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Determinants of Adaptation to Climate Change: A Case Study of Rice Farmers in Western Province, Iran

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Abstract: The decisions made by agricultural households to adjust to climate change (CC) in Iran are not well known. This study is intended to investigate the influence of perceptions and socioeconomic, institutional features on farmers' adaptation decisions about CC, which constitute the hypothetical statements of the study. We undertook a survey of 200 farm householders from 31 villages of Ilam Province, situated in the western Iran, as randomly selected. The result discloses that the proposed discriminant model matches the dataset well, with a strong effect size of partial eta-squared ($\eta^2 = 0.38$). The analysis further signals that adapters are younger and more well-educated than non-adapters. Adapters are also knowledgeable about CC risks and institutional policy barriers. The adapters have subsidiary work, better access to credit, and have good contacts with expansion agents and specialists. The paper concludes that government authorities should provide farmers with the enriched capabilities and competencies enabling them to adapt to CC.

Keywords: climate change (CC); drought; adaptation management; rice farmers; Iran

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1 Introduction

The climate change (CC) has made profound impacts on farming systems at different spatial scales (Jiang et al., 2012; Murthy et al., 2015; Abdelmalek and Nouiri, 2020; Hoque et al., 2021), especially in developing countries, owing to being exposed to unforeseeable climatic situations and highly dependent on these circumstances (Kurukulasuriya et al., 2006; Maponya and Mpandeli, 2012; Yegbemey et al., 2013; Makuvaro et al., 2018; Azadi et al., 2019). Droughts are extreme weather events that impose mainstay climatic constraints on agricultural water resources, crop yields, and ecosystem balance (Lobell et al., 2014; Leng and Hall, 2019), many vulnerable families in rural communities have encountered major problems (Campbell et al., 2010). This episode results in substantial economic losses and social harms worldwide (Zarch et al., 2015; Parente et al., 2018; Innes et al., 2021). To limit the rising impacts of drought, adaptation to CC serves as the best socio-economic initiative to reduce risks in most coping scenarios (Wang et al, 2018; Brèteau-Amores et al., 2019). Adaptation reduces endangered food supply, compulsory emigrations, and unpleasant changes in job structures (Bryan et al., 2009) and improves the welfare (Wossen et al., 2017) and resilience of a larger number

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of highly vulnerable farm households (Wang et al., 2018; Maione, 2020; Mfitumukiza et al., 2020).

In recent years, Sirwan and Chardawol, the northern areas of Ilam Province, Iran, have experienced problems, such as declining precipitation and water resources that have generated a massive decrease in yield and cultivation area (Jamshidi et al., 2014; IMO, 2018), for instance, decreased rice production, 4039 to 221 t, in 1996–2018. In general, decreased precipitation due to CC causes water stress in regional scales (Lioubimtseva and Henebry, 2009; Pathak et al., 2016; Blanco-Gómez et al., 2019; Nerantzaki and Nikolaidis, 2020; Noorisameleh et al., 2020) especially, in arid and semi-arid regions (Noorisameleh et al., 2020), making negative impacts on services done by natural ecosystems to achieve food security, human health, and well-being (Makuvaro et al., 2018; Guzman-Morales and Gershunov, 2019; Tang, 2019; Maione, 2020).

There is an increasing body of knowledge of adaptation initiatives (Wossen et al., 2017; de Frutos Cachorro et al., 2018; Owen, 2020), indigenous knowledge, adaptation practices (Makondo and Thomas, 2018; Son et al., 2019), adaptation participatory techniques (Khadka et al., 2018;Cradock-Henry et al., 2020; Palermo and Hernandez, 2020), adaptation options (Epule et al., 2017; Corbeels et al., 2018), and respective interactions (Lucena et al., 2018). With the help of discriminant analysis, the study is intended to examine the determinants of farmers' adaptation to CC, the following objectives are addressed:

(1) To examine the profile of the attitudes, socioeconomic features of research participants along with institutional context on the matter of adaptation to CC;

(2) To compare the two groups of farmers relying on their adaptation to CC;

(3) To identify factors differentiating farmers who adapt to CC and those do not uptake adaptation initiatives;

(4) To deliver management implications to increase farmers' adaptation to CC.

2 Theoretical Framework

2.1 Perceived climate change

Beliefs are generally regarded as truths, remarkably possess the potential to contribute to influencing adaptation behaviors (Blennow and Persson, 2009; Dang et al., 2014a, b; Guo et al., 2021; Li et al., 2021), although the beliefs are most often complex and not being simply recognizable (Holloway and Ilbery, 1996; Li et al., 2017; Mase et al., 2017; Abdollahzadeh et al., 2018; Shi-Yan et al., 2018; Khanal et al., 2018; Assan et al., 2020; Ali et al., 2021; Guo et al., 2021). The reports provide evidence on beliefs in CC in terms of its actual occurrence, reasons, and consequences (Heath and Gifford, 2006; Dang et al., 2014a). Holloway and Ilbery (1996) conclude that there are positive and negative attitudes towards CC among the surveyed farmers (i.e., an integration of positive and negative impacts of global warming). In the study intended to assess the perception of 210 rural households in the regions of the southern Khorasan Province, Iran, the results indicate that 90% of respondents believe that new changes have occurred in the climate of the region, resulting in hot days, the frequency of droughts, and decreasing rain (Esmailnejad and Pudineh, 2017). Arbuckle et al. (2015) gain insight into the truth that farmers' beliefs have a direct impact on perceived CC risks. Surveyed 5000 farmers across 22 Midwestern U.S. watersheds, Mase et al. (2017) have provided evidence that attitudes towards adaptation innovations are the most remarkable drivers of adaptation to CC. Li et al. (2021) have explored 1115 rice farmers' perception of CC in the Yangtze River Basin, therefore concluding that most of the farmers confirmed a substantial shift in local weather conditions strongly. Nnko et al. (2021) showed that designing adaptation strategies to CC requires an understanding of vulnerable pastoralists' perception of CC in the Maasai Steppe in Tanzania. Abdollahzadeh et al. (2018) surveyed 380 farmers in Zabol, the eastern Iran and provided evidence that farmers' perceptions of CC contribute to establishing adaptation strategies to cope with CC. The importance of this issue has been witnessed by Takakura et al. (2021), Ali et al. (2021), Assan et al. (2020). The perceived risk of CC are represented in terms of the severity and probability of occurrence (Grothmann and Patt, 2005; Grothmann and Reusswig, 2006; Dang et al., 2014a). The perception of risks of CC is heightened when people receive more awareness of observable consequences of harms generated by CC, such as soil fertility loss, water scarcity, unfavorable changes in crop yield, increased crop diseases, endangered physical and mental health, and harmed social relationships (Dang et al., 2014a; Li et al., 2017; Fahad and Wang, 2018).

$H_{Pcc}1$: Beliefs about CC have a positive impact on

farmers' adaptation behaviors.

$H_{Pcc}2$: Perceived risks have a positive impact on farmers' adaptation behaviors.

2.2 Demographic features

Several demographic features influence the process by which farmers make decisions to adapt to CC. For example, Zamasiya et al. (2017) and Shikuku et al. (2017) provide evidence that gender is a substantial predictor that stratifies rural families into two groups, including those who adapt to CC and those not adapt to CC. Paraïso et al. (2012) indicate that men are most often the owners of large-scale farms. Meanwhile, Asfaw and Admassie (2004) report men have higher access to information on new technologies. Moreover, Tenge et al. (2004) state that there is a weaker performance in taking care of water and soil resources in the families headed by female farmers rather the families directed by men. Cutter et al. (2003) have mentioned that female-headed households were more susceptible to natural hazardous risks due to poor literacy and less access to resources and land. Guo et al. (2021) indicated that gender has no significant influence on taking adaptation measures. Burton (2014) reported female farmers would be less likely to embrace adaptation strategies because they are conservative and want to maintain the status quo, as it was before changes intended to stand facing CC. Sam et al. (2020) found that female householders in India are likely to accept adaptation strategies like seeking help to change cropping pattern.

Age also contributes to establishing adaptation to CC (Ofuoku, 2011; Yegbemey et al., 2013; Li et al., 2021) and has significant influence on the selection and taking the adaptation initiatives (Khan et al., 2020; Funk et al., 2020; Islam et al., 2021). Adult farmers have more experience in agriculture and are likely to take adaptation enterprises (Ofuoku, 2011; Yegbemey et al., 2013; Stefanovic et al., 2019). In the context of adaptation measures, Wilson (1997) provides insight into farmers' reaction to adopt or refuse some of the government schemes and concludes that age contributes to establishing adaptation behaviors. However, Maya et al. (2019) and Guo et al. (2021) have reported age variable is not able to explain the acceptance of adaptation strategies.

As witnessed in the literature, farmers with a higher level of formal educational attainment have more tendency to implement adaptive enterprises in their farming systems (Maddison, 2006; Yegbemey et al., 2013). The well-educated farmers, in essence, adapt to CC as efficiently as possible, as they utilize modified technologies to attain adaptation (Maddison, 2006; Deressa et al., 2009; Yegbemey et al., 2013). Wilson (1997) and Abdollahzadeh et al. (2018) conclude that educational attainment plays a substantial role in forming adaptation behaviors, in the contrary vein, Nabikolo et al. (2012) declare that educational attainment has no significant impact on adaptation to CC. Al-Amin et al. (2020) have indicated that higher educational attainment lead farmers to pay for adaptation programs in Malaysia. The marital status (Jamshidi et al., 2014), being a head of the family (Tenge et al., 2004), and family size (Shikuku et al., 2017) are also drivers that predict adaptation behaviors. For example, the evidence from the study of Oluwatusin (2014) implies that married farmers acclimatize to CC better than single farmers. Ozor (2010) gains insight into the role of family size in grasping adaptation strategies because of having enough family labor available to take adaptation initiatives. As expressed by Oluwatusin (2014), the rate of the acceptance of adaptation strategies is higher in families with the larger household size than in families with the smaller household size.

$H_{DF}1$: Age has a negative impact on farmers'adaptation behaviors.

$H_{DF}2$: Gender has a positive impact on farmers' adaptation behaviors.

$H_{DF}3$: Marital status has a positive impact on farmers' adaptation behaviors.

$H_{DF}4$: Female family heads have a positive impact on farmers' adaptation behaviors.

$H_{DF}5$: Family size has a positive impact on farmers' adaptation behaviors.

$H_{DF}6$: Educational attainment has a positive impact on farmers' adaptation behaviors.

2.3 Economic features

The previous studies have established that individuals with better access to labor (Idrisa et al., 2012), credit (Shahidur et al., 2002; Nabikolo et al., 2012; Yegbemey et al., 2013; Muench et al., 2021), and economic returns (Knowler and Bradshaw, 2007) are more likely to suit a new condition generated by CC, especially when using adaptation strategies, such modern irrigation technologies and the replacement of conventional crops with the

varieties resistant to the drought (Howden et al., 2007; Deressa et al., 2009; Kurukulasuriya and Rosenthal, 2013). An off-farm enterprise, often spoken of as a secondary job plays a considerable role in utilizing the adaptation strategies, due to being supplemented to cover the surplus costs of livelihood and farm (Ghambarali et al., 2012; Khosravipour et al., 2013).

Associated with the on-farm activities, it is said that the acquired on-farm-revenue gives an authority to the family members to establish a favorable vision towards the prospective agricultural activities, having a greater role in the family and the farm economy than they did before (Jamshidi et al., 2014). It is discussed that farming experience is positively correlated to being aware of the occurrence of CC (Daberkow and McBride, 2003) and is perceived as a key factor that contribute to shaping farmers' adaptation to CC (Adesina and Baidu-Forson, 1995; Maddison, 2007; Ghambarali et al., 2012; Khosravipour et al., 2013; Jin et al., 2015; Arunrat et al., 2017; Mihiretu et al., 2019; Idrissou et al., 2020; Ojo and Baiyegunhi, 2020). Based on surveys undertaken by Liu et al. (2019) and Burton (2014), farmers with more years of experience and being engaged in agricultural activates would be more likely to take adaptation strategies. Abdollahzadeh et al. (2018) report income contributes to creating an impact on the adoption of strategies to cope with CC. Furthermore, the annual income of the household is a factor having a positive and significant influence on the decisions about adaptation behaviors (Sahu and Mishra, 2013; Jin et al., 2015; Al-Amin et al., 2020). Moreover, access to the credit is a positive driver of deciding about taking adaptation initiatives (Nabikolo et al., 2012; Sahu and Mishra, 2013).

$H_{EF}1$: Household income from farming has a negative impact on farmers' adaptation behaviors.

$H_{EF}2$: Secondary job has a positive impact on farmers' adaptation behaviors.

$H_{EF}3$: Access to credit has a positive impact on farmers' adaptation behaviors.

$H_{EF}4$: Farming experience has a negative impact on farmers' adaptation behaviors.

2.4 Social features

A large number of studies have demonstrated that farmers' affiliation to social associations (Ghambarali et al., 2012; Khosravipour et al., 2013; Jamshidi et al., 2014; Zamasiya et al., 2017; Shikuku et al., 2017), partnership in the services delivered by the agricultural extension (AE) (Maddison, 2007; Gbetibouo, 2009; Di Falco et al., 2011; Idrisa et al., 2012; Ghambarali et al., 2012; Khosravipour et al., 2013; Muench et al., 2021), and property rights (Maddison, 2007; Yegbemey et al., 2013) are found to be crucial drivers in explaining adaptation behaviors. The property rights are broken down two classes 1) institutional arrangements on land and 2) land rights (Jamshidi, 2015). The former refers to the ways by which farmers acquire and have access to the land, including land purchasing, heritage, gifts, dowry, and land reforms (Jamshidi, 2015; Yegbemey, 2013). The latter deals with farmers' right to use the land, which entails land ownership (i.e., land owner), leased land, sharecropping, endowment, cooperation, and agricultural corporate (Maddison, 2006; Quan, 2006; Yegbemey, 2013).

$H_{SF}1$: Membership in social associations has a positive impact on farmers' adaptation behaviors.

$H_{SF}2$: Partnership in the Extension programs has a positive impact on farmers'adaptation behaviors.

$H_{SF}3$: Rights on land have a negative impact on farmers' adaptation behaviors.

2.5 Characteristics of farm

As documented by Jamshidi et al. (2014), farm characteristics (e.g., land size, water resources, and farm slope) have a predictive potency for farmers to become accustomed to CC. The finding of the study conducted by Gebrehiwot and van der Veen (2013) reveals that a larger farm size gives rise to the probability of adapting to CC. By surveying 136 households in the eastern Uganda, Nabikolo et al. (2012) conclude that land size is one of the main determinants of making decisions to acclimatize to CC. Amsalu and Graaff (2007) demonstrate that Ethiopian farmers with larger farm holdings tend to pay for soil conservation measures. Sahu and Mishra (2013) also have documented the impact of the size of landholdings, which has a positive and significant influence on the Indian farmers' adaptation decisions. Jin et al. (2015), Al-Amin et al. (2020), and Wilson (1997) have mentioned that farm size impinges upon farmers' adaptation decisions. The same is declared to the infrastructural factors. For instance, the distance of farms to the target markets and nearby towns is one of the major factors influencing to take strategies to cope with CC (Sam et al., 2019), as it makes easier to

purchase agricultural inputs and supply their products (Maddison, 2006; Nhemachena and Hassan, 2007; Deressa et al., 2009; Yegbemey et al., 2013, Dang et al., 2014b).

$H_{CF}1$: Farm size has a positive impact on farmers' adaptation behaviors.

$H_{CF}2$: Land slope has a positive impact on farmers' adaptation behaviors.

$H_{CF}3$: Farm water resources have a positive impact on farmers'adaptation behaviors.

$H_{CF}4$: Distance of farm to the markets has a positive impact on farmers' adaptation behaviors.

2.6 Characteristics of institutions

The adaptive capacity is, in essence, an indication of the available resources and institutional processes (Basupi et al., 2019). The evidence indicates that, for example, access to extension service gives rise to the adaptation to CC (Di Falco et al., 2011; Zamasiya et al., 2017; Khanal et al., 2018; Muench et al., 2021). Muench et al. (2021) have revealed that institutional factors would influence the degree of tea farmers' adaptation behaviors. Accordingly, farmers are stimulated to be acquainted with newer methods and technologies relevant to farm husbandry, as they consult with experts on their problems and participate in the agricultural extension classes to receive sound and well-grounded solutions (Jamshidi, 2014), which facilitate their adaptation behaviors. Likewise, incentive and disincentive factors might be drivers through which farmers take adaptation initiatives. Incentives consist of supportive policies delivered by the governments to villagers (Jamshidi et al., 2014; Shi-Yan et al., 2018). The disincentive factors comprise, for example, the increased price of agricultural inputs (Jamshidi et al., 2014), the lack of credit, and timely information (Shi-Yan et al., 2018). Fig. 1 displays the conceptual framework of the study.

$H_{CI}1$: Institutional arrangements on land have a positive impact on farmers' adaptation behaviors.

$H_{CI}2$: Contact with the extension service has a positive impact on farmers' adaptation behaviors.

$H_{CI}3$: Perceived incentives have a positive impact on farmers' adaptation behaviors.

$H_{CI}4$: Perceived disincentives have a negative impact on farmers' adaptation behaviors.

3 Materials and Methods

3.1 Study area

This face-to-face survey study was carried out in Ilam Province, which is situated on the western part of Iran at a latitude of 33°38′N and longitude of 46°26′ E (Fig. 2). The research sites comprise the Townships of Sirwan and Chardawol, with a population of 41 469 and 37 981, respectively, accounting for 16.56% and 28.81% of the total rural population. 79.54% of the population of Sirwan are farmers, 15.65% of cattle breeders, the rest are employed in other services (4.81%). In addition, 54.15% of the population of Chardawol are farmers, 38.75% are livestock farmers, the remainder of the population have other service jobs (7.7%) (Statistical Yearbook of Ilam Province, 2016). Two townships are located in a stretch of the central Zagros Mountains, the areas where have been severely affected by declining rainfall and there-

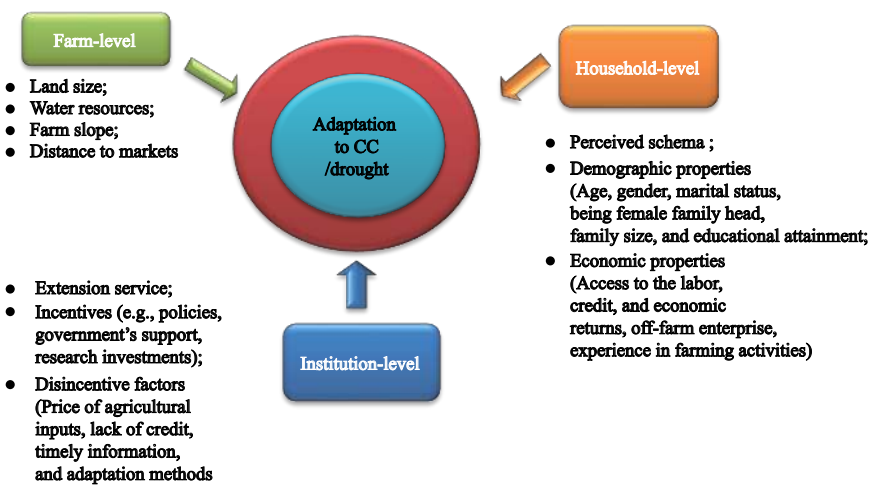

Fig. 1 The conceptual framework of the study

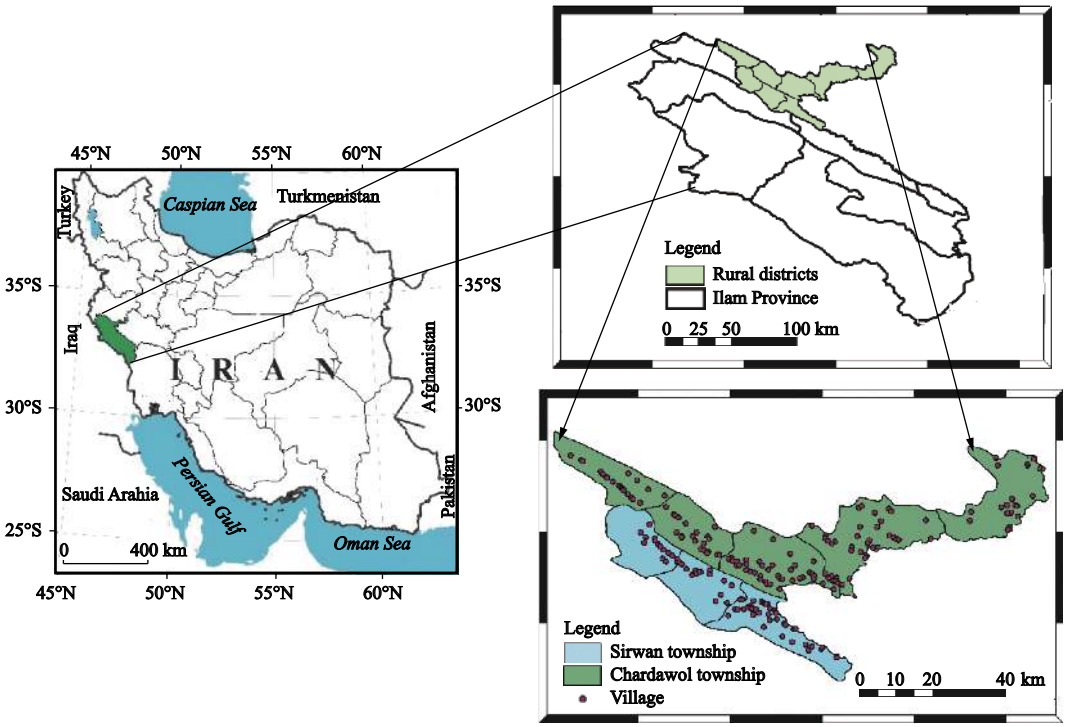

Fig. 2 Map of research area

fore decreased local ware resources (Seymareh River) due to frequent droughts. Before the occurrence of droughts, prior to 2001, these regions have been the center of producing a specific cultivar of rice, as locally spoken as *Anbarboo*. It is also, according to the information of the Agricultural Jahad Organization, in the western part of Iran, which includes parts of Kurdistan, Kermanshah, Hamedan, Lorestan and Ilam provinces, rice is planted only in Ilam Province and especially in Chardavol and Sirvan cities. Along with climate change and droughts in recent years and the drying up of agricultural water resources and reduced rice cultivation, rice farmers living in the villages of the study area have suffered socio-economic losses, including the loss of the main job, the disappearance of the main source of household income, the decrease in the level of household income, the return of households to false jobs such as peddlers along the streets of large cities and migration to larger cities such as Tehran.

3.2 Data

The research population includes all rural householders in the townships of Sirwan and Chardawol (N = 19 856). Using Bartlet et al.'s (2001) approach, 200 farm householders were determined and surveyed under the multistage stratified random sampling. By stratifying the research area based on the characteristics like the typology of cultivation (i.e., rice, grain, and vegetables), the topological structure of area (i.e., highland or close to rivers), and irrigation method (i.e., well water or rivers), the householders of 31 villages were surveyed in the rural districts of Karazan, Lowmar, Zangwan, and Roudbar.

Using exploratory field research and archival data analysis, we developed a four-page A4-format questionnaire consisting of sections containing questions derived from the conceptual frameworks. The experts of the DOA delivered their corrective suggestions on bias wording, thus approved the validity of the indices of the questionnaire. By trialing with 30 farmers in a small-scale pilot survey, the internal consistency of indicator variables with the respective latent variables in the questionnaire (i.e., reliability) was achieved using Cronbach's Alpha method (Thompson, 2003). The results include $\alpha_{BCC} = 0.91$, $\alpha_{PRCC} = 0.71$, $\alpha_{AES} = 0.80$, $\alpha_{AC} = 0.83$, $\alpha_{MSA} = 0.79$, $\alpha_{CES} = 0.92$, $\alpha_{PEC} = 0.82$, and $\alpha_{PDsI} = 0.72$. These variables are also abbreviated in Table 1.

3.3 Methodology

The predictor variables that were examined in the study are listed in Table 1, some of which are factual in nature, whereas, the remainder of which are attitudinal,

Table 1 The variables of predictor

Level	Dimension	Predictor variables	Abbreviated	References
Household-level	Perceived climate change	Belief in CC	BCC	Li et al. (2017); Shi-Yan et al. (2018); Khanal et al. (2018)
		Perceived risk of CC	PRCC	Dang et al. (2014a)
	Demographic factors	Age	AGE	Ofuoku (2011); Yegbemey et al. (2013)
		Gender	Gender	Zamasiya et al. (2017); Shikuku et al. (2017)
		Marital status	MS	Jamshidi et al. (2014)
		Female heads	FH	Tenge et al. (2004)
		Household size	SH	Jamshidi (2015)
		Educational attainment	EA	Maddison (2006); Yegbemey et al. (2013)
	Economic factors	Household income from farming	HIF	Jamshidi (2015)
		Household sources of income	HSI	Jamshidi (2015)
		Secondary job	SJ	Ghambarali et al. (2012); Khosravipour et al. (2013)
		Access to credit	AC	Shahidur et al. (2002); Yegbemey et al. (2013)
		Labor sources	LS	Jamshidi (2015)
		Farming experience	FE	Adesina and Baidu-Forson (1995); Maddison (2007);
		Rights on land	RL	Ghambarali et al. (2012); Khosravipour et al. (2013) Yegbemey (2013)
	Social factors	Membership in social associations	MSA	Jamshidi et al. (2014)
		Participation in extension classes	PEC	Jamshidi et al. (2014)
Farm-level		Farm size	FS	Jamshidi (2015)
		Land slope	LSE	Jamshidi (2015)
		Agricultural water resource	AWR	Jamshidi (2015)
		Distance to markets for agricultural inputs and products	DMAIs/DMAOs	Maddison (2006); Nhemachena and Hassan (2007); Deressa et al. (2009); Yegbemey et al. (2013), Dang et al. (2014a)
Institutional-level		Access to extension service	AES	Jamshidi et al. (2014)
		Institutional arrangements on land	IAL	Yegbemey et al. (2013)
		Contact with extension	CES	Jamshidi et al. (2014)
		Perceived incentives/ disincentives	PIs/PDs	Jamshidi (2015); Shi-Yan et al. (2018)

Note: Adaptation to CC was operationalized in terms of the different strategies of adaptation documented by Bradshaw et al. (2004); Kurukulasuriya and Mendelsohn (2006); Maddison (2006); Nhemachena and Hassan (2007)

measured on a 5-point Likert scale, (1) strongly disagree to (5) strongly agree. Also, the criterion variable of the study was established based on the literature review, which contains a vast variety of strategies that farmers use to adapt to CC like changing the irrigation methods, application of drought-resistant varieties, changing the time of planting, and the usage of the livestock breeds adaptable to CC (Yegbemey et al., 2013).

The Linear Discriminant Analysis (LDA) is a multivariate classification procedure used to model the variation of a criterion variable or dependent variable based on its association with one or more predictors or independent variables. The data analysis was carried out at the interface of SPSS. To achieve a realistic interpretation of the data, the statistics of *U* and Wilks' Lambda were utilized, which helped us to compare the equality of means of the respective groups.

4 Results

4.1 Inferential statistics

4.1.1 Adaptation to CC

As demonstrated by the findings, the study participants made use of the five types of adaptation strategies as follows: 1) crop diversification and crop management strategies (12.0%) (e.g., different crops and rotation); 2) agricultural water management strategies (4.5%) (e.g., rainwater storage and harvesting the groundwater to use during the dry season by pumping water from the river); 3) adjusting farm management strategies (6.5%)

(e.g., making adjustment to the cultivation calendar and the use of insurance); 4) diversification strategies (8.0%) (e.g., raising the livestock, planting the crops before the outbreak of drought, and usage of drought-resistant crops), and 5) diversification in activities, for instance, fishery and mining (5.0%).

4.1.2 Impediments of adaptation to CC

In this section, we deliver four major impediments as farmers adapt to CC, including: 1) water shortage (20.0%), 2) the lack of alternative jobs (13.5%), 3) the dispersed lands owned by the same farmers (13.0%), and 4) the shortage of a permanent source of income (11.0%).

4.1.3 The estimation of the linear discriminant function

At the first stage of the analysis (i.e., preliminary data exploration), we examined the measure of Kolmogorov-Smirnov test to probe into normality (KST) of data distribution, therefore, resulting in 0.52 for KST at the *P*-value more than 0.5, acceptable measure was achieved (Kolmogorov-Smirnov = 0.54, *P*-value = 0.92). Using the backward stepwise method, the discriminant function was developed in 11 steps to minimize the measurement of the Wilk's Lambda at each step. The result reveals that 11 variables are the major differentiating drivers ($F > 3.84$), by which the research sample would be divided into two groups of adapters and non-adapters (G_1 and G_2). The rest of the variables were disregarded owing to having the respective value of the *F* statistic lower than the input value (i.e., $F < 2.71$) (Table 2).

As resulted by the classification analysis model, the resulting measures of canonical correlation analysis (CCA) and Wilks' Lambda test indicated that the canonical correlation coefficient between the variables of two groups and the discriminant score was 0.878 ($R_{cononical}$= 0.878), there is therefore a strong relationship between the two groups and discriminant score. When canonical correlation coefficient is high, it indicates the relevance of the derived function in dividing farmers into target groups, in this case, adaptors and non-adaptors. The eigenvalue is another measure relating to the estimation of the discriminating function, which explains the variation of the criterion variable. According to Marey-Pérez and Rodríguez-Vicente (2011), a large value for this measure indicates that the function has a convincing power to account for the variation (Eigenvalue = 0.787 or 78.7%). The Wilks' Lambda test shows that 22.9% of the total variance in discriminative scores is not explained by the differences between adapters and non-adaptors.

For a better interpretation of Wilks' Lambda test results, it is recommended to use the converted Chi-square. The result unveils that the level of critical significance for the chi-square test (i.e., transformed value of the Lambda statistic) is lower than 0.05 ($\chi^2 = 283.345$, $df = 11$; $P \leq 0.001$), thus disclosing that there is a highly significant difference between the group centroids, more

Table 2 Results of the discriminant analysis with the backward stepwise selection method

Step	Entered variables	Wilks' Lambda							
		Value	*df*-1	*df*-2	*df*-3	*F* exact			
						Value	*df*-1	*df*-2	*P*-value
1	Farming experience	0.589	1	1	198	138.3	1	198	0.001
2	Farm size	0.435	2	1	198	127.8	2	197	0.001
3	Earned farming income / %	0.372	3	1	198	110.4	3	196	0.001
4	Education	0.335	4	1	198	96.6	4	195	0.001
5	Rights on land	0.305	5	1	198	88.2	5	194	0.001
6	Age	0.285	6	1	198	80.9	6	193	0.001
7	Access to extension services	0.269	7	1	198	74.6	7	192	0.001
8	Belief in CC	0.256	8	1	198	69.3	8	191	0.001
9	Perceived risk of CC	0.242	9	1	198	66	9	190	0.001
10	Subsidiary jobs	0.235	10	1	198	61.5	10	189	0.001
11	Access to credit	0.229	11	1	198	57.3	11	188	0.001

clearly, little overlap between the adapters and non-adapters (Table 3).

We also assessed the relative impact of different factors that contribute to the discriminant scores of the differentiation of adapters and non-adapters, hereby the standardized coefficients of the canonical discriminant function were used (Table 4). Therefore, variables such as farm experience, farm size and land rights had the most notable share in the discriminant function. Moreover, beliefs in CC, the perceived risks of CC, educational attainment, household income from farming, access to extension, subsidiary jobs, age, and access to credit were priorities, respectively. The discriminant analysis predicts the likelihood of positioning a farmer in groups of farmers that adapt to CCs and others that do not. This is done by placing the individual values for each variable into the discriminating function. The average discriminating score for the group of farmers who adapt CC is 2.54 and –1.309 for another group. By subtracting these two numbers from one another, the average value of the total function of the two groups gave 1.23. Therefore, if the value is less than 1.23, it is predicted that a farmer is not able to adapt to CC. In the opposite vein, the measures more than 1.23 indicate that a farmer falls into adapting group, being able to adapt to CC.

The values of β_i coefficients correspond to the estimated measures for each of the groups. X_P is the variable P. Fisher classification functions are calculated to complete the LDA and then weightings for each predictor are obtained for each group (i.e., adopters and non-adaptors). Equation 1 is the discriminant function of adapters.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_P X_P \quad (1)$$

$$Y = -72.62 - 0.569X_{AGE} + 2.39X_{FE} + 0.157X_{HIF} + 4.16X_{FS} + 2.49X_{EA} + 1.52X_{SJ} + 6.2X_{BCC} + 6.2X_{PRCC} + 0.026X_{RL} + 3.49X_{AES} + 2.93X_{CES} \quad (2)$$

4.1.4 *Validating the classification of farmers*

As shown in Table 5, using cross-validated procedure, the result of classification of the samples indicate that 64 observations (94.1%) of 68 participants in the adapter-group have been accurately predicted to be embedded in the group of the farmers who adapt to CC. Furthermore, 4 observations (5.9%) were mistakenly incorporated in group 2 (i.e., non-adapters). Moreover, 130 observations (98.5%) out of 132 observations of group 2 (i.e., non-adapters) were accurately placed in the target group, and 2 observations (1.5%) have been mistakenly placed in group 1. Accordingly, 95% of the total observations have been accurately assigned in the

Table 3 Canonical correlation and Wilks' Lambda in the discriminant model

Statistics	Measure
Eigenvalue	0.787
Percentage of variance	100%
Cumulative percentage	100%
Canonical correlation	0.878
Wilks' Lambda	0.229
Chi-square	283.345
df	11
P-value	0.0001

Table 4 The standardized coefficients of the canonical discriminant function

Predictor variables	Coefficient	Correlation
Farming experience	–0.454	–0.456
Farm size	0.387	0.409
Rights on land	–0.322	–0.34
Belief in CC	0.297	0.181
Perceived risk of CC	0.266	0.263
Education	0.259	0.365
Household income from farming / %	–0.235	–0.412
Access to extension service	0.229	0.178
Subsidiary jobs	0.219	0.329
Age	–0.208	–0.344
Access to credit	0.181	0.141

Table 5 The matrix of classification from discriminant analysis

Group			Predicted group membership		Total
			Group 1	Group 2	
Original	Count	G1	64	4	68
		G2	2	130	132
	Percentage / %	G1	94.1	5.9	100
		G2	1.5	98.5	100
Cross-validated	Count	G1	63	5	68
		G2	5	127	132
	Percentage / %	G1	92.6	7.4(%)	100
		G2	3.8	96.2	100

Note: G1: Adapters to CC, G2: Non-adapters to CC

respective groups.

4.1.5 The measure of effect size

To realize the real impact of the predictor variables in differentiating the two groups of adapters and non-adapters as more precisely as possible, we calculated eta-squared (η^2) that is a measure of effect size for LDA, consistent with the procedure delivered by Vacha-Haase and Thompson (2004). The eta-squared values of 0.01, 0.06, and 0.14 are interpreted as small, moderate, and large, respectively (Cohen, 1992). The corresponding effect size was calculated using the following formula (Eq. 2) (Hahs-Vaughn, 2016):

$$\text{Partial } \eta^2 = 1 - \lambda^{1/3} \quad (3)$$

where η^2 is eta squared for effect size, λ is a measure for Wilks' Lambda, which is equal to 0.22 in this study. Therefore, the value of 0.38 is calculated for Partial η^2, which indicates a powerful effect size of the LDA.

5 Discussion

5.1 Personal features to predict adaptation to CC (Belief in CC)

The result indicates that there is a positive significant difference in the two groups of farmers in terms of belief in CC and perceived risks of CC. Therefore, farmers who adapt to CC understand the risks of CC well and do not deny the risks of CC, as opposed to fatalist farmers. Awoye et al. (2012) maintain that farmers' belief in CC determines the extent to which whether they take the adaptation initiatives. This finding deals with the issue of certainty and uncertainty about CC, as statistics provide evidence that CC have occurred in the research site (Jamshidi and Khatounabadi, 2012; Azadi et al., 2019), therefore, farmers believe in the occurrence of the episode and perceive the respective risks. The results are consistent with those reported by Grothman and Patt (2005) and Dang et al. (2014a), showing a perceived certainty about CC (Awoye et al., 2012; Yegbemey et al., 2013).

5.2 Demographic features to predict adaptation to CC

5.2.1 Age, Gender and female head of families

A negative difference between two adapter and non-adapter groups of farmers relative to the age of respondents indicates that younger farmers are more likely to adjust to CCs. This finding is justified by the notion that states younger farmers take more risks and therefore they, for instance, use newer technologies and innovations in their own farms to adapt to CC. This claim is in line with the conclusions of studies, such as Maponya and Mpandeli (2012) and Bryan et al. (2009), which makes sense that the younger farmers make use of innovative technologies to reduce the negative impacts of CC and change their job sooner than expected. Furthermore, this result is not compliance with Ofuoku (2011) and Yegbemey et al. (2013), advocating that adult farmers have a tendency to adapt to CC because they have more experience in farming than young farmers.

The result also reveals that there is a negative difference in the two groups of male and female participants as well as female heads. The logical reason for this finding is that rural women have been severely dependent on male farmers in the patriarchal families where they have no sufficient access to information and facilities to make strategic decisions about the situation of farm and family. For this reason, they could not provide new technologies easily and have no access to facilities to implement to adapt to CC. This result complies with Yegbemey et al. (2013), Asfaw and Admassie (2004) and Tenge et al. (2004).

5.2.2 Educational attainment

A positive difference in the two groups of well-educated farmers and those farmers who are with no educational attainment reveal that education is a remarkable factor in making decision about adaptation, as declared by Bryan et al. (2009). The level of education of adapter is higher than non-adapters. It is declared that when farmers become more educated, they are likely to receive insights by which they find new methods of taking adaptation initiatives, as they are familiar with massage sources and media. They are familiar with modified crops, innovative cropping methods, changes in cropping time, etc. These results correspond to Bekele and Drake (2003), Deressa (2008), Maddison (2006) and Yegbemey et al. (2013).

5.3 Economic features to predict adaptation to CC

5.3.1 Farming experience

Farming experience is a differentiating factor between adapters and non-adaptors. This is because experienced farmers tread their farm environment as a fixed entity, intangible to being inflexible in their view, particularly

as they become more experienced in farm husbandry activities (Shahrodi et al., 2008; Deressa et al., 2009; Stefanovic et al., 2019). It is unlikely that experienced adult farmers believe in land dependence on modern technologies.

5.3.2 Household income

Income from agriculture makes a negative difference in both groups of adapter and non-adapters. The negative impact of income on adaption to CC is accounted for by the notion that expresses a remarkable portion of income gained from farming activities is spent to cover livelihood, especially for subsistence farming systems. On the other hand, as illuminated by the result, farmers who adapt to CC have a secondary job. The secondary job provides additional monetary sources to cover the costs of purchasing new agricultural technologies to adapt to CC.

5.3.3 Access to extension and credit, respective obstacles

The result also shows that two groups of farmers differ with regard to access to extension services. Access to the extension service plays a vital role in persuading farmers to adapt to CC. Adesina and Baidu-Forson (1995), Maponya and Mpandeli (2012) state that these centers are the main sources giving information to farmers due to their collaboration with farmers to analyze their decisions about acclimatizing to CC.

The obstacles, such as lack of budget, credit, subsidy, and insurance in support of farmers restrict the provision of technologies (Maponya and Mpandeli, 2012), as farmers need to adapt to CC. This is in line with Maponya and Mpandeli (2012), Kandlinkar and Risbey (2000), declaring that if farmers received no support from governmental agricultural institutions, they would no longer adapt to CC.

Access to credit also distinguishes both groups of farmers. It means that the farmers who have better access to credit have a better adaptation because, for instance, access to credit enables farmers to purchase the improved technologies like drought-resistant varieties. Furthermore, access to the service of the department of agriculture (DOA) increases farmers' information on CC and how to take respective initiatives. As such, they are likely to take CC risks by applying adaptive methods and technologies. The results correspond with the findings and remarks by Bryan et al. (2009), Gbetibouo (2009), Deressa et al. (2009) and Ghambarali et al. (2012).

5.4 Social features to predict adaptation to CC

5.4.1 Rights on land

The perceived rights on land are significantly different in the two groups of farmers. The result unveils that ownership determines 92% of the rights on land, according to Yegbemey et al. (2013), land ownership is one of the most determining factors leading farmers to decide to adapt to CC. The evidence also indicates that the right on land is a determining driver in decreasing poverty in the areas where a farmer earns their living through just farming (Quan, 2006). The finding conforms with the studies by Jamshidi et al. (2009, 2012); Jamshidi and Khatounabadi (2012).

5.4.2 Membership in social associations

The membership in social groups differentiates the farmers in the two groups of adopters and non-adopters. When farmers increase their collaboration with the social associations, they are more likely to adapt to CC because of their disposal to informant farmers (i.e., message sources) who take adaptation initiatives successfully or partially in their farms (Jamshidi et al., 2014). According to the results, there is no significant difference in the two groups of farmers in terms of participation in extension classes.

5.5 Characteristics of farms to predict adaptation to CC

Farm size is a differentiating factor that separates adapters from non-adapters. According to Jamshidi et al. (2014) and Nabikolo et al. (2012) adapters who have larger farm size adapt to CC rather than non-adapters with small-scale farms. Farm size influences farmers' adaptation decisions, for example, large-scale farmers tend to pay for some adaptation measures (Amsalu and Graaff, 2007; Al-Amin, 2020). On the other hand, Farmers who adapt to CC were closer to the markets for purchasing agricultural inputs and supplying their products and also to agricultural service centers, which facilities access to the agricultural institutions, farming technologies, and information. These results are in line with the findings by Maddison (2006) and Deressa et al. (2009), stating that the greater the distance between farms and markets, the less adaptation is achieved.

5.6 Institutional features to predict adaptation to CC

As achieved in this study, there is a positive significant difference between the two groups of farmers in terms of disincentives. As such, farmers who adapt to CC are those who understood the execution of the socio-economic rules well (e.g., increased the price of agricultural inputs due to the implementation of targeting subsidy plan). For instance, some of the farmers declare that the increased price of the inputs leads them to use the input more efficiently or resort to adaptation strategies, such as the establishment of a new business, livestock husbandry, the usage of the water-saving measures. The results are in harmony with the findings by Dang et al. (2014a) and Dang et al. (2014b). Also, the research also indicates that there is no significant difference between the two groups of farmers in terms of institutional arrangements on land, contact with extension service, and perceived incentives.

6 Conclusions

This study was intended to investigate the key factors differentiating farmers who decide to adapt to CC and those who are reluctant to adapt to CC. The results indicate that a complex and variety of factors (e.g., attitudinal, structural, social, and institutional) influence significantly farmers' decisions about becoming accustomed to CC. In this section, in order to facilitate farmers' adoption of adaptation strategies, practical solutions are proposed to policymakers as follows.

As noted, age and farming experience contribute to distinguishing the two groups of farmers under study. Although a major goal of any development scheme relevant to the reduction of the impacts of CC is to cover the majority of rural groups, they have no similar reactions to adaptation strategies, as they are empirically divided into the five stratifications based on Rogers' innovation diffusion model. Accordingly, the AE needs to inform younger farmers about the hazardous impacts of CC entirely, even these people should be recruited as contact farmers, through their mediations, it would be possible to disseminate adaptation strategies from the AE to other rural stratifications. Moreover, the AE is suggested introducing new vocational opportunities, especially opportunities that are directly not dependent on farming activities, for example, non-farming economic activities, which help farmers compensate for the additional costs appearing during the drought periods. Non-farming economic activities are of handcraft, rural tourism, agro-tourism, etc. Furthermore, the result indicates that educational attainment is a factor that differentiates adapters and non-adapters. As a result, the AE is recommended to establish educational classes; by which farmers are acquainted with a wide variety of adaptation strategies. The perceived risks of CC also make a distinction between the two groups of farmers. For this reason, the AE needs to give the respective information to farmers so that they are persuaded that CC is a real episode, potentially contributes to confining the ability of them, particularly as the resources of production are limited and go out their disposal. Access to extension service also differentiates in the two groups of farmers. The AE needs to give rise to the dissemination of technologies and innovations appropriate to the adaptation to CC (e.g., drought-resistant varieties, sprinkler irrigation systems, the change of cultivation time, *etc*.).

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