Concerned or not? Investigating determinants of climate change concerns among Saudi Arabian farmers and their adaptation behavior

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Concerned or not? Investigating determinants of climate change concerns among Saudi farmers and their adaptation behavior

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Abstract

Concern for a particular stimulus constitutes a major driver to mitigate its negative effects. This study was undertaken to know the level of concern for climate change among Saudi farmers in Jazan province and to evaluate the role of various socioeconomic indicators in relation to their concern level. Moreover, an account of farmers' beliefs about climate change and capacity building initiatives needed to address this issue at the community level is also presented. Field level data collected through a face-to-face survey using a structured questionnaire were utilized to draw insights. The ordered logit model was used to find out the determinants for the level of concern for climate change among respondent farmers regarding three top concern categories. Farmers ranked insect infestation, higher incidence of crop diseases, and drought as the first, second and third, respectively, as top climate change concerns in the study area. Results of the ordered logit model showed that higher farmer income significantly reduces their level of concern for the first two categories of concern while it has a positive influence on concern for drought. Access to credit and information has a mixed impact on the farmers' concern level. Farmer's age, education, perceived source of climate change, and perceived changes in temperature and rainfall have a mixed impact on the top three climate change-related concerns. The findings support the provision of timely warning, capacity building of the farmers and personnel, credit provision, improvement of rural infrastructure, and creating awareness among farmers to address particular climate change-related concerns.

Keywords: climate change, concern, indicator, Saudi Arabia; adaptation.

1. Introduction

Climate change is a serious global issue with implications for every domain of human life (IPCC 2018, UNESCO 2020, WMO 2019). The evidence suggests that global warming and a change in precipitation patterns will be experienced as a result of ongoing change in the climate. It is expected that the global average temperatures may rise by 1.4—5.8 °C by the end of 2100 (DeNicola et al. 2015). Shifts in seasonal water availability throughout the year are likely to be induced across different regions (IPCC 2014). It is also predicted that the frequency and intensity of extreme weather events like drought and flooding will also increase (Asadieh & Krakauer 2017, Hirabayashi et al. 2013).

Such predicted impacts due to climate change threaten global agricultural systems and food security on a fundamental level (Sillmann & Roeckner 2008, UNESCO 2020, Zhang et al. 2017). The extent and productivity of both rain-fed and irrigated agriculture will be affected. A greater proportion of the population will experience the potential negative impacts of the climate change, and in many regions, there will be a decrease in crop productivity (Du et al. 2015, Gosling &Arnell 2016, Mancosu et al. 2015). Projections suggest that at a temperature increase of 2°C, around 540–590 million people will be undernourished (WHO 2018). Some regions of the world could lose up to 6% of their national Gross Domestic Product (GDP) due to climate-induced water scarcity (FAO 2018). The regions that are already vulnerable to food insecurity and rural poverty will be the most adversely affected (Vermeulen et al. 2012).

Saudi Arabia is one of the largest countries with an arid climate (Al Zawad &Aksakal 2010, DeNicola et al. 2015). In some areas, temperatures can rise above 50 °C (DeNicola et al. 2015). A study estimated that there was a 1.9 °C increase in average temperature over the last 50 years in the Kingdom (Haque & Khan 2020). The rate of increase was higher (0.72 °C per decade) in the dry season as compared to the wet season (0.51 °C per decade) (Almazroui et al. 2012). Several studies predict that the average temperature in the Kingdom can further elevate 2 to 4 °C by the end of 2100 as a result of climate change (Chowdhury &Al-Zahrani 2013, Gosling et al. 2011, Williams et al. 2012).

Rainfall in Saudi Arabia is extremely limited. Across the country, the long-term average precipitation is about 100 mm per annum. In the south of the country, it falls below 100 mm while in the north, it varies between 100 to 200 mm per annum. In the western part, however, rainfall can even rise up to 500 mm annually (DeNicola et al. 2015). A significant change in rainfall has not been observed over the last 50 years (Haque & Khan 2020). However, future rainfall projections suggest a decrease in rainfall in many parts of the Kingdom (Gosling et al. 2011, Tarawneh & Chowdhury 2018). Intense and frequent precipitation events in Saudi Arabia are rare (Almazroui et al. 2017). Kingdom lacks recurrent rivers and permanent water bodies. The United Nations have classified countries of the Gulf Cooperation Council (GCC) as water-scarce nations (Samad & Bruno 2013). According to Water Resources Institute, 14 out of 33 countries that are most likely to be water-stressed nations in 2040 would be in the Middle East, and Saudi Arabia is ranked at 9th position (Luo et al. 2015).

Due to its arid climate, the Kingdom is highly vulnerable to the negative impacts of climate change. A 3to 5 °C increase in temperature would have dire consequences for the agriculture and other sectors of the economy (Al Zawad & Aksakal 2010, Allbed et al. 2017). Due to climate change, significant impacts on agriculture have been reported by a number of studies (Alam et al. 2011, Alkolibi 2002, Allbed et al. 2017). It has been estimated that crop irrigation water requirements would increase by 602 and 3,122 million cubic meters at increases of 1 and 5 °C, respectively (Zatari 2011). To maintain the current levels of crop production, global warming could increase agricultural water demand by about 5to 15% (Chowdhury & Al-Zahrani 2013). Lack of water may result in significant yield losses as about 90% of agriculture in the Kingdom is irrigated (MEWA 2017). The agriculture sector has the largest share of annual water use that is about 70% (Haque &Khan 2020). A study showed that climate suitability for date palm production in the Kingdom will be significantly reduced (Allbed et al. 2017). Another study reported that many farmers observed unusually early date palm blooming in 2010 (Darfaoui &Assiri 2009). Moreover, global warming will particularly affect the diurnal desert animals by reshaping their population and distribution in the desert (Williams et al. 2012).

Climate change severely affects crop production owing to its sensitivity to variations in precipitation and temperature. Plant diseases and water shortage resulted in a decline in the total annual income of date palm growers in the Middle East from 1990 to 2000 (Zaid &Arias-Jimenez 2002). A reduction in food production would increase food prices at the domestic level with implications for food imports (Nelson et al. 2009). Water scarcity further increases the vulnerability of the region to the impacts of climate change (Sowers et al. 2011). A recent study indicates that reduction in crop yields ranges between 5 and 25% with a one-degree Celsius increase in temperature. The Jazan region has been already experiencing climate change manifestations in the form of land degradation in coastal areas, rising temperatures, droughts, soil erosion, altered rainfall patterns, floods, and changes in weed species and distribution (Abd El-Hamid et al. 2019). In a previous study, Jazan farmers indicated that they are very concerned about increased drought, floods, and appearance of weeds.

Saudi Arabia is one of the countries that are addressing climate change in a serious manner and putting suitable measures in place (Haque & Khan 2020). One key aspect of various climate change adaptation and mitigation approaches is that farmers and growers at the grassroots level are well aware of this global issue and are using sustainable agricultural practices to effectively address this issue. However, farmers with different socioeconomic characteristics and life experiences may conceptualize climate change issues in different ways that in turn would affect their ability to implement appropriate adaptation practices for building resilience against undesirable climatic impacts.

The present study was undertaken with the objective of identifying the major concerns of the farming community regarding climate change and exploring various determinants that affect their understanding of climate change. Additionally, an account of farmers' beliefs about climate change along with the perceived capacity-building measures/initiatives is also presented. The study findings offer insights into the adaptation behavior of the farmers in relation to different climatic concerns. The findings may also assist in the design of appropriate extension interventions to help farmers implement relevant adaptation and mitigation practices for combating climate change in Saudi Arabia.

2. Methodology

2.1 *Description of the Study Area*

Jazan Region is located in the southwest of Saudi Arabia. The area of the region is approximately around 11,671 sq.km and covers 300 km of the Southern Red Sea coast. Administratively, Jazan region consists of 16 governorates: Al-Darb, Al-Reath, Beash, Haroob, Al-Daer, Savya, Al-Idabi, Faifa, Damad, Al-Aridah, Abu Arish, Jazan, Al-Harth, Ahad- Al-Musrarihah, Samttah, and Al-Twal. The region is characterized by fertile loamy soil. Despite the region representing only 0.7% of the total area of Saudi Arabia, it is one of the richest agricultural regions and contains approximately 8% of Saudi Arabia's farms (Alotaibi et al. 2020). The majority of farmers in the region are characterized as smallholder farmers with farms averaging between 1–3 ha in size. It is considered the capital of Saudi Arabia's mango production, with annual production of around 35,000 mangos from approximately 750,000 trees. The region also produces sesame, millet, maize, okra, and tomatoes. Annually, rainfall varies from year to year, with an average of 55–150 mm; the majority of the rainfall has been observed between January and October. The temperature ranges from 31 to 35 °C in the summer, whereas in the winter range is from 25 to 28 °C (PME, 2019).

2.2 Research Design

The survey was designed to collect data from the farmers. The survey was developed and validated by a group of experts including extension agents. The data were collected using face-to face interviews, as well as by meeting the farmers at extension centers. A total of 200 farmers were invited to participate in the study; 164 completed and provided full information, resulting in an 82% response rate. Prior to data collection, the purpose of the research project was explained to all the farmers, and they were assured that the information gathered would only be used for academic purposes. Moreover, they were informed that it was not compulsory to answer all questions in the survey.

2.3. Instrument

The questionnaire covered a wide range of issues that related to climate change, including farmers' background information related to socio-economic status, beliefs, concerns, capacity building, perceived changes in rainfall patterns, and perceived changes in temperature patterns. Beliefs and concern items were adopted and modified based on the approach by Arbuckle et al. 2013, and the instrument for perceived changes in rainfall and temperature were adopted from (Habtemariam et al. 2013).

2.4 Data Analysis

Cumulative Frequency

To identify the relative importance of sources of concerns, the following formula has been employed. The cumulative score for each source of concern has been calculated and the sources have been ranked based on the cumulative score.

$$CS = C_1 x f_1 + C_2 x f_2 + C_3 x f_3 + C_4 x f_4 + C_5 x f_5 \quad (1)$$

CS = Cumulative Score

$C_{1\text{-}5}$ = Categories

$f_{1\text{-}5}$ = Frequency in respective category

Three dominant sources of concerns have been selected from the listed based on the cumulative score calculated (Eq. 1) and were treated as dependent variables in the study.

Ordered Logit Model

Ordered logit model, also known as the proportional odds model, is an estimation technique where there is an observed ordinal variable, Y. There is also an unmeasured latent variable y* with various cut points. The general form of the ordered logit model is provided as follow:

$$Y = \beta_0 + \beta iXi + ei \quad (2)$$

where

Y = Concerns related to climate change (not concerned, slightly concerned, concerned, very concerned)

β_0 = Constant

β_i = Parameters to be estimated

Xi = Observed variables (Socioeconomic factors, perceived causes of climate change, perceived impacts of climate change and access to credit)

ei = Error Term

There are four categories of responses used for the observed ordinal variables in our study: 1 = not concerned, 2 = slightly concerned, 3 = concerned, and 4 = very concerned with three cut points in each of the equation. The categorical variable Y has various threshold points; the value for the observed variable Y depends on whether one has crossed a threshold. In the present study, since there are four categories of responses (not concerned, slightly concerned, concerned and, very concerned), this yields three cut points. The probability of an individual to fall into one of the four categories is subjected to the following conditions:

Y_i = 1 (Not Concerned) if Y^*_i is $\leq K_1$

Y_i = 2 (Slightly Concerned) if $K_1 \leq Y^*_i \leq K_2$

Y_i = 3 (Concerned) if $K_2 \leq Y^*_i \leq K_3$

Y_i = 4 (Very Concerned) if $Y^* \leq K_3$

Where:

K_1 = Cut point 1

K_2 = Cut point 2

K_3 = Cut point 3

The probability of each respondent for the four categories has been calculated using the following equations:

$$P(Y=1) = \frac{1}{1+\exp\,(Zi-K1)} \tag{3}$$

$$P(Y=2) = \frac{1}{1+\exp\,(Zi-K2)} - \frac{1}{1+\exp\,(Zi-K1)} \tag{4}$$

$$P(Y=3) = \frac{1}{1+\exp\,(Zi-K3)} - \frac{1}{1+\exp\,(Zi-K2)} \tag{5}$$

$$P(Y=4) = 1 - \frac{1}{1+\exp(Zi-K3)} \tag{6}$$

The ordered logit model was estimated separately for the three dominant sources of concerns faced by the agricultural producers in the study area, which were increased insect and pest infestation, increased frequency of diseases, and increase in frequency and severity of droughts as shown in the following table on the ranking of concerns (Table 1).

Table 1. Ranking of farmers' concerns about climate change impacts

Concerns	**Cumulative Score**	**Ranking**
Increased drought	*467*	***III***
Increased flooding	461	**VI**
Increased appearance of weeds	464	**IV**
Increased insect pressure	*489*	***I***
Higher incidence of crop diseases	*473*	***II***
Increased soil erosion	443	**VIII**
Increased heat stress on crops	463	**V**
Increased saturated soils and ponded water	452	**VII**

4. Results and Discussion

This section provides the findings in light of the main objectives of the study as indicated in the introduction. The discussion revolves around the farmers' beliefs and concerns about climate along with the prioritization of perceived mitigation strategies against such stimuli among sampled respondents for countering climate change impacts. The potential role of various factors in shaping the concerns of the individuals is further highlighted through the use of the ordered logit model in order to reveal their potential impact in shaping such perceptions. The first sub-section provides the summary statistics of variables used in the study along with ranking of beliefs and perceived/implemented strategies, while the second sub-section highlights the role of these factors in shaping the concerns of the sampled respondents.

Table 2 indicates that the majority of the sampled respondents (44.5%) were concerned regarding increased insect infestation due to climate change, followed by 29.3 percent who were very concerned regarding increased insect infestations. For increased frequency of diseases, the majority (53%) of the sampled respondents were concerned, while 29.9 percent were very concerned. Similarly, 71 sampled respondents reported concern over droughts while 54 sampled respondents were slightly concerned regarding droughts due to climate change. A general observation of the table shows that most of the respondents were either concerned or very concerned about the three mentioned sources of climate change impacts.

Half of the sampled farmers were found to have less than a high school education (50 percent) followed by farmers with a high school diploma (17.7 percent) indicating that the sampled farmers have lower educational attainments in the study area. During the surveys, farmers were asked to report the potential impacts of climate change. The majority of the farmers reported that changes in rainfall patterns and changes in temperature are the major impacts of climate change observed by them. The majority of the respondents during the surveys either agree (47.9 percent) or strongly agree (42.3 percent) with the statement that human activities are the main cause of climate change. Similarly, most of the sampled farmers (54 percent) agreed with the statement that nature itself is a cause of climate change followed by 39.3 percent respondents who strongly agreed with the same statement. This reflects that the sampled farmers consider both human activities and nature to be the potential causes of climate change. Among the sampled farmers surveyed for the study, only 23 sampled farmers have access to credit facilities while 141 farmers reported to have no access to credit facilities. The frequencies of the categorical/discrete variables are provided in the Table 2 along with their percentages.

Table 2: Frequency distribution of discrete variables of the model

Variables	Categories	Frequency	percentage
Increased Insects infestation	Not concerned	4	2.4
	Slightly Concerned	39	23.8
	Concerned	73	44.5
	Very concerned	48	29.3
Increased Frequency of Diseases	Not concerned	5	3.0
	Slightly Concerned	23	14.0
	Concerned	87	53.0
	Very concerned	49	29.9
Droughts	Not concerned	2	1.2
	Slightly Concerned	54	32.9
	Concerned	71	43.3
	Very concerned	37	22.6
Education	Less than high school	82	50.0
	High school	29	17.7
	Bachelor	25	15.2

	Graduate School	28	17.1
Perceived Changes in Rainfall Patterns	Yes	128	78
	No	36	22
Perceived Changes in Temperature	Yes	140	85.4
	No	24	14.6
Human as a cause of climate change	Strongly Disagree	6	3.7
	Disagree	1	0.6
	Neutral	10	6.1
	Agree	78	47.9
	Strongly Agree	69	42.3
Nature as a cause of climate change	Strongly Disagree	5	3.1
	Disagree	2	1.2
	Neutral	5	3.1
	Agree	88	54
	Strongly Agree	64	39.3
Access to Credit	Access	23	14.1
	No access	141	85.9

Table 3 presents the averages and standard deviations of the variables included in the ordered logit models. As evident from the Table 3, the average age reported in the study area was 47 years with a standard deviation of 9.47, while the average monthly/yearly income was found to be SAR 7894.71 with a standard deviation of 9064.89. The high standard deviation in the income of the sampled respondents reflects a high degree of variation in incomes of the farmers. The average number of contacts by the farmers with extension workers for information related to climate change was found to be 4.43 with a standard deviation of 1.79.

Table 3: Descriptive statistics of variables

Variable (unit)	**Mean**	**Standard Deviation**
Age (years)	47.10	9.47
Income (SAR[1]/year) from farming	7894.71	9064.89
Access to information (contacts with extension workers)	4.43	1.79

Ranking of beliefs about climate change and capacity-building initiatives for effective climate change adaptation: Similar to the ranking of concerns about climate change, ranking of responses was conducted regarding the farmers' beliefs about climate change as well as requisite strategies for capacity building in order to avoid/mitigate harmful effects of climate change within the region. These rankings, estimated by using equation 1, are presented in Table

[1] SAR is abbreviation for Saudi Riyal, I SAR = 0.27 USD (Approx.)

4 and Table 5. This is necessary for placing policy guidelines in perspective and to align them with farmers' perceptions about possible impacts as well as the potential adaptation options. Many researchers have noted the need for aligning policy interventions such that people are mentally-prepared and think the interventions are effective within a given scenario (Abbas et al. 2016, Kellens et al. 2011, Lindell &Hwang 2008, Seifert et al. 2013, Thieken et al. 2007). These studies point towards the introduction of initiatives that people perceive to be effective in terms of their efficacy and control. When done so within the proper context, the uptake of these strategies becomes relatively faster as ultimate beneficiaries are assured of the effectiveness and applicability.

As shown in Table 4, many farmers in the study area believe that climate change is a form of natural change. This is evident from the rankings of statements about climate change beliefs by the respondent farmers. At the first and second place are, respectively, natural changes and anthropogenic activities that cause climate changes. At the third place, the cause of climate change is reported to be the combined effect of human and natural causes. The 4th and 5th rankings show a sort of skepticism among respondents who believe that either they do not have sufficient evidence to comment on the nature of climate change or there is no climate change, with cumulative scores of 454 and 320, respectively using Equation 1.

Table 4: Ranking of Beliefs towards climate change among survey respondents of the study area.

Beliefs	Cumulative Score	Ranking
Anthropogenic activities are causing climate change.	690	II
Nature is causing climate change.	693	I
Lack of concrete evidence that climate change is happening.	454	IV
Both nature and anthropogenic activities are behind climate change.	635	III
There is no climate change.	320	V

In the similar fashion and calculated with the same equation, capacity building initiatives deemed useful or necessary for effective climate change adaptation are listed with their respective scores in Table 5. The top three strategies obtained are namely: use of information and communication technologies (ICTs) in disseminating information and awareness creation about climate change impacts and adaptation measures; capacity building and theme-specific training of the extension staff related to climate change for promoting adaptation interventions; and linking smallholder farmers with agricultural research for on-farm adaptive mechanisms for climate change under various types of farming systems. The other least-popular or least-effective strategies perceived and reported by the respondents are the use of farmers' fields schools for training farmers (10th rank), conducting awareness meetings with farmers (9th rank), and conducting demonstrations for providing innovations on climate change adaptation (8th rank). These findings do imply that the traditional methods of agricultural extension are not perceived as effective thus necessitating a paradigm shift in agricultural information transmission mechanism.

In a nutshell, the farmers perceived the most effective and desired strategies to be institution-led awareness campaigns through ICTs, and personnel training and on-farm adaptive training related to climate change. Farmers do not perceive traditional ways of awareness creation at the micro level to be effective or give them low preference, such as awareness meetings, demonstration events, or farmers' field schools.

Table 5: Ranking of capacity building initiatives necessary for effective climate change adaptation in the region

Strategy/Initiative	Cumulative Score	Ranking
Awareness meetings with the farming community.	647	**IX**
Field days for showing technology related to climate change adaptation.	668	**V**
On-farm demonstrations for enhancing farmers' skills.	661	**VIII**
Farmer-to-farmer extension approach.	677	**IV**
Farmers' training on post-harvest food management.	665	**VI**
Weather forecast alerts.	664	**VII**
Use of farmer field school extension approaches for developing farmers' problem-solving skills.	639	**X**
Building a link between smallholder farmers and agricultural research bodies.	687	**III**
Capacity building of the extension personnel.	692	**II**
Employment of ICT tools for improving the delivery of extension services and products.	694	**I**

Factors Affecting Concerns of the Farmers

The findings of the empirically estimated ordered logit model are provided in Table 6. The findings highlight the importance of various factors affecting the top concerns (insect infestation, disease prevalence, and droughts) of farmers regarding climate change. Evaluating awareness about the consequences of a particular change provides evidence of pro-environmental and altruistic attitudes along with some degree of perceived personal responsibility, which could lead to effective adoption or at least willingness to adopt avoidance mechanisms and strategies (Cooper et al. 2004, Farizo et al. 2016). This study reveals some interesting points related to the covariates of pro-environmental behavior (concerns about climate change) taking into account socioeconomic, anthropogenic, and environmental aspects either stated or observed.

Socioeconomic Attributes:

Among the socioeconomic attributes of the farmers, age positively affects the concerns of farmers regarding droughts. The relationship is positive and significant at the 5 percent probability level and the odds-ratio indicates that a one unit (one year) increase in the age raises concerns of farmers for droughts by 1.042 times (4.2 percent). The nature of the impact of this variable as well as the positive sign are in line with our a priori expectations. Such an observation is justified by many researchers who posit that increase in the age of a person would lead to enhanced awareness and concern about environmental dynamics because of his/her life experiences over time (Casaló &Escario 2018, Grothmann &Reusswig 2006, Melo et al. 2018, Peacock et al. 2005, Rungie et al. 2014). Nevertheless, literature also exists showing an contrasting nature for this variable (i.e., age) as having a negative impact on environment-related awareness/concerns (Botzen et al. 2009, Grønhøj &Thøgersen 2009, Miceli et al. 2008). Thus, our results and previous empirical findings do provide insights into the role of age of a particular individual in realizing a pertinent issue associated with unwanted consequences, particularly drought. However, age is negatively but non-significantly related with concern for insect infestations and the increased frequency of diseases in the study area.

Findings on education vis-à-vis the percieved probability of increased concern for insect infestation are somewhat surprizing yet justifiable. Education has an inverse and significant relationship with concern for increased insect infestation. The odds-ratio suggest that an increase in education of farmer from lower category of education to higher category will decrease the concerns of farmers for increased insect infestation due to climate change by 0.730 times (27 percent). This finding may imply that with increased levels of education, farmers will be more prepared and confident to monitor, to pest-scout, and to curb insect outbreaks, thus leading to effective control. In other words, farmers are not highly concerned about insects when they have more knowledge – via higher educational attainment – about how to monitor and counter insect infestation. This argument is justified on two grounds: more education helps farmers to locate any insect population in a timely manner and then taking viable and pest-specific control measures based on their information inventory either in the form of field-level knowledge, technical know-how, effective use of ICTs in agriculture, or access to field staff from pest control departments and organizations. Such outcomes for education have been evidenced by Aryal et al. 2020, Li et al. 2020, and Mahmood et al. 2020. Another aspect of this finding points towards the increased ability of educated farmers to diagnose insect attacks and subsequently and speedily plan its remedy instead of panicking or developing concerns and thereby failing to devise mitigation strategy.

In a similar vein, farmers' income plays a critical role in shaping their concerns regarding climate change impacts. The findings show that higher income of the farmers significantly reduce their concerns about increased insect infestation and increased frequency of diseases, while it signficantly increases concerns of droughts. These findings are intuitive too with varying implications. With higher incomes, farmers can use various tools for ex ante mitigation and ex post coping with the insect infestation and diseases. However, their incomes cannot, in general, help in easing their concerns of droughts, the effect of which are generally beyond their control. Such a relationship between farmers' income and pro-environmental behavior is reported by Lindell & Hwang 2008, Hirsh 2010, and Hasan et al. 2017.

As a matter of fact, increased income of households may make them well-prepared to control any insect or disease outbreaks as they can use their income to achieve timely application of pesticides and chemicals instead of developing concerns when faced with income constraint. However, as drought is beyond human control to a large extent, farmers with relatively higher incomes will be more concerned about drought compared with those having lower incomes. This is understandable because the high-income farmers may have relatively large cropped areas at risk of destruction due to drought leading to a larger quantity of loss expected. Such a perception of higher farm losses in the wake of incessant drought may increase their concerns. The ultimate mitigation options towards drought might include some limited options adopted at the farm level such as sowing of drought-resistant varieties, water conservation through the construction of mini dams, among other techniques (Alauddin & Sarker 2014, Ali & Erenstein 2017, Daramola et al. 2016).

Table 6: Parameter estimates of the Ordered Logit Model

Variables	**Increased Insects Infestation**		**Increased Frequency of Diseases**		**Droughts**	
	Co-efficient	**Odds-ratio**	**Co-efficient**	**Odds-ratio**	**Co-efficient**	**Odds-ratio**
			Socioeconomic Attributes			
Age	-0.011 (0.019)	0.988	-0.020 (0.019)	0.979	0.041** (0.019)	1.042
Education	-0.313** ((0.154)	0.730	0.181 (0.159)	1.199	0.235 (0.156)	1.265
Income	-0.00005** (0.00002)	0.999	-0.00003* (0.00002)	0.999	0.00004** (0.00001)	0.999
			Perceived Changes in Climatic Parameters			

Changes in Rainfall Patterns	1.725*** (0.473)	1.778	0.904** (0.454)	1.405	0.021 (0.449)	1.019
Changes in Temperature	0.732 (0.688)	2.080	1.306* (0.735)	3.691	1.675** (0.682)	5.339
Perceived Causes of Climate Change						
Human	0.537** (0.247)	1.711	0.679*** (0.260)	1.974	0.249 (0.234)	1.283
Nature	0.145 (0.252)	1.156	0.303 (0.260)	1.354	-0.136 (0.240)	0.872
Access to Credit and Information						
Credit Access	1.534*** (0.561)	4.638	1.570*** (0.558)	4.808	2.395*** (0.573)	10.968
Access to information	-0.022* (0.013)	0.878	-0.038** (0.018)	0.862	-0.119 (0.172)	0.943
Cut 1	-4.223 (1.530)		0.058 (1.583)		-1.896 (1.653)	
Cut 2	-1.392 (1.471)		2.470 (1.576)		2.370 (1.475)	
Cut 3	1.001 (1.463)		5.449 (1.619)		4.697 (1.517)	
Log likelihood	-163.321		-149.189		-159.155	
LR chi2 (12)	42.95*** (0.000)		47.95*** (0.000)		40.89*** (0.000)	
Pseudo R^2	0.116		0.138		0.114	

Note: figures in parenthesis are standard errors. *, **, and *** represent significance at 10%, 5% and 1% probability levels, respectively.

Changes of Climatic Parameters

The perceived changes in the climatic parameters particularly changes in rainfall patterns have a signficant impact on the concerns of farmers particularly related to insect infestation and disease frequency. In particular, perceived changes in rainfall patterns signficantly affect the concerns of farmers regarding increased insect infestation and increased frequency of diseases. Farmers with higher perceived changes in rainfall patterns have more concerns over incidence of insect infestation (77.8 percent higher concern as compared to farmers with lower perceived changes in rainfall patterns) and diseases (40.5 percent higher concerns over farmers with lower perceived changes in rainfall patterns). For perceived changes in temperature, the concerns for increased frequency of diseases and droughts are signficantly higher. Farmers with higher levels of perceived changes in temperature tend to have higher concerns for increased frequency of diseases (3.69 times higher concerns compared to farmers with lower levels of perceived changes in temperature) and droughts (5.339 times higher concerns compared to farmers with lower levels of perceived changes in temperature). In addition, higher levels of perceived changes in rainfall do not show a significant impact on the level of concern linked with drought. Similarly, higher levels of perceived changes in temperature show a non-significant but positive association with increased insect infestation.

However, there is a convincing evidence of the imapct of increased rainfall in perceving higher level of concern for insect infestation as well as disease attack among farmers of the study area. This is because increased moisture content and humidity is thought to have a positive linkage with increased level of insect infestation as well as incidence and severity of diseases (add a citation here) leading to increased concern level among farmers. Likewise, decline in rainfall will reduce the number of insects as well as disease severity by reducing moisture content in the air, thus putting a downward pressure on farmers' concerns about insects related to climate change. Regarding perceived changes in temperature, an upward shift in temperature exerts a significantly positive effect on farmers' concerns related to climate change in the form of increased concern about disease severity and droughts. Increasing temperatures will evidently increase evaporation of water sources along with scarce rainfall, and therefore could lead to higher incidence and severity of droughts (Dai 2013, Ding et al. 2011, Spinoni et al. 2014). However, increased temperatures having positive influence on disease severity can be subjected to further research.

Perceived Causes of Climate Change

The findings reflect that among the perceived causes of climate change, human causes are reported to be significant in increasing farmers' concerns for higher rates of insect infestation and plant diseases. Farmers perceiving humans as the cause of climate change are more concerned for increased insect infestation (1.71 times more than farmers perceiving humans as not being the cause of climate change). Similarly, farmers who perceive humans as a cause of climate change have 1.97 times higher concerns over increased frequency of diseases compared to farmers perceiving otherwise. The perception of farmers about nature as primarily causing climate change is found to be less prominent and non-significant as well as the cause of concerns related to the top three concern categories.

Access to Farm Credit and Information

For the variable of access to farm credit, the results are surprising although having theoretical validity. The credit beneficiaries were expected *a priori* to be more secure and thus less-concerned because of the availability of financial support forinstalling climate mitigation facilities, tools, and infrastructure. However, our findings suggest that farmers with access to credit facilities have more concerns for all three types of selected (major) concern sources. This result implies that increased use of and/or access to farm credit by the farmers would increase their concerns for insect infestation, disease severity and drought amidst climate change. The finding is intuitive, however, and should be subject to academic and empirical falsification by future research. Nevertheless, we posit it as one of the policy factors indirectly influencing farmers' attitude towards risk. There is economic reasoning that could explain this outcome as well because firms (here farmers) relying on external funds would be more cautious and vigilant towards any risk of external shock(s) threatening the sustainability of their enterprise as well as their repaying capacity. Thus, farmers relying on or using farm finance would be much more concerned if they perceive any abrupt change(s) in climate-related phenomena. Therefore, one can argue for the mediating role of credit availability and utilization in the farm business in promoting climate vigilance through increased concern levels (Daramola et al. 2016). One of the research implications of this finding is to test the role of farm credit in promoting pro-environmental behavior and/or perceived impacts of climate change among credit beneficiaries. On the other hand, policy implication of this finding lies in the linking of farm-credit with climate change adaptation packages. The findings of the estimated ordered logit model revealed that farmers with access to credit facilities have 4.638, 4.808 and 10.968 times higher concerns for increased insect infestation, increased frequency of crop diseases and droughts, respectively, compared to farmers with no access to credit facilities.

Access to information has greatly affected the concerns of farmers about climate change globally (Adesina et al. 2000, Adger et al. 2003, Gaillard & Mercer 2013, Mercer et al. 2010, Pour et al. 2018) and in the study area. As evident from the results, an increased frequency of contact with extension workers for climate related information significantly reduces farmers' concerns for increased insects infestation and increased frequency of diseases. Based on the odds-ratios, an additional contact with extension workers for information on climate change reduces the concerns of the farmers for increased insects infestation 0.878 times (12.2 percent), while it reduces the concerns of farmers for increased frequency of diseases 0.862 times (13.8 percent). However, the parameter on access to information in case of droughts is expected a proiri to have a negative sign though being non-significant. This finding implies that farmers finding themselves less effective to mitigate the onset would not be much bothered if they already had knowledge of incidence of drought. However, when they get information about the former two categories of concern (i.e., insect infestation and disease attack), their concern leveldecreases significantly. This outcome is expected as providing such information would lead them towards proper and timely action to curb insect infestation and disease severity while in case of drought, such information would not be much effective as the onset and impact of drought can hardly be avoided at farm level.

Concluding Remarks

The present study attempted to identify different concerns of the farming community regarding climate change impacts and explored various factors that influence these concerns. The findings revealed that a vast majority of the farmers believed that climate change is happening and major factors behind this global change are both anthropogenic activities as well as natural processes. The majority of the farmers expressed their concerns for increased insect infestations and increased frequency of crop diseases as a consequence of climate change. Although farmers were also concerned about drought, but they were relatively less concerned about it as compared to insect infestations and crop diseases. The results of ordered logit models showed a significant relationship among various variables. Age and income level had a significant positive relationship with farmers' concern regarding drought. Farmers' education and income level had a significant negative relationship with their concern regarding insect infestations. Income level also showed a significant negative relationship with farmer's concerns regarding increased frequency of diseases. Farmers who had access to credit facilities expressed high concern regarding all three climate change impacts. Similarly, farmers who perceived that climate change is happening due to anthropogenic activities were more concerned about increased insect infestations and increased frequency of diseases. On the other hand, farmers' access to information related to climate change significantly reduced their concerns for increased insect infestations and increased frequency of diseases. Higher perceived changes in rainfall were shown to significantly increase farmers' concerns regarding insect infestations and increased frequency of diseases whereas higher perceived changes in temperature significantly increased farmers' concerns regarding increased frequency of diseases and drought.

Three major capacity-building initiatives that were considered effective for developing and enhancing climate change adaptation were: use of ICT tools for creating awareness among farmers regarding climate change issues and relevant adaptation practices; capacity development of the extension personnel to enhance their knowledge; and linking of the smallholder farmers to agricultural research bodies for developing on-farm climate adaptation solutions. Findings suggest that the government should design and implement extension programs, particularly for the smallholder farmers with low educational background for developing climate change awareness and adaptability. We also suggest that credit opportunities for such farmers should also be ensured. Moreover, the government should also emphasize capacity building of the extension staff in terms of their ability to understand and offer appropriate solutions related to sustainable climate change adaptation and mitigation practices. The findings also provided important insights to inform policy discourse and enrich academic discussion on climate change concerns and their associated perceived risks.

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