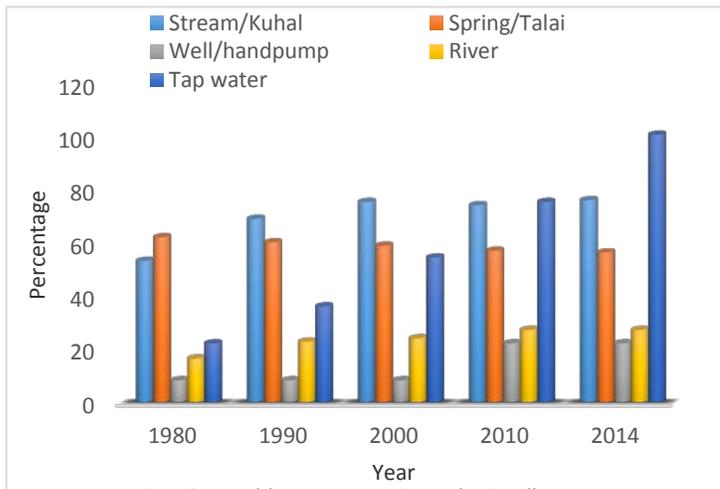


Fig. 19: Potable water uses in Parbati Valley

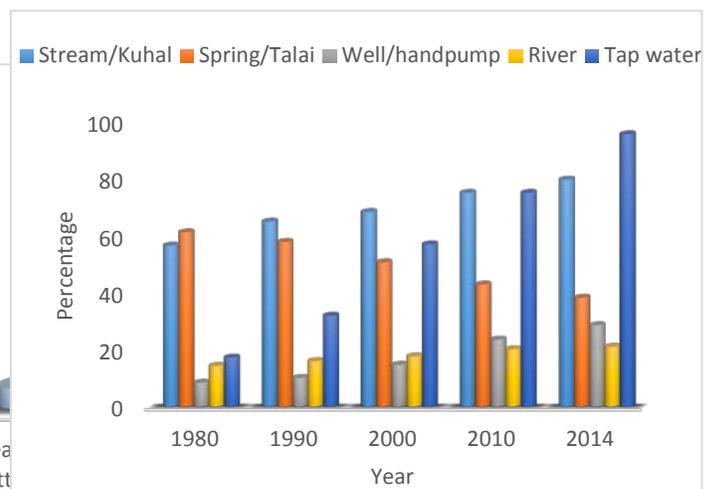


Fig. 20: Potable water uses in Upper Beas Catchment

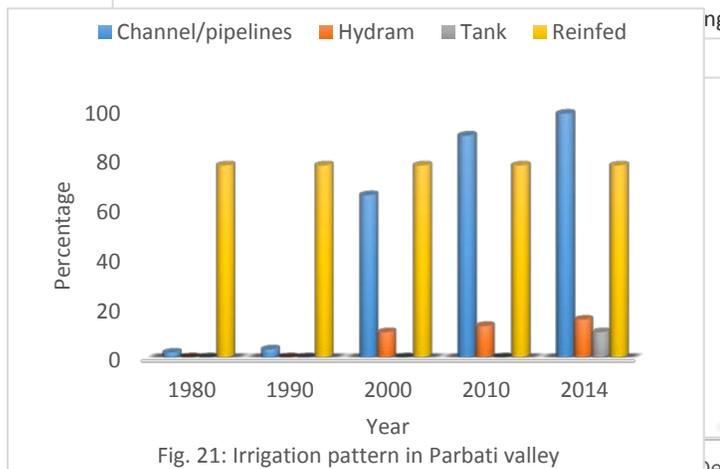


Fig. 21: Irrigation pattern in Parbati valley

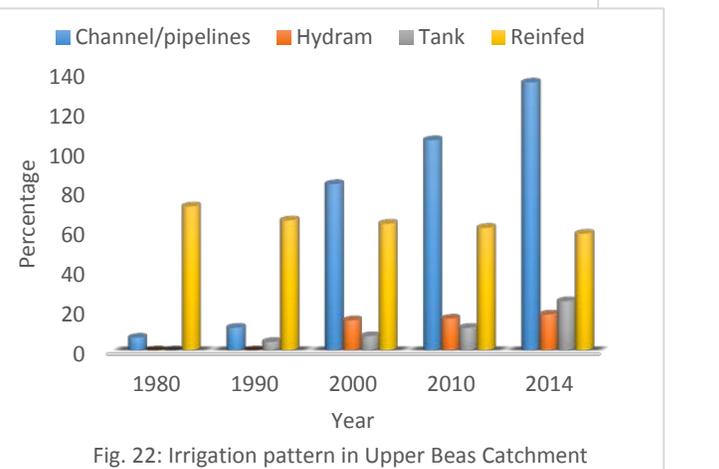


Fig. 22: Irrigation pattern in Upper Beas Catchment

Temp. Cattle population. Degradation Diseases

Fig. 16: Factors affecting vegetables in Upper Beas Catchment

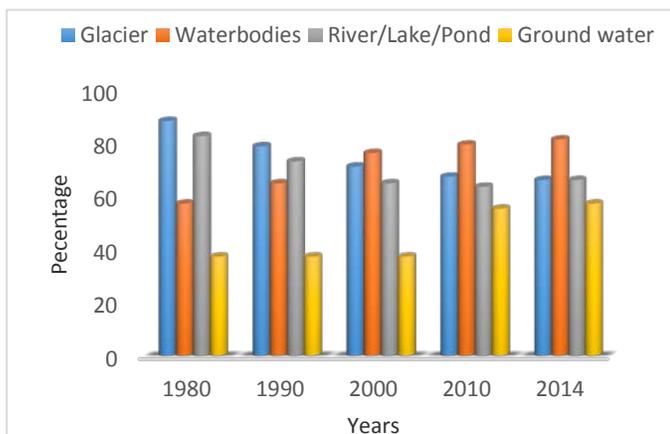


Fig. 17: Water resources in Parbati Valley

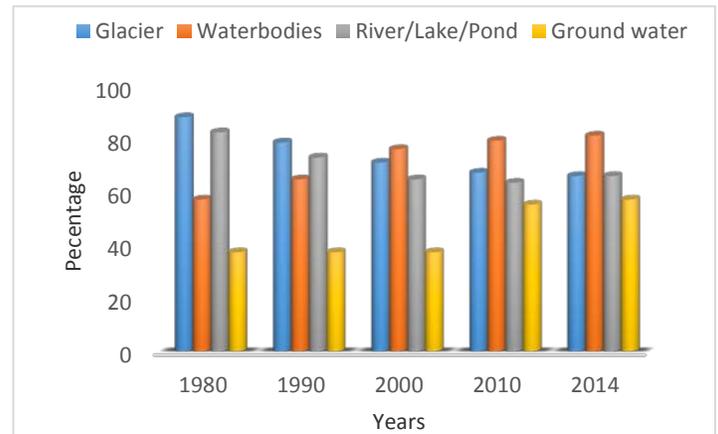
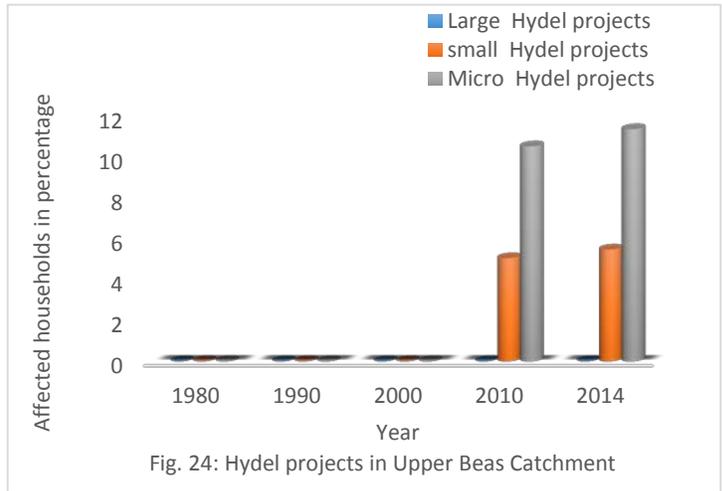
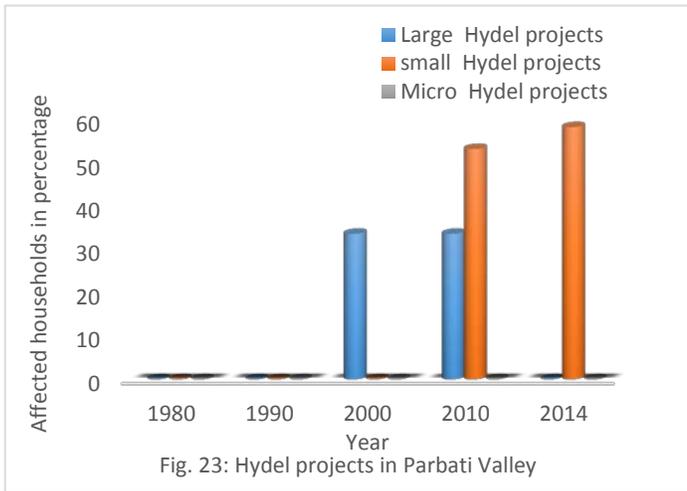
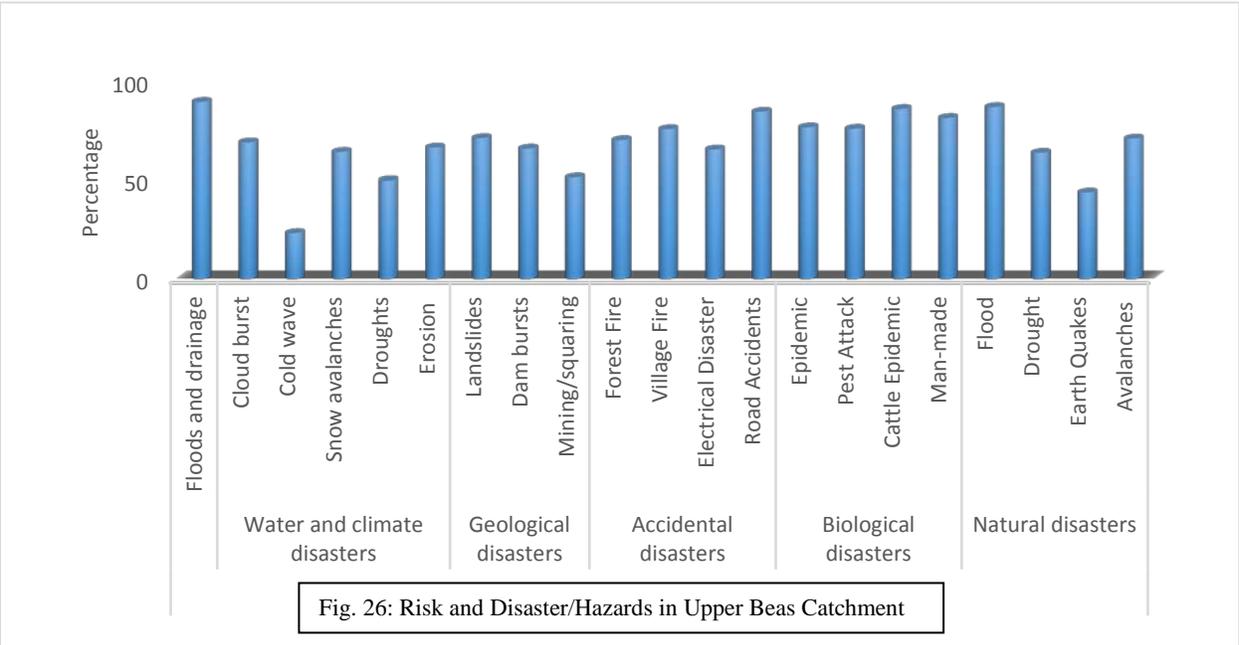
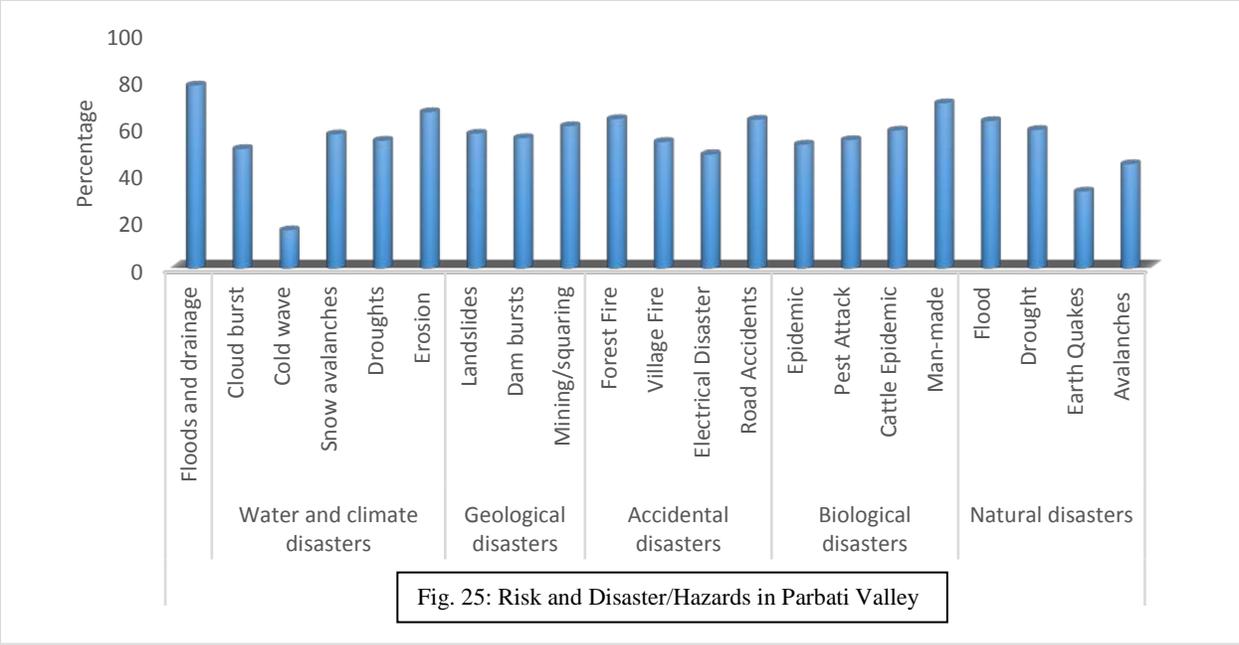
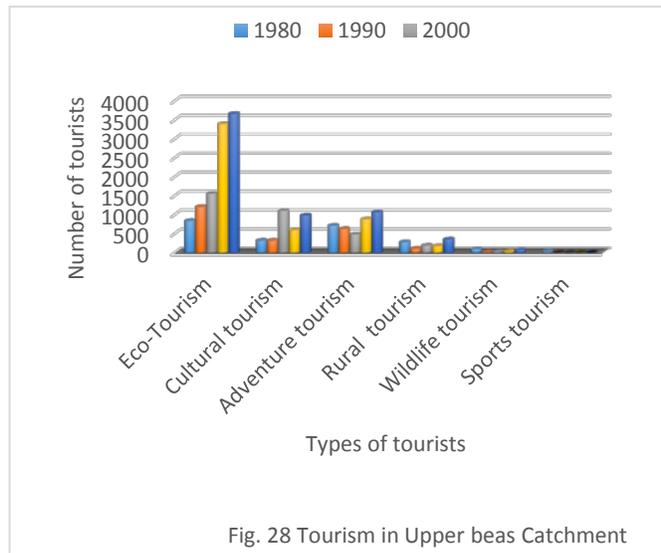
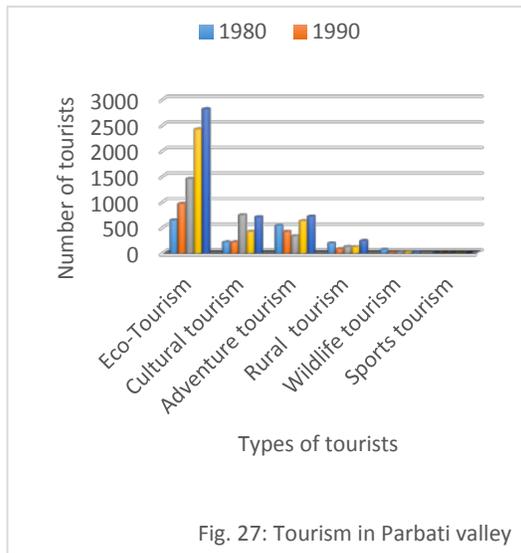


Fig. 18: Water resources in Upper Beas Catchment







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