Regional Economic Development Research
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Case Study

How Do Marginal and Small Farmers Perceive the Impacts of Climate Change on Livelihoods? A Case Study from Jammu Region, India

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Received: 29 June 2021; **Revised:** 23 August 2021; **Accepted:** 24 August 2021

Abstract: This study investigated the perceived impacts of climate change on livelihoods of marginal and small farmers in Jammu region, India. The objectives of the study have been to analyze the impacts of climate change on crop farming and livestock rearing by marginal and small farmers in study area, to understand socio-economic implications of climate change impact on livelihoods, and to draw policy implications for ameliorating the livelihoods of marginal and small farmers in changed climatic conditions. The study is confined to irrigated and non-irrigated areas in Jammu and Rajouri districts of Jammu region. The study is based on primary data collected from household survey using pre-tested structured questionnaires. A total of 600 farm households were selected using the multistage sampling technique. The study findings revealed that while climate change was negatively affecting livelihoods of marginal and small farmers in both irrigated and non-irrigated agriculture through reduced crop and animal yields, crop damages, crop and animal diseases, weed infestations and pest/insect attacks on crops, the adverse impacts were experienced by comparatively more marginal and small farmers in non-irrigated agriculture. The study further noted finer variations in socio-economic impacts from households to households which can be attributed to their involvement in diverse livelihood strategies providing them with increased income security. For enhancing their resilience to climate change, the governments should-create more research capacity to enhance development and timely supply of hybrid seeds and varieties at subsidized rates; strengthen agriculture extension services to give them knowledge, information and technical support; improve animal health service delivery system with improved knowledge and technique to prevent and timely treatment of climate change-induced disease outbreaks among animals; introduce small irrigation schemes like drip irrigation and sprinkle irrigation schemes in non-irrigated areas and promote rainwater harvesting technique for irrigation in dry periods.

***Keywords*:** climate change, Jammu, livelihoods, livestock, marginal farmers, small farmers

JEL Code: Q1, Q10, Q12, Q22, Q15, Q54

1. Introduction

Climate change is a significant global environmental challenge being faced by humanity (Arbuckle et al., 2015; MacCracken, 2004; Malhi et al., 2021; Mishra, 2017) and is emerging as a potent threat to agriculture-based livelihoods

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(Obokata et al., 2014). Climate change refers "to any change in climate over time, whether due to natural variability or a result of human activity" (Intergovernmental Panel on Climate Change (IPCC), 2007). The synthesis report of the Intergovernmental Panel on Climate Change (IPCC) (2001), states that the climate system of the earth has demonstrably changed on both global and regional scales since the preindustrial era largely due to human-induced greenhouse gas emissions. The impacts of climate change are becoming increasingly and rapidly evident around the world in the form of rising temperatures, shifting rainfall patterns, melting glaciers, and increased frequency and intensity of extreme weather events such as droughts, floods, and cyclones (IPCC, 2007; Mendelsohn & Dinar, 2005; Ganguly & Panda, 2010) all of which are expected to increase further during this century (Zurovec & Vedeld, 2019).

Climate change is a major challenge to economic growth, long-term prosperity, and survival of already vulnerable populations and amplifies economic, social, and environmental vulnerabilities (Intergovernmental Panel on Climate Change (IPCC), 2007; Mugula & Mkuna, 2016). Agriculture is one of the most sensitive sectors to climate change (Jamshidi et al., 2018; Kumar & Viswanathan, 2019; Malhi et al., 2021; Menike & Arachchi, 2016; Ahmed, 2019; Mulinya, 2017; Somboonsuke et al., 2018) and is expected to suffer the most due to its adverse impacts (Auffhammer & Schlenker, 2014; Campbell et al., 2016; Cline, 2007; Khanal & Mishra, 2007; Makate et al., 2016; Salvo et al., 2013). Climate change can affect crop yields as well as the types of crops that can be grown in certain areas, by impacting agricultural inputs such as water for irrigation, amounts of solar radiation that affect plant growth, as well as the prevalence of pests and diseases (Kumar, 2014; Porter et al., 2014). The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC) indicates that climate change during the last 3 decades has already led to a 1-5 percent reduction in global agriculture production (Porter et al., 2014). It is estimated that by 2080, global agricultural productivity will be reduced by 15.9 percent with developing countries experiencing a disproportionately large decline of 19.7 percent (Cline, 2007).

The negative impacts of climate change on agriculture may bring food and livelihood insecurity for those depending heavily on agriculture (Zurovec & Vedeld, 2019; United Nations Environment Programme (UNEP), 2013; Kumar & Viswanathan, 2019; Panthi et al., 2016). Among others, small and subsistence farmers are particularly vulnerable to the negative impacts of climate change. Climate change affects small and subsistence farmers through the increased likelihood of bad harvest, pest attack, crop diseases, animal diseases, food insecurities (Harvey et al., 2014; Morton, 2007), livestock deaths, rise in food prices, and destruction of properties and thereby forces farmers to decrease consumption, reduce nutrition, pull children out of school, and sell their assets. All these choices limit their capabilities to recover from the distress and reinforce inequalities (United Nations Development Programme, 2007).

Climate change is an issue of great concern for the erstwhile State now Union Territory of Jammu and Kashmir because of its fragile ecosystem and also because 70% of its population depends directly or indirectly on agriculture for its livelihood security. Jammu and Kashmir have been ranked as 3rd most vulnerable states to climate change after Assam and Mizoram in the Indian Himalayan region (Indian Himalayas Climate Adaptation Programme (IHCAP), 2019). Agriculture in Jammu and Kashmir is already facing several problems such as low growth, declining yields, unviable farming, lack of adequate agricultural research, and small and fragmented landholdings. Moreover, 58% of agriculture production in the state is rainfed which makes it more susceptible to vagaries of changing weather and climatic conditions.

Agriculture in Jammu and Kashmir is mainly dominated by small and marginal farmers. The agriculture census (2014) of India classifies farmers based on their land holdings into five major categories as-marginal (below 1ha), small (1-2 ha), semi medium (2-4 ha), medium (4-10 ha) and large (10 ha and above). Marginal and small farmers who constitute about 94 percent of operation landholders in the state are particularly vulnerable to the impacts of climate change on agriculture. Adaptation to climate change is critical in increasing the resilience of those depending on agriculture for their livelihoods (Zurovec & Vedeld, 2019). To evolve effective climate adaptation strategies and policies to secure and sustain the livelihoods of marginal and small farmers in changed climatic conditions, a thorough understanding of how they perceive the impact of climate change on their livelihoods is essential.

In the background of the above stated, the present study investigated the perceived impacts of climate change on livelihoods of marginal and small farmers in the Jammu region, India with specific objectives-to analyze the perceived impacts of climate change on crop farming and livestock rearing by marginal and small farmers in the study area, to examine socio-economic implications of climate change impacts on livelihoods, and to draw policy implications for ameliorating the livelihoods of marginal and small farmers in changed climatic conditions.

2. Review of literature

According to Intergovernmental Panel on Climate Change (IPCC) (2014), climate change is real and is altering both biophysical and socio-economic systems around the world (Indian Himalayas Climate Adaptation Programme (IHCAP), 2019). During the past century, significant warming trends have been seen in the earth's atmosphere which in 2019 reached 1.1 ^{o}C above preindustrial levels (World Meteorological Organization (WMO), 2020) and is expected to reach 1.5 ^{o}C or even more by 2050 if deforestation, greenhouse gas emissions, etc. continue to occur at the same pace (Arora, 2019). While climate change is a global phenomenon, its associated impacts differ across space and time. Developing countries are particularly vulnerable to adverse impacts of climate change due to their small economies, inadequate infrastructure, and limited economic diversification (United Nations Conference on Trade and Development (UNCTAD), 2021).

According to Mishra (2017), the adverse impacts of climate change fall heavily on the agricultural sector which is expected to be severe in the near future with developing countries being the most affected (IPCC, 2014; Singh et al., 2019). Climate change impacts agricultural productivity both directly and indirectly. It directly affects agricultural yield by bringing physiological changes in crops through changes in temperature and rainfall pattern (Chakraborty et al., 2000; Sowunmi & Kintola, 2009) and indirectly by altering water availability, soil fertility, and pests and diseases outbreak in crops and livestock (Porter et al., 2014). However, the overall effect of climate change may be negative or positive depending on region's geographical location and socioeconomic development and crops being produced (Mendelsohn et al., 2006; Tripathi, 2016; Mulinya, 2017). Rainfed agriculture is more adversely affected by the vagaries of climate change (FAO, 2019). Lack of irrigation reveals a lack of adaptive capacity to mitigate and adapt to climate change, and thus leads to crop loss and reduced income of households dependent on rainfed agriculture (Rani et al., 2011).

Climate change is a formidable threat to the livelihoods of people across the globe especially for those whose livelihoods depend on climate-sensitive sectors like agriculture. Livelihood constitutes means of making a living (Ellis, 1998). Livelihood is considered to be sustainable when it is able to cope with and recover from stresses and shocks and sustain or improve its assets, capabilities, and activities both at present and future without undermining the natural resource base (Carney, 1999; Serrat, 2017). Since marginal and small farmers are directly dependent on agriculture for their livelihoods, any reduction in agricultural yield will significantly impact their food and livelihood security, nutrition, income, and well-being (Hertel & Rosch, 2010).

Small farmers are particularly vulnerable to climate change (Harvey et al., 2014; Mulinya, 2017; Frank & Buckley, 2012; Aniah et al., 2019; Mbuli et al., 2021; Jamshidi et al., 2018; Menike & Arachchi, 2016; Morton, 2007) because of their marginalized status, small landholdings, and high reliance on climate-dependent agriculture (Debela et al., 2015; Frank & Buckley, 2012; Gain et al., 2012; Harvey et al., 2014). Moreover, they possess limited resources to sustain or increase agricultural yield and have little or no access to technical assistance, financial assistance, or government support (Vorley et al., 2012). They generally use rudimentary technology and have limited access to market information (Lipton, 2013). Besides, many smallholders in developing countries are food insecure and reside in highly remote and environmentally fragile areas with low-quality infrastructure which in turn limits their access to markets, financial assistance, or government support (Morton, 2007; Harvey et al., 2014). Given their marginalized status and other socio-economic and development constraints, the predicted increase in temperature and changes in rainfall pattern will adversely affect agricultural productivity and thus, increase their livelihood insecurity which results in the sale of livestock and assets at disadvantageous prices, indebtedness, migration to other places in search of employment, dependence on food aid, and reduced expenditure on health and education of children (Easterling et al., 2007).

Jammu and Kashmir which nestles in the fragile Himalayan ecosystem are particularly vulnerable to climate change (State Action Plan for Climate Change (SAPCC), 2014). Climate change impacts are evident in Jammu and Kashmir in the form of erratic rainfall and snowfall, snow tsunamis, floods, rising temperatures, loss of glaciers, water bodies, and depletion of biological diversity (Ishtiyak et al., 2016; Murtaza & Romshoo, 2016). Jammu and Kashmir is the 3rd most vulnerable state to climate change in the Indian Himalayan region. The major drivers of vulnerability for the state include little road density, no area under crop insurance, the small area under forests per 10,000 rural households, the prevalence of marginal and small landholdings, less percentage area under horticulture crops, low livestock to human ratio, and lack of women's participation in the total workforce in the state (Indian Himalayas Climate Adaptation Programme (IHCAP), 2019).

According to Sharma et al. (2017) during the past two decades, the average temperature has shown a rise of 1.45 ^{o}C in Kashmir and 2.32 ^{o}C in the Jammu region with a significant increase in maximum temperature of 0.05 ^{o}C per year in the Kashmir region and 0.08 ^{o}C per year in Jammu Region. Rainfall has also shown decreasing trend, particularly during the rabi season. Due to the increase in temperature and decrease in rainfall, rainfed agriculture in the Northwestern Himalayan region including Jammu and Kashmir has been hit hard. Summer varieties of rice (nick cheena) and traditional Kashmiri apples have more or less disappeared from some areas of the state. Due to climate change, about 11909 kanals of paddy land have been converted into rainfed dryland farming in various parts of Jammu and Kashmir. Insufficient or no rain in the winter season (December to February) has severely affected the cultivation of wheat, mustard, and lentil.

Jammu and Kashmir is already a food deficit state as it meets 40% and 20% of its requirement for food grains and vegetables respectively through supplies from outside (Bhat, 2019b; Jain, 2020). According to Bhat (2019a) the state has to import about 7 lakh MTs of food grains every year from outside states to fill the gap between food production and consumption which is projected to increase further with projected increase in population. Climate change is likely to create havoc in the future as the projected increase in temperature, intense rainfall, wildfires, floods, droughts, snowstorms, hailstorms, landslides, etc. will impact agriculture and allied sector in the state which will further cause food scarcity and social and economic conflicts.

The adverse impact of climate change on agriculture has serious implications not only for livelihood and food security of marginal and small farmers but also for the food security of the entire state. The review of literature given above clearly points towards the alarming threat being posed by climate change on agriculture and livelihoods based on agriculture and also the vulnerability of marginal and small farmers. In the context of Jammu and Kashmir, although the literature is growing on climate change and its impacts on natural ecosystems, agriculture, food security, etc. No research study has been undertaken on the impact of climate change on the livelihoods of marginal and small farmers who constitute the majority of operational landholders in the state. Understanding how marginal and small farmers perceive impacts of climate change on their livelihoods and socio-economic conditions is the essential baseline for formulating appropriate strategies for building their resilience to climate change. The present paper, therefore, contributes to the existing literature by analyzing the perceived impacts of climate change on livelihoods of marginal and small farmers and its implications for their social and economic status in irrigated and non-irrigated agriculture in Jammu and Rajouri districts for drawing policy implications for ameliorating the livelihoods of marginal and small farmers in changed climatic conditions.

3. Objectives and methodology

The major objective of this research paper is to analyze the impact of climate change on the livelihoods of marginal and small farmers in irrigated and non-irrigated agriculture in the Jammu region. The specific objectives are to analyze the impact of climate change on crop farming and livestock rearing perceived by marginal and small farmers in the Jammu region of India; to examine socio-economic implications of climate change impact on livelihoods of marginal and small farmers; to draw policy implications for ameliorating the livelihoods of marginal and small farmers in changed climatic conditions. The present study is confined to irrigated and non-irrigated areas in Jammu and Rajouri districts of erstwhile State now Union Territory of Jammu and Kashmir. Jammu and Kashmir comprise two regions, namely, Jammu and Kashmir. Jammu region comprises 10 districts viz. Jammu, Kathua, Samba, Rajouri, Poonch, Kishtwar, Doda, Udhampur, Reasi, and Ramban (Figure 1). The average size of landholding in the Jammu region is 0.76 ha and the number of operational holdings is 5.88 lakhs. 92 percent of operation holders in the Jammu region fall in the category of small and marginal farmers. The net sown area in the Jammu region is 397,204 ha out of which only 27.52 percent is irrigated and 72.48 percent is non-irrigated. The irrigated areas in the Jammu region are largely concentrated in districts Jammu, Kathua, and Samba while non-irrigated areas are spread over large drought-prone areas in districts Doda, Kishtwar, Ramban, Reasi, Udhampur, and Rajouri.

Jammu and Rajouri districts (see Figure 1) were selected for the study area because, in the Jammu region, district Jammu has the largest net sown area (91,095 ha) and is 61 percent irrigated, and district Rajouri has the third-largest (after districts of Jammu and Kathua) net sown area (53,082 ha) but it is more than 91 percent non-irrigated. Thus, these two districts gave the best opportunity for undertaking a comparative study of climate change impact on livelihoods of the

marginal and small farmers in irrigated and non-irrigated agriculture. Sampled farm households for irrigated agriculture were taken from district Jammu and sampled farm households for non-irrigated agriculture were taken from district Rajouri.

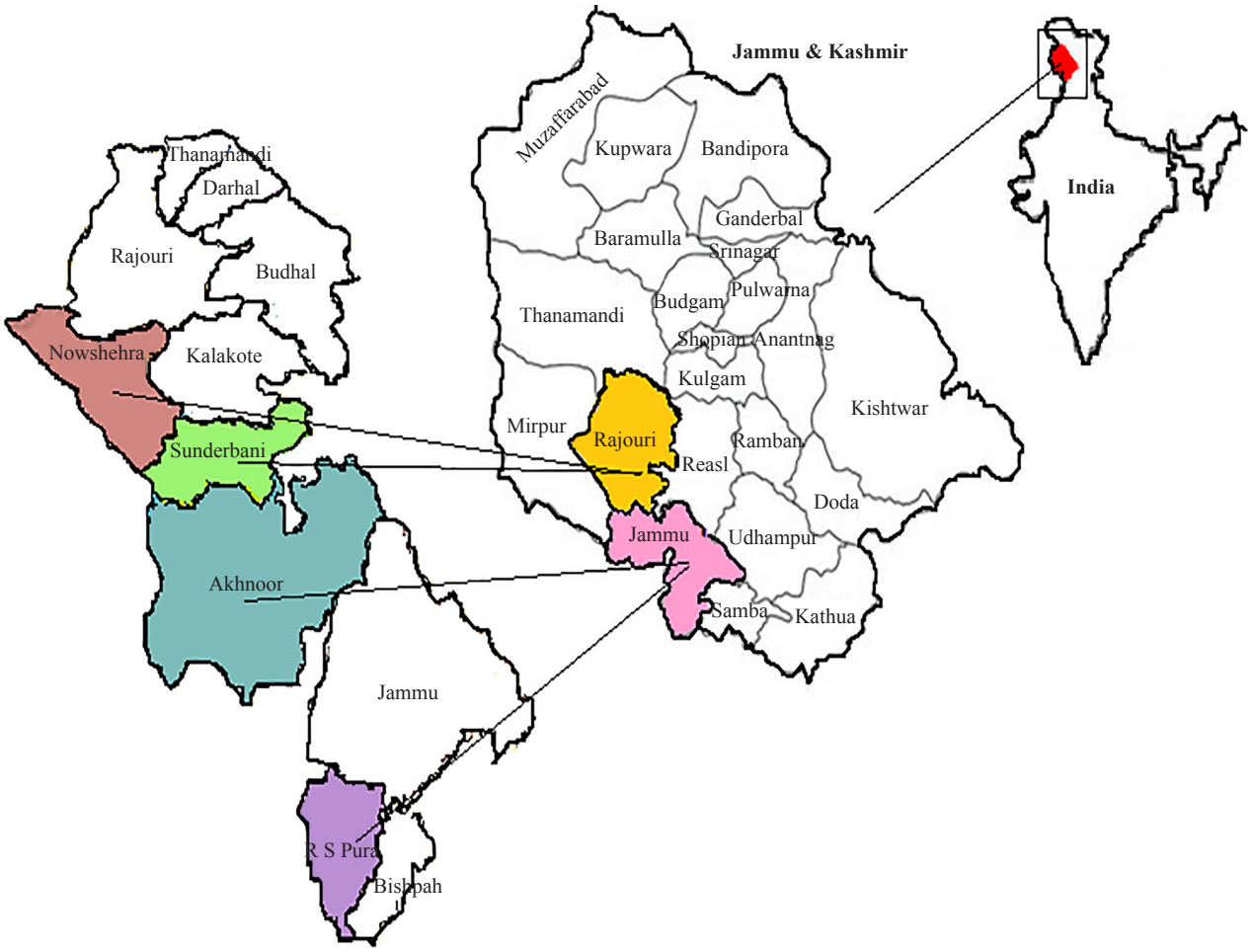

Figure 1. Map of the study area

A total of 600 farm households (300 farm households from district Jammu and 300 farm households from district Rajouri) were selected to draw relevant information and data on phenomena under the proposed study. The study was confined to 20 villages randomly selected from four blocks which were also randomly selected from 2 districts of the Jammu region of Jammu and Kashmir. For the selection of farmers, a multistage sampling technique was used. In the first stage, districts of Jammu and Rajouri were purposively selected. In the second stage, two blocks R. S. Pura and Akhnoor from district Jammu wherein irrigated agriculture is practiced and two blocks-Nowshera and Sunderbani from district Rajouri wherein non-irrigated agriculture is practiced were selected. In the third stage, from each selected block, 5 villages were randomly selected, and finally, from each village, a random selection of 30 households was made taking an equal proportion of marginal and small farmers. The study is primarily based on primary data collected from a household survey using pre-tested structured questionnaires. In addition to the household survey, a number of focus group discussions were also undertaken with villagers, panches, village heads, etc. to have in-depth knowledge on the phenomenon under study. The quantitative data collected from the household survey was processed using the Microsoft Excel tool. It was then analyzed using descriptive statistical tools such as frequency, percentage, and averages.

4. Results

4.1 *Socio-demographic and economic characteristics of farmers*

Table 1 shows the socio-demographic characteristics of farmers. About 46% of all farmers were in the age group of 50 to 59 years and 9% were aged 70 years and above. Since climate change and its impacts are long-term phenomena the information of which can be given by an adult and experienced person, the study deliberately involved farmers aged 40 years and above. The majority of farmers were male and about one-fifth were female. Most of the farmers were having primary education followed by nearly one-third with middle school education. While higher secondary education was received by just 4% of all farmers, about one-fourth had not received any formal education. More than half of all farmers had a family size of 6-8 members.

Table 1. Socio-demographic characteristics of farmers

Characteristics	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
Age (years)							
40-49	36 (24.00)	45 (30.00)	81 (27.00)	41 (27.33)	36 (24.00)	77 (25.67)	158 (26.33)
50-59	60 (40.00)	77 (51.33)	137 (45.67)	73 (48.67)	66 (44.00)	139 (46.33)	276 (46.00)
60-69	42 (28.00)	15 (10.00)	57 (19.00)	21 (14.00)	30 (20.00)	51 (17.00)	108 (18.00)
70 and above	12 (8.00)	13 (8.67)	25 (8.33)	15 (10.00)	18 (12.00)	33 (11.00)	58 (9.67)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Sex							
Male	114 (76.00)	129 (86.00)	243 (81.00)	111(74.00)	117 (78.00)	228 (76.00)	471 (78.50)
Female	36 (24.00)	21 (14.00)	57 (19.00)	39 (26.00)	33 (22.00)	72 (24.00)	129 (21.50)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Level of education							
No Formal education	36 (24.00)	39 (26.00)	75 (25.00)	36 (24.00)	32 (21.33)	68 (22.67)	143 (23.83)
Primary Education	54 (36.00)	51 (34.00)	105 (35.00)	52 (34.67)	49 (32.67)	101 (33.67)	206 (34.33)
Middle School Education	43 (28.67)	48 (32.00)	91 (30.33)	49 (32.67)	45 (30.00)	94 (31.33)	185 (30.83)
High School Education	9 (6.00)	8 (5.33)	17 (5.67)	10 (6.67)	15 (10.00)	25 (8.33)	42 (7.00)
Higher Secondary Education	8 (5.33)	4 (2.67)	12 (4.00)	3 (2.00)	9 (6.00)	12 (4.00)	24 (4.00)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Family Size							
3-5	54 (36.00)	48 (32.00)	102 (34.00)	61 (40.67)	66 (44.00)	127 (42.33)	229 (38.17)
6-8	88 (58.67)	90 (60.00)	178 (59.33)	78 (52.00)	69 (46.00)	147 (49.00)	325 (54.17)
9 and above	8 (5.33)	12 (8.00)	20 (6.67)	11 (7.33)	15 (10.00)	26 (8.67)	46 (7.67)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis shows percentages
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

Table 2. Economic characteristics of farmers and their households

Characteristics		Irrigated agriculture			Non-Irrigated agriculture			Total
		MF	SF	ST	MF	SF	ST	
Livelihood strategy of major earner of household								
Agriculture only		9 (6.00)	11 (7.33)	20 (6.67)	8 (5.33)	10 (6.67)	18 (6.00)	38 (6.33)
Agriculture and non-agriculture activities		141 (94.00)	139 (92.67)	280 (93.33)	142 (94.67)	140 (93.33)	282 (94.00)	562 (93.67)
Total		150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Non-agricultural activities undertaken by major earner of household								
Government service		45 (30.00)	36 (24.00)	81 (27.00)	56 (37.33)	52 (34.67)	108 (36.00)	189 (31.50)
Private service		22 (14.67)	20 (13.33)	42 (14.00)	15 (10.00)	16 (10.67)	31 (10.33)	73 (12.17)
Trader/shop ownership		18 (12.00)	20 (13.33)	38 (12.67)	11 (7.33)	21 (14.00)	32 (10.67)	70 (11.67)
Self employment		30 (20.00)	36 (24.00)	66 (22.00)	24 (16.00)	27 (18.00)	51 (17.00)	117 (19.50)
Wage labour		26 (17.33)	27 (18.00)	53(17.67)	36 (24.00)	24 (16.00)	60 (20.00)	113 (18.83)
Total		150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Ownership of livestock		150 (100)	150 (100)	300 (100)	146 (97.33)	150 (100)	296 (98.67)	596 (99.33)
Main source of household income								
Agriculture		66 (44.00)	91 (60.67)	157 (52.33)	51 (34.00)	68 (45.33)	119 (39.67)	276 (46.00)
Non-agricultural activities		84 (56.00)	59 (39.33)	143 (47.67)	99 (66.00)	82 (54.67)	181 (60.33)	324 (54.00)
Total		150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Annual household income from all sources (₹)								
up to 1,00000		48 (32.00)	30 (20.00)	78 (26.00)	51 (34)	35 (23.33)	86 (28.67)	164 (27.33)
1,00000-2,00000		36 (24.00)	16 (10.67)	52 (17.33)	40 (26.67)	33 (22.00)	73 (24.33)	125 (20.83)
2,00000-3,00000		26 (17.33)	50 (33.33)	76 (25.33)	13 (8.67)	33 (22.00)	46 (15.33)	122 (20.33)
3,00000-4,00000		21 (14.00)	28 (18.67)	49 (16.33)	20 (13.33)	16 (10.67)	36 (12.00)	85 (14.17)
Above 4,00000		19 (12.67)	26 (17.33)	45 (15.00)	26 (17.33)	33 (22.00)	59 (19.67)	104 (17.33)
Total		150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Annual household income from agriculture (₹)								
Negligible		21 (14.00)	0 (0.00)	21 (7.00)	39 (26.00)	0 (0.00)	39 (13.00)	60 (10.00)
Less than 10,000		15 (10.00)	0 (0.00)	15 (5.00)	15 (10.00)	0 (0.00)	15 (5.00)	30 (5.00)
10,000-30,000		17 (11.33)	0 (0.00)	17 (5.67)	55 (36.67)	14 (9.33)	69 (23.00)	86 (14.33)
30,000 50,000		58 (38.67)	23 (15.33)	81(27.00)	36 (24.00)	61 (40.67)	97 (32.33)	178 (29.67)
50,000-70,000		39 (26.00)	67 (44.67)	106 (35.33)	5 (3.33)	53 (35.33)	58 (19.33)	164 (27.33)
More than 70,000		0 (0.00)	60 (40.00)	60 (20.00)	0 (0.00)	22 (14.67)	22 (7.33)	82 (13.67)
Total		150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)
Major crops grown								
Kharif	Paddy	150 (100)	150 (100)	300 (100)	0 (0.00)	0 (0.00)	0 (0.00)	300 (50.00)
	Maize	19 (12.67)	37 (24.67)	56 (18.67)	150 (100)	150 (100)	300 (100.00)	356 (59.33)
	Pulses	0 (0.00)	0 (0.00)	0 (0.00)	23 (15.33)	51 (34)	74 (24.67)	74 (12.33)
Rabi	Wheat	150 (100)	150 (100)	300 (100)	150 (100)	150 (100)	300 (100)	600 (100.00)
	Pulses	9 (6.00)	26 (17.33)	35 (11.67)	15 (10.00)	33 (22.00)	48 (16.00)	83 (13.83)
	Oil seeds	22 (14.67)	32 (21.33)	54 (18.00)	43 (28.67)	65 (43.33)	108 (36.00)	162 (27.00)
	Fodder	99 (66.00)	115 (76.67)	214 (71.33)	15 (10.00)	22 (14.67)	37 (12.33)	251 (41.83)
Total		150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019. Note: Figures in the parenthesis shows percentages. MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

Table 2 reveals the economic characteristics of farmers' households. While just 6% revealed their total dependence on agriculture (crop farming, livestock rearing) for their livelihood, nearly 93% of all farmers revealed both agriculture and non-agricultural activities as livelihood strategies of major earners of households. This largely supports the studies of Dev (2011) and Aniah et al. (2016) that farm households obtain livelihoods from diverse sources such as agriculture (crop and livestock) and non-agricultural activities (labor, self-employment, etc.). Nearly one-third of farmers reported government services as the non-agricultural activity of major earner of the family, followed by self-employment and wage labor. More than one-tenth of all farmers revealed shop ownership as a non-agricultural livelihood strategy. Although the farmers in the study area indicated diverse livelihood strategies, agriculture continued to be their significant source of livelihood. Almost all farmers mentioned their ownership of livestock.

As far as the main source of household income is concerned, 46% of all farmers indicated agriculture as the main source of their household income and more than half of farmers revealed non-agricultural activities as the main source of their household income. Agriculture constitutes the main source of household income for comparatively more farmers in irrigated agriculture than their counterparts in non-irrigated agriculture. In addition, more small farmers than marginal farmers in both irrigated and non-irrigated agriculture derived a major proportion of their household income from agriculture. More than one-fourth of all farmers reported annual household income up to 100,000, about 14% revealed annual household income between 300,000-400,000. Whereas comparatively more farmers in irrigated agriculture fell under the middle (between 200,000 and 400,000) income categories, more farmers in non-irrigated agriculture came under lowest and highest income ranges. Besides, the majority of small farmers in irrigated agriculture reported annual household income between 200,000-300,000, whilst most of the marginal farmers in irrigated agriculture and majority of marginal and small farmers in non-irrigated agriculture came under the lowest income range of up to 100,000.

As far as annual household income from agriculture is concerned, more than half of all farmers earned between 30,000-70,000 and 5% of them earned less than 10,000 annually from agriculture. While 13% revealed annual agriculture income of more than 70,000, one-tenth of them indicated negligible earnings from agriculture.

The major crops grown were paddy-wheat and maize-wheat in irrigated and non-irrigated agriculture, respectively. In the Kharif season, paddy was the main crop grown in irrigated agriculture and maize was the main crop grown in non-irrigated agriculture. In addition to these major crops, less than one-fifth of farmers were growing maize in irrigated agriculture and about one-fourth of farmers were growing pulses as Kharif crops in non-irrigated agriculture. In the rabi season wheat was grown as the main crop in both irrigated and non-irrigated agriculture. In addition to wheat, the other crops grown in the rabi season were fodder, oilseeds, and pulses in irrigated agriculture and oilseeds followed by pulses and fodder in non-irrigated agriculture. Fodder was the second popular rabi crop in irrigated agriculture, while oilseeds crop was the second major rabi crop in non-irrigated agriculture.

4.2 *Perception of farmers about climate change and its impacts*

Farmers' perception of climate change and its impacts on their livelihoods is essential for adaptations. There was a consensus among farmers that climate change and variability were occurring during the past 20 years which was continuously affecting their agricultural-based livelihoods. Table 3 depicts the percent of farmers reporting changes in their local climate which shows that a significantly high proportion of all farmers with very little variations in irrigated and non-irrigated agriculture experienced changes in their local climate during the last 20 years. It is worth mentioning here that the farmers who did not affirmatively respond about changing climatic conditions also pointed in one way or another towards growing climate anomalies.

Farmers in both irrigated and non-irrigated agriculture noticed many climate changes which are summarized in Table 4 which reveals that 82% of all farmers perceived that summers have become hot now as compared to two decades earlier. Milder winters in recent years were other manifestations of changing climate perceived by 47% of all farmers. While about 64% of all farmers felt that the length of the summer season has increased, two-third of all farmers perceived decreased length of winter season during the last 20 years. All these pointed towards rising temperature which confirms with Sharma et al. (2017) study reporting 2.32 ^{o}C average rise in temperature in the Jammu region in the last two decades with a significant increase in maximum temperature of 0.08 ^{o}C per year.

Table 3. Farmers' responses on changes in climate experienced during the last 20 years

Responses	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
Yes	132 (88.00)	135 (90.00)	267 (89.00)	140 (93.33)	133 (88.67)	273 (91.00)	540 (90.00)
No	8 (5.33)	7 (4.67)	15 (5.00)	6 (4.00)	11 (7.33)	17 (5.67)	32 (5.33)
Don't Know	10 (6.67)	8 (5.33)	18 (6.00)	4 (2.67)	6 (4.00)	10 (3.33)	28 (4.67)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis shows percentages
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

Table 4. Percent of farmers experiencing different manifestations of climate change in their areas (multiple responses)

Manifestations of climate change	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
Hotter summers	119 (79.33)	125 (83.33)	244 (81.33)	125 (83.33)	123 (82)	248 (82.67)	492 (82.00)
Milder winters	60 (40.00)	68 (45.33)	128 (42.67)	80 (53.33)	75 (50.00)	155 (51.67)	283 (47.17)
Increase in the length of summer season	103 (68.67)	93 (62.00)	196 (65.33)	92 (61.33)	95 (63.33)	187 (62.33)	383 (63.83)
Decrease in the length of the Winters season	97 (64.67)	88 (58.67)	185 (61.67)	102 (68.00)	111 (74.00)	213 (71.00)	398 (66.33)
Decrease in rainfall	140 (93.33)	138 (92.00)	278 (92.67)	146 (97.33)	143 (95.33)	289 (96.33)	567 (94.5)
Increase in the incidences of very heavy and erratic rainfall	122 (81.33)	120 (80.00)	242 (80.67)	112 (74.67)	110 (73.33)	222 (74.00)	464 (77.33)
Unpredictable and untimely rainfall	115 (76.67)	112 (74.67)	227 (75.67)	120 (80.00)	118 (78.67)	238 (79.33)	465 (77.50)
Increase in the incidences of droughts	98 (65.33)	99 (66.00)	197 (65.67)	107 (71.33)	111 (74.00)	218 (72.67)	415 (69.17)
Increase in the incidences of floods	81(54.00)	96 (64.00)	177 (59.00)	51 (34.00)	59 (39.33)	110 (36.67)	287 (47.83)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis shows percentages, Multiple Responses
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

A significantly high percentage of farmers perceived decreasing trend in rainfall particularly during the winter season which has adversely affected their rabi crop. About three-fourth of farmers have reported an increase in the incidence of very heavy and erratic rainfall. About 69% of all farmers believed that incidences of droughts or dry spells have been increased over the years and about 48% viewed that incidences of floods have increased.

4.3 *Impact of climate change on livelihoods of marginal and small farmers*

Climate change is reported to have adversely affected agricultural-based livelihoods of marginal and small farmers in the study area. According to farmers, impacts of climate change included among others, declining crop yields and animal yields, increase in pest and disease outbreak in crops and animals, weed infestations, destruction of crops due to increased incidences of heavy and erratic rainfall, etc.

4.3.1 *Impact of climate change on crop farming and livestock rearing*

Table 5 reveals that all farmers in non-irrigated agriculture and about 91% in irrigated agriculture believed that their livelihood activities such as crop farming and livestock rearing were being adversely affected by climate change.

Table 5. Farmers' responses on crop farming and livestock rearing being affected by climate change

Responses	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
Yes	139 (92.67)	135 (90)	274 (91.33)	150 (100.00)	150 (100.00)	300 (100.00)	574 (95.67)
No	11 (7.33)	15 (10.00)	26 (8.67)	0 (0.00)	0 (0.00)	0 (0.00)	26 (4.33)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis shows percentages
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

Table 6 shows the percentage of farmers on various impacts of climate change on crop farming which reveals that three-fourth of all farmers (83% of farmers in irrigated agriculture and 68% of them in non-irrigated agriculture) observed an outbreak of new crop diseases which did not exist in the past. The particular type of disease reported was yellow rust in the wheat crop which according to them has emerged as the major threat to the wheat crop in recent years. The farmers also mentioned an increase in the occurrence of some pests and also the emergence of new insects and pests feeding on their crops especially maize in recent years which earlier were unknown to them.

Table 6. Percent of farmers experiencing different impacts of climate change on crop farming (multiple responses)

Perceived impacts	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
Increase in Pests and Diseases outbreak	127 (84.67)	123 (82)	250 (83.33)	100 (66.67)	103 (68.67)	203 (67.67)	453 (75.50)
Increase in weed infestations in crop fields	139 (92.67)	136 (90.67)	275 (91.67)	109 (72.67)	110 (73.33)	219 (73.00)	494 (82.33)
Reduction in crop yields	48 (32.00)	31 (20.67)	79 (26.33)	136 (90.67)	142 (94.67)	278 (92.67)	357 (59.50)
Crop damage due to heavy and erratic rainfall	139 (92.67)	135 (90)	274 (91.33)	124 (82.67)	132 (88)	256 (85.33)	530 (88.33)
Abandonment of growing crop varieties	0 (0.00)	0 (0.00)	0 (0.00)	87 (58.00)	96 (64.00)	183 (61.00)	183 (30.5)
Change in sowing and harvesting dates/timings	0 (0.00)	0 (0.00)	0 (0.00)	150 (100.00)	150 (100.00)	300 (100.00)	300 (50.00)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis show percentages. Multiple Responses
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

In addition to increased occurrences of diseases and pests infestations, 82% of farmers (about 92% of farmers in irrigated agriculture and 73% of farmers in non irrigated agriculture) observed increased occurrences of weed in their crop fields. Farmers in both study areas have reported the emergence of thorny weeds, blue flower weed, and white

flower weed (congress booty in their local language) in their crop fields which according to them were not there before. They further stated that to manage these weeds, they have to apply herbicides which increases their cost of production. The weeds compete with the crops for water, sunlight, nutrients, and space and thus bring a reduction in both quantity and quality of crop yields and thus incurs losses to farm households.

About 59% of all farmers reported a reduction in crop yield due to climate change in recent years. Those reporting reductions in crop yields were comparatively more in non-irrigated agriculture as compared to their counterparts in irrigated agriculture. 88.33% of all farmers comprising about 91% of farmers in irrigated agriculture and 85% of them in non-irrigated agriculture reported crop damage due to heavy and erratic rainfall during recent years. The most pronounced incident of crop damage reported was that occurred due to 2014 heavy and erratic monsoons rain which led to unprecedented flooding in the state with many devastating effects on agriculture, lives, livestock, and infrastructure in the state.

Climate change is also reported to have affected cropping patterns in non-irrigated agriculture. While none of the farmers in irrigated agriculture reported having abandoned cultivating any crop variety due to climate change, 61% of farmers in non-irrigated agriculture indicated that they have abandoned cultivating some crop varieties like horse gram (locally known as kulth), black gram (maa ki daal), black-eyed peas, cowpeas (moth) due to changing rainfall pattern.

The farmers also reported that climate change has changed the previously known calendar of sowing and harvesting altogether. While none of the farmers in irrigated agriculture reported changing sowing and/or harvesting dates/timings due to climate-induced changes in rainfall pattern, all farmers in non-irrigated agriculture revealed that sowing timings are changing according to change in rainfall pattern. One of the participants of the focus group discussion narrated "*earlier, the period of planting and harvesting was well known, but now the sowing is shifting according to rainfall pattern. When rains start late, the planting process delays which means a shorter growing period. Due to delayed planting, crops failed to mature or produce fewer yields and thus inflict losses. The late harvesting delays cultivation of subsequent crop*". Changing planting dates were not reported in irrigated agriculture because the farmers there have irrigation facilities that allow them timely sowing and harvesting.

Climate change impacts livestock production by affecting the quantity and quality of feed, fodder, and pasture for livestock (Chauhan & Ghosh, 2014). In addition to crop farming, climate change is also reported to have adversely affected livestock rearing in the study area. Table 7 reveals the distribution of farmers according to perceived impacts of climate change on livestock rearing.

Table 7. Percent of farmers experiencing different impacts of climate change on livestock rearing (multiple responses)

Perceived impacts	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
Shortage of fodder for livestock	67 (44.67)	39 (26.00)	106 (35.33)	132 (88.00)	126 (84)	258 (86)	364 (60.67)
Reduction in milk yield due to heat stress	103 (68.67)	116 (77.33)	219 (73.00)	118 (78.67)	126 (84.00)	244 (81.33)	463 (77.17)
Increased incidences of diseases among animals	95 (63.33)	99 (66)	194 (64.67)	100 (66.67)	107 (71.33)	207 (69)	401 (66.83)
Reduction in animal reproduction	49 (32.67)	45 (30.00)	94 (31.33)	44 (29.33)	38 (25.33)	82 (27.33)	176 (29.33)
Reduced livestock number	52 (34.67)	32 (21.33)	84 (28.00)	66 (44.00)	41 (27.33)	107 (35.67)	191 (31.83)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis show percentages. Multiple responses
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

About 61% of all farmers reported that they generally experienced a shortage of fodder for livestock during rabi season. The farmers further stated that reduced rainfall coupled with increased temperature causes stress to fodder

crops and thus reduces yield and contributes to fodder shortage for livestock. More than one-third of farmers in irrigated agriculture against 86% of farmers in non-irrigated agriculture reported that they generally experience fodder shortage during the periods of a poor harvest of food and fodder crops. The proportion of both marginal and small farmers indicating a shortage of fodder for livestock was more in non-irrigated agriculture. This is in consonance with Chauhan and Ghosh (2014), Downing et al. (2017) who in their respective studies revealed that increased temperature and decreased rainfall reduce pasture for grazing and also reduce the yield of both food and fodder crop thereby trigger fodder shortage especially in dryland areas. It is worth mentioning that in irrigated agriculture, about two-thirds of all farmers reported that they grow fodder (berseen) due to which they do not encounter fodder shortage for livestock.

An increase in temperature causes heat stress in livestock which results in reduced growth and decreased productivity. Nearly 77% of all farmers with 73% of farmers in irrigated agriculture and 81% of farmers in non-irrigated agriculture reported a reduction in milk yield during dry and hot periods. This confirms the studies of Chauhan and Ghosh (2014), Kebede (2016), Prathap et al. (2017) that due to heat stress, feed intake in animals decreases which ultimately leads to a reduction in the production of milk and its composition in dairy animals during dry periods.

About two-thirds of farmers reported that due to climate change incidences of disease (like hemorrhagic septicemia known as gal-ghotu in local language and foot and mouth diseases) in livestock have increased during the last couple of decades. This aligns with Chauhan and Ghosh (2014), Downing et al. (2017) studies that climate change accelerates the growth and survival of pathogens, parasites, and viruses and thus increase outbreak of severe diseases or even introduce new diseases among animals. In addition to increased incidences of disease outbreaks in animals, heat stress due to increased temperature is changing reproductive behavior and fertility among animals (Thakur & Karki, 2018). Nearly 29% of all farmers were in agreement that due to increased heat stress, reproduction and fertility among livestock have been reduced. The adverse impacts of climate change on livestock production and health were making livestock rearing difficult and unprofitable and were forcing rural communities to reduce their livestock number. About 36% of all farmers reported that they had reduced the number of livestock as a response to the adverse impact of climate change on livestock production and health. The reported impacts of climate change on crop farming and livestock rearing are in agreement with the study conducted by Aniah et al. (2016) which state that climate change through changes in rainfall pattern and increased incidences of pests and diseases has adversely affected crop farming and through shortage of fodder/pasture and increased animal diseases have disrupted livestock rearing by small farmers in Upper East Region of Ghana.

4.4 *Socio-economic implications of the impact of climate change on livelihoods*

Adverse impacts of climate change on livelihoods have massive socio-economic impacts on farm households that mostly depend on agriculture for survival. When crop and animal yield decreases it results in increased food insecurity and indebtedness, reduced income and savings, and increased sufferings of poor farmers and thus adversely affect the social and economic status of farm households.

4.4.1 *Food security*

Food security is one of the major issues linked with climate change. Food security is defined as the situation which exists "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meet their dietary needs and food preferences for an active and healthy life". Climate change impacts food security in multifaceted ways. It affects adversely crops, livestock, forests aquaculture leading to severe social and economic problems in the form of decreased incomes, corroded livelihoods, and adverse health impacts (Chakrabarty, 2016). The study findings revealed that decreased crop yield and crop loss due to extreme weather events like droughts, untimely, heavy, and erratic rainfall have also led to food insecurity among marginal farmers in both study areas. Although all farmers in both study areas reported a drop in food reserves in the year of bad or reduced harvest, food shortage following extreme weather events causing crop loss was reported by only one-third of all marginal farmers with comparatively more (about 41%) of them in non-irrigated agriculture (see Figure 2). Small farmers in both study areas seemed to be more food secure as none of the small farmers in both irrigated and non-irrigated agriculture reported food shortages due to climate change.

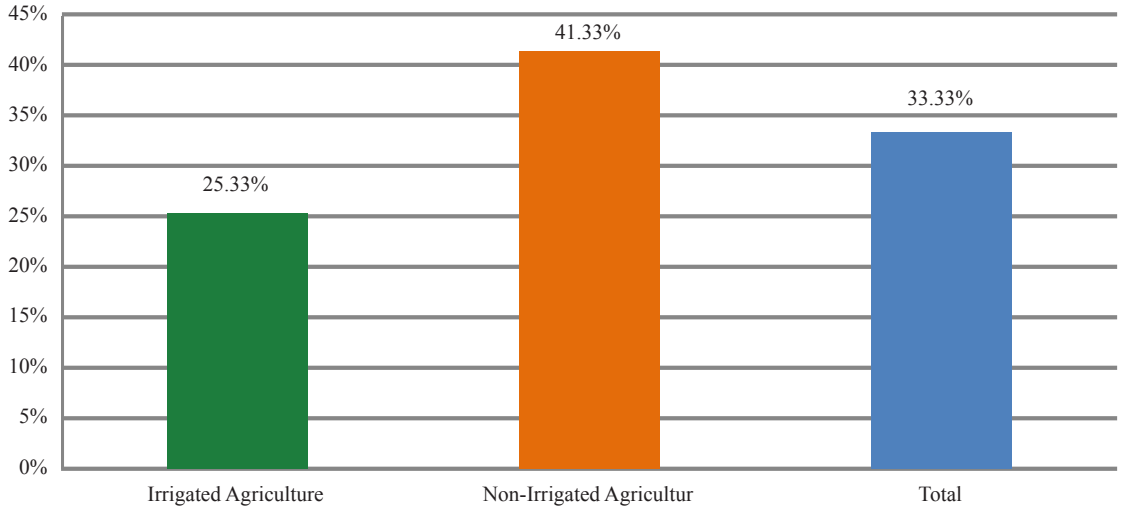

Figure 2. Marginal farmers reporting food shortage

4.4.2 *Impact of climate change on income, savings, indebtedness and expenditure*

Table 8. Percent of farmers reporting impact of climate change on income, savings, and household borrowing

Responses	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
				Decrease in farm income			
Yes	125 (83.33)	134 (89.33)	259 (86.33)	141 (94)	145 (96.67)	286 (95.33)	545 (90.83)
No	25 (16.67)	16 (10.67)	41 (13.67)	9 (6.00)	5 (3.33)	14 (4.67)	55 (9.16)
				Decrease in household savings			
Yes	139 (92.67)	150 (100.00)	289 (96.33)	127 (84.67)	141 (94.00)	268 (89.33)	557 (92.83)
No	11 (7.33)	0 (0.00)	11 (3.67)	23 (15.33)	9 (6.00)	32 (10.67)	43 (7.17)
				Increased borrowing			
Yes	59 (39.33)	47 (31.33)	106 (35.33)	72 (48.00)	49 (32.67)	121 (40.33)	227 (37.83)
No	91 (60.67)	103 (68.67)	194 (64.67)	78 (52.00)	101 (67.33)	179 (59.67)	373 (62.17)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis show percentages
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

Table 8 reveals the percent of farmers reporting a decrease in income and savings and increased indebtedness due to climate change. The adverse impacts of climate change on crop and livestock yield directly eventuate in decreased farm income. A significantly large proportion of all farmers representing more than 90% reported decreases in farm income following crop loss and/or decreased yield and livestock yield. The percent of farmers experiencing income reduction was pronounced by more marginal and small farmers in non-irrigated agriculture as compared to their counterparts in irrigated agriculture. Climate-induced changes in agricultural yield and income also affect household savings. About 92% of all farmers with 96% in irrigated agriculture and 89% in non-irrigated agriculture were in agreement that

climate change-induced loss of crop yield and subsequent loss of income has led to a decrease in household savings. Those who were in disagreement with a decrease in household savings due to climate change mentioned that they could not generally save anything as they could hardly make both ends meet even during normal period. For them, climate change was leading to increased borrowing for meeting even bare necessities of life. A decrease in savings has serious repercussions for climate change adaptation as low savings implies insufficient funds available for investing in adaptation practices which in turn reduce the ability of farm households to withstand climate shocks and survive in new situations created by climate change.

Climate change not only decreases household savings but also pushes households into indebtedness. When the farm income of households decreases, farmers are forced to borrow money to maintain their basic consumption and to make other unavoidable expenses. Table 8 shows that about 37% of all farmers indicated borrowing money and buying things on credit to maintain consumption and meet other expenses of sudden nature during the period following bad harvest. The proportion of both marginal and small farmers in non-irrigated agriculture reporting borrowing following the disaster was more as compared to their counterparts in irrigated agriculture. Besides, impacting household income, savings, and indebtedness, climate change is reported to have impacted household expenditure on food, clothing, children's education, and health. Table 9 summarizes the impact of climate change on household expenditure.

Table 9. Percent of farmers reporting impact of climate change on household expenditure (multiple responses)

Parameters	Irrigated agriculture			Non-Irrigated agriculture			Total
	MF	SF	ST	MF	SF	ST	
Increase in expenditure on staple food	54 (36.00)	18 (12.00)	72 (24.00)	90 (60.00)	48 (32.00)	138 (46.00)	210 (35.00)
Decrease in expenditure on cloth	52 (34.67)	68 (45.33)	120 (40.00)	61 (40.67)	79 (52.67)	140 (46.67)	260 (43.33)
Decrease in Expenditure on children education	48 (32.00)	66 (44.00)	114 (38.00)	44 (29.33)	58 (38.67)	102 (34.00)	216 (36.00)
Increase in Expenditure on health problems	101 (67.33)	99 (66.00)	200 (66.67)	96 (64.00)	99 (66.00)	195 (65.00)	395 (65.83)
Total	150 (100.00)	150 (100.00)	300 (100.00)	150 (100.00)	150 (100.00)	300 (100.00)	600 (100.00)

Source: Field Survey, 2019
Note: Figures in the parenthesis show percentages. Multiple Responses
MF: Marginal Farmers; SF: Small Farmers; ST: Sub Total

The negative impact of climate change on crop and livestock yield not only lead to decreased farm income but also increases household expenditure on staple food as due to bad harvest farmers have to buy even basic staple food for consumption which otherwise they get from their fields which eventuate in increased expenditure on food consumption. In this study, more than one-third of all farmers reported an increase in expenditure on food due to climate-induced decreases in crop yield and crop loss. Increased food expenditure was more pronounced by both types of farmers in non irrigated agriculture and also among marginal farmers in both study areas. In addition, the decrease in milk yield during dry periods also adds to expenditure as they have to buy milk and milk products from markets to sustain their household consumption. Besides, increasing household expenditure on food, climate change also influence dietary preferences and related expenditure of farm household. In this study, all farmers unanimously revealed that loss of agricultural income due to climate change reduces expenditure on dietary products like fruits, vegetables, meat, cheese, and other superior food articles during hard times as their main concern shifts from dietary consumption to survival.

As far as expenditure on clothing is concerned, about 43% of all farmers reported a decrease in expenditure on cloths as a result of decreased agricultural income. The proportion of farmers reporting a decrease in expenditure on cloths was more in non-irrigated agriculture as compared to their counterparts in irrigated agriculture. Loss of income also influences the education of children of poor households. More than one-third of all farmers agreed that they generally decrease and many times delay expenditure on books, uniforms, etc. as a result of loss of agricultural income.

The farmers further illustrated that during the hard times, it becomes very difficult for them to pay school fees and tuition fees due to which they have to pull children from tuition which adversely affects children's education.

The negative impacts of climate change on health increase the medical expenditure of the household. As is revealed by table 9, two-third of farmers were in agreement that due to climate change household expenditure on health issues also increases due to adverse impacts of climate change on health. The percent of farmers who believed that they were spending more on health issues induced by climate change was slightly more in irrigated agriculture.

5. Conclusion and policy implications

Crop farming and livestock rearing as a livelihood strategy are being severely affected by climate change in both irrigated and non-irrigated agriculture in terms of decreased crop and animal yield and increased crop damage. Climate change through changes in rainfall and temperature patterns and increased incidences of crop diseases, pest/insect attacks, and weed infestation has reduced agricultural productivity in the study area. Besides, increased incidences of heavy and erratic rainfall have caused crop damage. Climate change has not only reduced agricultural productivity but it also has impacted cropping pattern as farmers reported to have abandoned cultivating some crop varieties due to decreased rainfall. Livestock rearing was also reported to have been disrupted by climate change-induced shortage of fodder for livestock and increased incidences of diseases among animals which resulted in reduced milk productivity. The adverse impacts of climate change on livelihoods have resulted in social and economic hardships in the form of food shortage, reduced farm income, reduced savings, and increased indebtedness, increased expenditure on staple food and health problems leading to increased cost of living. The study, however, found that while climate change was negatively impacting agricultural-based livelihoods in both irrigated and non-irrigated agriculture, the negative impacts were experienced by comparatively more marginal and small farmers in non-irrigated agriculture than in irrigated agriculture. Furthermore, in both irrigated and non-irrigated agriculture, marginal farmers suffered the most in terms of food shortage and indebtedness than small farmers. The study further noted finer variations in terms of socio-economic impacts of climate change from household to household. While many farmers reported food shortage, inability to pay school fees, and increased indebtedness, many farmers did not indicate any adverse impact on their social and economic wellbeing which can be attributed to their involvement in diverse livelihood strategies with increased income security and their relative dependence on climate-sensitive agricultural-based livelihoods.

The study draws following policy implications for policymakers and governments interested in enhancing the resilience of marginal and small farmers' livelihood to climate change. Marginal and small farmers should be encouraged and supported to grow climate-resilient varieties including drought, heat, pests, and disease-resistant crop varieties that can survive in changed climatic conditions. For this government should create more research capacity to enhance the development and supply of hybrid seeds at subsidized rates to help them to increase their agricultural productivity. Information access, knowledge, and training are well documented in the literature to enhance the adaptive capacity of farm households to meet the challenges created by climate change. Agriculture extension plays an important role in creating awareness, sharing knowledge, and imparting training to farmers to change their farming practices in response to climate change. The study, therefore, suggests strengthening extension services in the study area to provide knowledge, information, and technical support to marginal and small farmers for enhancing their resilience to climate change. Farmers in the study area follow conventional cropping patterns like producing wheat maize and rice and do not produce cash crops. The practice of monoculture runs a high risk of yield and income loss due to climate change. Farm households should, therefore, be supported to adopt crop diversification choosing both food and cash crops to increase agricultural yield and income. The farmers should be encouraged to practice crop rotation, intercropping patterns, crop portfolio, and crop substitution to enhance their agricultural productivity and income in the face of climate change.

Efforts should be made to improve the animal health service delivery system with improved knowledge and technique to prevent and timely treatment of climate change-induced disease outbreaks among animals. Livestock holders should be informed and encouraged to timely vaccinate their livestock to avoid disease outbreaks. They should be educated to keep their livestock and their shelter clean to avoid vector-borne diseases, to keep them cool in summer and warm in winter to avoid heat and cold stress. Marginal and small farmers should be encouraged and supported to diversify their cropping patterns by growing fodder crops or practice agroforestry with fodder trees and shrubs to avoid fodder scarcity during lean periods. They should be taught on feed management to improve livestock production such as

altering feeding time and changing diet composition by including agroforestry species or legumes in livestock diet.

Irrigated agriculture is less vulnerable and more resilient to climate change than non-irrigated agriculture which points towards the importance of irrigation in the successful and effective adaptation in the changed climatic conditions. Therefore, the study suggests the development of small irrigation schemes wherever possible in non-irrigated agriculture to help farmers to adapt to climate change. Micro-irrigation schemes like drip irrigation and sprinkle irrigation schemes should be developed and promoted for optimal and efficient use of surface and groundwater for irrigation. However, the adverse impact of climate change on the availability and accessibility of water necessitates water conservation and water management techniques for sustainable use of water for irrigation. The rainwater harvesting technique should be promoted in non-irrigated areas by building artificial ponds and surface structures to capture and store rainwater for irrigation in dry periods. Marginal and small farmers should be encouraged to avail crop insurance for safeguarding them from loss arising from damaged crops due to excessive and erratic rainfall.

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