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# Farmer's perception and adaptation strategies to changing climate in Kashmir Himalayas, India

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**Abstract** Climate change and variability has far reaching impacts on agriculture particularly in ecologically sensitive areas like the Himalayas. The present study attempts to understand the farmer's perception and adaptation strategies to changing climate in Lidder watershed of Kashmir Himalayas, India. Based on a cross-sectional database of 266 farm operating families, the study adopts a bottom-up approach to investigate farmer's perceptions of changes in climatic variables as well as various farm-level adaptation measures, determinants and barriers at the farm-household level. The results show that the majority of farmers have developed a perception of climate change and have engaged themselves in adaptive behaviour with regard to agricultural land use and planning. A weighted average index used to measure the most relevant adaptation strategies revealed that conversion of agricultural land to horticulture, improving irrigational facilities and water harvesting were the main adaptation methods implemented by farmers in the study area. Utilizing the logit regression model, the study confirmed that household characteristics such as land holding size, age of the farmer, years of schooling, farm experience and labour force highly influence household decisions to adapt to climate change. The study calls for policy intervention at the farm-household level to enhance the adaptive capacity of farmers in the region.

**Keywords** Climate change · Perception · Adaptation strategies · Kashmir Himalayas · Policy interventions

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## Introduction

Adaptation to climate change is typically characterized as an adjustment in ecological, economic and social systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities (IPCC 2001). Adaptation to climate change is often linked with a thought process and is initially driven by the perception that climate is changing (Maddison 2006; Koech et al. 2020). Adaptation options may include crop diversification, mixed cropping, using different crop varieties, adjusting crop calendar, growing high-value crops, introducing drought-resistant varieties and high yield water sensitive crops (Bradshaw et el. 2004; Adger et al. 2003; Loe et al. 2001; Orindi and Eriksen 2005). However, the perception of climate change is multi-faceted in nature and varies on individual, community, and region basis (Spence et al. 2011).

As such adaptation aims to increase the capacity of a system to survive external shocks and subsequently implementing and transforming such capacity building measures into actions using existing social norms and processes (Reilly and Schimmelpfenning 1999). Climate change adaptation is a complex procedure and one size doesn't fit all phenomenon; since adaptation strategies and farmer responses vary across regions (Berry et al. 2006) based on agro-ecological contexts, socio-economic factors (Adger et al. 2009), climatic impacts, and existing infrastructure and capacity. The identification of drivers and impediments is thus necessary for following adaptation strategies to assist communities and policymakers in devising targeted adaptation strategies (Howden et al. 2007).

Adaptation occurs both at micro and macro scales. The former includes the analysis of tactical decisions undertaken by a farmer at the farm level. Such tactical decisions are mainly driven by socio-economic and demographic factors like household characteristics, household resource endowments and access to climatic awareness and local agricultural information. The latter one i.e. macro level is concerned with the decision making process about the agricultural production at the regional and national level and its affinity with domestic and international policy taking into account long term variations in climatic conditions, market and other factors operating at global scale (Kandlinkar and Risbey 2000; Bradshaw et al. 2004).

In the present study, an attempt is made to analyse micro-level analysis of self-reported adaptations by farmers at the farm level to find the best possible ways to improve agricultural efficiency under climate change. Based on the review of existing literature, there has been hardly any study focussing on perceptions of climatic change and farm level adaptation options and its determinants in the context of Kashmir Himalayas. The Lidder valley in the Kashmir Himalayas was purposively selected because the region is highly agriculture dependent and at the same time one of the most vulnerable to climate change and variability in the upper Indus basin (Shafiq et al. 2018 and Negi et al. 2012). The region has witnessed extreme weather events since the early 1990's inflicting far-reaching impacts on marginal farmers because of their inability to adapt to changes in climatic conditions (Negi et al. 2012, 2017; Ahmadi and Azizzadeh. 2020). The present study, therefore, will respond to paucity of empirical gaps of knowledge addressing mainly two-fold purpose: (1) investigate farmer's perception, adaptation and constraints to climate change adaptation in the Lidder watershed (2) Investigate household characteristics that influence farmers' adaptive decisions to avert climate change.

## Literature review

The ever-increasing emissions of greenhouse gases from various sources has led to catastrophic climate changes including the well pronounced 'global warming'. Serge Planton et al. gives an overview of the expected change of climate extremes during this century due to greenhouse gases and aerosol anthropogenic emissions like decreasing number of days of frost, increasing growing season length, trends for drought duration and change of wind-related extremes (Serge et al. 2008). The global climate change data provided by the IPCC from the first version of the Canadian Global Coupled Model (CGCMI), GIS based EPIC is run by Guoxin Tan and Ryosuke Shibasaki, for scenarios of future climate in the year of 2010, 2020, 2030, 2040 and 2050 to predict the effects of global warming on main crop yields and the results showed that the global warming will be harmful for most of the countries and an efficient adaptation to alternative climates tends to reduce the damages (Guoxin and Shibasaki 2003). The change in climate is likely to have a profound effect on hydrological cycle viz. precipitation, evapotranspiration and soil moisture, evapotranspiration (ET) being the major component of hydrological cycle will affect crop water requirement and future planning and management of water resources (Ramana et al. 2012).

There is unanimity of opinion that agriculture is vulnerable to climate change and adaptation strategies are needed in minimizing adverse climatic implications (Smit and Menabb 1997; Rosenzweig et al. 2013; Adger et al. 2003; Kandlinkar and Risbey 2000; Toros et al. 2019; Islam et al. 2020). As such the need of the hour is to adapt to a changing climate and adjust various practices to offset the fallout on the agricultural sector. In this context understanding farmer's perceptions, beliefs, and concerns about climate change are extremely important for the development of appropriate policies and communication strategies

(Abid et al. 2015; Nhemachena and Hassan 2007; Islam et al. 2020).

Adaptation refers to the regulating strategies employed under actual or expected climatic stimulation (Pan and Zheng 2010); their objective being to mitigate climate change impacts and promote adaptive capacity. Effective implementation of adaptive measures could reduce regional vulnerability and simultaneously create potential growth opportunities. Interest in adaptation developed relatively recently compared to mitigation, and as a result, research into adaptation is still in the early stages and often inadequate, especially in developing countries (Zhao et al. 2018).

Failure to implement successful adaptation options to ensure better agricultural performances at the micro-level may be attributed to many constraints confronted by farmers to varying degrees in one way or other. This includes poor infrastructural conditions, resource limitation, lack of market access, farmer's level of education, lack of access to extension services, information limitation on climate change, adaptive options and production cycles and other limiting demographic characteristics (Jawahar and Msangi 2006; Kandlinkar and Risbey 2000; Jones 2003; Archer et al. 2005; Hassan and Omran 2017). Several studies (Nicholls and Leatherman 1995; Mendelsohn et al. 1996; Rosenzweig and Parry 1994; Bradshaw et al. 2004; Nhemachena and Hassan 2007; Kurukulasuriya and Mendelsohn 2006; Mendelsohn and Dinar 2003; Downing 1993) have demonstrated the significance of adaptation measures in substantially decreasing the adverse impacts of changing climate and taking benefits of opportunities arising out of changing climate.

The basic premise regarding adaptation is to protect initially those parts of the agricultural sector and communities which have the least ability to cope (Wreford et al. 2001). As such understanding, local perception and adaptation behaviour are extremely vital to assist policy measures (Asrat 2018) that help to address the challenge of sustainable agriculture development in the face of variable environments (Adger et al. 2003; Simane et al. 2016; Kandlinkar and Risbey 2000).

## Study area

The Lidder watershed is part of the upper Jhelum river system and occupies the south-eastern part of Kashmir valley. It has an area of around 1235 km$^2$ (Fig. 1). It forms part of Middle Himalayas and is bounded by Pir Panjal range in the south and south-east, north Kashmir range in the northeast and Zanskar mountains in the southwest. The study area reveals a diverse topography carved by glacial and fluvial processes, comprising of mountains valleys to flat terrain. The mean annual rainfall ranges between 850 and 1030 mm in the study area (Shafiq et al. 2019). The Lidder valley has a varied climate resembling close to Mediterranean type, i.e., Koppen Cool dry summer (Csb) although moist monsoon incursions at times cross Pir Panjals and cause ample precipitation. Being a side valley, the study area possesses different climatic and agricultural settings compared with other physiographic divisions such as Karewa's and Jhelum floor. Agriculture is the mainstay of the economy, considerably dominated by paddy and apple cultivation. Owing to its fragility and mountainous character, the study area is among the most vulnerable agro-climatic zones in the Kashmir valley and as such climate change and variability possess a challenge to the adaptive capacity of small landholders. According to census of India, 2011 study area has a total population of around 11 lakh souls. Majority of the population in the study area thrives on informal sector of agriculture with subsistence farming and rice being the staple food of population. A lot of transformation has taken place particularly during last three decades where majority of the area has witnessed huge land use changes from agriculture to built-up and horticulture. A small section of people are also involved in tourism activities, services sector among other economic sectors.

## Materials and methods

### Materials

The present study describes farmer's perceptions of climate changes as well as various self-reported farm-level adaptation measures, determinants and barriers to adaptation at the farm household level. The study is based upon the primary data generated using

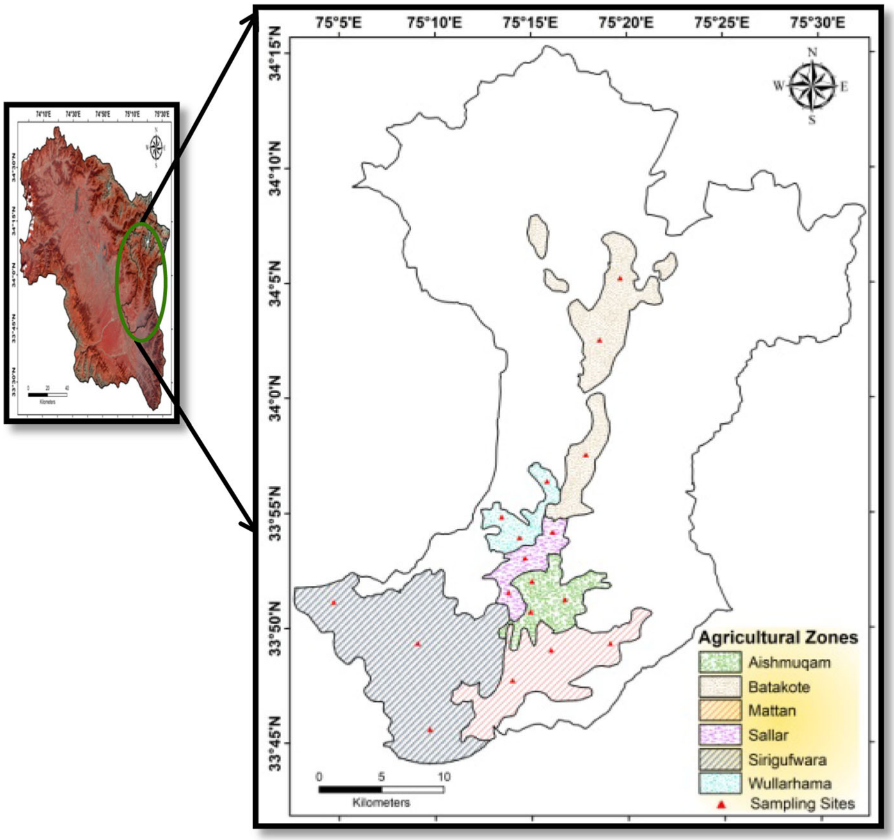



**Fig. 1** Location map of the study area showing sampling villages in Lidder valley of Kashmir Himalayas

Questionnaire as the basic research instrument along with interview method. The study area was divided into six agricultural zones where cross sectional data was obtained from the farm operating families using household as the basic unit to collect the data. Each agricultural zone consists of at least one thousand farm operating families. A Cronbach's alpha was used to measure the reliability of various constructs used in the questionnaire. A total of 266 farmers were selected representing over 1% farm operating household families in the region.

## Methods

### Descriptive statistics

The data collected using questionnaire from 266 farmers of Lidder valley were used to measure the perception and adaptation strategies to changing climate. Descriptive statistics and econometric models based on binary logit regression model were used to analyse the data using several statistical software's. Descriptive statistics were used to analyse farmer's perceptions of climate change and variability, and rank the array of adaptation options available at farm household level on the 5-point Likert scale (Fagariba et al. 2018). Farmers' perception and adaptation options were ranked by computing Weighted Average Index (WAI) of the respondents' variables using the following formula:

$$\frac{\sum fiwi}{\sum fi}$$

where $f$ = frequency of response; $w$ = weight of each score; and $i$ = score (For example, 1—no importance, 2—low importance, 3—moderate importance, 4—high significance and 5—very high significance).

### Henry Garret ranking method

The Henry Garrett ranking method (Garret and Woods 1971) was used to measure the degree to which specific problems are confronted by farmers in the undertaking of adaptation strategies. To find the most significant problem, the farmers were asked to assign the rank for all the given problems and the outcomes of such ranking process were converted into scores using percent position in the Garrett table. Then for each individual problem, the scores were added and subsequently the severity of each problem was calculated on the basis of the overall summative score. The formula used to obtain Garrett scores is:

$$Percent\ position = 100\frac{(Rij - 0.5)}{Ni}$$

where Rij = Rank given for the ith variable by jth respondents. Ni = Number of variable ranked by jth respondents.

### Linear probability model

The present study further helps in the identification of household characteristics and other socioeconomic factors affecting adaptation options available to farmers. An attempt was made to examine the relationships between adaptation options and a common set of explanatory variables. In the determination of the best econometric model for the analysis, Linear Probability Models (LPM), Probit models, and Logit models were considered for the study. Since LPM results can exceed probabilities beyond the realm of the Bernoulli distribution (that is that results lie beyond and between 0 and 1) thus, LPMs are least preferred when other statistical applications such as Probit and Logit regression model are available (Studenmund 2006). Both Logit and Probit models are closely similar in their structure and their results, depending on a "link" function using cumulative distribution functions (CDFs) which are logistically and normally distributed, respectively (Gujarati and Porter 2009; Studenmund 2006) (Table 1).

As a matter of fact, CDFs present a sigmoid (S-shaped) distribution; it likely resembles the observed distribution of dichotomous data (Studenmund 2006). However, probit models are more or less suited for experimental data and likely fail in calculating precision robustness to adjust for covariates (Studenmund 2006). Therefore, the Linear Probability Model (LPM) and probit models were rejected in favour of a logit model formulation. Hence, a binary logit regression model was employed to identify the socio-economic factors at the farm-household level affecting the overall farmers' adoption of adaptive options. Prior to the estimation of the Binary logit model, the explanatory variables were checked for the existence of multi-collinearity, using a correlation coefficient matrix of independent variables. Based on the results of this procedure, variables diagnosed with collinearity were omitted from the final model.

The functional form (Gujarati and Porter 2009) of the determinants affecting the probability of adaptation for the present study is:

$$\begin{aligned} ADPT = {} & \beta 0 + \beta 1FAGE + \beta 2YRSS + \beta 3FARMEXP \\ & + \beta 4LANDHDSZ + \beta 5FARMIN \\ & + \beta 6LABRFRC + \beta 7ACSSTINF + \mu i \end{aligned}$$

where ADPT = probability of adapting to climate change; FAGE = Age of the farmer; FARMEXP = farm experience; LANDHDSZ = Land holding size; YRSS = Years of schooling; FARMIN = Farm income; LABRFRC = Labour force; ACSSTINF = Access to information.

The detailed methodology used in the study is presented in Fig. 2.

## Results and discussion

### General perceptions of climate change

Do farmers perceive that changes in weather patterns are taking place in the study area? Before answering this question, it is necessary to mention a limitation to the analysis. Firstly, perceptions of changes in weather patterns do not necessarily mean that weather patterns are actually taking place or the frequency of weather events has changed. Secondly, the questions were asked using climate change narratives which increases the probability of biasness from the respondent. In addition, the questions were asked over the last three decades and it is likely that the respondent may not recall past weather experiences accurately or even may be influenced by recent weather fluctuations in the region. Nevertheless, perceptions of climate change, even if they may not always reflect reality, they are vital to understand how changes in weather patterns affect farmer's livelihoods, and how farmers respond to such events. It is a matter of fact that decisions on how to cope with and adapt to changes in weather patterns partly depend on how much farmers perceive those changes than by the actual events themselves. Thus the information on climate change perceptions becomes highly valuable.

Whether people are concerned about climate change is a basic construct often attempted to explore in repeated national and international surveys. The current survey attempted to measure this important construct by asking farmers how much worried they are (instead of how much concerned they are) about climate change and its impacts. This was done to ensure easy translation and comparability among farmers. The Fig. 3a summarises the results of the percentage of farmers indicating the seriousness of the climate change problem. About 63% of surveyed farmers in the Lidder valley reported that they are extremely worried about the climate change while around 28% indicated fairly worried (about 19%) to very worried (more than 9%). Only a small proportion of farmers reported that they are not worried at all (3%) or not very worried (5.64%). This is further supplemented by the fact that 87% of farmers have perceived climate change in the region and only a small fraction of around 13% are saying otherwise.

General perceptions of farmers about the weather conditions are summarized in the Fig. 3a, b. About 80% of farmers have reported decrease in snowfall in the studied period which is in line with the numerous empirical studies carried in the study area (Murtaza and Romshoo 2016; Shafiq et al. 2018; Dar et al. 2013). About 85% of the farmers have perceived an increase in both summer and winter temperatures and almost three-fourths of the surveyed farmers have reported an increase in the hailstorm events (Fig. 4). In the case of droughts and heat and cold spells, only half of the respondents have perceived an increase in their frequency. it is worthy to mention here that slightly more than 43% of sample farmers have reported an increase in rainfall while it is countered by around 38% farmers reporting otherwise.

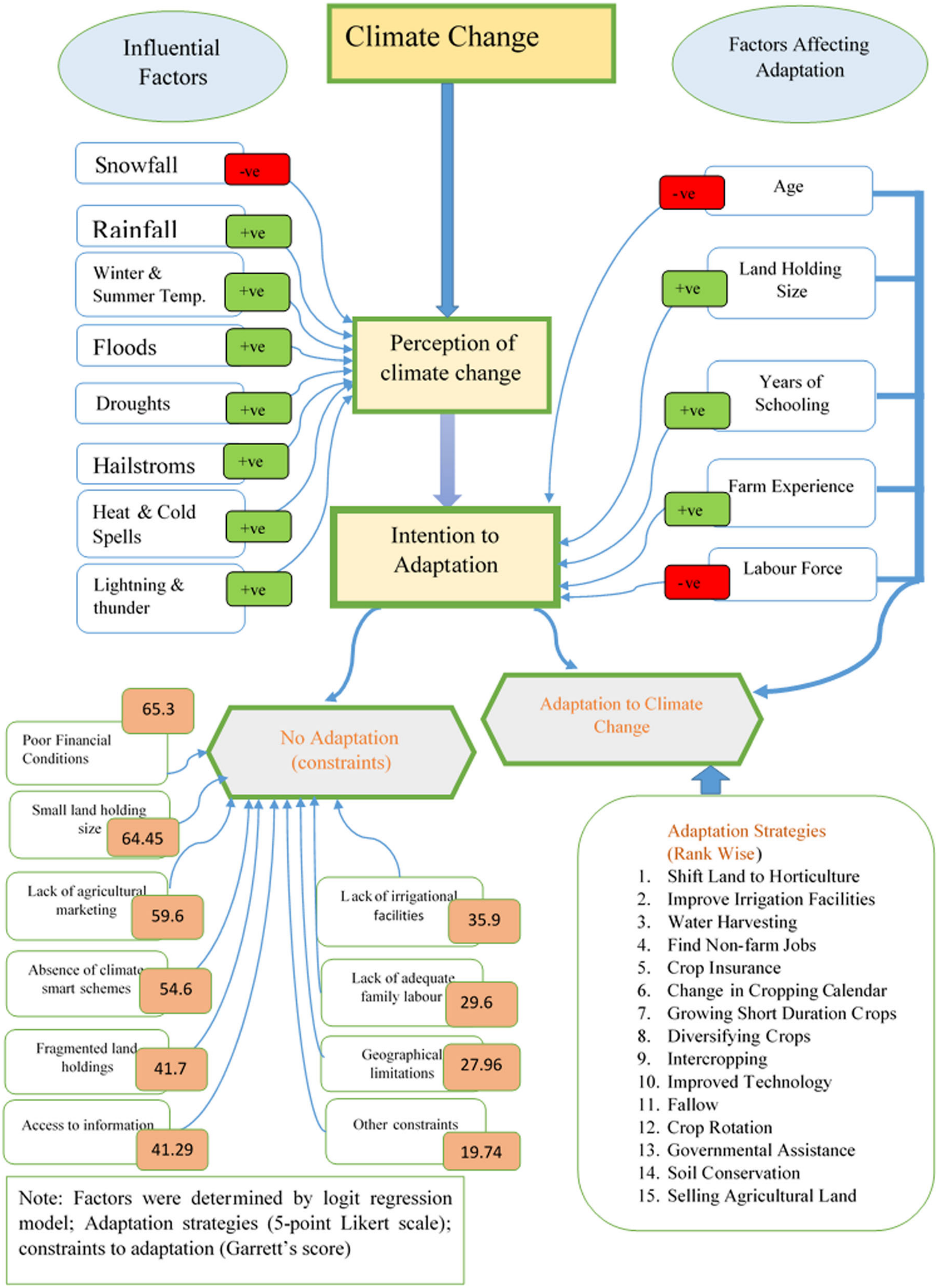
**Fig. 2** Schematic framework of farmers' perception of climate ▶ change and adaptation behaviour in the Kashmir valley, North western Himalayas

The empirical studies on precipitation have confirmed that a slight increase in precipitation has been observed in the Lidder valley (Shafiq et al. 2018). However, a few of the weather events often associated with climate change and variability such as cloud bursts, floods, lightning, and thunder are not perceived as more frequently by the majority of farmers.

It was expected that a small percentage of farmers would report these events because of their more localised nature and partly their occurrence in remote areas although it does not necessarily concur that their frequency is somewhat arguable. Some farmers also have reported that all these weather events have

**Table 1** Definition of variables used in the study area to compile information ($N$ = 266)

| Dependent variable | Mean | Standard deviation | Variable description | Expected sign[2] |
|---|---|---|---|---|
| Adaptation | 0.52 | 0.52 | Dummy takes the value of 1 if farmer has adapted and 0 if otherwise | ± |
| Explanatory variables | | | | |
| Age (years) | 42.83 | 11.079 | Continuous | ± |
| Land Holding size (Hec) | 0.45 | 0.55 | Continuous | ± |
| Farm income (rupees) | 30,000.62 | 69,040.04 | Continuous | ± |
| Farm experience (years) | 14.4333 | 12.77304 | Continuous | + |
| Access to information | 0.5000 | 0.50855 | Dummy takes the value of 1 if farmer has access to information and 0 if otherwise | ± |
| Years of schooling | 9.8000 | 6.91 | Continuous | ± |
| Labour force (number) | 1.8000 | 1.47 | Continuous | ± |


Climate Change
Influential Factors
Factors Affecting Adaptation
Snowfall -ve
Rainfall +ve
Winter & Summer Temp. +ve
Floods +ve
Droughts +ve
Hailstroms +ve
Heat & Cold Spells +ve
Lightning & thunder +ve
Perception of climate change
Intention to Adaptation
Age -ve
Land Holding Size +ve
Years of Schooling +ve
Farm Experience +ve
Labour Force -ve
No Adaptation (constraints)
Adaptation to Climate Change
Poor Financial Conditions 65.3
Small land holding size 64.45
Lack of agricultural marketing 59.6
Absence of climate smart schemes 54.6
Fragmented land holdings 41.7
Access to information 41.29
Lack of irrigational facilities 35.9
Lack of adequate family labour 29.6
Geographical limitations 27.96
Other constraints 19.74
Adaptation Strategies (Rank Wise)
1. Shift Land to Horticulture
2. Improve Irrigation Facilities
3. Water Harvesting
4. Find Non-farm Jobs
5. Crop Insurance
6. Change in Cropping Calendar
7. Growing Short Duration Crops
8. Diversifying Crops
9. Intercropping
10. Improved Technology
11. Fallow
12. Crop Rotation
13. Governmental Assistance
14. Soil Conservation
15. Selling Agricultural Land
Note: Factors were determined by logit regression model; Adaptation strategies (5-point Likert scale); constraints to adaptation (Garrett's score)

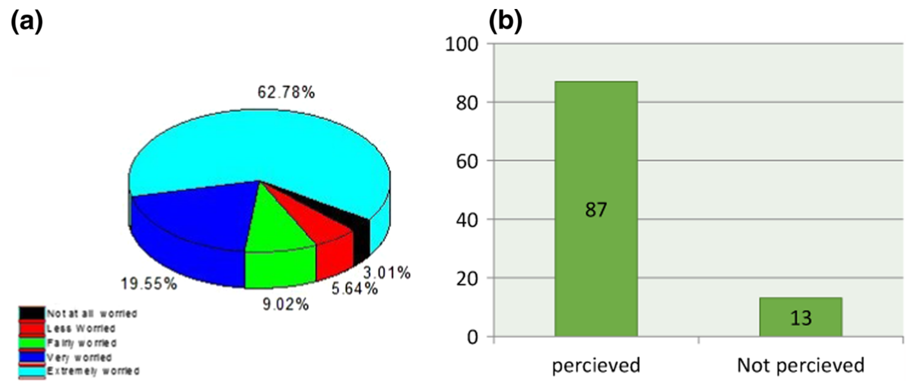



**Fig. 3** (**a**) Portion of farmers expressing concern over climate change. (**b**) Percentage of farmers percieved the climate change and its effects. ($n$ = 266)

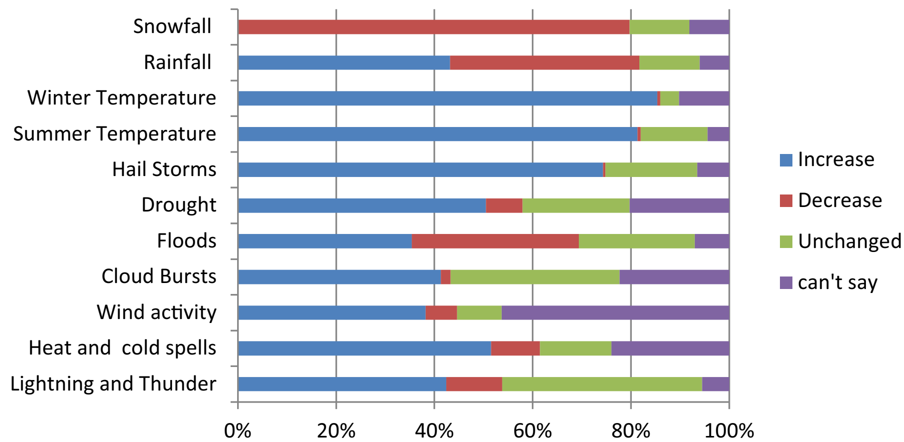



**Fig. 4** Percentage of farmers reporting changes in weather elements/events (n = 266)

remained unchanged over the last three decades but it is a case represented by a minority of respondents. The analysis clearly gives us an overall picture indicative of negative perceptions of changes in weather patterns and the climate more or less becoming drier and uncertain.

## Perceived impacts of climate change on agriculture

To assess the perceived impacts of climate change on agriculture, nine climate nuanced statements were used to which farmers were asked to show the degree of agreeness or disagreeness on a five-point Likert scale. Table 2 summarizes the results of the mean perception score (MPS) on each statement pertaining to the impacts of climate change on agriculture. The majority of farmers in the Lidder valley reported that climate change is happening and affects all aspects of farming in the Lidder valley. The most weighted perception score among the local farmers was that they are more concerned about climate change (MPS: 4.485). Thereafter, the farmers expressed their concern due to climatic factors that it is affecting their farming in one way or another (MPS 4.69).

The next problem of concern was reported that the area is experiencing frequent untimely weather events affecting crop productivity in the region (WAI). The surveyed farmers were also anxious of the serious effects of hailstorm activity on apple cultivation in the study area (WAI). However, the majority of farmers (83.78%) have reported that the horticultural crops find better economic viability than agricultural crops such as paddy under the current scenario of climate change. It is also verified indirectly by other statements related to agricultural land-use changes and also by land conversion data obtained from District Agricultural Statistics, J&K (2018).

**Table 2** Farmers' general perception of climate change effects on agriculture (N = 266)

| Statement | Strongly agree(5) | Agree (4) | Neutral (3) | Disagree (2) | Strongly Disagree(1) | WAI |
|---|---|---|---|---|---|---|
| Farmers in Kashmir valley are concerned about the climate change. | 200 | 40 | 1 | 15 | 10 | 4.48 |
| Climate change has increased the frequency of untimely rainfalls and other weather events such as hailstorms, lightning, thunder and cloud bursts affecting crop production in the region. | 173 | 49 | 19 | 7 | 18 | 4.32 |
| Climate change has affected farming in one way or other. | 171 | 53 | 21 | 11 | 10 | 4.37 |
| Hailstorm activity has intensified in the region seriously affecting apple cultivation. | 169 | 49 | 22 | 13 | 13 | 4.3 |
| The productivity of paddy in Kashmir catchment has witnessed a declining trend because of changing climatic variables. | 85 | 61 | 70 | 24 | 26 | 2.89 |
| The land-use response to the occurrence of persistent drier regime in the Kashmir valley is reflected in the shift of agricultural practices to horticulture. | 152 | 81 | 7 | 10 | 4 | 4.24 |
| In the light of changing climatic conditions, horticulture crops find more economically viability than agricultural crops. | 174 | 55 | 2 | 18 | 17 | 4.32 |
| The climatic variability has posed a threat to the availability of water resources in the region | 71 | 138 | 11 | 28 | 18 | 3.81 |

## Farmer's climate change adaptation strategies

Conversion of agricultural land to horticulture has been ranked as the topmost adaptation strategy by the surveyed farmers in the Lidder valley. The changing climate provided farmers an opportunity for the development of horticultural crops since the climate became somewhat drier with untimely rainfall events, which is ideal for crops such as apple. In other words, climate change proved to be a blessing in disguise for the horticulture sector because of its high economic returns and can be safely identified as climate change cum profit land use change driver in the area. Improving irrigational facilities was ranked the second adaptation strategy in the region since it decreases the risk factor associated with crop failure by not allowing sensitive stages of growth period to exceed under harsh climatic conditions.

The next most adaptation strategy as per WAI is assigned to water harvesting techniques since the region has witnessed a drastic decrease in snowfall in the studied period (Table 3). Farmers adapt crop management practices that include water harvesting techniques to ensure that this additional water could be used to modify or lengthen the growing seas. However, this measure should be accompanied by other good cop management practices such as crops that require less amount of water.

The farm financial management strategies that have been highly preferred in the region such as finding non-farm jobs and crop insurance can be considered as an attempt to diversify and stabilize household income by switching to less weather sensitive options. It may be pointed out that the adaptation strategies that come under technological development and innovation were moderately prioritized (Table 3). This includes crop-related strategies such as changing cropping calendar, growing short duration crops, crop diversification, intercropping, improved technology and so on. A number of studies (Bryan et al. 2009, 2013; Deressa et al. 2009; Mideksa 2010) have revealed the relevance of these adaptation strategies where the land holding size tends to be small.

## Constraints impeding climate change adaptation

The perusal of Table 4 summarises the severity perception of each problem identified by surveyed farmers which can hinder the adoption of adaptation strategies to climate change. Survey respondents were asked to assign a rank for each problem confronting in the region. Since ten items were given to farmers thus the highest rank of 1 was given to the most severe

**Table 3** Weighted Average Score and Index of sampled households in Kashmir Valley (N = 266)

| Adaptation strategies | Aggregate Weighted Score (AWS) | Weighted Average Index (WAI) | Rank |
|---|---|---|---|
| Shift Land To Horticulture | 894 | 3.361 | 1 |
| Water Harvesting | 788 | 2.890 | 3 |
| Diversify Crops | 553 | 2.079 | 8 |
| Intercropping | 483 | 1.816 | 9 |
| Government Assistance | 511 | 1.921 | 13 |
| Growing Short Duration Crops | 645 | 2.425 | 7 |
| Improve Irrigation Facilities | 797 | 2.996 | 2 |
| Find Non-Farm Jobs | 746 | 2.805 | 4 |
| Crop Rotation | 428 | 1.609 | 12 |
| Crop Insurance | 725 | 2.726 | 5 |
| Change in Cropping Calendar | 715 | 2.687 | 6 |
| Improved Technology | 455 | 1.711 | 10 |
| Fallow | 437 | 1.643 | 11 |
| Soil Conservation Measures | 372 | 1.398 | 14 |
| Selling Agricultural Land | 262 | 0.985 | 15 |

Cronbach's Alpha 0.801

problem perceived and the lowest of 10 was assigned to least one perceived. For all the items the Cronbach's, s alpha of 0.735 was obtained using SPSS 16 which is well within the threshold value of acceptance (0.70). Although deleting of items such as geographical limitations and access to information would have further increased the consistency to 0.81 for the construct but they were still considered because of their significant roles in constraining adaptation strategies.

Poor financial status associated with farmers in the Lidder valley happens to be the most perceived problem confronting adaptation measures. Failure of implementing adaptation strategies has quite often been blamed on low farm income levels (Archer et al. 2005). with poor financial conditions, farmers are not able to afford transaction costs needed to acquire adaptation measures which are at times available for combating any environmental and social compulsions. The poor financial conditions of farmers in the study area were more than expected on account of small land holding size which tends to be around 0.44 ha/household as per official records of 2018 for the district. Further 87.5% of farmers in the study area belong to marginal land holding category and fragmented land holdings add more severity to the adaptation process.

**Table 4** Constraints impeding climate change adaptation

| Problems | Garrett score | Mean Garrett score | Rank |
|---|---|---|---|
| Poor financial position of a farmer | 17,376 | 65.32 | 1 |
| Small Land holding size | 17,144 | 64.45 | 2 |
| Fragmented land holdings | 11,108 | 41.76 | 5 |
| Lack of irrigational facilities | 9573 | 35.99 | 7 |
| Access to information | 10,983 | 41.29 | 6 |
| Lack of agricultural marketing | 15,870 | 59.66 | 3 |
| Geographical limitations | 7438 | 27.96 | 9 |
| Lack of adequate family labour | 7885 | 29.64 | 8 |
| Lack of climate smart schemes | 14,529 | 54.62 | 4 |
| other constraints | 5250 | 19.74 | 10 |

Cronbach's Alpha 0.735

Lack of agricultural marketing also hinders adaptation options in the study area. The significance of agricultural marketing can be understood from the fact that not only it facilitates number of adaptation options but also acts as an adaptive measure itself. Farmers with better access have more chances to implement adaptation measures because it allows farmers to acquire the necessary inputs needed for farming operations such as different seed varieties, fertilizers, and irrigation technologies and at the same time provide them with positive incentives to produce cash crops that can boost their resource base. Lack of climate-smart schemes was another problem impeding adaptation strategies in the region. Since implementing such schemes can't be ensured individually, this reflects the absence of policy intervention which should have been there to ensure climate resilient agriculture.

Access to information was perceived as the sixth-ranked constraining hindrance in the way of adaptation measures followed by lack of irrigational facilities, non-availability of labour, geographical limitations and other socio-economic constraints. Similarly, improving irrigational facilities reduce the risk of crop failure and disease. Despite having the well-interconnected network of canals, the study area still has around 43% of its area under irrigation and most of the horticulture is rain-fed (District Agricultural Statistics 2018).

## Econometric analysis of factors affecting farmer's adaptation measures to climate change effects

Before the data analysis, a multi-collinearity diagnostic test for all the independent factors was carried out using statistical software SPSS 16. However, collinearity test was confined to the development of the correlation matrix of independent variables and thus certain factors were omitted from the econometric model on account of strong correlation existing between them. The variance inflation factor and condition index were not considered for the study.

The binary logit regression results are presented in Table 5. The model was statistically significant ($p < 0.05$) the model explained 84.7% of the variance in farmers' decisions to adapt to climate change effects and correctly predicted 93.2% of decisions. Out of the total respondents, around 52% of farmers are going for some adaptation measures in their farmlands. There are various adaptation strategies available in the literature. These strategies are region specific and depend highly on the socio-economic and demographic characteristics of people. Using a binary logit regression model, we have analysed the probability of above-mentioned variables in the determination of adaptation behaviour.

The findings of the model indicate that age is negative and significantly (at 1%) related to farmers' adaptation strategies to climate change effects.in other words, the probability of a farmer in the study area adapting to climate change decreases with age. This finding is consistent with Uddin et al. (2014) and Solomon et al. (2014). It can be predicted that the older farmers are less innovative and do not see a necessity to adapt to any environmental and socio-economic compulsions. However, there appears to be no agreement in the available adaptation literature on the effects of age. The effect of age is more or less location or technology specific and thus expected results of age are an empirical question (Adesina and Forson 1995).

The logit estimates for land holding size is positive (at 1% level) and results specifically show that with the increase in land holding size the likelihood of adaptation increases considerably in the study area. The larger the farm, the more farmers opted for coping strategies like crop diversification, shifting land to horticultural practices, crop rotation, opting high-value crops and so on. Given that the average land holding size for the study area is 0.44 ha, classifying farmers into different categories of landholders is a relative one. Nevertheless, on average larger farms require less economic costs that are incurred during the execution of farming activities (Table 6).

The results for farm experience are positive and logit estimates for the same indicate that it significantly affects the choice of a farmer to adapt in response to the effects of climate change. Farming experience is expected to bring more competence in weather forecasting and as such, it increases the likelihood of a farmer to practice more adaptive strategies to climate change. The experienced farmers are usually leaders in rural communities and can easily be targeted in promoting adaptation management to those farmers who lack such experience and are yet to adapt to changing climatic variables. Making local successful farmers as entry points, more farmers will be persuaded to make use of adaption options available in the region.

**Table 5** Correlation matrix between independent variables diagnosing multi-collinearity

| Variables | Age | Land holding size | Farm income | Family size | Number of operational landholdings | Farm experience | Access to information | Years of schooling | Contact with extension service agents | Labour force |
|---|---|---|---|---|---|---|---|---|---|---|
| Age | 1.000 | | | | | | | | | |
| Land Holding size | 0.062 | 1.000 | | | | | | | | |
| Farm income | 0.094 | 0.803** | 1.000 | | | | | | | |
| Family size | 0.012 | 0.192 | 0.333* | 1.000 | | | | | | |
| Number of operational landholdings | 0.045 | 0.808** | 0.559** | − 0.092 | 1.000 | | | | | |
| Farm experience | 0.418** | 0.388* | 0.293 | −0.093 | 0.429* | 1.000 | | | | |
| Access to information | −0.358* | 0.051 | 0.025 | 0.362* | −0.055 | −0.040 | 1.000 | | | |
| Years of schooling | −0.458* | 0.062 | −0.173 | 0.432* | 0.153 | −0.036* | 0.491* | 1.000 | | |
| Contact with extension service agents | −0.027 | 0.577** | 0.280 | 0.612** | 0.536** | 0.389* | 0.401* | 0.474* | 1.000 | |
| Labour force | −0.008 | 0.441* | 0.438* | 0.682** | 0.475* | 0.192 | 0.092 | 0.118 | 0.471* | 1.000 |

Years of schooling is positive and significantly (at 10%) related to the dependent variable. The positive sign for this factor was already perceived and the logic being that educated farmers have more knowledge and a better understanding of the future scenario and, overall, a better ability to respond to any anticipated changes. The results of our model for years of schooling variable are consistent with the finding of several studies (Kolleh and Jones 2018; Abid et al. 2015; Tamesegen et al. 2008).

The unexpected results were observed for family income, labour force and access to information. Farm income which was initially expected to encourage adaptation options proved to have the least role and was confirmed by an insignificant $p$ value of 0.152. Given our negative results for family income, the possible explanation may be that members of the farm operating families might have lost interest in agricultural activities and prefer to invest in off-farm activities instead which are less weather sensitive and involve insignificant risk factor. The other explanation may be that the effects of family income will be better visualized under larger sample sizes. The same justification may be forwarded in case of access to information and labour force for which model estimates were either unexpected or statistically insignificant.

## Conclusion and Policy intervention

Climate change is emerging as an environmental concern posing serious threats to a small-scale farming community in the Lidder valley, Kashmir Himalayas. The present study is a preliminary effort to explore farmer's perception and adaptation behaviour related to climate change and variability at the farm-household level. The study reveals that majority of farmers have perceived a change in climatic variables (around 87%) over the last three decades and in response diversity of autonomous adaptation measures have been implemented by them to avert climate change effects. As such perceptions of climate change and variability act as a principal driver of land-use change in agricultural areas. More than 63% of the respondents were extremely worried about the changes in the climate. The ranking of adaptation variables highlighted the significance of various agronomic options used by farmers at the farm level. This includes shift

**Table 6** The logit estimates of independent variables affecting farmers' adaptation strategies to climate change effects (n = 266)

| Independent factors | Coefficient (B) | S.E | p value |
|---|---|---|---|
| Age | −0.225*** | 0.046 | 0.00004 |
| Land Holding size | 0.595*** | 0.109 | 0.000489 |
| Access to information | 0.144 | 0.588 | 0.806 |
| Family income | 0.000007 | 0.00 | 0.152 |
| Labour force | −0.434* | 0.228 | 0.057 |
| Years of schooling | 0.086* | 0.044 | 0.051 |
| Farm experience | 0.082* | 0.032 | 0.010 |
| Constant | 4.475*** | 1.648 | 0.007 |

Pseudo $R^2$ 0.847 (Nagelkerke)

*, **, and ***imply 10%, 5% and 1% levels of significance respectively

farming practices, water harvesting, crop diversification, intercropping, changing plant varieties, opting short duration crops and so on. The Garrett method revealed that most of the constraints to adaptation faced by farmers are location-specific. The logit model results revealed that household characteristics such as the age of the farmer, farming size, farming experience, years of schooling and labour force are the significant determinants influencing farmers' decision and his ability to adapt climate change. Another significant research outcome of this study is that the questionnaire results of temperature and precipitation variability nearly corroborates with the empirical findings indicating the validity of farmer perceptions.

The study provides interesting yet initial observations and at the same time demonstrates verifiability. However, being a first preliminary venture to understand farmer's perception and behaviour, the study was limited to a small geographical region. As such an attempt to draw generalizations from our results should be taken very carefully. Nevertheless, the results obtained at farm operating families provide both inertia and novelty for further research and possibly at large representative samples. An interesting subject of this further research is to extend the present methodology and analysis outside the study area to include more impacts of climate change and variability.

In line with the findings of this study, there is an urgent need for addressing local-specific constraints that impede farm-level adaptation. Since the government is the major stakeholder of the agricultural sector, it must eliminate constraints through crop development, credit availability, facilitate extension services, disseminate agronomic and climatic knowledge, improve weather forecasting, and enhance maximum farmer participation in decision-making process. The important policy message from this study is that policies at different institutional levels need to transform and reorient agricultural systems into a more resilient one to ensure sustaining agricultural productivity under changing climate. This requires identification of optimal interventions so that context-appropriate solutions are made at different levels (local to global). Addressing and prioritizing the most vulnerable groups such as small farmers should be the heart of government strategies to facilitate climate change adaptation and is a proven effective strategy than stand-alone solutions.

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