J. Agr. Sci. Tech. (2023) Vol. 25(3): 521-534

Climate Change Adaptation Intensity in Bakhtegan-Tashk Basin, Iran

N. Kargar Dehbidi[1], M. Zibaei[1], and M. H. Tarazkar[1*]

ABSTRACT

Adoption of multiple climate change adaptation strategies is the most important solution to mitigate the negative consequences of climate change. Therefore, in the present study, economic and social characteristics that affect the intensity of adaptation strategies in the Bakhtegan-Tashk Basin, Iran, were examined using an ordered probit model. A total of 300 farmers were selected using a multi-stage sampling method. The results showed that household income level, access to the credit, availability of irrigation water, number of crops, and farmer membership in agricultural extension classes had significant positive effects on the intensity of adaptation to climate change. Therefore, it is suggested that the government facilitates the use of different climate change adaptive strategies by increasing financial incentives. Also, changing the cropping pattern by planting less water demanding crops that are appropriate for the region is recommended.

Keywords: Adaptive strategies, Ordered probit model, Irrigation.

INTRODUCTION

The rate of Earth's temperature rise has nearly doubled compared to the last 50 years, and it is predicted that by 2100, it will increase by another 6.4°C (Barros *et al.,* 2014). Meanwhile, the agricultural sector is most vulnerable to the consequences of climate change because of its dependence on climatic parameters such as temperature, rainfall, and humidity (De Medeiros Silva *et al.* 2019; Chandio *et al.,* 2020). Changes in climate parameters, such as temperature and rainfall, affect the availability of water resources, including surface and groundwater, for farmers. Also, climate change can lead to changes in crop yield and supply of agricultural products, and as a result, farmers' livelihoods (Wangchuk and Siebert, 2013). In addition, changes in the supply of agricultural products lead to changes in the relative prices of agricultural items and increase the vulnerability and food insecurity of farmers (Wossen *et al.,* 2018).

Climate change refers to changes in climatic conditions, including temperature and rainfall over a long period of time (Hoegh-Guldberg *et al.,* 2007). Climate change is the first among the ten most dangerous anthropogenic phenomena and can affect various economic, political, and social sectors on a global scale (Kurukulasuriya *et al.*, 2006; Jha and Gupta, 2021). Meanwhile, the Middle East is one of the regions that are highly vulnerable to climate change. In this region, climate change has originated from various factors. But, one of the most important factors that cause climate change in the Middle East is the increase in greenhouse gas emissions (Al-Mulal and Ozturk, 2015; Tarazkar *et al.*, 2021).

Iran is one of the countries located in the dry belt of the Earth, with its growing need for agricultural products. In addition, Iran has been exposed to climate change. The

[1] Department of Agricultural Economics, School of Agriculture, Shiraz University, Shiraz, Islamic Republic of Iran.
*Corresponding author, e-mail: Tarazkar@shirazu.ac.ir

[DOI: 10.22034/jast.25.3.521]

average annual temperature in most provinces of the country is more than 15°C, and the average annual rainfall is less than 250 mm, which is approximately one-third of the global average (Khalili and Rahimi, 2018; Mesgaran *et al.*, 2016). Therefore, water scarcity is a major obstacle in Iran's agricultural sector. The agricultural sector, with a share of 12.18% of the total economy and 17.37% of the total number of employees, plays a key role in Iran's economy (Global Economy, 2021).

According to previous studies, the most important strategy for mitigating the consequences of climate change and improving farmers' livelihoods is to adopt the adaptation strategies such as modern irrigation technology, water storage technology, use of new drought-tolerant crop varieties, conservation tillage, and livelihood diversification (Amare and Simane, 2017a; Amare and Simane, 2018; Ali *et al.*, 2018; Bedeke *et al.*, 2019; Teklewold *et al.*, 2019; Piedra-Bonilla *et al.*, 2020; Khan *et al.*, 2021).

Adoption of such strategies is largely influenced by the individual, economic, and social characteristics of the farmer. Personal characteristics of the farmer include age of the head of the household (Uddin *et al.*, 2014; Ali, 2017; Ali and Erenstein, 2017; Amare and Simane, 2018; Alhassan, 2020), education (Uddin *et al.*, 2014; Kassie *et al.*, 2015; Bedeke *et al.*, 2019), and family size (Uddin *et al.*, 2014; Khanal and Wilson, 2019; Jabbar *et al.*, 2020), which could influence adoption of climate change adaptation strategies.

The economic capabilities of farmers, such as farmers' income, farm size, ownership of agricultural machinery such as tractors, access to credit, and so on, could influence the use of adaptation technologies. However, the most important economic dimension of farmers is income level, which increases the possibility of further investment in the adoption of climate change adaptation strategies (Uddin *et al.*, 2014; Ali and Erenstein, 2017; Esfandiari *et al.*, 2020). In addition, access to credit has an important role in adopting different strategies for reducing financial constraints (Salazar and Rand, 2016; Ali, 2017; Amare and Simane, 2017; Bedeke *et al.*, 2019; Khanal and Wilson, 2019; Alhassan *et al.*, 2019). In addition, agricultural machinery ownership, which facilitate the use of agricultural machinery, and farm size, can reduce average production costs and, consequently, increase farmers' willingness to adopt climate change adaptation strategies (Salazar and Rand, 2016; Ali and Erenstein, 2017; Sileshi *et al.*, 2019).

The effective social characteristics of farmers include membership in cooperatives or agricultural extension agents, participation in agricultural extension classes, access to required information such as meteorological data, knowledge of new cultivars, etc., which increases farmers' awareness of new agricultural technologies and understanding of the benefits of climate change adaptation strategies (Uddin *et al.*, 2014; Ali, 2017; Ali and Erenstein, 2017; Amare and Simane, 2017; Bedeke *et al.*, 2019; Jabbar *et al.*, 2020). These factors play an important role in resilient and effective shields to mitigate the negative consequences of climate change.

Literature review shows that most previous studies have focused on the economic or social characteristics that affect the adoption of climate change strategies (Amare and Simane, 2017a; Ali and Erenstein, 2017; Amare and Simane, 2018; Ali *et al.*, 2018; Mulugeta, 2018; Ali *et al.*, 2018; Bedeke *et al.*, 2019; Alhassan *et al.*, 2019; Piedra-Bonilla *et al.*, 2020; Alhassan, 2020; Jabbar *et al.*, 2020; Esfandiari *et al.*, 2020). However, few studies examined the effects of socio-economics on the intensity of adoption strategies (Maguza-Tembo *et al.*, 2017; Teklewold *et al.*, 2019; Piedra-Bonilla *et al.*, 2020; Khan *et al.*, 2021).

Therefore, the present study aimed to fill the gap in the previous studies by answering the main research question, i.e., whether socio-economic parameters affect the climate change adaptation intensity in the study area. To the best of the authors'

[DOI: 10.22034/jast.25.3.521]

knowledge, this topic is the first research in the study area. The results of this study are essential for agricultural planners and policymakers in Iran to design appropriate strategies to mitigate the effects of climate change on households' livelihoods.

MATERIALS AND METHODS

Study Area

The present study focuses on the intensity of adoption of climate change adaptation strategies in the Bakhtegan-Tashk Basin, Fars Province, southern Iran. The Bakhtegan-Tashk Watershed is part of the Central Plateau Catchment Area and has an area of approximately 31,492 km^2. Bakhtegan-Tashk Basin, despite some shortcomings, due to its diverse climate, plant cultivars, and basic production resources (soil and water) is one of the most important agricultural production region in Iran. The main job of the households living in this basin is farming. More than 90% of the cultivation area in this region is allocated to wheat and barley in winter and rice, tomatoes, and forage corn in summer (Jahangirpour and Zibaei, 2022).

The Bakhtegan-Tashk Basin has played a strategic role in supplying water to farmers in Fars Province for many years. The Bakhtegan-Tashk Basin is in a critical situation due to various reasons, such as reduced rainfall, occurrence of successive droughts, and construction of several dams. Figure 1 shows the location of Bakhtegan-Tashk Basin, Fars Province, southern Iran.

Currently, due to reduced rainfall, all rivers leading to Bakhtegan-Tashk Lake, such as Kor and Sivand, are no longer flowing and runoffs have dried off. In other words, the inflow of water from Bakhtegan-Tashk Lakes is limited to floods in the region. Figure 2 illustrates the rainfall trends in the Bakhtegan-Tashk Basin from to 1992-2018.

As illustrated in Figure 2, rainfall in the study area shows a declining trend and has decreased significantly, especially in recent years. In 1992, the rainfall was approximately 527 mm, and in 2018, it decreased by more than 50–180 mm. In addition, according to Figure 3, the average

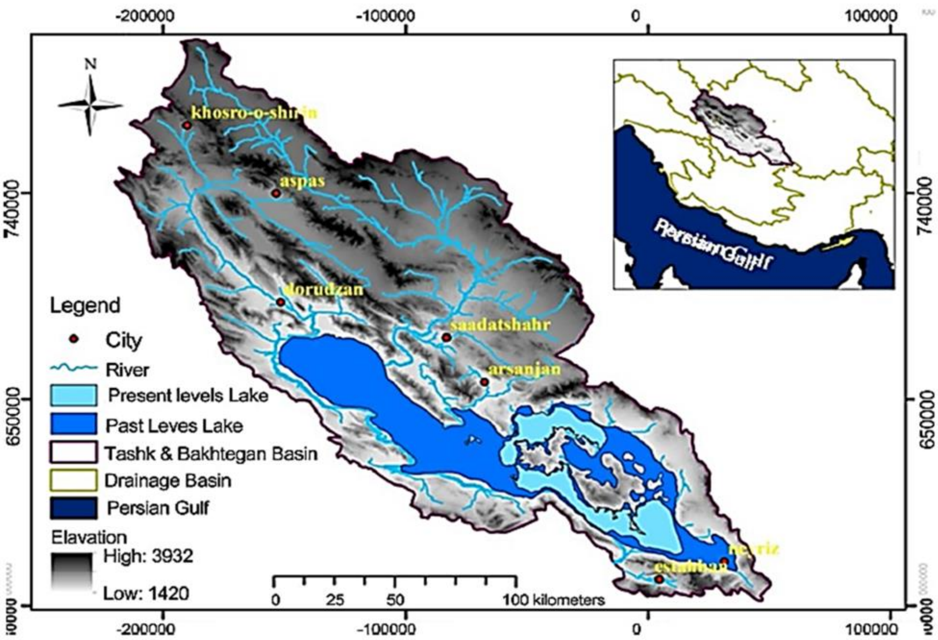

Figure 1. Location of Bakhtegan-Tashk Basin, Fars Province, southern Iran**.**

[DOI: 10.22034/jast.25.3.521]

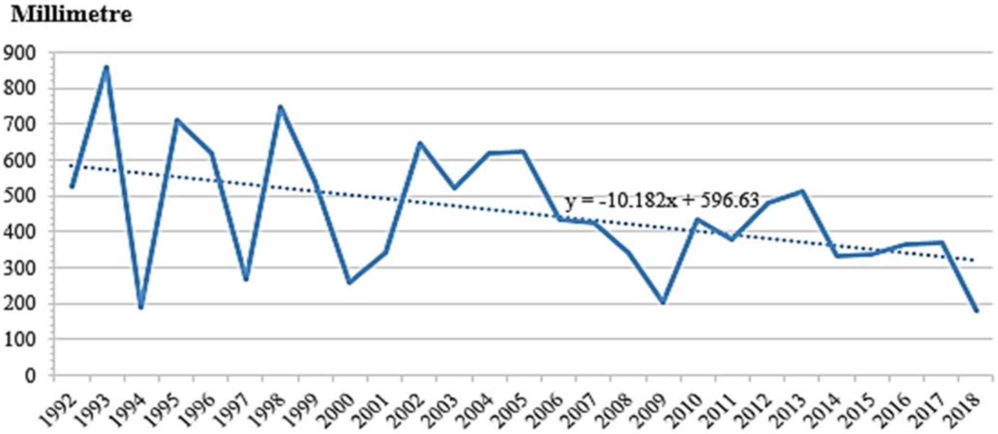

Figure 2. Rainfall trend in Bakhtegan-Tashk Basin (IMO, 2019).

temperature showed an increasing trend. In 1992, the average temperature was approximately 17.27°C and in 2018, it increased by more than one degree to 18.29°C.

The most important river in the Bakhtegan-Tashk Basin is the Kor River, on which the Doroodzan Reservoir Dam, one of the oldest water projects in Iran, was constructed. The main canal of the Dorodzan Irrigation Network starts from the exit of the dam power plant, and its length is approximately 22.5 km. The main canal at the location of the water distribution structure was divided between the left canal (first zone), the right canal or Hamoon (second zone), and the Ordibehesht Canal (third zone).

Because of the geomorphological and geographical situation of the Bakhtegan-Tashk Basin, these three zones are facing the phenomenon of climate change and limited water resources more than other areas of the basin. In addition, by moving from the first to the second and then to the third zone, restrictions on water resource accessibility become more severe. In other words, farmers in the third zone face lower groundwater levels than those in the first and second zones. Accordingly, farmers located in the first, second, and third zones of the Bakhtegan-Tashk Basin are the case study of this study.

Sampling Method and Data Collection

In this study, due to the lack of information about the exact number of farmers, Equation (1) was used to determine the sample size (Teddlie and Yu, 2007; Kanyenji *et al*., 2020; Khan *et al*., 2021) :

$$n = \frac{Z^2 pq}{e^2} = \frac{(1.96)^2(0.5)(0.5)}{(0.0565)^2} \cong 300 \quad (1)$$

Where, n is the sample size, Z is the standard deviation at a 95% confidence interval (approximately 1.96), p is the estimated proportion of an attribute that exists in the population (P= 0.5), q is 1-p and e is the desired level of precision. The sample size for this study was approximately 300 farmers according to the parameters of Equation (1).

In addition, a multi-stage sampling method was used to select farmers in the Bakhtegan-Tashk Basin, which was first classified into three zones with low, moderate, and severe water resources limitation. In the second step, two districts were randomly selected from each zone. In the third step, ten villages were randomly chosen from each district. In the fourth and last step, ten farmers were randomly selected from each village.

[DOI: 10.22034/jast.25.3.521]

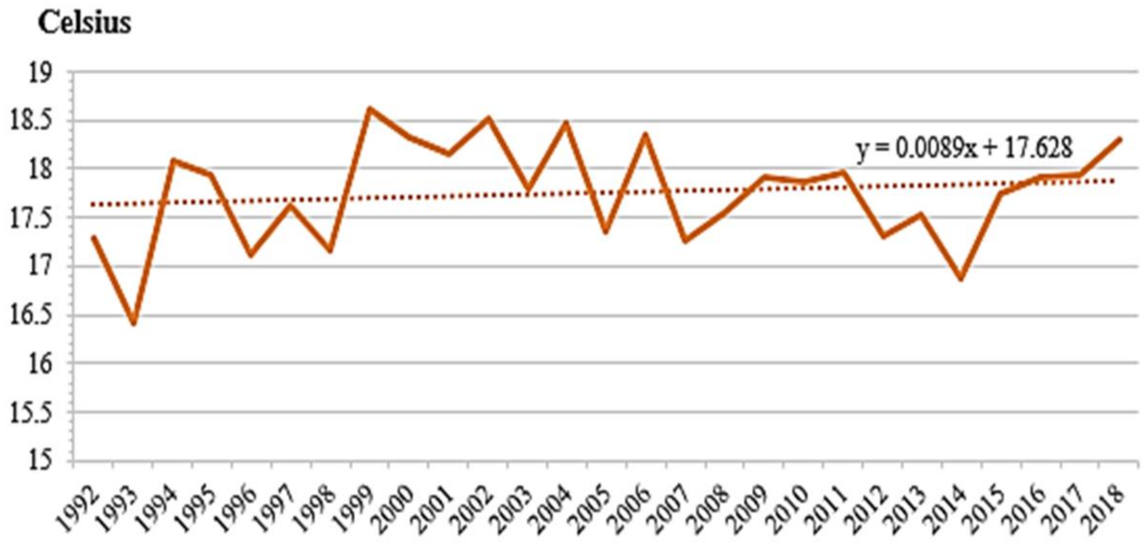

Figure 3. Temperature trend in Bakhtegan-Tashk Basin (IMO, 2019).

In this study, the necessary information was collected from 300 farmers through a structured questionnaire in the 2018-2019 crop year.

Econometric Approach

Through field research and presence in the Bakhtegan-Tashk Basin, several climate change adaptation strategies used by farmers were identified. These adaptation strategies included the use of drip irrigation, conservation tillage, new drought-resistant varieties, livelihood diversification, and water storage pools. According to the literature, the ordered probit model was used to evaluate the intensity of climate change adaptation measures adopted by farmers. The main application of this method is the classification of the dependent variable for more than two categories (Kpadonou *et al.*, 2017; Maguza-Tembo *et al.*, 2017; Teklewold *et al.*, 2019; Piedra-Bonilla *et al.*, 2020; Khan *et al.*, 2021). According to Teklewold *et al*. (2019) and Khan *et al*. (2021), the ordered probit model is expressed as Equation (2):

$$A_{ij} = \chi_i.\beta + u_i \quad (2)$$

Where, *i* and *j* are the farmer and status of the adaptive strategy, respectively. *A* is the dependent variable and is ordinal. If farmer *i* did not adopt the climate change adaptation strategies, A= 1; if farmer adopts 1–2 adaptation measures (Small adaptors), A= 2; If farmer adopts 3–4 adaptation measures (Medium adaptors), A= 3; If farmer adopts more than four adaptation measures (Big or High adaptors), A= 4. In addition, *X* expresses the vector of observable characteristics, including individual, economic, and social characteristics of farmers. Furthermore, β and u represent the estimated and error terms, respectively.

RESULTS AND DISCUSSION

Table 1 shows the different climate change adaptation strategies adopted by farmers in the study area.

Considering the reduction of groundwater reserves and the decrease in rain, the modern irrigation method is an appropriate and necessary strategy for adapting to the existing conditions. Meanwhile, the use of new and modern irrigation systems, especially drip irrigation, is one of the strategies adopted by farmers in the study area to adapt to climate change. According to the results in Table 1, most farmers (50.67%) adopted the drip irrigation method.

[DOI: 10.22034/jast.25.3.521]

Table 1. Adaptation strategies in the study area.

Adaptation strategies	Adoption rate (%)
Modern irrigation system (Drip irrigation)	50.67
Conservation tillage	66.33
improved crop varieties (Drought-resistant crop varieties)	61.67
livelihood diversification	31.67
Water storage pool	27.33

Source: Research findings.

In addition, considering the recent advances in knowledge-based companies and agricultural research centers in the production of new improved crop varieties adapted to the climate of each region, the approach of using drought-resistant crop varieties has been proposed as a suitable adaptive strategy to increase yield, improve crop quality, and adapt to climate change in the study area. According to the results in Table 1, most of the superior farmers (61.67%) adopted the adaptive strategy of using new drought-resistant varieties, whereas 38.33% did not adopt this strategy.

One of the common features of field preparation is traditional tillage operations. The most common of these is the use of moldboard plows, discs, and plant residue management (residue moving, residue incorporated into the soil, and burning). Some of these measures may destroy the physical properties of the soil, and the excessive traffic of farm machinery makes the soil denser. In other words, excessive tillage and reduction of soil organic matter due to the removal of plant residues lead to further degradation of soil, which can be considered a threat to the amount of produced crops and their quality. Therefore, conservation tillage is one of the most important strategies for sustainable field management and adaptation to climate change. In conservation tillage, the previous year’s crop residues are left in the field to conserve soil moisture and nutrients (Bedeke *et al.*, 2019). Plant residue management and crop rotation are important components of conservation tillage (Van Den Putte *et al.*, 2010). According to the results in Table 1, more than 66% of farmers adopted and applied the conservation tilling strategy.

Another adaptive strategy for farmers to have an alternative income in climate change conditions is the ability to combine economic activities or diversify livelihood activities. Table 1 illustrates that about 31.67% of farmers can use various income activities, while nearly 68.33% of them do not have income diversification. Due to the reduction in groundwater amount and water limitation, some farmers constructed a water storage pool to provide an appropriate amount of water during irrigation. According to Table 1, 27.33% of farmers had built a water storage pool, while about 72.68% did not adopt this adaptive strategy.

According to the research literature and related studies in the study area, 13 variables were used in the ordered probit model. The variables reflect the individual, economic, and social characteristics of farmers, which can affect adoption of climate change adaptation strategies. A summary of the descriptive statistics of the variables is presented in Table 2.

According to the results in Table 2, the average age of the sample farmers was approximately 53 years, which indicates a middle-aged population. In addition, the average farmers’ education was about six years, which shows a low level of literacy. According to the sampling data, 79% of farmers did not finish high school, 16% had high school diploma, and 5% had a university degree. The average household size was approximately four people, which shows a moderate population. The average size of farms was about 10.62 hectares and the average income of farmers was about 9.31 million Rials per month, which is a relatively low income. In addition, 51% of farmers owned tractors, 68% of farmers had

[DOI: 10.22034/jast.25.3.521]

Table 2. Data and descriptive statistics of variables.

Variable	Description	Data type	Mean	Std dev
Adaptation strategies				
Drip irrigation	1 if farmer adopted new drought-resistant varieties, 0 otherwise	Binary (1,0)	0.506	0.500
Conservation tillage	1 if farmer adopted conservation tillage, 0 otherwise	Binary (1,0)	0.663	0.473
Drought-resistant varieties	1 if farmer adopted new drought-resistant varieties, 0 otherwise	Binary (1,0)	0.616	0.487
livelihood diversification	1 if farmer adopted having income diversification, 0 otherwise	Binary (1,0)	0.316	0.465
Water storage pool	1 if farmer adopted water storage pool, 0 otherwise	Binary (1,0)	0.273	0.446
Explanatory variables				
Age of farmers	Age of the farmer/household head	Continuous	53	13.272
Farmers' education	Number of years of education of the farmer/household head	Continuous	6.016	3.271
Household size	Number of family members in the household	Continuous	3.786	1.414
Farm size	Farmland holding, ha	Continuous	10.625	8.780
Household's farm income	Household income from all sources, (Rial million/month)	Continuous	9.314	4.523
Tractor ownership	1 if farmer owns a tractor, 0 otherwise	Binary (1,0)	0.510	0.500
Number of crops planted	Total number of crops planted	Continuous	2.573	1.135
Access to credit	1 if farmer accessed credit, 0 otherwise	Binary (1,0)	0.683	0.465
Access to deep well	1 if farmer accessed Tube well, 0 otherwise	Binary (1,0)	0.440	0.497
Depth of well	Depth of well, meter	Continuous	92.738	96.513
Soil quality	1 if farmers have good quality soil, 0 otherwise	Binary (1,0)	0.476	0.500
Access to climate information	1 if farmers had access to the daily climate information, 0 if otherwise	Binary (1,0)	0.400	0.490
Agricultural extension membership	1 if farmer receives advice from agricultural extension organization, 0 otherwise	Binary (1,0)	0.670	0.470

Source: Research findings.

access to agricultural credits and used the relevant facilities. Furthermore, the average number of crops planted by the farmers was approximately three. According to field research, due to the lack of Doroodzan Reservoir water release in canals during the 2018-19 crop year, the water required by farmers was provided through access to groundwater resources. Furthermore, the groundwater level had decreased

[DOI: 10.22034/jast.25.3.521]

significantly, and continuation of agricultural activity depends on the construction of deep wells or increasing the depth of the hand dug wells. According to the results in Table 2, about 44% of farmers have access to deep wells, and the average depth of farmers' wells is approximately 92.7 meters. In addition, about 47% of farmers declared that their soil fertility increased over the long-run (more than a decade). Also, about 67% of farmers were served by agricultural extension agents, and about 40% of farmers were informed of daily climate information through the internet, television, and radio.

Then, an ordered probit model was used to evaluate the individual, economic, and social characteristics of the intensity of adaptation strategies. The results of the ordered probit model are presented in Table 3.

According to the results of the marginal effects in Table 3, with a 1% increase in the income of a household, farmers are 27% more likely to be the high adaptors, and 20.2 and 16.5% less likely to be small and non-adaptors, respectively. Also, with a 1% increase in access to credit, 9.1% are more likely to be high adaptors, while 5.5% are less likely to be non-adaptors compared to those who do not have access to credit. Therefore, an increase in household income and access to credit, which creates more investment opportunities, reduces the probability of non-adaptors and small adaptors of climate change adaptation strategies. Also, an increase in household income and access to credit could increase the probability of medium adaptation and especially high adaption to climate change strategies. These results are in line with those reported by Khan *et al.* (2021), who found that off-farm income and access to credit services had a significant effect on adopting climate change adoption strategies in Pakistan. Also, Ali and Erenstein (2017) found that household income and access to credit were positively associated with the number of climate change adaptation strategies in Pakistan.

The results of Table 3 show that farmers who cultivate several crops in one year are more intensely adapted to climate change. Marginal effects showed that with one crop increase in cultivated crops, farmers are 10.2% more likely to be in the category of high adaptors, while 7.6 and 6.2% were less likely to be in the low and non-adopters category, respectively. In other words, multi-crop cultivation increases the probability of farmers being medium climate change adaptors, especially high climate change adaptors. According to the results, with a 1% increase in access to deep well, farmers are 28.4% more likely to be the high adaptors, and 21.2 and 17.3% less likely to be low and non-adaptation, respectively. Therefore, having a deep well and, consequently, more water facilities increase the probability of climate change strategies adoption in medium and high adaptors. These results are consistent with Wollni *et al.* (2010), who found a significant positive effect of access to irrigation and river on the number of soil conservation strategies in the Honduran hillsides. Also, Khan *et al.* (2021) reported that tube-well ownership for irrigation and access to canal water has a significant positive correlation with climate change adoption strategies in a rice-growing zone of Pakistan.

Table 3 findings illustrate that the probability of climate change adaptation for farmers who have good soil quality is very low. Accordingly, good soil quality and, consequently, more soil fertility increase the probability of non-adaptation and, especially, low adaptation strategies. In contrast, good soil fertility reduces the probability of medium adaptation and high adaptations of climate change adaptation strategies. These results are in line with Wollni *et al.* (2010) findings, which revealed that the natural conditions of farms such as slope and soil quality have a positive relationship with the number of soil conservation strategies in the Honduran hillsides.

[DOI: 10.22034/jast.25.3.521]

Table 3. The results of the ordered probit model.[a]

Variable	Coefficient	Std error	Non-adaption		Small adaptors		Medium adaptors		Big adaptors	
			Marginal effects	Std error	Marginal effects	Std error	Marginal effects	Std. Error	Marginal effects	Std error
Age of farmer	-0.014	0.008	0.002	0.001	0.003	0.001	-0.001	0.0009	-0.004	0.002
Farmers' education	0.010	0.028	-0.001	0.005	-0.002	0.006	0.001	0.002	0.003	0.008
Household size	-0.090	0.068	0.016	0.012	0.019	0.015	-0.009	0.007	-0.026	0.020
Farm size	-0.009	0.011	-0.001	0.002	-0.002	0.002	0.001	0.001	0.002	0.003
Household's farm income	0.927***	0.221	-0.165***	0.045	-0.202***	0.057	0.096***	0.035	*** 0.270	0.064
Tractor ownership	-0.036	0.212	0.006	0.037	0.007	0.046	-0.003	0.022	-0.010	0.062
Number of crops planted	0. 351***	0.095	-0.062***	0.018	-0.076***	0.024	0.036***	0.013	*** 0.102	0.028
Access to credit	0.312*	0.174	-0.055*	0.031	-0.068*	0.039	0.032	0.020	0.091*	0.051
Access to deep well	0.972**	0.428	-0.173**	0.079	-0.212**	0.099	0.101*	0.053	0.284**	0.124
Depth of well	-0.0003	0.002	0.00005	0.0003	-0.0006	0.0004	-0.00003	0.0002	- 0.00009	0.0006
Soil quality	-0.527***	0.199	0.094**	0.037	0.115**	0.046	-0.055**	0.025	-*** 0.154	0.058
Access to climate information	0.136	0.210	-0.024	0.037	-0.029	0.046	0.014	0.022	0.039	0.061
Agricultural extension membership	0.691***	0.177	-0.123***	0.035	-0.151**	0.044	0.072***	0.026	*** 0.202	0.052
Hamoon District	0.478**	0.216	-0.085**	0.040	-0.104**	0.049	0.050*	0.026	0.139**	0.063
Ordibehesht District	-0.254	0.208	0.045	0.037	0.055	0.046	-0.026	0.022	-0.074	0.061
Log likelihood= -263.845 LR Chi Square= 282.80*** Prob> Chi Square= 0.000 Number of observations= 300										

[a] Non-adapters= Farmers who adopted no adaptation measure; Small adapters= 1–2 adaptation measures; Medium adapters= 3–4 adaptation measures; Big adapters= more than four adaptation measures.
***, **, and *: Represent significance at the 1 %, 5 %, and 10% levels, respectively.

Also, the results show that, by participating in agricultural extension programs, more awareness level increases the probability of climate change strategies adoption in medium and high adaptors. In other words, with a 1% increase in access to extension agents, farmers are 20.2% more likely to be in the category of high adaptors, while 15.1 and 12.3% less likely to be low and non-adapters, respectively. These results are consistent with various studies such as Ali and Erenstein (2017), Kpadonou *et al.* (2017), and Khan *et al.* (2021). They found that the number of climate change adaptation strategies used by farmers was positively associated with access to extension services or farm advisory services.

The results in Table 3 show that farmers living in the second district had a significant effect on climate change adaptation . In other words, more restrictions on water resource accessibility reduce the probability of non-adaptation and low adaptation strategies, and in contrast, increases the probability of medium adaptation and especially high adaptation strategies. These results are in line with Ali and Erenstein, (2017) that found the significant effect of the province on the number of climate change adaptation strategies in Pakistan.

CONCLUSIONS

Considering the negative effect of climate change on atmospheric precipitation in the Bakhtegan-Task Basin, continuing agricultural production requires the adoption of climate change adaptation strategies. In the Bakhtegan-Tashk Basin, adaptation strategies include the use of drip irrigation, construction of a water pool, use of new drought-resistant varieties, application of conservation tillage, and a variety of livelihood activities that are used by the farmers. Therefore, in the present study, individual, economic, and social characteristics affecting the intensity of climate change adaptation strategies in the Bakhtegan-Tashk Basin were evaluated using the ordered probit model.

The results showed that farmers' guidance by agricultural extension agents had a positive effect on the intensity of adaptation strategies. In general, farmers' decision to adopt climate change adaptation strategies depends on a proper understanding of the benefits of these strategies, their adaptation capacity, and ease of implementation. Considering the significant role of agricultural extension classes in increasing farmers' knowledge and technical information, it is suggested that climate change concepts and climate change adoption strategies should be taught in agricultural extension classes. In addition, by adopting supportive policies and financial incentives, the necessary incentives should be provided for the formation of social institutions by the local farmers themselves.

The results demonstrated that access to credits and the amount of income had a significant positive effect on the adoption of adaptation strategies and the intensity of climate change adaptation strategies. In other words, the higher the income levels, the greater the possibility of investing in the application of multiple adaptive strategies. Due to the lack of agricultural financial market development in Iran, the low-income level of farmers, and the disproportionate time of repayment of loans with the type of agricultural activity, there are several challenges to meeting farmers' financial needs. Therefore, it is suggested that by amending financial laws to support small farmers and provide the necessary facilities in the shortest possible time, it is possible to invest more in implementing adaptive strategies. Also, by improving the business environment in rural areas, income diversification, and more financial resources, investment in various adaptive strategies increases.

As stated above, the most important limitation of farmers at the Bakhtegan-Tashk Basin level is the lack of proper access to the required water. According to the results of this study, access to deep wells has a positive effect on the intensity of adaptation to climate change. Hence, continuation of agricultural activity by farmers in many areas of the Bakhtegan-Tashk Basin requires access to

[DOI: 10.22034/jast.25.3.521]

deep wells. According to the increasing rate of groundwater use in Iran, the level of groundwater resources and their changes in the basin area should be constantly monitored and controlled. Hence, it is also recommended that all water wells must be equipped with smart meters for determining the optimal contribution of water to each agricultural activity in accordance with the regional cropping pattern. In addition, water markets and water trade among farmers are other solutions for mitigating groundwater depletion in the study area. Based on the positive effect of multi-crop cultivation on the intensity of climate change adaptation, it is suggested that different crops suitable for the region but with lower water requirements are included in the cropping pattern.

One of the main limitations of the present study is the lack of access to time series data over the long- run. Access to the farmer conditions and farm data over a long period can provide a better assessment of the effects of socio-economic variables on the adoption of climate change strategies. Therefore, future studies should use panel data instead of cross-section data to analyze the effect of different variables on the adoption of climate change strategies.

REFERENCES

1. Alhassan, H. 2020. Farm Households' Flood Adaptation Practices, Resilience and Food Security in the Upper East Region, Ghana. *Heliyon*, **6(6):** e04167.
2. Alhassan, H., Kwakwa, P. A. and Adzawla, W. 2019. Farmers Choice of Adaptation Strategies to Climate Change and Variability in Arid Region of Ghana. *Rev. Agric. Appl. Econ. (RAAE)*, **22(1):** 32-40.
3. Ali, A. 2017. Coping with Climate Change and Its Impact on Productivity, Income, and Poverty: Evidence from the Himalayan Region of Pakistan. *Int. J. Disaster Risk Reduct.,* **24:** 515-525.
4. Ali, A. and Erenstein, O. 2017. Assessing Farmer Use of Climate Change Adaptation Practices and Impacts on Food Security and Poverty in Pakistan. *Clim. Risk Manag.,* **16:** 183-194.
5. Ali, A., Rahut, D. B. and Mottaleb, K. A. 2018. Improved Water-Management Practices and Their Impact on Food Security and Poverty: Empirical Evidence from Rural Pakistan. *Water Policy*, **20(4):** 692-711.
6. Al-Mulali, U. and Ozturk, I. 2015. The Effect of Energy Consumption, Urbanization, Trade Openness, Industrial Output, and the Political Stability on the Environmental Degradation in the MENA (Middle East and North African) Region. *Energy,* **84:** 382-389.
7. Amare, A. and Simane, B. 2017. Determinants of Smallholder Farmers' Decision to Adopt Adaptation Options to Climate Change and Variability in the Muger Sub Basin of the Upper Blue Nile Basin of Ethiopia. *Agric. Food Secur.*, **6(1):** 64.
8. Amare, A. and Simane, B. 2017a. Assessment of Household Food Security in the Face of Climate Change and Variability in the Upper Blue-Nile of Ethiopia. *J. Agric. Sci. Technol. B,* **7:** 285-300.
9. Amare, A. and Simane, B. 2018. Does Adaptation to Climate Change and Variability Provide Household Food Security? Evidence from Muger Sub-Basin of the Upper Blue-Nile, Ethiopia. *Ecol. Process.*, **7(1):** 13.
10. Barros, V. R. and Field, C. B. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Cambridge University Press.
11. Bedeke, S., Vanhove, W., Gezahegn, M., Natarajan, K. and Van Damme, P. 2019. Adoption of Climate Change Adaptation Strategies by Maize-Dependent Smallholders in Ethiopia. *NJAS-Wageningen J. Life Sci.*, **88**: 96-104.
12. Chandio, A. A., Ozturk, I., Akram, W., Ahmad, F. and Mirani, A. A. 2020. Empirical Analysis of Climate Change Factors Affecting Cereal Yield: Evidence from Turkey. *Environ. Sci. Pollut. Res.,* **27(11):** 11944–11957 .
13. De Medeiros Silva, W. K., de Freitas, G. P., Junior, L. M. C., de Almeida Pinto, P. A. L.

[DOI: 10.22034/jast.25.3.521]

and Abrahão, R. 2019. Effects of Climate Change on Sugarcane Production in the State of Paraíba (Brazil): A Panel Data Approach (1990–2015). *Clim. Change*, **154(1-2):** 195-209.

14. Esfandiari, M., Khalilabad, H. R. M., Boshrabadi, H. M. and Mehrjerdi, M. R. Z. 2020. Factors Influencing the Use of Adaptation Strategies to Climate Change in Paddy Lands of Kamfiruz, Iran. *Land Use Policy*, **95:** 104628.
15. Global Economy. 2021. Business and economic data for 200 countries. https ://www.theglobaleconomy.com /. Accessed 23 June 2021.
16. Hoegh-Guldberg, O., Mumby, P. J., Hooten, A.J, Steneck, R. S, Greenfield, P., Gomez E., Harvell, C. D., Sale P. F., Edwards, A. J., Caldeira, K., Knowlton, N., Eakin, C. M., Iglesias-Prieto, R., Muthiga, N., Bradbury, R.H., Dubi, A. and Hatziolos, M. E. 2007. Coral Reefs under Rapid Climate Change and Ocean Acidification. *Science,* **318**: 1737-1742.
17. IMO. 2020. Ministry of Roads and Urban Development, Iran Meteorological Organization.https ://www.irimo.ir /. Accessed 27 May 2020.
18. Jabbar, A., Wu, Q., Peng, J., Zhang, J., Imran, A. and Yao, L. 2020. Synergies and Determinants of Sustainable Intensification Practices in Pakistani Agriculture. *Land*, **9(4):** 110.
19. Jahangirpour, D. and Zibaei, M. 2022. Cropping Pattern Optimization in the Context of Climate-Smart Agriculture: A Case Study for Doroodzan Irrigation Network- Iran. *J. Agric. Econ. Dev.,* **35(4):** 407-422.
20. Jha, C. K., and Gupta, V. 2021. Farmer’s Perception and Factors Determining the Adaptation Decisions to Cope with Climate Change: An Evidence from Rural India. *Environ. Sust. Indic.*, **10:** 100112.
21. Kanyenji, G. M., Oluoch-Kosura, W., Onyango, C. M. and Karanja Ng'ang'a, S. 2020. Prospects and Constraints in Smallholder Farmers' Sdoption of Multiple Soil Carbon Enhancing Practices in Western Kenya. *Heliyon*, **6(3):** e03226.
22. Kassie, M., Teklewold, H., Jaleta, M., Marenya, P., and Erenstein, O. 2015. Understanding the Adoption of a Portfolio of Sustainable Intensification Practices in Eastern and Southern Africa. *Land Use Policy*, **42**: 400-411.
23. Khalili A., and Rahimi J. (2018) Climate. In: “*The Soils of Iran*”, (Eds.): Roozitalab, M., Siadat, H. and Farshad, A. World Soils Book Series, Springer, Cham.
24. Khan, N. A., Qiao, J., Abid, M. and Gao, Q. 2021. Understanding Farm-Level Cognition of and Autonomous Adaptation to Climate Variability and Associated Factors: Evidence from the Rice-Growing Zone of Pakistan. *Land Use Policy*, **105:** 105427.
25. Khanal, U. and Wilson, C. 2019. Derivation of a Climate Change Adaptation Index and Assessing Determinants and Barriers to Adaptation among Farming Households in Nepal. *Environ. Sci. Policy*, **101:** 156-165.
26. Kiani, T., Ramesht, M. H., Maleki, A. and Safakish, F. 2017. Analyzing the Impacts of Climate Change on Water Level Fluctuations of Tashk and Bakhtegan Lakes and Its Role in Environmental Sustainability. *Open J. Ecol.,* **7(2):** 158-178.
27. Kpadonou, R. A. B., Owiyo, T., Barbier, B., Denton, F., Rutabingwa, F., and Kiema, A. (2017). Advancing Climate-Smart-Agriculture in Developing Drylands: Joint Analysis of the Adoption of Multiple On-Farm Soil and Water Conservation Technologies in West African Sahel. *Land Use Policy*, **61**: 196-207.
28. Kurukulasuriya, P., Mendelsohn, R., Hassan, R., Benhin, J., Deressa, T., Dip, M., Fosu, K. Y., Jain, S., Mano, R., Molua, E., Ouda, S., Sene, I., Seo, S. N. and Dinar, A. 2006. Will African Agriculture Survive Climate Change?. *World Bank Econ. Rev.*, **20(3):** 67-88.
29. Maguza-Tembo, F., Mangison, J., Edris, A. K. and Kenamu, E. 2017. Determinants of Adoption of Multiple Climate Change Adaptation Strategies in Southern Malawi: An Ordered Probit Analysis. *J. Dev. Agric. Econ.*, **9(1):** 1-7.
30. Mesgaran, M., Madani, K., Hashemi, H. and Azadi, P. 2016. *Evaluation of Land and*

[DOI: 10.22034/jast.25.3.521]

Precipitation for Agriculture in Iran. Stanford Iran 2040 Project, Encina Hall East, Room E017, Stanford University, Stanford, CA 94305-6055.

31. Mulugeta, M., Tiruneh, G., and Alemu, Z. A., 2018. Magnitude and Associated Factors of Household Food Insecurity in Fedis Woreda East Hararghe Zone, Oromia Region, Ethiopia. *Agr. Food Secur.*, ***7*(3)**: 1-8.
32. Piedra-Bonilla, E. B., da Cunha, D. A. and Braga, M. J. 2020. Climate Variability and Crop Diversification in Brazil: An Ordered Probit Analysis. *J. Clean. Prod.,* **256:** 120252.
33. Salazar, C. and Rand, J. 2016. Production Risk and Adoption of Irrigation Technology: Evidence from Small-Scale Farmers in Chile. *Latin Am. Econ. Rev.,* **25(1):** 2.
34. Sileshi, M., Kadigi, R., Mutabazi, K. and Sieber, S. 2019. Impact of Soil and Water Conservation Practices on Household Vulnerability to Food Insecurity in Eastern Ethiopia: Endogenous Switching Regression and Propensity Score Matching Approach. *Food Secur.*, **11(4):** 797-815.
35. Tarazkar, M. H., Dehbidi, N. K., Ansari, R. A. and Pourghasemi, H. R. 2021. Factors Affecting Methane Emissions in OPEC Member Countries: Does the Agricultural Production Matter?. *Environ. Dev. Sust.*, **23(5):** 6734-6748.
36. Teddlie, C. and Yu, F. 2007. Mixed Methods Sampling: A Typology with Examples. *J. Mix. Methods Res.,* **1(1):** 77-100.
37. Teklewold, H., Mekonnen, A. and Kohlin, G. 2019. Climate Change Adaptation: Astudy of Multiple Climate-Smart Practices in the Nile Basin of Ethiopia. *Clim. Dev.,* **11(2):** 180-192.
38. Uddin, M. N., Bokelmann, W. and Entsminger, J. S. 2014. Factors Affecting Farmers' Adaptation Strategies to Environmental Degradation and Climate Change Effects: A Farm Level Study in Bangladesh. *Climate*, ***2*(4):** 223-241.
39. Van den Putte, A., Govers, G., Diels, J., Gillijns, K. and Demuzere, M. 2010. Assessing the Effect of Soil Tillage on Crop Growth: A Meta-Regression Analysis on European Crop Yields under Conservation Agriculture. *Eur. J. Agron.*, **33(3):** 231-241.
40. Wangchuk, S. and Siebert, S. F. 2013. Agricultural Change in Bumthang, Bhutan: Market Opportunities, Government Policies, and Climate Change. *Soc. Nat. Resour.*, **26(12):** 1375-1389.
41. Wollni, M., Lee, D. R. and Thies, J. E. 2010. Conservation Agriculture, Organic Marketing, and Collective Action in the Honduran Hillsides. *Agric. Econ.*, **41(3-4):** 373-384.
42. Wossen, T., Berger, T., Haile, M. G., and Troost, C. 2018. Impacts of Climate Variability and Food Price Volatility on Household Income and Food Security of Farm Households in East and West Africa. *Agric. Syst.,* **163:** 7-15.

[DOI: 10.22034/jast.25.3.521]

شدت تطبیق با تغییر اقلیم در حوضه آبریز بختگان- طشک، ایران

ن. کارگر ده‌بیدی، م. زیبایی، و م. ح. طرازکار

چکیده

اتخاذ ترکیبی از استراتژی‌های تطبیق با تغییرات اقلیم، مهم ترین راه‌حل به‌منظور کاهش پیامدهای منفی تغییرات اقلیم است. از این‌رو، در پژوهش حاضر، ویژگی‌های اقتصادی و اجتماعی مؤثر بر شدتِ استراتژی‌های تطبیق با تغییر اقلیم در حوضه بختگان-طشک واقع در ایران با استفاده از مدل پروبیت ترتیبی مورد بررسی قرار گرفت. در مجموع ۳۰۰ کشاورز با استفاده از روش نمونه‌گیری چند مرحله‌ای انتخاب شدند. نتایج نشان داد که سطح درآمد خانوار، دسترسی به اعتبارات، در دسترس بودن آب آبیاری، تعداد محصولات زراعی و دسترسی به خدمات ترویج کشاورزی تأثیر مثبت و معناداری بر شدت تطبیق با تغییر اقلیم دارد. بنابراین، پیشنهاد می‌شود که دولت با افزایش مشوق‌های مالی، امکان استفاده از انواع استراتژی‌های تطبیقی با تغییر اقلیم را تسهیل نماید. همچنین توصیه می‌شود که الگوی کشت با کاشت محصولاتِ متناسبِ منطقه و با نیاز آبی کم تغییر کند.

[DOI: 10.22034/jast.25.3.521]