RESEARCH ARTICLE

Impacts of Climate Change on Agro-biodiversity in Hamirpur Region of Himachal Pradesh, India

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Abstract

A survey was conducted to record perceptions of three hundred farmers towards the impact of climate change on agro-biodiversity of Hamirpur region in Himachal Pradesh, India. Stratified data was collected through personal interviews and PRA technique with both structured and unstructured schedule. The statistical analysis of data indicates that every farmer has unanimously reported irregular and decreased rainfall along with rise in mean temperature in the study area. Forty two per cent farmers reported increase in temperature in winter season than summer season. A little less than three-fourth (73%) farmers reported delayed monsoon. All the farmers (100%) admitted that major crop production had declined in the study area. Major climatic impacts on agro-biodiversity were change in sowing time (43%), change in harvesting time (38%), decline in Beas river water level (55%), decline in milk production (38%) and migration of people (63%). Seventy nine per cent farmers had reported low frequency of storm and 83 per cent reported increased frequency and intensity of hot wave. Yellow rust and black bunt diseases in wheat, yellowing of leaves and aphids infestation of mustard plant, sweet, fruit fly attack in cucurbit etc. were reported in high magnitude.

Keywords: Agro-biodiversity, Climate change, Hamirpur region, Impacts, Perception.

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Introduction

Climate-related disasters have brought widespread misery and huge economic losses to India, while adversely affecting public health, food security, agriculture, water resources and biodiversity. The Himalayan ecosystem is one of the most vulnerable ecosystems and 90 per cent of the population is dependent on agriculture and animal husbandry. The situation is likely to worsen if human beings continue to pump greenhouse gases (GHGs) like carbon dioxide into the atmosphere. Himachal Pradesh is a state with mesmerizing natural beauty coupled with the skyscraping Himalayan Mountains with their lush white snowy tips. The wide forests with snow leopards residing in them, is also equally alluring. The state is known as *Debbhumi* or The land of the God due to its amazing natural beauty. It is spread over 21,495 square miles (55,670 km^2), and is bordered by Jammu and Kashmir on the north, Punjab on the west and southwest, Haryana and Uttarakhand on the south-east and by the Tibet Autonomous Region on the east. It is a mountainous state with elevation ranging from about 350 metres (1,148 ft) to 7,000 metres (22,966 ft) above the sea level. Agriculture contributes nearly 45 per cent to the net state domestic product. It is the main source of income as well as employment for majority of the people in Himachal Pradesh. About 93per cent of the state population depends directly upon agriculture. The main cereals grown in the state are wheat, maize, rice and barley (Devendra and Chittedi, 2010). Hamirpur, Kangra, Mandi and the Paonta valley of Sirmaur are the major producers of the first three cereals. Though the state is deficient in food grains, it has gained a lot in other spheres of agricultural production such as seed potato, ginger, vegetables, mushrooms, chicory seeds, hops, olives and fig. Pulses and oilseed cultivation have also proved to be an economic boon (Maria *et al*., 1986). There are huge tracts of land suitable only for growing fruits. Cash crop cultivation does not add to the problem of soil erosion and its employment potential is more than conventional farming. Climate change is a global phenomenon and its impacts are being observed all over the world. However, its impacts are most seriously felt in the Himalayan ecosystems of India.

So, any change in the natural resources of the region due to climate change will have far reaching repercussions. Farmers in Himachal Pradesh are already experiencing low snowfall, high temperature, erratic rainfall and late snowfall. Major crop production showed a declining trend and crop growing area are shifted to higher altitude. The late arrival of monsoon and erratic behavior of rainfall have already drawn the attention of national media as more than 80 per cent farmers depend on arrival of monsoon to start cultivation. Hamirpur region also recently experienced changes in rainfall pattern and temperature. All these changes pose a serious threat to agriculture, and therefore to country's economy and food security. The impacts have been felt in all aspects of agro-biodiversity i.e. agriculture, livestock and health beside climatic parameters (Solomon *et al*., 2007). There is now a significant body of research that demonstrates that climate change is and will increasingly have dramatic impacts on ecological and social systems. The term vulnerability has been defined in many different ways by various scholars.

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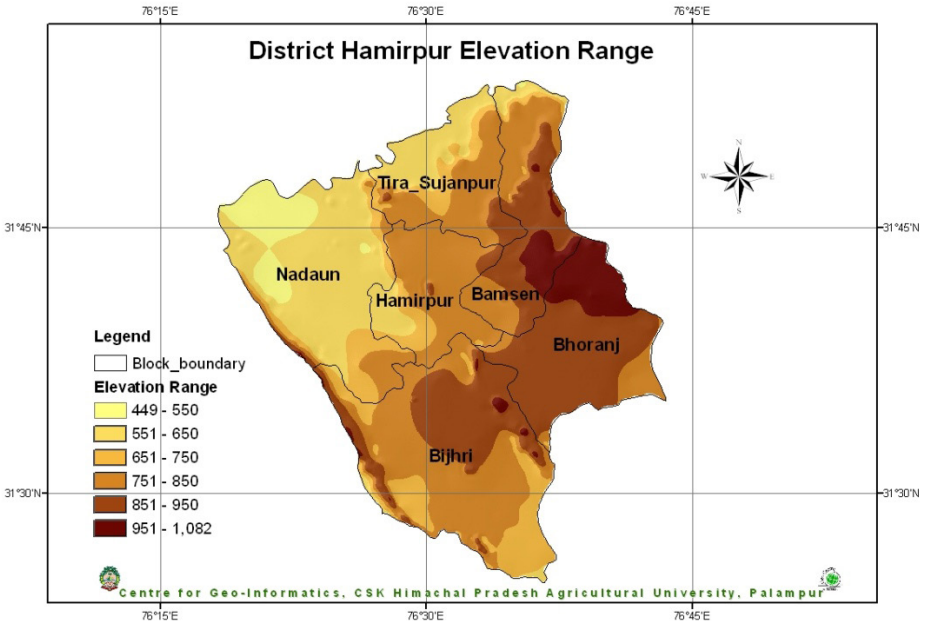
In general the term "vulnerability" refers to the capacity to be wounded or the degree to which a system is likely to experience harm due to exposure to a hazard. Considerable research attention has been given traditionally only on the first two components i.e. geophysical and biological aspects ignoring the socio-economic aspects (Kavi-Kumar and Parikh, 1998, 2001). The farmers in rainfed region used to follow mono cropping involving traditional agricultural methods and mainly grew the crops like pearl millet, fodder and pulses. But the farmers in this rainfed region are now experiencing some extreme climatic changes like increase in temperature, change in precipitation pattern, flooding etc. These changes in climatic situation directly or indirectly affects their livelihood by changing the soil structure, drainage, oxygen availability, increased soil salinity and prolonged dry spell during crop growing period. Most of the previous study investigated the impacts of climate change on bio-physical aspect. Social dimension of vulnerability have largely been ignored mainly due to lack of appropriate indicators and difficulties in quantifying them. To date, there has been little research focus on measuring agro-ecological and social vulnerability of climate change. The risks are such that they may undermine human security by reducing access to and the quality of natural resources that are important to sustain livelihoods. There is emergent need to document agro-ecological impacts of climate change to formulate appropriate adaptation policy. But most of the previous studies concentrated on only physical impacts of climate change. However, agriculture in the state suffers from certain limitations, especially in the production of wheat and maize crops as well as oilseed crops. One of these reasons is that the area under cultivation is reducing as large numbers of farmer are leaving farming due to unfavorable climate (Lal, 2004). With this background, the present study tried to document the diverse impacts of recent climate change on the agro ecosystems in Hamirpur region of Himachal Pradesh.

Research Methodology

One hundred seventy farmers from Nadaun block and one hundred thirty from Bhoranj in Hamirpur district of Himachal Pradesh were selected randomly (Fig. 1). Thus, total 300 farmers were interviewed in the present study. Beside farmers, experts from CSKHPKV Palampur; and KVK Subject matter specialists, Hamirpur at Bara were also interviewed to enrich our primary observations. So, the present study tried to measure the vulnerability level of farmers through vulnerability index by taking different socio-economic and psychological indicators more quantitatively. An exhaustive list of vulnerability indicators and sub-indicators under each broad indicator was identified and finalized after extensive literature review and discussion with experts and innovative farmers. The indicators of vulnerability index selected were- economic factors (income, area, physical resources and livestock resources), socio-psychological variable (education, age, family member, adaptive behavior, awareness, knowledge, achievement motivation, attitude, value, innovativeness, openness in farming, production orientation, risk orientation, perception, stress, pessimism, fatalism, egalitarianism, communication behavior, social participation, cohesiveness and dependency level).

Thus total twenty nine indicators were identified to measure the vulnerability level of farmers. Linear Regression analysis was employed to test the validity of the vulnerability level of respondents through our measurement tools**.** The climate change was operationalized as a study on reciprocal interaction between climate change and social processes of agro-ecosystem. It analyses both quantitatively and qualitatively the different socio-economic factors that influence the climate change process and in turn are affected by that process. The perceived socio-economic impacts, changes in their cropping systems, changes in livelihood status, changes in agricultural practices etc. were evaluated. The perception of farming



Source: *www. centreforgeoinformatics.cskhpkvpalampur.in.*
Fig. 1: Map of study area

community about climate change were analyzed by taking into account different socioeconomic variables like awareness, knowledge, adaptive behavior, communication pattern, social cohesiveness and social participation, income, assets, cropping pattern, land use pattern, access to resources; psychological and cultural variables like attitude, value orientation, risk perception, achievement motivation, openness, stress , pessimism, production orientation etc; and demographic variables like age, sex, caste, education, family size and member; etc. The impact assessment was done using both quantitative and qualitative techniques. The impacts were generally studied in term of changes in agricultural practices, perceived changes in climatic parameter, changes in bio-diversity, changes in livestock production and productivity and changes in their social and cultural practices. We followed an exploratory research design to identify the in-depth and unconventional impact of climate change. All the information was collected through open ended questionnaire with extensive use of "probing" technique and "funnel technique" of data collection. The data were quantified using frequency and percentage analysis.

Results

The major impacts of climate change on agro-biodiversity documented are presented in Tables 1-6.

Discussion

Majority of the farmers reported that temperature had increased significantly in recent years. Smart farmer from Nadaun block disclosed that increase in temperature and decline in rainfall in

Table 1: Normal Rainfall and Actual Rainfall from 2011-2016 received in Hamirpur Region of Himachal Pradesh (mm) (Auto Weather Station, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

Month	*Normal rainfall (mm)*	*Actual-2011*	*Actual-2012*	*Actual-2013*	*Actual-2014*	*Actual-2015*	*Actual-2016*
January	41.74	33 (1)	58.75 (7)	42.45 (3)	60.4 (2)	77.8 (5)	8.6 (2)
February	63.62	132.5 (7)	15 (3)	79.8 (6)	104.8 (5)	77.5 (5)	17.2 (2)
March	48.44	40.5 (2)	-Nil-	50.7 (3)	76.1 (6)	154.2 (5)	64.4 (50
April	42.93	38.75 (1)	64.75 (4)	7.5 (3)	34.4 (2)	47.5 (3)	20.6 (1)
May	32.16	33.25 (2)	-Nil-	13.27 (2)	69.8 (4)	22.8 (3)	73.6 (6)
June	145.88	133.25 (7)	26.25 (3)	228.68 (12)	104.5 (20)	140.8 (8)	99.1 (8)
July	302.65	221.75 (5)	169 (7)	207.8 (13)	428.0 (14)	281.0 (9)	338.6 (11)
August	420.13	317.5 (10)	319.9 (13)	745 (13)	260.6 (12)	371.3 (8)	516.5 (11)
September	136.30	102.5 (5)	229.2 (8)	102.5 (4)	63.0 (7)	73.6 (5)	76.4 (5)
October	29.03	-Nil-	-Nil-	28 (1)	-Nil-	5.2 (1)	-Nil-
November	5.41	-Nil-	5.4 (1)	22 (1)	2.0 (1)	11.0 (1)	-Nil-
December	26.41	-Nil-	47.7 (2)	32.3 (3)	61 (1)	21.6 (1)	-Nil-
Total	1294.7	1053.45	935.05	1560	1264.6	1284.3	1215

*(mm) = millimeter, ( ) = Number of rainy days in a month

Table 2: Climate resilient practice/technology adaptation behavior of the smart farmers and existing practices of non-smart farmers of Hamirpur region under Natural resource management (NRM) (Annual Progress Report, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

Technology	*Climatic constraint*	*Details of existing practice of non smart farmer in the Bhoranj block*	*Details of climate resilient practice / technology adapted by smart farmers in Nadaun block*	*Measurable indicator (s)*
Renovation of defunct water harvesting structures (Jalkund community based)	Scarcity of water during lean periods from October –November onwards till June	Defunct almost the year except rainy season	By renovation stored water is used in their cultivated fields and for fish farming	No. of irrigations up to one and half hectare area, impact on crop and fish yield
Renovation of water bodies (2no.)	Defunct structure/ Seepage losses.	Only use for domestic purposes like construction and animals	By renovation providing hygienic water for drinking and irrigation	Comparison between natural and existing water sources through water testing
Use of organic mulch	Due to less water availability and organic matter; crops are damaged during fruit set if growth stand is good	Due to threat of diseases; farmers put their fields neat and clean	Use locally available biomass in Cucurbits, Colocasia , Turmeric, Elephant foot yam	Soil moisture content, no. of irrigation reduced and Crop yield,
Ridge and furrow method under vegetable cultivation	Less water availability except rainy season	Flood Irrigation on availability of water	Cultivation of Cucurbits in channels	Number of Irrigations, status of fertilizer applications.

Table 3: Climate resilient practice/technology adaptation behavior of the smart farmers and existing practices of non-smart farmers of Hamirpur region under Crop production system: (Annual Progress Report, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

Technology	*Climatic constraint*	*Details of existing practice of non smart farmer in the Bhoranj block*	*Details of climate resilient practice / technology adapted by smart farmers in Nadaun block*	*Measurable indicator (s)*
Cucurbits, cauliflower and onion	Poor fruit set in cucurbits, small curd size in cauliflower and bulb size affected in onion	Indigenous system	Sprinkler and Ridge and furrow method of irrigation	Number of harvesting, fruits, curd & bulb size respectively
Mustard KBS -3, Gobhi- sarson GSC-7 and ONK1	Low- water requirement/ marginal lands	Mix crop and broadcast method	Early sowing after receding monsoon/ recommended in monkey menace area	Crop yield and oil yield
Zinger, turmeric and Elephant foot yam	Less water consuming crops	Indigenous system	Biomass mulching	Rhizome size
Maize 4640,	Lodging problem in maize hybrids	Indigenous system	Integrated nutrient & water management on soil test basis	Plant height, cob size and grain yield and disease assessment from sowing to harvest
Wheat early sown HPW- 360	1. Poor germination percentage in moisture stress condition	Only seed treatment and use of insecticides/ pesticides as per need	1. Early sown wheat variety to exploit residual moisture	Plant-height and Crop- yield.
Timely sown HPW-349 (Seed bank)	2. Yellow rust infestation		2. Yellow rust resistant variety	Insect pest and diseases assessment from sowing to harvest

Table 4: Climate resilient practice/technology adaptation behavior of the smart farmers and existing practices of non-smart farmers of Hamirpur region under Livestock production systems (Annual Progress Report, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

Technology	*Climatic constraint*	*Details of existing practice of non smart farmer in the Bhoranj block*	*Details of climate resilient practice / technology adapted by smart farmers in Nadaun block*	*Measurable indicator (s)*
Prophylaxis and mitigation of mineral deficiencies in live stock	Non availability of green fodder, Low nutrient availability from dry fodder	Indigenous system	Mineral mixture-Supplementation	Milk yield, Service period and Conception rate
Fodder conservation through *Azolla* cultivation, silage making	Non availability of green fodder from Nov to Dec and May to July.	Indigenous system	Silage making in Plastic drums. Hay making and storage.	Milk yield in milch animals and weight gain in heifers
Uromol bricks	Negative protein energy balance	Indigenous system	Uromol brick licks	Milk yield.

winter season was more than summer season. The behavior of climate was highly uncertain in recent time. All the smart farmers and non smart farmers unanimously from both Nadaun and Bhoranj blocks told that rain fall has decreased sharply in last 20 years. The frequency and degree of monsoonal and winter rainfall (July-August month) decreased. Moreover, it was not occurring timely, sometimes it came early and sometimes too late. Few farmers reported that rainfall occurred continuously in *kharif* season and then suddenly stopped, impacting rice seedling in Hamirpur region. Rainfall used to come by mid June even 10 years back but now it comes by mid August and suddenly heavy rainfall was experienced by a particular place and was not equally distributed even within the place. The incidence of water logging had increased. More frequent and intensive drought with prolonged dry spell was reported from the Hamirpur region (April-July as well as September to December). Hailstorm was reporting in winter season and causing severe damage to tender seedlings and fruit crops as well as huge economic loss in the region. So, the present study tried to reveal the impact of climate change on major cereals and oilseeds crop cultivation. All the farmers unanimously agreed that crop yield had declined in Hamirpur region. They were of the view that delayed and uneven rainfall was unfavorable for farming. Decline and uneven rainfall and rise in temperature significantly also provide favorable environment for breakout of the multiple diseases like yellow rust, kernel bunt disease in wheat crop, increase the attack of borer and aphids in oilseed crops and fruit fly attack in cucurbits was reported. The farmers reported that the fertility of soil had decreased across the valley due to increased use of chemical fertilizers. A little less than three-fourth (73%) farmers reported delayed monsoon. All the farmers (100%) admitted that major crop production had declined in the study area. Major climatic impacts on agro-biodiversity were change in sowing time (43%), change in harvesting time (38%), decline in

Table 5: Climate resilient practice/technology adaptation behavior of the smart farmers and existing practices of non-smart farmers of Hamirpur region under Institutional interventions (Annual Progress Report, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

Technology	*Climatic constraint*	*Details of existing practice of non smart farmer in the Bhoranj block*	*Details of climate resilient practice / technology adapted by smart farmers in Nadaun block*	*Measurable indicator (s)*
Seed Production Of Wheat Variety HPW 349	Yellow rust infestation during unseasonal weather fluctuation	HPW-236	Yellow rust and other disease management	1. Percent diseases infestation 2. Crop yield
Agro advisory base on IMD weather forecast and block weather observatory	Drought/frost	1.Through VCRMC/ personnel contents 2. SMS	Time to time advise to the farmers on climate change through trainings and other awareness programme	Daily weather data recording
Training 2-3 rural youth of each village for maintain micro irrigation system	Water scarcity during lean periods	Rain fed / flood irrigation	Demonstration cum training on micro- irrigation techniques	Rural youth to be trained at KVK and CSKHPKV Palampur

Table 6: Impacts of climate change on agro-ecosystem, animal husbandry and socio-cultural aspects of agro-biodiversity in Hamirpur region of Himachal Pradesh (Annual Progress Report, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

Area of change		*Kind of change*	*Factors associated with change*	*%*
		Meteorological Parameter		
Temperature		Temperature has increased more in winter season in Hamirpur region	Pollution, deforestation, invasion of exotic weeds and pests, increased number of vehicle	73
Rainfall		Rainfall is coming late. Earlier rainfall used to come by the end of June. But now it is coming in the month of July (15 to 30th August) which is affecting the sowing of *kharif* crops viz; Maize and Rice.	Due to decline in precipitation, rice cropping land had reduced along with vegetations and forest area	47
Drought		Frequency and intensity of drought is increasing, dry spell is reported.	Rise in temperature, low rainfall.	64
Hailstorm		Increased events of hailstorm.	Tender loss and severe damage to agricultural and fruit crops	73
Frost		Excess frost is reported from the area and as a result low soil moisture and severe damage to leafy vegetables and fruit crops in the field is reported.	Due to decrease temperature at the atmosphere	44
Cold		Winter season is delayed by one month. Earlier winter used to start before November but now it starts from December and lasts upto March. This is affecting the *rabi* season crop like wheat, mustard, vegetables etc.	Due to rise in temperature and decline in winter rainfall	72
		Agro-Ecosystem		
Major cultivation crops	Decline in crop yield	Production of all the major crops declined due to adverse climatic condition like high temperature coupled with erratic and uneven rainfall	Due to delay rainfall and increasing temperature.	100
	Change in cropping season	*kharif* season has shifted from mid June to mid July	Due to changes in rainfall	45
	Change in sowing time	Sowing is reported to be late by around fortnightly in *kharif* season due to late rainfall. Time of sowing has shifted from mid June to mid July. Similarly in *rabi* season sowing is delayed by second week of November to second week of December due to late onset of winter season	Due to advancement in winter season and delayed rainfall	38

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	Change in harvesting time	Earlier harvesting was done by last week of September but it is second week of October	For advancement in winter season and early maturity of the crops.	42
	Change in cropping pattern	Farmers were adopting intercropping like *soyabean* and maize and *til* etc.	To reduce the risk of crop failure and more income.	36
Change in water table		Water level went down significantly. Earlier, water was available at 20 ft depth in tubewell. Now it goes down to 60 ft depth.	Low and uneven rainfall etc.	86
Crop diversification		Now smart farmer are growing cabbage, cauliflower, brinjal, cucurbits, capsicum, peas and rhizome crops.	To adapt to changing climatic conditions.	69
Change in disease and insect infestations		Whitening of leaves of *soybean* plant.	Delayed rainfall.	73
		Fruit fly attack on cucurbits, yellow rust infestation in wheat crop, *Moila* diseases (sucking pest) in blackgam, yellowing of leaves and aphids infestation of mustard plant etc. were reported to be occurring in high magnitude.	Rise in temperature and less rainfall.	64
		Problem of termite increased to a large extent in the area.	Changing weather.	89
Soil health status		Decline in soil fertility level. Earlier only applied cow dung during winter followed by 1 spray. But now they have to apply huge amount of chemical fertilizer.	Indiscriminate application of fertilizer.	31
		Animal Husbandry		
Milk yield		Production of milk of cow and buffalo had decreased in the area.	Extreme cold and hot in both seasons.	77
Milk quality		Decrease in quality.	Lack of nutritional fodder during lean period and due to application of urea in the field, which indirectly goes as a feed to the animals.	34
Livestock ailments		Increased retention of placenta. Diseases like pneumonia, cold, foot and mouth diseases etc. were increasing day by day.	Extreme cold in winter season and Due to high temperature.	33
Population Increase in certain animal species		Monkey population increased.	Climatic suitability and deforestation and destruction of habitat.	23
		Socio-cultural Impacts		
Economic status		Increased rate of poverty	Rural people depend on agriculture and livestock for their livelihood but crop yield as well as income had reduced due to negative impact of climate change which led to increase in poverty.	51
Discrimination distance between rich and poor		Widening the gap between rich and poor	Climate change could widen the gap between rich and poor as others sector like- service, businesses was less affected compared to agriculture on which most of the poor people depend.	48
Capital generation		Income of the farmers has reduced due to low production and increase in cost of cultivation	Increasing cost of integrated pest management (IPM). Earlier only one spray was sufficient to manage the disease and pest problem in apple. But now they have to spray 8-10 times to control diseases like yellow rust and powdery mildew etc.	84

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People Migration	People migrate towards Baddi-Nalagarh, Delhi, Chandigarh, Ludhiana	For ensuring job and regular Employment in industries and private sector.	63
Shifting of farming to non farming occupation	Migration of farmers from agriculture to non agricultural activities like tourism, business, rural artisans, private jobs etc. were reported	Due to high uncertainty in agriculture sector	18

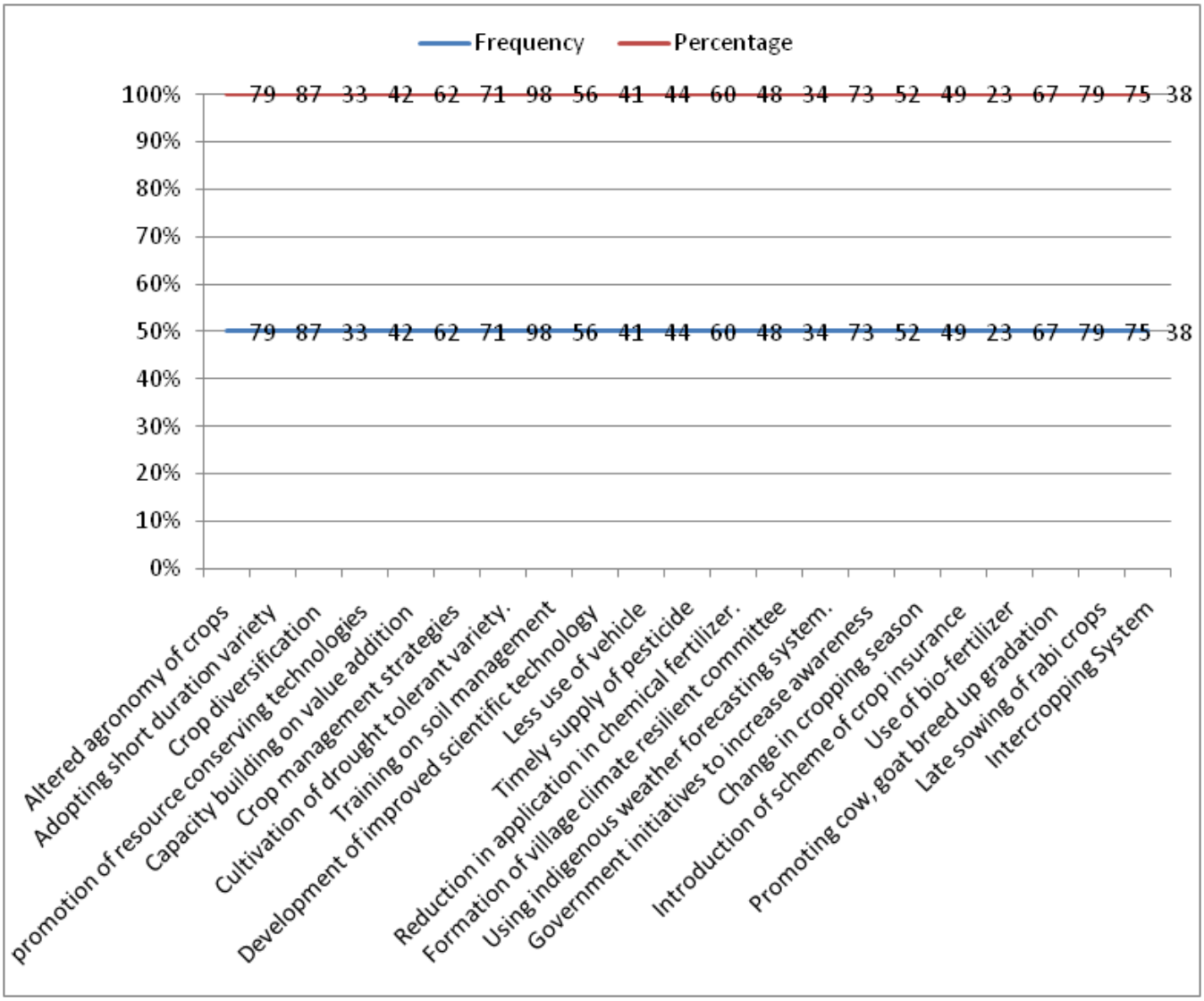

Fig. 2: Farmer's adaptation strategies with their vulnerable climate along with frequency and percentage (Annual Progress Report, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

Beas river water level (55%), decline in milk production (38%) and migration of people (63%). Seventy nine per cent farmers had reported low frequency of storm and 83 per cent reported increased frequency and intensity of hot wave (Figs. 2-3). Yellow rust and black bunt diseases in wheat, yellowing of leaves and aphids infestation of mustard plant, sweet, fruit fly attack in cucurbit etc. were reported in high magnitude. Advancement in sowing time of vegetables in rabi season was reported. Cropping pattern had undergone a rampant change. Earlier farmers used to grow cereals like wheat, rice and maize which had been replaced by cash crops. The farmers in Nadaun block already had left conventional cultivation of cereal crops and shifted towards vegetable cultivation. Now, some farmers in Bhoranj block also had started to leave conventional farming due to unfavorable climate and adopting vegetable cultivation. They were engaged in cultivation of vegetable like cabbage, cauliflower, pea, potato, carrot, brinjal, chili, onion, capsicum, and cucurbits etc. Production of milk had decreased due to extreme low temperature in the morning and evening in winter season and extreme high temperature in summer season. Pneumonia as well as mouth and foot disease of animal was also reported in a higher frequency. Some farmers told that the area under wild green grass had reduced which was supposed to give higher milk under changing climatic condition. The farmers were

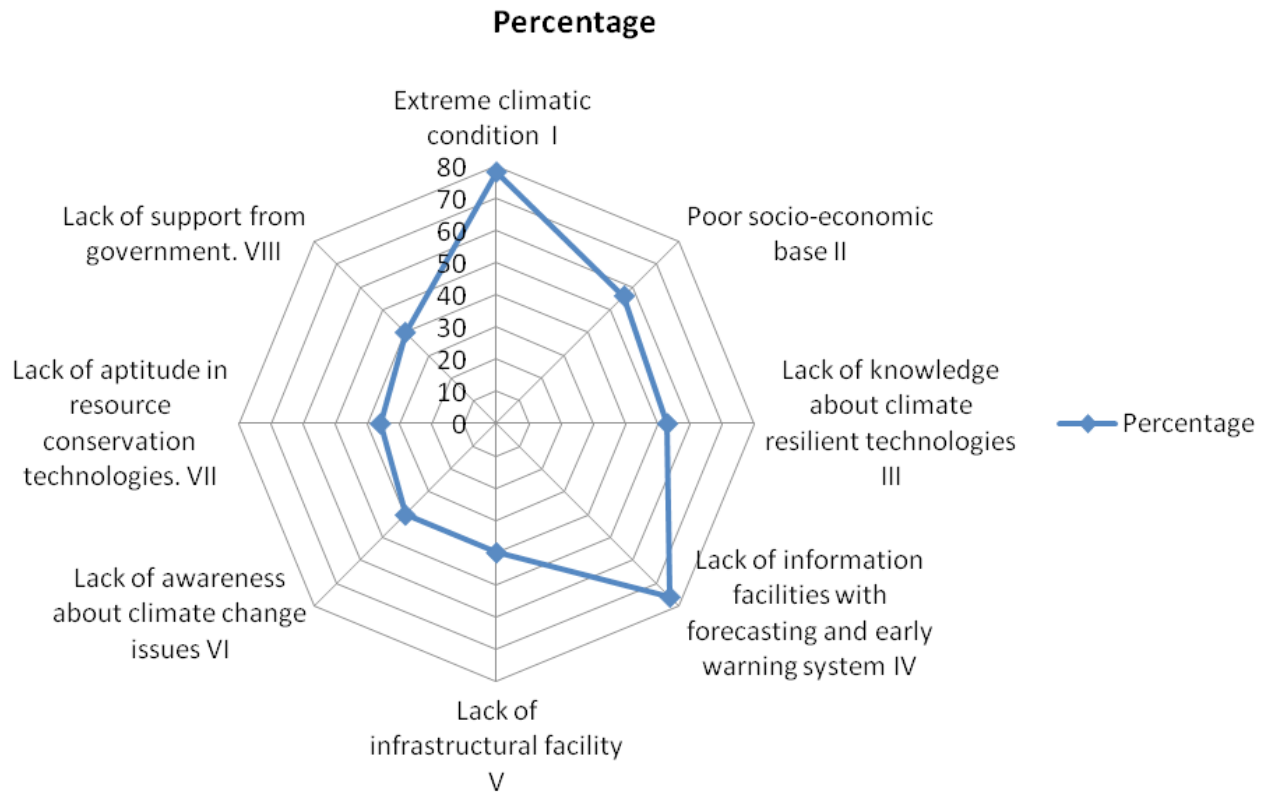

Fig. 3: Distribution of farmers on the basis of ranking of local constraints in Hamirpur region of Himachal Pradesh (Annual Progress Report, Krishi Vigyan Kendra, Hamirpur, Himachal Pradesh)

leaving farming in the area and migrating towards nearby cities like Baddi-Nalagarh, Jalandhar, Delhi, Chandigarh, Ludhiana, etc. for regular employment and security. The climate change was also expected to increase the gap between rich and poor in the area as poor farmers were engaged in climatic sensitive sectors like farming. The income of the farmers was also skewed down due to increased application of chemicals and pesticide to prevent the diseases and insects besides fertilizers to maintain the productivity under reduced rainfall condition. The belief system of the local people about cropping season and weather also had changed under changing climatic scenario. Now people rely more on God for the onset of rain in time (Shifraw, 2014; Simpson and Burpee, 2014; Swaminathan, 2009; Tiessen and Cuevas, 1994; Jamali, 2009; Kaur, 2008).

Based on their ecological, socio-personal and psychological impacts of the respondents and their vulnerability index, it is deduced that the people in the area need concerted approach in their capacity building for developing their adaptive capabilities. It is imperative to make proactive interventions in areas of importance like livelihood mechanism and resource utilization pattern. Thrust areas of intervention for effective adaptation strategy were elicited from the farmers, which included emphasis upon afforestation, legislative measures, use of eco-friendly agro-technologies for crop cultivation, development of suitable short hybrid varieties for drought and frost tolerance, measures for educating them in health and environment protection, supply of inputs and services with subsidy, etc.

While identifying the important constraints related to adaptation capacity, the respondents ranked extreme climatic condition as first, followed by lack of knowledge about adaptive practices, poor infrastructural facilities, lack of information facilities with forecasting and early warning system, lack of awareness about climate change issues, and lack of aptitude towards resource conservation.

Conclusion

The study attempted to address the impacts of changing climatic conditions on the agro-biodiversity of the Hamirpur region of Himachal Pradesh. The study revealed that the recent changes in climate impacted farming system as well as the livelihood of farmers both directly and indirectly. The farmers of Hamirpur region had also started to leave conventional cultivation and adopted vegetables as cash crop as well as alternative crop. From the findings, it can be concluded that the discontinuance of conventional cultivation was influenced by climatic parameters like reduced rainfall and rise in temperature. The meteorological data also showed that there was high month to month and year to year fluctuation in temperature while overall trend was almost same. So, it can be deduced that the farmers were more affected by climatic variability. The major impact felt in hilly ecosystem included decline in area and production of cereal and oilseed crops, increased temperature, irregular rainfall, fluctuation in sowing and harvesting time, loss of bio-diversity, decrease in milk production, increased health problem, and migration

of people towards plain area and non agricultural sector. Hence, it could be deduced that the agro-ecosystems were highly vulnerable to the climate change and it is of immense importance to take appropriate measures both at the local level and national level to frame appropriate policy to adapt to the climate change.

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