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Determinants of farmers' adaptation decisions under changing climate: the case of Fars province in Iran

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Abstract
Climate change is a serious concern for the agricultural sector given that this sector is highly dependent on climate conditions. Moreover, farmers adaptation process under changing climate can be explained by the psychological factors and the incorporation of socio-environmental background. Therefore, the current study aimed at socio-cognitive perceptions and extended protection motivation theory (PMT) as the basis. This paper estimated the influence of cognitive factors on individuals views and decisions regarding climate change adaptation. Data from this study came from a survey with 245 rural farmers in temperate mount areas of Fars province, Iran. Structural equation modeling (SEM) was used to estimate the different factors. Results showed that three core elements of the theory, namely, risk evaluation, adaptation evaluation, and maladaptation, were the statistically significant factors that could directly explain farmers adaptation decisions to adopt appropriate coping strategies under changing climate. Findings also suggested that another structural factor, adaptation incentives, had a statistically significant influence on adaptation decision-making among farmers. The study proposed valuable insights on social discourse to promote adaptation. Findings strongly offered that social discourse should focus more strongly on confirming the truth and timeliness of information that individuals gained. Eventually, further investigations are necessary to conduct the measurement model in other cultures and geographical areas and see how socio-environmental components can influence risk evaluation and adaptation evaluation.

Keywords Coping strategies · Maladaptation · Protection motivation theory · Structural equation modeling · Temperate mount areas

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1 Introduction

One of the most important sectors that are immediately affected by changes in climate conditions is agriculture (Chen et al., 2016; Bocchiola et al., 2019). Climatic effects on this sector include the loss in both quantity and quality of food. For example, projected rises in temperature, changes in rainfall patterns, and severe climatic events may lead to lower agricultural productivity (Hasegawa et al., 2018). Some farmers may go for coping strategies which can decrease disadvantageous progress and take benefits of emerging opportunities under changing climate. Thus, such farmers take adaptation decisions (Delfiyan et al., 2020; Neisi et al., 2020; Pakmehr et al., 2020a; Pakmehr et al., 2020b), which can take place at different levels, like local or higher scales, and adaptation decisions may be taken in different spheres, like private or public measures (Kaplan-Hallam and Bennett, 2017).

Other farmers may avoid adopting the coping strategies, so it leads to a lack of adaptation, known as maladaptation (Sousa et al., 2018; Azadi et al., 2019a). Maladaptation is a process that leads to increased vulnerability to climate change, and it can directly undermine capacities or opportunities for present and future adaptation (Flórez Bossio et al., 2019).

Farmers adaptation decisions, like other behaviors, are based on socio-cognitive processes (SCP) that relate to perceiving other people in surrounding environment. The SCP is involved in understanding, remembering, thinking about, and joining other people in the social world. The processes are mental operations of thought that help adapt to the environment. The SCP believes that human cognition is conditioned on the wider socio-environmental background, which may vary by spatio-temporal profiles of cases (Grothmann and Patt, 2005; Kastanakis and Voyer, 2014; Mitter et al., 2019).

According to the SCP for adaptation under the changing climate in the agricultural sector, farmers adaptation decisions are taken at local levels. Therefore, socio-environmental backgrounds, e.g., social institution support, values and norms, geographical attributes, and climatic phenomena, are emphasized to react to the changing climate (Mitter et al., 2018). In line with this background, different studies investigated the SCP for farmers cultivating crops in various cultures and geographical areas, including major farming areas in America (e.g., McClaran et al., 2015; Arbuckle et al., 2015; Eakin et al., 2016; Roesch-McNally et al., 2017), Europe (Alcon et al., 2014; Woods et al., 2017), Asia (Dang et al., 2014; Truelove et al., 2015; Arunrat et al., 2017; Burnham and Ma, 2017), Africa (Mulenga et al., 2017), Australia and New Zealand (Niles et al., 2016; Sanderson and Curtis, 2016), and Oceania (Kuruppu and Liverman, 2011). For example, Truelove et al. (2015) proposed a risk coping and social assessment model of adaptation intentions of 192 sample farmers in Sri Lanka. Findings showed that the model was a superior predictor of adaptation intentions in the agricultural sector rather than a purely demographic model. The strongest predictors of behavioral intentions were identified as effectiveness faiths, with descriptive norms also systematically relating to intentions. Arbuckle et al. (2015) examined how climatic beliefs differed with Iowa farmers trust in the environmental or agricultural beneficiary community as sources of climatic data. The perceived risks under changing climate had been significantly influenced by climatic beliefs. Finally, perceived climate risks had significant effects on agricultural adaptation support. The structural equation modeling (SEM) was applied to evaluate the relationships among trust, belief, perceived risk, and adaptation support. Sanderson and Curtis (2016) used values, beliefs, and norms theory to assess the relation between climate change risks and execution of coping strategies by multivariate models in the Australian Murray-Darling Basin. Results indicated that there were important factors such as values,

beliefs, and norms to explain climatic risk perceptions that affected coping strategies. Woods et al. (2017) assessed the effect of farmers climate change perceptions, associated risks weights, and the adaptation barriers on their likelihood to undertake coping strategies in Denmark. The study extracted the value and orientation of the cognitive factors supporting farmers adaptation likelihood by descriptive statistics and an ordered probit model. The results on 1053 farmers were not extremely worrying regarding climatic effects and adaptation barriers, but the more concerned farmers were about climate change, the more they were likely to adapt in reaction to negative climatic effects. As stated by evidence-based studies, it is necessary to investigate the SCP in a specific culture and geographical area. Therefore, cultural and geographical components affect farmers risk perception which apprises their adaptation decisions under changing climate (Sanderson and Curtis, 2016).

The current study investigated farmers adaptation decisions under changing climate regarding the psychological factors in temperate mount areas of Fars province, Iran, for several causes. First, climatic effects may menace those farmers more than others because climatic predictions for temperate mount areas are especially unreliable. Farmers uncertainties on climate change occurrence can decline their adaptation decisions and are mostly due to high climate of those areas (Mitter et al., 2019). The second reason is diverse agriculture in temperate mount areas. Regional agriculture provides multiple services including a variety of crops, garden, forage, livestock products, mountain honey, and landscape aesthetics. Those multiple services are linked to other economic sectors, so climatic adaptation in agricultural sector has multi-sectoral effects (Esteve et al., 2015). Third, farmers attitudes toward adaptation are restricted to a tiny district and chosen climate change coping strategies (Probstl-Haider et al., 2016). It is challenging to choose a coping strategy without a critical perception of Iranian farmers risk and adaptation evaluations under changing climate, even if it is claimed that such data could be beneficial to development attempts and the agricultural and climate policy plans (Zobeidi et al., 2016). However, experts working in agricultural administrations understand that Iranian farmers attempts for adaptation are restricted, and climatic threats and opportunities are not entirely directed in various areas (Karimi et al., 2018).

The agricultural sector of Iran is in an early stage of adaptation. Other studies displayed that a lot of coping strategies were applied by farmers in Iran in order to decrease the negative climatic effects (Karimi et al., 2018). Farm production practices have been identified as the most usual coping strategies of farmers adaptive reactions in Iran. Among farm production practices, three coping strategies of reduction of farm area, crop rotation, and diversification of crops have been adopted respectively by 37.1%, 33.4%, and 24% of farm households (Azadi et al., 2019b).

A strategy of microcredit loans is distinguished as a method of farm financial management under the changing climate in Iran. Wealthier households and those having more sensitive agricultural products are more probable to access credits. Among farm financial management strategies, request for financial aid from others has been adopted by 30.9% of farm households (Karimi et al., 2018; Azadi et al., 2019b). Other common types of adaptation to climate change in Iran are government programs applying the science, data, and education provided by agricultural authorities and related agencies and secure agricultural production (Azadi et al., 2019b). The lack of timely climatic adaptation of farmers is obvious even if chosen coping strategies have been recognized as beneficial plans for specific areas, and cooperation among agricultural experts has been strengthened.

For this type of research, the farming area is selected purposefully. Therefore, the research results are of restricted transferability to other cultures and geographical areas. Nevertheless,

the results can be partially translated into agricultural areas that partake in analogous views and norms and are placed in similar socio-environmental areas (Mitter et al., 2019). Hence, it is expected that there will be similar reactions under changing climate in temperate mount areas, where quantifying farmers risk perceptions and adaptation decisions is restricted.

The current study aims to explore the SCP based on protection motivation theory (PMT) influencing rural farmers risk and adaptation evaluations that are anticipated to cause either maladaptation or adaptation. Actually, the PMT has an assumption that threat perception and harm avoidance stimulate farmers to modify their behavior themselves (Floyd et al., 2000). Although the PMT has recently appeared in the field of climatic research in Iran, the theory has succeeded to explain farmers adaptation decisions by psychological factors (Delfiyan et al., 2020; Neisi et al., 2020; Pakmehr et al., 2020a; Pakmehr et al., 2020b). Neisi et al. (2020) determined farmers risk management decisions under the drought condition of Karkheh River in Iran. The PMT was applied to design a causal framework. According to their findings, the PMT could explain about 47% of the management decisions variance. Delfiyan et al. (2020) surveyed farmers coping strategies and factors affecting the selection of coping strategies through the PMT in Dehloran county, located in southwestern Iran. Their results displayed that three elements of perceived adaptive capacity, perceived risks, and perceived adaptation cost had a significant effect on the adaptation decision. Pakmehr et al. (2020a) investigated farmers adaptation decisions on drought due to climate change using the PMT in Shushtar, located in Khuzestan province, Iran. Their findings revealed that the core elements of the PMT computed 39% of farmers adaptation decisions variance. In addition, Pakmehr et al. (2020b) explored the main causes of farmers adaptation decisions to the negative impacts of climate change by the PMT in the southwest of Iran. According to their results, both demand evaluation and self-efficacy were significant factors of farmers adaptation decisions. There are two major lacks in the recent studies with similar topics conducted in Iran: (1) the studies have considered the factors influencing farmers adaptation decisions and did not pay attention to farmers maladaptation, and (2) they focused on core elements of the PMT framework and ignored the socio-environmental background. The novelty of the current study compared to the previous ones is that both adaptation decision and maladaptation have been considered, while other studies disregarded maladaptation. In addition, based on Grothmann and Patt s (2005) theory, the PMT has been extended by socio-environmental components, including risk experience evaluation, trust in national adaptation, social discourse, exact adaptive capacity, and adaptation incentives.

The following research questions are considered to investigate farmers adaptation decisions and maladaptation:

How do rural households perceive and evaluate climatic risk?
To what extent are farmers aware of coping strategies?
How do rural farmers perceive their adaptive capacity?
How are farmers adaptation decisions explained by the core elements of the PMT?
How are socio-environmental components considered in the extended PMT?

2 Conceptual framework

The two cognitive processes of menace and coping assessment form the PMT and have been successfully applied in the context of health behavior for the first time (Rogers and Prentice-

Dunn, 1997). Although the theory is recognized within different scopes of research, climate change investigations have paid less attention to this issue. The PMT was developed to explain farmers adaptation decisions under changing climate. There are two different perceptual processes of the PMT, comprising risk evaluation and adaptation evaluation, whereas the theory neglected the socio-environmental factors (Grothmann and Patt, 2005). The first process evaluates the occurrence probability of climatic phenomena without any changes in individuals behavior. The second process assesses individuals ability to avoid being harmed by climate change, considering the costs of adopting such a coping strategy. The processes of risk evaluation and adaptation evaluation respectively result in specific risk perception and perceived adaptive capacity. Figure 1 demonstrates the framework that is applied to farmers adaptation decisions under changing climate.

Risk evaluation contains two parts: firstly, perceived probability describes the farmers anticipation of being exposed to climatic phenomena, and secondly, perceived intensity illustrates the farmers assessment of how harmful the subsequences of climate change are. After the risk perception process, there is an adaptation evaluation that begins if climate change evaluation exceeds a specific threshold. Adaptation evaluation contains three parts. The first one is the applicability that mentions the farmers perceived ability to execute coping strategies. The second one is the effectiveness that mentions the coping strategies which are effective in protecting farmers under changing climate. The third one refers to perceived adaptation costs that consist of the supposed costs of adopting the coping strategies (Luu et al., 2019; Ghanian et al., 2020). The adaptive reaction costs can comprise money, person, time, endeavor, and expenditures. According to risk and adaptation evaluations, a farmer may choose one of the two decisions, adaptation and maladaptation, under changing climate. If risk evaluation and adaptation evaluation are high, then adaptation decisions are taken (Mitter et al., 2019). Maladaptation is taken when rural households find the implementation of coping strategies ineffective and believe in fate and God as the guardian of their farm. As a consequence, farmers are inadvertently increasing the damage caused by climate change. If risk evaluation is high but adaptation evaluation is low, then maladaptation is taken (Grothmann and Patt, 2005). Moreover, maladaptation has been found to decrease adaptation decisions (Warnatzsch and Reay, 2020).

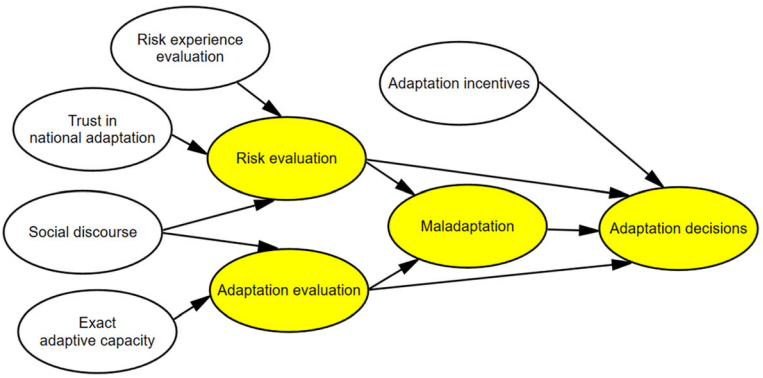

Fig. 1 The extended PMT by socio-environmental context to explain determinants of farmers adaptation decisions under changing climate. The yellow ellipses indicate four core elements of the PMT framework. Source: Grothmann and Patt, 2005

A farmer first makes decisions to adopt coping strategies based on adaptive reactions. This intention is labeled adaptation decisions. In the extended PMT, the two processes of risk evaluation and adaptation evaluation were considered as cognitive processes, and the model was extended by socio-environmental factors (Grothmann and Patt, 2005). Therefore, some other supplementary variables were added to the PMT framework. Risk experience evaluation has an important effect on farmers adaptation decision to adopt appropriate coping strategies under changing climate. This evaluation that evaluates the intensity of a climatic phenomenon experienced in the past positively influences risk perception (Hamilton-Webb et al., 2019). Furthermore, trust in national adaptation is incorporated into the model. If farmers trust the effectiveness of the national adaptation, then they will likely assess smaller climate change risks. The socio-cultural background also influences risk perception and adaptation decisions (Hamilton-Webb et al., 2019). For instance, what my neighbors do or not do may influence what I do next, which in turn will influence what others will do. Thus, friends, relatives, neighbors, media, or public agencies have an important role in farmers risk evaluation and adaptation evaluation. Accordingly, the social discourse that includes social interactions well is taken as an effective factorial construct on risk perception and perceived adaptive capacity. An absence of exact adaptive capacity (e.g., absence of assets such as time, money, knowledge, and institution support) prevents adaptive realization. Therefore, exact adaptive capacity is considered as another determinant of perceived adaptive capacity. Finally, adaptation incentives (e.g., tax decline and beliefs or social norms of adaptation) are comprised as determinants of the adaptation decisions (Grothmann and Patt, 2005).

3 Methodology

3.1 Survey zones, sampling, and data accumulation

The north of Fars province, southwest Iran, contains the south slopes of Zagros Mountains. These areas have two types of climate, cold and temperate. Two counties of Shiraz and Marvdasht, in this district, were identified as temperate mount areas (Keshavarz and Karami, 2016). Figure 2 displays geographical locations of survey zones. The study zone has a total area of 4890 km^2. The population of the rural areas is 74,350. The main rural livelihood is based on agricultural activities. Approximately, 67,400 ha of the total surface are arable lands in which wheat, barley, corn, and rice are cultivated as the main crops. The average size of the farm is about 5 ha per household, in which most farmers have a modern irrigation system (sprinkler). The study area has relatively cold winters with rainfall and relatively warm summers. The rainfall in this area is between 200 and 400 mm/year. Such climate lowers the probability of farmers perception of changing climate.

A multi-stage cluster sampling procedure was applied to choose farmers who live in temperate mount areas in Fars province, Iran. The sample measure was calculated based on the relevant formula suggested by Scheaffer et al. (1979). Initially, the plains located in temperate mount areas were determined according to the climatological table of Fars province (Keshavarz and Karami, 2016). The name and geographical location of survey zones have been shown in Fig. 2. Then, an appropriate number of villages have randomly been chosen from the two plains. In the last step, an appropriate random sample of farm households has been chosen in every village. Altogether, survey zones consisted of 11 villages. The ultimate sample also included 245 rural households. The investigation of farmers adaptation decisions

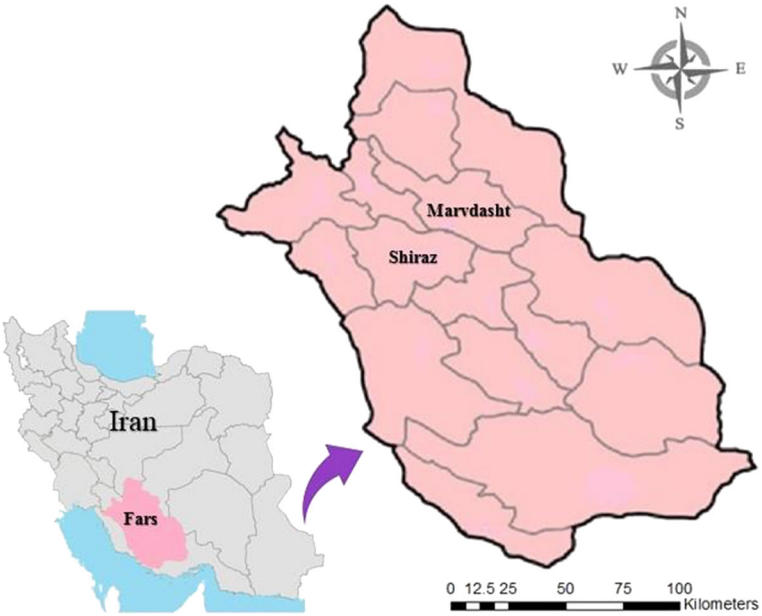

Fig. 2 Geographical locations of survey zones in Fars province, Iran

to deal with climate change was conducted by survey research and face to face interviews from November 2019 to February 2020. Required data were accumulated by a semi-structured questionnaire made for the current study.

3.2 Variable evaluation and SEM process

The SEM was applied to quantify the interacting relationship between structures. However, the attention was on the core elements of the PMT, and the effects of more factorial constructs on farmers adaptation decisions were surveyed, too. There are nine structures in the whole model, including risk evaluation, adaptation evaluation, maladaptation, risk experience evaluation, trust in national adaptation, social discourse, exact adaptive capacity, adaptation incentives, and adaptation decisions (Fig. 1).

The perceived climatic risks evaluated risk evaluation through five aspects of rural households lives, including health, finance, production, socio-relations, and psychology. Sample farmers were inquired to what extent they perceived that climate change risks can affect each aspect of their lives. The questions consisted of the probability and the intensity of climatic effects according to seven dot levels. By multiplying the relevant probability and the intensity of each aspect, the risk evaluation has been evaluated (Dowling, 1986; Grothmann and Patt, 2005; Grothmann and Reusswig, 2006; Dang et al., 2012; Dang et al., 2014). Applicability and effectiveness of coping strategies that were perceived by farmers were used to assess adaptation evaluation. Chiefly, farmers were inquired to what extent they perceived that each coping strategy can be applicable and effective, according to seven dot levels (Grothmann and Patt, 2005; Grothmann and Reusswig, 2006; Dang et al., 2012; Dang et al., 2014). The perceived adaptation cost was eliminated from adaptation evaluation according to small factor loading on this construct. To increase farmers resilience under changing climate, nine coping strategies

were implemented in the study area. Informant experts from the Agricultural Department were consulted to know about coping strategies. In addition, an open-ended question of adaptation decisions was designed to address all the coping strategies in the questionnaire. Farmers have executed coping strategies to manage future climatic risks. The selection of such coping strategies can increase farmers potentials to reduce economic, environmental, and social losses in the future. In this regards, four management classes were defined for nine coping strategies as follows:

1) Farm management that includes changing timing of irrigation (A1), changing timing of fertilizer use (A2), changing timing of chemical use (A3), crop diversity (A4), and crop rotation (A5)
2) Water management that covers investing in water storage (A6) and changing water use practices (A7)
3) Livelihood management that contains changing from traditional livelihood to semi-industrialization (A8)
4) Diversification management that incorporates diversifying income earning activities (A9).

Changing from traditional to semi-industrial livelihood is a management approach that can ensure the sustainability of agricultural production under changing climate (Gao et al., 2018). The livelihood management approach can be implemented through plastic mulching on farms (Mo et al., 2017; Yu et al., 2018). Plastic mulch is a product used, in a similar process to mulch, to preserve water in crop production. Crops grow through holes in thin plastic sheeting. Plastic mulch is often used in conjunction with drip irrigation. In addition, diversification of income earning activities can lead to activities that are less sensitive to climate change (Call et al., 2019). For example, handicraft activities are not sensitive to climatic variables such as rainfall and temperature and can be a source of income for farmers.

In addition, the dynamics of farmers adaptation serve as a concept defined as the ability of farmers to adapt to climate change over time. Adaptation decisions can thus be indicated as a dynamic process in time (Robert et al., 2016). In the current study, the dynamics of farmers adaptation were analyzed by an anthropological approach that refers to studying long-term adaptation decisions of farmers (Kabir et al., 2017). Dynamic factor models are flexible models for multivariate time series in which the endogenous variables are linear functions of exogenous covariates, which can capture dynamics (Chen et al., 2020). The dynamic factor models need time series data, but the current study is based on cross-sectional data. To solve this limitation, adaptation dynamics were captured by the questionnaire that considered farmers adaptation decisions in the present and future. However, other questions were designed based on perceptions, experiences, and evaluations in the past. Table 1 demonstrates the measurement of each construct used in the model based on seven dot levels that were arrayed from one (not at all) to seven (extremely high).

Factor analysis based on principal component analysis (PCA) was applied to load factorial construct from individual items. For example, a PCA of the risk experience evaluation showed that risk experience on products and risk experience on farm household members loaded together on the factor. The indicator of convergent accuracy was considered as the average variance extracted (AVE). If the indicator is more than half, then it indicates sufficient convergence (Hair et al., 2010).

The specification and test of structural equations can linearly be performed by the SEM, and the estimation of their parameters can simultaneously be accomplished (Grace et al.,

Table 1 Measurement of factorial construct

Factorial construct	Variables description	Subvarieties
Risk experience evaluation	To what extent do farmers experience climatic phenomena damaging	Products? Household members?
Trust in national adaptation	To what extent do the government	Provided disaster warning information? Applied appropriate actions, like agriculture insurance?
Social discourse	To what extent do farmers perceive that	Climate change is actually happening since the media and public agencies have mentioned it? Farmers livelihood will be affected by climate change since their friends, relatives, and neighbors believed in it? A coping strategy should be conducted since their friends, relatives, and neighbors took it?
Exact adaptive capacity	To what extent do farmers have resources like	Time? Money? Knowledge? Institution support?
Adaptation incentives	To what extent do	Decreasing energy prices influenced farmers adaptation decisions? Supporting farmers coping strategies influenced farmers adaptation decisions?
Risk evaluation	To what extent do farmers perceive that climatic risk affects	Health? Finance? Production? Socio-relations? Psychology?
Adaptation evaluation	To what extent do farmers perceive that	A1 is applicable and effective? A2 is applicable and effective? A3 is applicable and effective? A4 is applicable and effective? A5 is applicable and effective? A6 is applicable and effective? A7 is applicable and effective? A8 is applicable and effective? A9 is applicable and effective?
Maladaptation	To what extent do farmers agree that	It is not essential to apply coping strategies since they do not work? Everything is determined by fate? God will keep safe their farms?
Adaptation decisions	To what extent do farmers decide to execute	A1 in the present and future? A2 in the present and future? A3 in the present and future? A4 in the present and future? A5 in the present and future? A6 in the present and future? A7 in the present and future? A8 in the present and future? A9 in the present and future?

Source: Dang et al., 2014

2012). The SEM is distinguished by different typical features in comparison to other statistical methods. The model designs a frame to learn causal processes (Byrne, 2013). This model also

assesses direct and indirect results (Grace, 2006). In the end, the model represents its procedures graphically and mathematically (Pearl, 2009). The SEM pursues the main stages of identifying and estimating the model. The whole procedure was manipulated by IBM SPSS Amos 20 package.

Sets of equations have simultaneously constructed the SEMs (Grace, 2006). Designing the theoretical framework is considered as the first step of the modeling process (Savalei and Bentler, 2010); then the assumptions are regarded as relations among variables. Creating a hypothesis is linked to model identification that is done by diagrams or simultaneous equations (Bowen and Guo, 2011). Linear regression among two variables indicates a direct effect. For instance, risk evaluation and adaptation evaluation have a direct effect on adaptation decisions and maladaptation, based on hypotheses (Fig. 1). Maladaptation has a direct effect on adaptation decisions, too. Therefore, risk evaluation and adaptation evaluation also have indirect effects on adaptation decisions. Finally, the total effects of risk evaluation and adaptation evaluation on adaptation decisions have been evaluated.

For model estimation, a correlation matrix is suggested by the SEM (Markus, 2012). Several statistical measures assess the fitness of models. These measures consist of checking an individual parameter (t test) and an entire model (chi-square). Unstandardized and standardized regressions of coefficients are also generated by estimating the model. R squared of the model displays what percent of variance in dependent variable has been explained by independent variables.

4 Results

4.1 Climate change risk, rural farmers' awareness, and coping strategies applicability

The studied farmers included rural household heads. Gathered data indicates that respondents perceived climate change risk differently in five aspects (Fig. 3). No one among the rural farmers stated that climate change had not affected health, finance, production, and socio-relations at all. Just 2% of them expressed no risk in the psychology aspect at all. More than 20% of farmers declared that climate change influences extremely high in five different aspects.

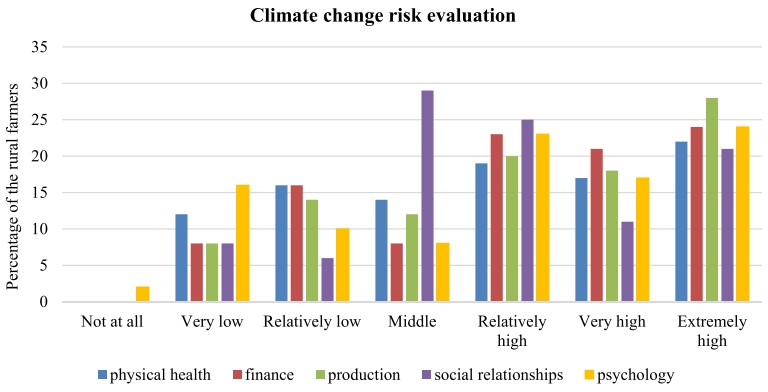

Fig. 3 The percentage of the rural farmers who perceived climatic risks in five aspects

The percentage of rural farmers who were aware of different types of coping strategies is shown in Fig. 4. More than 90% of rural households are aware of the various coping strategies of farm management, water management, and livelihood management. Furthermore, most farmers (85%) are aware of diversification management. However, all the coping strategies were not applied effectively by the farmers. Figure 5 indicates farmers perception toward the effective applicability of different types of coping strategies. A1 was adopted by farmers at different levels. About 20% of the rural households changed their timing of irrigation in both middle and very low levels. Furthermore, 9% of the farmers adopted A2, extremely high, and 25% of them changed the timing of fertilizer use at the middle level. A3 was adopted by 10% of the respondents at the relatively high level and 20% of them at the relatively low level. Based on the findings, 23% and 21% of the household heads adopted A4 at the very high level and A5 at the relatively high level, respectively. Most farmers applied water adaptations at the extremely high level; thus, 27% and 30% of the farmers adopted A6 and A7 at this level, respectively. A8 was the most common coping strategy, in a way that 36% of the rural households changed their coping strategies from traditional to semi-industrial farming activities at the extremely high level. Finally, A9 was adopted by 23% of the farmers at the middle level.

4.2 Estimation outcomes of the extended PMT

According to the first step of SEM process, model identification was theoretically supposed to use the extended PMT diagram in Fig. 1. Results of factor loadings by the PCA are indicated in Table 2. All standardized factor loadings were above half. Load of this measure displays that individual items have robustly been linked to their factorial constructs. It provides sufficient convergence, too. The AVE indicators were at acceptable levels in the current model, implying good reliability. In addition, the research is based on exploration in essence; thus, the results indicate acceptable accuracy.

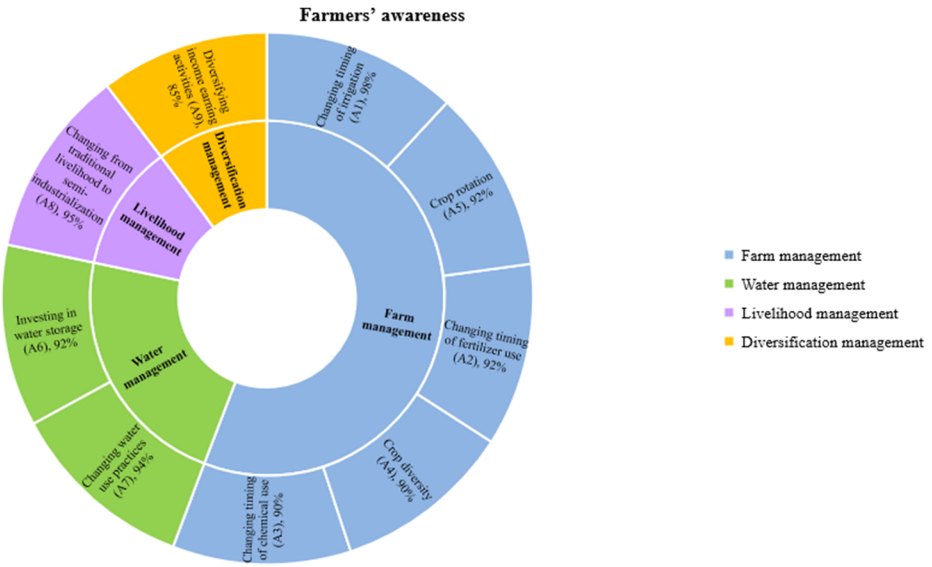

Fig. 4 The percentage of the rural farmers who were aware of different types of coping strategies

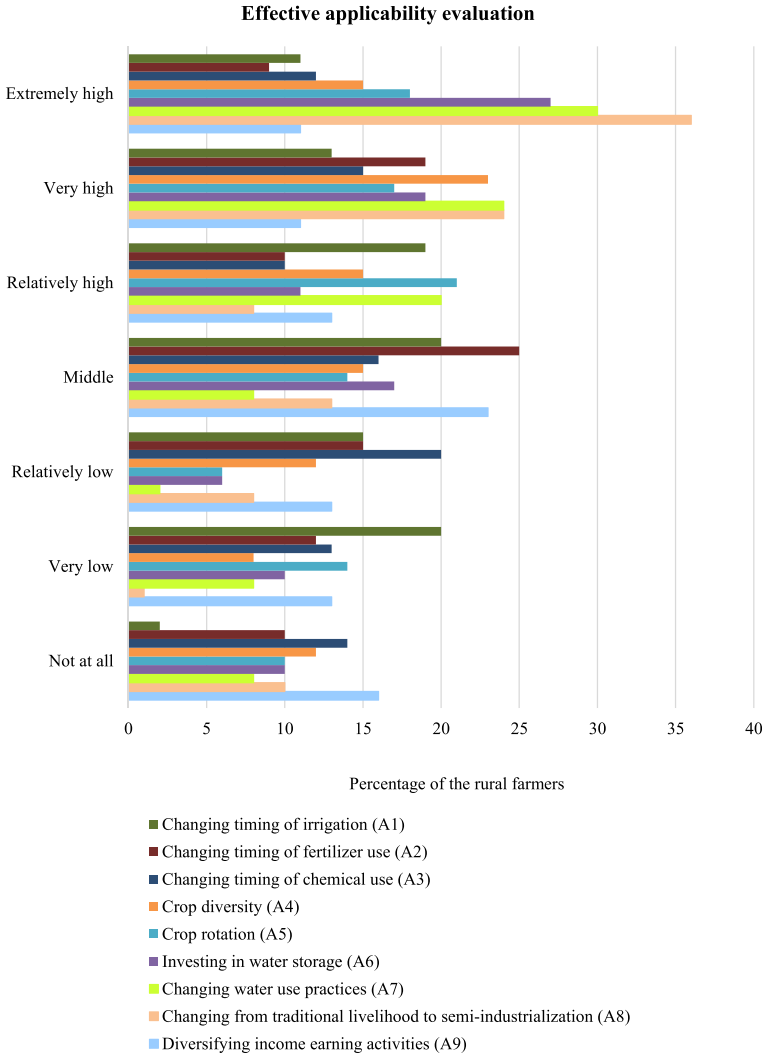

Fig. 5 The farmers evaluation toward the effective applicability of different types of coping strategies

For the second step of SEM process, model estimation and results of Spearman s correlation coefficients between the factorial constructs are indicated in Table 3. The results of the analysis showed a positive correlation between adaptation decisions and risk evaluation and adaptation evaluation. In addition, there was a negative correlation between adaptation decisions and maladaptation. Maladaptation was significantly and negatively correlated with risk evaluation and adaptation evaluation.

No alteration was directed because alterations of the model should be robustly defended by the literature. However, a good fit of the model is generally supported by the findings of the structural model. According to freedom degree which was 702, the chi-square was calculated to be 9279.37, and it was statistically significant (probability level = .000). The comparison of the target model fitness with the fit of an independent model, or a null model, was conducted by the comparative fit index (CFI). The CFI that is not very sensitive to sample size was

Table 2 Factor loadings by PCA

	Risk experience evaluation	Trust in national adaptation	Social discourse	Exact adaptive capacity	Adaptation incentives	Risk evaluation	Adaptation evaluation	Maladaptation	Adaptation decisions
Risk experience on products	0.89***								
Risk experience on farm household members	0.96***								
Disaster warning information		0.95***							
Appropriate actions		0.95***							
Climate change is really occurring.			0.96***						
Farmers livelihood is impressed by climate change.			0.97***						
Coping strategies should be conducted.			0.90***						
To what extent do farmers have time?				0.74***					
To what extent do farmers have money?				0.84***					
To what extent do farmers have knowledge?				0.71***					
To what extent do farmers have institutional support?				0.82***					
Decreasing water price, electricity price, and fuel price					0.87***				
Supporting farmers coping strategies					0.89***				
Perceived risks to health						0.93***			
Perceived risks to finance						0.95***			
Perceived risks to production						0.93***			
Perceived risks to socio-relations						0.95***			
Perceived risks to psychology						0.93***			
Adaptation by A1							0.83***		
Adaptation by A2							0.86***		
Adaptation by A3							0.84***		
Adaptation by A4							0.85***		
Adaptation by A5							0.83***		

Table 2 (continued)

	Risk experience evaluation	Trust in national adaptation	Social discourse	Exact adaptive capacity	Adaptation incentives	Risk evaluation	Adaptation evaluation	Maladaptation	Adaptation decisions
Adaptation by A6							0.74***		
Adaptation by A7							0.75***		
Adaptation by A8							0.74***		
Adaptation by A9							0.64***		
Coping strategies have not been effective.								0.59***	
Everything is predetermined.								0.92***	
My livelihood is preserved by God.								0.94***	
Adaptation decisions on A1									0.76***
Adaptation decisions on A2									0.71***
Adaptation decisions on A3									0.68***
Adaptation decisions on A4									0.79***
Adaptation decisions on A5									0.87***
Adaptation decisions on A6									0.89***
Adaptation decisions on A7									0.78***
Adaptation decisions on A8									0.70***
Adaptation decisions on A9									0.80***
AVE	0.87	0.91	0.89	0.61	0.78	0.88	0.63	0.76	0.61

*** Significant at 1%

Table 3 Construct correlation matrix

	Risk experience evaluation	Trust in national adaptation	Social discourse	Exact adaptive capacity	Adaptation incentives	Risk evaluation	Adaptation evaluation	Maladaptation	Adaptation decisions
Risk experience evaluation	1								
Trust in national evaluation	0.65***	1							
Social discourse	0.49***	0.48***	1						
Exact adaptive capacity	−0.32***	−0.08*	−0.33***	1					
Adaptation incentives	0.47***	0.58***	0.48***	−0.18**	1				
Risk evaluation	0.68***	0.56***	0.60***	−0.50***	0.52***	1			
Adaptation evaluation	0.37***	0.47***	0.51***	−0.20***	0.33***	0.63***	1		
Maladaptation	−0.11**	−0.32***	−0.22***	0.22***	−0.12**	−0.26***	−0.26***	1	
Adaptation decisions	0.39***	0.36***	0.44***	−0.45***	0.43***	0.63***	0.72***	−0.08*	1

*, **, *** Significant at 10%, 5%, and 1%

assessed to be 0.93. Finally, the standardized root mean square residual (SRMR) was obtained to be 0.06. This statistical measure is the square-root of the residuum between the residuals of the sample covariance matrix and the considered model. The findings of the SEM are displayed in Table 4.

There was no significant relationship between the trust in national adaptation and risk evaluation. The relationship between the exact adaptive capacity and adaptation evaluation was not significant either. The standardized coefficient was −0.06 (Table 4). The significance of the remained constructs was statistically acquired. Risk experience evaluation and social discourse had significant and positive effects on risk evaluation (β= 0.73 and 0.19, respectively). Adaptation evaluation was positively affected by social discourse (β = 0.52). The perceived risks to five different aspects, including health, finance, production, socio-relations, and psychology (risk evaluation), and farmers ability to execute each effective coping strategy (adaptation evaluation) were found to decrease maladaptation. Adaptation incentives, risk evaluation, and adaptation evaluation were detected to have positive effects on adaptation decisions, while maladaptation had negative effects on adaptation decisions. In this model, risk evaluation and adaptation evaluation directly affected adaptation decisions. In addition, those two evaluations indirectly influenced adaptation decisions. The indirect effects were from the maladaptation path (Fig. 1). Therefore, those households who had lesser maladaptation took better adaptation decisions.

The findings of the SEM totally confirm the conceptual framework of the extended PMT as the nine coefficients of the eleven factorial constructs were significant. The squared multiple correlation (R^2) is 64% for the targeted construct, i.e., adaptation decisions. This means that the 64% variation in adaptation decisions was explicated by factorial constructs in the SEM.

5 Discussions

5.1 Risk perception, awareness level, and perceived adaptive capacity

Perceived climatic risk on four aspects of health, psychology, finance, and production was evaluated at the low level by 28, 26, 24, and 22% of rural households, respectively. Therefore,

Table 4 Standardized parameter estimates of the SEM

	Endogenous factorial constructs			
	Risk evaluation	Adaptation evaluation	Maladaptation	Adaptation decisions
Exogenous variables				
Risk experience evaluation	0.73***			
Trust in national adaptation	−0.03			
Social discourse	0.19**	0.52***		
Exact adaptive capacity		−0.06		
Adaptation incentives				0.03*
Endogenous variables				
Risk evaluation			−0.17*	0.31***
Adaptation evaluation			−0.12*	0.64***
Maladaptation				−0.18***
Structural equation fit (R^2)	0.71	0.30	0.58	0.64

*, **, *** Significant at 10%, 5%, and 1%

almost one-fourth of sample farmers have not taken the climatic risk seriously. Those farmers, compared to others, are more vulnerable to sudden occurrence of climatic events.

According to the findings, about 15% of the sample households were not aware of the diversification of income earning activities. Furthermore, about 10% of the farmers had no awareness of other coping strategies including farm management, water management, and livelihood management. The perceived adaptive capacity on those three coping strategies including A8, A7, and A6 was understood to be applicable and effective by 36%, 30%, and 27% of the rural households, respectively. In addition, almost 10%, 8%, and 10% of the farmers had problems with converting traditional livelihood to semi-industrial livelihood, using modern irrigation strategies, and preparing water reservoirs, respectively. Therefore, a group of farmers has perceived the applicability of those coping strategies at the ineffective level. It means that the adaptive capacity of those farmers is extremely low to deal with the sudden occurrence of climatic events.

5.2 Contribution of core elements of the PMT

The outcomes of the SEM show that rural households would have likely taken adaptation decisions if they had perceived greater climatic risks and higher applicability and effectiveness of coping strategies. Especially when rural households suppose that higher climatic risks have menaced their health, finance, production, socio-relations, and psychology, they would have likely taken adaptation decisions under changing climate. Adaptation decisions have also increased when rural households have comprehended higher applicability and effectiveness of coping strategies in common. The current findings are in line with the results of other climatic studies such as those by Grothmann and Patt (2005) on two sample surveys in Germany and Zimbabwe; Grothmann and Reusswig (2006) in Cologne, Germany; Dang et al. (2014) in the Mekong Delta, Vietnam; Pietrzykowski et al. (2020) in Poland with a global view and local cases on temperate forest role in climate mitigation; Vulturius et al. (2018) on forest owners in Sweden; and Mitter et al. (2019) in Austria. The findings of those studies strongly support that cognitive factors are statistically significant that can directly explain farmers adaptation decisions to climate change. High levels of trust in climate knowledge and belief in the prominence of climate change, besides climatic risk perception, positively affect farmers decisions to adopt coping strategies.

Other research outcomes confirm the current survey that risk and adaptation evaluations are the main drivers for adaptation decision and behavior. Furthermore, results suggest useful insights for communication works that focus on increasing public participation in adaptation. This highlights the emphasis of communication interventions on improving risk perception and perceived adaptive capacity through raising knowledge about climate change impacts and coping measures. Moreover, findings provide scholars with a further understanding of how to assist farmers adaptation by increasing information about the climatic consequences. The current findings also reveal that farmers belief in climate change can cause a higher level of perception and decision on adaptation behavior.

The cultural and geographical components affect farmers adaptation decisions under changing climate. In temperate geographical areas, most farmers cannot properly experience and perceive climatic risk and thus reject climatic threat. Furthermore, in traditional culture, most farmers are optimistic that God will protect them from climate change, and thus, they reject the adoption of coping strategies (Dang et al., 2014; Mitter et al., 2019). Another conclusion is that those rural households who perceive higher climatic risks are less likely to

find the coping strategies ineffective or leave everything to fate. However, risk evaluation and maladaptation had been positively linked in the PMT research by Grothmann and Patt (2005). Milne et al. (2000) also declared a positive relationship between the climatic risk evaluation and the lack of preservative reactions. Therefore, the positive relationship between risk evaluation and maladaptation specifies that more perceived risks can cause either maladaptation or adaptation decisions (Grothmann and Reusswig, 2006). In the current study, the inverse relationship between risk evaluation and maladaptation is confirmed by the finding of Dang et al. (2014) that was explained through little entity of the rejection of the climatic threat, predeterminism, and optimistic thought in local community. Adaptation evaluation significantly affected maladaptation, just as this significant relation between adaptation evaluation and maladaptation was suggested in other surveys (Grothmann and Patt, 2005; Grothmann and Reusswig, 2006; Mitter et al., 2019). Therefore, all of the five relations among core elements of the PMT (e.g., risk evaluation, adaptation evaluation, maladaptation, and adaptation decisions) were statistically significant.

5.3 Contribution of socio-environmental components in the extended PMT

Farmers who have realized higher effects of adaptation incentives (e.g., a decrease in energy prices and supportive policies of coping strategies) have taken more adaptation decisions. This is explicated by the alteration of coping strategies which were cost efficient (e.g., changing water use practices to save water, changing from traditional to semi-industrial farming activities, and diversifying income earning activities). Other studies also showed that adaptation incentives affected adaptation decisions (Grothmann and Patt, 2005; Dang et al., 2014; Mitter et al., 2019).

Since farmers adaptation decisions under changing climate are affected by risk evaluation, adaptation evaluation, and maladaptation, there are several implications that require major attention. Rural households are more likely to evaluate risk and adaptation if they comprehend major data from other individuals (e.g., friends, relatives, neighbors, media, and public agencies) regarding the seriousness of changing climate and the necessity of conducting coping strategies. This means social discourse is indirectly important in determining the coping strategies of local farm households. Therefore, the confirmation of the truth and timeliness of such data is necessary. Other researchers displayed that farmers were significantly affected by whether other people executed coping strategies (Grothmann and Patt, 2005; Dang et al., 2014). Additionally, higher perceived risk regarding changing climate may not lead to adaptation decisions when rural households perceive less adaptive capacity. The rejection of the climatic threat, predeterminism, and optimistic thought may prevent adaptation decisions. Thus, opinions may be shaped by the information that individuals gain. Therefore, the validity of the sources of information is highly emphasized. Eventually, risk experience evaluation influences risk evaluation significantly. Farmers who experienced risks of climatic phenomena damaging to products and farm household members during the last decade are more likely to have risk evaluation. Grothmann and Patt (2005) and Dang et al. (2014) confirmed such a result.

The current study developed the measurement of current constructs in the form of the extended PMT. According to it, the extended PMT was quantified by SEM. The measurement model can be generalized to similar socio-environmental areas. Furthermore, additional constructs contributed to a more perfect comprehension of adaptation decisions of farmers in reaction to climate change.

6 Conclusions

To address the first research question, it should be mentioned that most rural farmers perceive climate change risk in five aspects above the average, but there is about one-third of the sample rural households that evaluate the risk at relatively low and very low levels. Such a low evaluation of the climatic risk and an underestimation of this climatic phenomenon by those farmers can lead to a lack of adaptation for their farms.

To address the second research question, it should be underlined that the awareness of the farmers about various types of coping strategies is generally high. While more than 85% of the rural households are aware of various coping strategies, about 15% of them have not heard of those strategies and, consequently, have minimum awareness.

To address the third research question, it should be noted that rural farmers are well aware of climate change coping strategies, but a few farmers have not adopted coping strategies at all, or some other farmers have adopted coping strategies at the very low and the relatively low levels. It is because those farmers evaluate the low applicability and effectiveness of adoption of coping strategies. However, such a lack of adaptation or adaptation at the very low and relatively low levels results in the climatic vulnerability of farm households.

The fourth research question should be addressed through the core elements of the PMT; rural households will likely take adaptation decisions if they evaluate greater climatic risks and more effectiveness of coping strategies. Inversely, rural households are less likely to take adaptation decisions if maladaptation is already taken. Thus, rural households find the implementation of coping strategies ineffective and believe in fate and God as the guardian of their farm.

To address the fifth research question, we must refer to the extended PMT by which farmers adaptation decisions would have increased if individuals had possessed more incentives, including the decreasing of energy prices and the supportive policies of coping strategies. The adaptation decisions have indirectly increased through the information that rural households have realized from friends, relatives, neighbors, media, and public agencies. If rural farmers do not gain social information, they evaluate fewer climatic risks and less effectiveness of coping strategies that finally lead to maladaptation. Such social information has formed farmers perception of climatic risk and the effectiveness of coping strategies. Inaccurate data can lead to maladaptation that has affected the lack of adaptation decisions. Therefore, the truth and timeliness of information are substantial. The sources of information are as important as the data itself. Agronomic promotion experts can support rural households through the practical science of coping strategies.

6.1 Implications of findings and recommendations

Ultimately, the findings of the SEM show that the extended PMT is an effective framework to explore farmers adaptation decisions under changing climate and can bring useful results and interpretations. Such useful findings based on the extended PMT contribute to supportive policymaking of farmers at the local level. Supportive farmers policies should motivate them to adapt to climate change impacts. Decreasing energy prices and providing the necessary facilities and instruments to execute coping measures can increase farmers incentives to adapt under changing climate. Supportive policies can be implemented with the support of the media and public agencies to increase farmers knowledge about climate change and its risk. Such supportive policies should consider the cultural and geographical characteristics. Thus, it is

necessary to adopt supportive policies for farmers locally and taking into account the characteristics of the region.

Farmers perceptions and experiences of the past construct the socio-environmental components, including risk experience evaluation, trust in national adaptation, social discourse, exact adaptive capacity, and adaptation incentives. The results of the extended PMT can support policymaking on farmers adaptation to the present and future climate change through coping strategies. The strategies should be selected according to regional characteristics and farmers needs. Accordingly, farmers perceptions toward the applicability and effectiveness of coping strategies indicate their adaptive capacity which can be innovative. In this regard, two coping strategies based on semi-industrialization of traditional livelihood and diversification of income earning activities have been associated with farmers innovation. In the field of farmers innovation, households can take the initiative for plastic-mulching on farms for semi-industrialization of their traditional livelihood and engaging in handicraft activities for diversification of their income earning activities. Such two coping strategies are technically resistant to unforeseen climate change conditions.

Policymakers can introduce such innovative coping strategies that were highly adopted by nearly one-fifth of the farmers and were considered to be totally applicable in the future. In this regard, policymakers can act in two ways as follows: (1) strengthening farmers belief in the effectiveness of innovative coping strategies under changing climate and (2) enhancing farmers ability to apply innovative coping strategies through skills training. Policymaking without considering the appropriate theoretical framework can lead to inaccurate and misleading outcomes. As a result, an improper policy increases the farmers vulnerability, endangers their livelihoods, and intensifies rural migrations.

According to the findings, it is suggested that farmers with relatively low and very low comprehension of climatic risk be identified to be introduced to agricultural policymakers. Therefore, appropriate policies should be adopted to increase the awareness of this group of farmers about climatic risk. Considering the lack of adaptation or adaptation at low levels for some farmers, it is recommended that appropriate policies be implemented to increase the applicability of the coping strategies. In this line, farmers ability to execute coping strategies and the effectiveness of coping strategies should be improved. Ultimately, it is suggested that farmers be encouraged to execute coping strategies. To this end, cognitive factors can help agricultural policymakers in terms of risk assessment, adaptation and maladjustment, and socio-environmental factors, such as adaptation incentives and social discourse.

6.2 Limitation of the study and further research directions

The PMT is distinguished as an effective framework to examine farmers adaptation decisions under changing climate. The application of the extended PMT can be expanded above the common usages of surveys of climatic adaptation strategies. However, the results are limited to one specific culture and a certain geographical area. Therefore, it can be considered as a limitation that the findings of the current study were only generalized to the areas with similar cultures and temperate climatic geographies. Accordingly, further investigations are necessary to conduct the measurement model in other cultures and geographical areas. Such studies can investigate how socio-environmental components in other cultures and geographical areas can influence risk and adaptation evaluations. In addition, future surveys can focus on how to increase farmers awareness of the climatic risk and identify ways in which the media and public agencies can be effective. Another limitation that this study faced was the lack of gender

diversity in the household heads because there are a limited number of females as household heads in the study area. To direct future research, we suggest investigating other factors such as "gender" which should be included as a determinant in behavioral patterns. In this regard, future studies can evaluate and analyze the effect of gender differences along with psychological factors on farmers maladaptation and adaptation. The studies can also advance the relevant discussions by addressing critical topics such as the role of equality and innovation in adapting to climate change.

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