Climate Change Concerns of Saudi Arabian Farmers

Subjects: Area Studies

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Climate change is a serious threat to the sustainability of global agriculture and food supply that necessitates taking appropriate action for building resilient food production systems and preserving rural economies. In this regard, farmers' beliefs and concerns about the effects of climate change on agriculture may influence their adoption of adaptation and mitigation practices to address this emerging issue.

climate change concern indicator Saudi Arabia adaptation

1. Introduction

Climate change is a serious global issue with implications in every domain of human life [1][2][3]. 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 [4]. Shifts in seasonal water availability throughout the year are likely to aggravate different regions [5]. It is also predicted that the frequency and intensity of extreme weather events like drought and flooding will also increase given weaker coping capacity and poor adaptation planning particularly in developing countries [6][7].

Many studies have predicted a range of harmful impacts due to climate change that potentially threaten global agricultural systems and food security on a fundamental level [3][8][9]. The extent and productivity of both rain-fed and irrigated agriculture will be affected. A greater proportion of the population is projected to experience the potential negative impacts of the climate change and, in many regions, there will be a decrease in crop productivity [10][11][12]. Projections suggest that at a temperature increase of 2 °C, around 540–590 million people will become undernourished [13]. Some regions of the world could lose up to 6% of their national Gross Domestic Product (GDP) due to climate-induced water scarcity [14]. The regions that are already vulnerable to food insecurity and rural poverty will be the most-adversely affected [15].

Saudi Arabia is one of the largest countries with an arid climate [4][16]. Within this country's area, temperatures can rise above 50 °C due to climatic changes [4] that have already taken their effect. A study estimated that there was a 1.9 °C increase in average temperature over the last 50 years in the Kingdom [17]. 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) [18]. 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 [19][20][21].

Rainfall in Saudi Arabia is extremely limited. Across the country, the long-term average precipitation is about 100 mm per annum. In the southern part of the country, rainfall goes 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 [4]. A significant change in rainfall has not been observed over the last 50 years [17]. However, future rainfall projections suggest a decrease in rainfall in many parts of the Kingdom [21][22]. However, it is worth-mentioning that intense and frequent precipitation events in Saudi Arabia are rare [23]. The Kingdom lacks recurrent rivers and permanent water bodies. The United Nations have classified countries of the Gulf Cooperation Council (GCC) as water-scarce nations [24]. According to Water Resources Institute, 14 out of 33 countries that are most likely to be water-stressed in 2040 are located in the Middle East, where Saudi Arabia is ranked at 9th position [25].

Due to its arid climate, the Kingdom is highly vulnerable to the negative impacts of climate change. A 3 to 5 °C increase in temperature would have dire consequences for the agriculture and other sectors of the economy [16][26]. Due to climate change, significant impacts on agriculture have been reported by a number of studies [26][27][28]. It has been estimated that crops' irrigation water requirements would increase by 602 and 3122 million cubic meters at temperature increases of 1 and 5 °C, respectively [29]. This is in conformity to a study which reports that maintaining the current levels of crop production, global warming may lead to increase in agricultural water demand by about 5to 15% [20]. Lack of water may result in significant yield losses as about 90% of agriculture in the Kingdom is irrigated [30]. The agriculture sector has the largest share of annual water use that is about 70% [17]. A study showed that climate suitability for date palm production in the Kingdom will be significantly reduced [26]. Another study reported that many farmers observed unusually early date palm blooming in 2010 [31]. Moreover, global warming will particularly affect the diurnal desert animals by reshaping their population and distribution in the desert [19].

Climate change severely affects crop production owing to its sensitivity to variations in precipitation and temperature. Plant diseases and water shortage have resulted in a decline in the total annual income of date palm growers in the Middle East from 1990 to 2000 [32]. A reduction in food production would increase food prices at the domestic level with implications for food imports [33]. Water scarcity further increases the vulnerability of the region to the fast-happening climatic changes [34]. 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 the coastal areas, rising temperatures, droughts, soil erosion, altered rainfall patterns, floods, and changes in weed species, and their geographical distribution [35]. 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 [17]. One key aspect of various climate change adaptation 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.

2. Literature Review and Development of Research Framework

There are a range of drivers and factors that have a significant bearing on the farmers' concerns for climate change with different dynamics leading to adaptation concerns [36]. The concerns for climate change among people are thought to emanate from the risk attached with extreme events such as, inter alia, droughts, floods, cyclones, heat waves, avalanches [33][34][37]. People form their concern level with their exposure to risk such as the events associated with climate change. In this regard, demographic, socioeconomics, geo-environmental and institutional characteristics and features possessed/faced by individuals would play a greater role in affecting their concerns for such stimuli as well as their perceived interventions to enable them effectively face and cope the vagaries of such events through person-specific or community-based approaches [38][39][40][41].

We posit such initiatives/interventions as capacity-building options deemed effective and needed to equip community members for better preparing them to mitigate and cope climate change risks. This work presents an integrated framework to portray the significance of concerns for climate change among farmers as well as the direly-needed capacity building initiatives deemed appropriate by the end-users, i.e., the farming community. Nevertheless, the factors related with the concerns and capacity-building needs are not all-inclusive rather represent those identified by a particular set of a community, although, a considerable cross-cultural variation is reported in both the intensity of collective public concerns as well as general willingness on addressing the issue [42][43]. One of the major factors related with concern for climate change is shown to be awareness level as noted by [42] who show that awareness and concern have grown throughout the world in the last two to three decades.

The Climate Change Risk Perception Model (CCRPM) given by [44] integrates four key theoretical dimensions to express concern/perception for climate change taking into account 'cognitive', 'experimental', 'sociodemographic', and 'sociocultural' factors. Taking insights from this model, the study in hand has taken lead to link some of these factors to express the level of concern among the study area respondents. In this regard, age and income are used to draw some insights on the concern level apart from education. On the role of knowledge, contrasting views are found about its impact on concern level thus enticing to go for further investigation. In this regard, [45] finds no impact of the knowledge (education) being largely unrelated to concern, however, [46] reveals a positive link between the two. A still different viewpoint is portrayed by [47] who posits that the knowledge-concern linkage may be moderated by political ideology. Findings on age and income level too are inconsistent with some studies revealing a negative relationship between age and global warming concerns while others portray no significant or positive correlation [48][49][50][51]. Similarly, a mixed pattern of impacts and linkages are observed in the case of income and concern level [49][52].

However, this study hypothesizes a positive linkage of income with the climate change concern in the study area. In a similar vein, access to credit is supposed to positively influence people/farmers' concern as does the access to information. However, wide and contrasting findings are reported on their influence on people's concerns for climate change. Keeping in mind the above empirical account, we construct two multivariate models in the present study to test the hypothesized relationships between the unobserved discrete response variables and the observed variables. Our approach (in model 1) links the observed responses on socio-economic attributes (age, education, and income), perceived changes in climatic parameters (perceived changes in rainfall and temperature), farmers' beliefs regarding climate change (climate change is due to human and nature) and their access to credit and information sources to unobserved ordinal variables and climate change concerns, through an ordered logit model.

The dominant concerns selected for the present study were identified from a list of potential sources of climate change concerns through a cumulative frequency method. The three dominant sources of climate change concerns identified through the cumulative frequency method based on their higher cumulative frequency scores are 'increased insect pressure', 'higher incidence of crop diseases', and 'droughts'. These sources of climate change concerns were then treated as dependent variables in the ordered logit model and the potential impacts of the observed variables were estimated. For model 2, we used a list of capacity-building needs of the farmers to cope with the adverse impacts of climate change and identified three major capacity building needs (Employment of ICT tools for improving the delivery of extension services, capacity building of the extension personnel and building a link between smallholder farmers and agricultural research bodies) through the cumulative frequency method. As the variables associated with the capacity building needs of the sampled respondents were dichotomous in nature, a logit model was used to estimate the impacts of climate change concerns on the capacity-building needs of the farmers as shown in **Figure 1**.

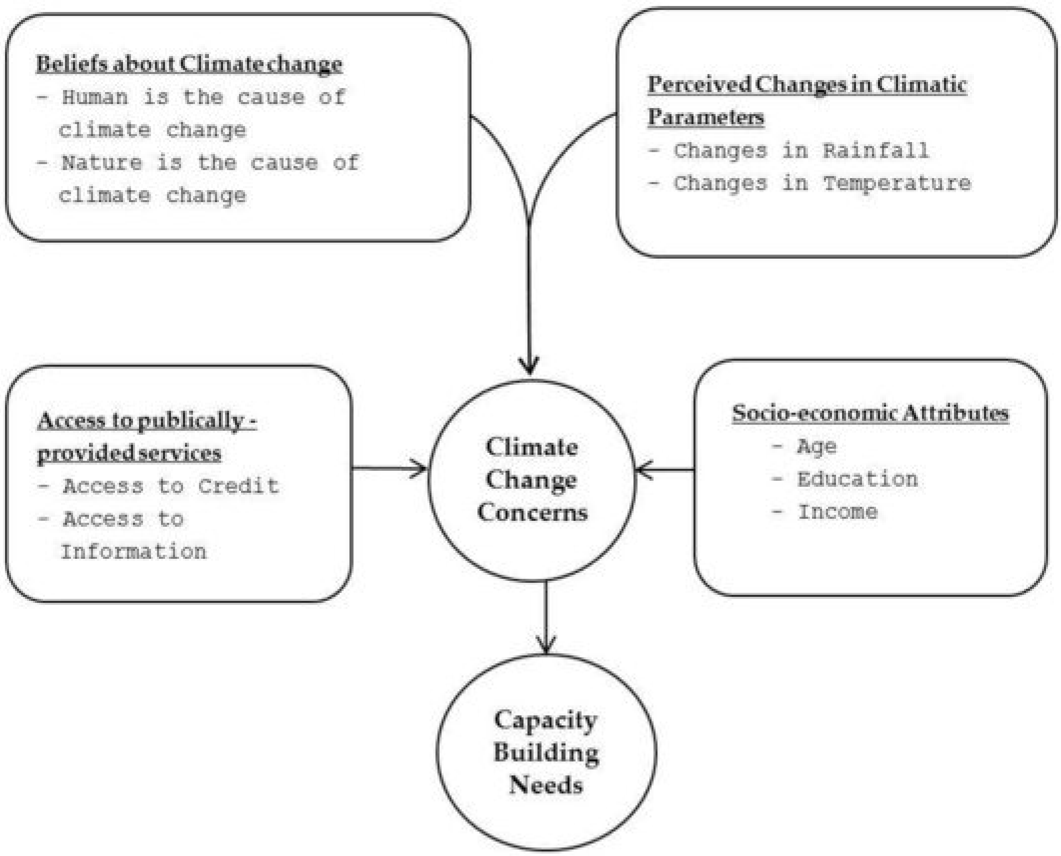

Figure 1. Conceptual model of the study.

3. Ranking of Climate Change Concerns, Beliefs and Capacity-Building Initiatives

There were a number of climate change concerns identified from the previous studies and the respondents were asked to rank each of the climate change concern on a five-point likert scale from 1 (very low) to 5 (very high). The cumulative frequency score (Equation (1)) was then used to rank the sources of climate change 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

There were a number of perceived capacity-building initiatives for climate change mitigation identified during the surveys, however, the present study considered the three dominant capacity-building measures for further analysis, namely 'employment of ICT tools for improving the delivery of extension services and products', 'capacity-building of the extension personnel', and 'building a viable link between smallholder farmers and agricultural research bodies'.

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 study area. These rankings, estimated using Equation (1), are presented in **Table 2** and **Table 3**, respectively. 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 [53][54][55][56][57]. 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.

Table 2. 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

Table 3. 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 viable 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

As given in **Table 2**, 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 natural changes and anthropogenic activities that cause climate changes, respectively. At the third place, the cause of climate change is reported to be the combined effect of human and natural causes. The fourth and fifth 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).

In the similar fashion and calculated with the same equation, the capacity-building initiatives deemed useful and felt necessary by the respondents for effective climate change adaptation are listed with their respective scores in **Table 3**. The top three strategies obtained are: ‘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 (tenth rank)’, ‘conducting awareness meetings with farmers (ninth rank)’, and ‘conducting demonstrations for providing innovations on climate change adaptation (eighth 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. 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.

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