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Adaptive capacity of smallholder farmers toward climate change: Evidence from Hamadan province in Iran

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Abstract

The global climate is changing, and farmers must increase their adaptive capacity to avoid negative impacts. This study aimed to examine the adaptive capacity of farmers' household to tolerate climate changes and identify factors affecting the climate in Hamadan province, Iran. The adaptive capacity was evaluated quantitatively by using 23 indicators and was categorized into high, moderate, low, and very low adaptive capacity. The study was based on a cross sectional survey and was conducted with a random sample of 280 household farmers distributed in five counties of Hamadan province in the west of the country whose climatic data revealed signs of climate change. The result showed that farmers' negative perception toward climate change generally increases during dry seasons and decreases when the precipitation and water resources are more available. Regarding the available information, only 15% of farmers had a high level of adaptive capacity, while 10% of them were highly adapted, and 27.5% showed a very low level of adaptive capacity. Adaptive capacity in the current study

was influenced by some socio-economic variables including total farm size, irrigated farm size, number of agricultural land plots, and perception and knowledge of climate change.

Keywords: Adaptive capacity; Cross sectional survey; Socio-economic variables; Adaptation strategies; Hamadan province

1. Introduction

Human activities in recent decades have contributed to global warming, and apart from causing environmental pollution, climate change has become one of the main and most important environmental challenges of the 21st century (IPCC, 2007).

In another context, climate change threatens sustainable development and has a significant negative impact on the ecosystems of the Earth as well as human societies (IPCC, 2014). The average global temperature rose by about 0.6 °C in the 20th century (IPCC, 2014) and is expected to rise from 1.4 to 5.8 °C by the end of the 21st century (Stocker et al., 2013). This is more than what has happened over the past 10,000 years.

Although Iran is subjected to a range of climatic conditions, it is mostly located geographically in a dry area of earth, in which precipitation is significantly less than the global average, and the area is expected to become drier due to reduced precipitation and increased temperature. Intergovernmental Panel on Climate Change (IPCC, 2014) has predicted that Iran’s temperature will increase by 0.5 to 1.5 °C in 2020-2029. Climatology research institute of Iran predicted a 9% decrease in precipitation in the 2010-2039 period, and in the following decades, the temperature of almost all provinces of Iran will increase. Moreover, the temperature will increase between 2.4 and 5°C in the distant period of 2080-2099 in the country. These researches implied that this country is faced with the climate change phenomenon, and its entire economic sector, especially agriculture, could be impacted in the near and distant future.

On the other hand, changes in climatic conditions would, directly and indirectly, impact natural ecosystems (Wang, 2012) as well as human and social systems (Feola et al., 2015). However, agriculture is inherently sensitive to climate conditions (Feng et al., 2017) and is directly influenced by changes in precipitation level and pattern, as well as temperature alterations (Sima et al., 2015). Besides, agriculture is still a pillar for rural economies and subsistence of smallholder farmers (Bouroncle et al., 2017), especially in developing countries like Iran. In Iran, agriculture plays a major role in economic growth and accounts for 18% of GDP, 25% of nonoil export, 20% of employment, and 85% of the total food supply. In addition, about 27% of Iran's population lives in rural areas, and their main source of subsistence and income is agriculture. This large population strongly depend on agriculture, and any changes in production would impact their livelihood. As Hamdan (2013) reported, climate change threatens not only the environment but also the communities, particularly those who depend on the environment for their livelihood. Although climate change and its obvious sign, drought, are not a new phenomenon for farmers, the complexity of the underlying factors and the inter-connection of its negative impacts, make climate change the main concern of farmers who live in the critical area of the country. In this regard, as IPCC 2007 mentioned, incapability of target population in adaptation to unwanted impacts of climate changes will intensify the vulnerability. Therefore, the vulnerability of smallholder farmers whose access to recourses is limited must be taken into account (Donatti et al., 2018).

Iran is one of the water-scarce regions in the world and is highly vulnerable to climate change impacts because of its high dependency on climate-sensitive agriculture (Karimi et al., 2018). Iran's per capita freshwater availability was about 2000 m3 per year in 2005. However, it is predicted that it will reduce to 1500 m3 per capita per year by 2030 due to the population growth (Abbaspour et al., 2009). Hence, the occurrence of the likely climate change in this region seems to have a destructive impact on water resources. Furthermore, Iran has a wide range of climate conditions across regions with considerable precipitation (Abbaspour et al., 2009).

As the largest consumer of water, agriculture is one of the most vulnerable sectors to climate change in Iran. Although the impact of climate change on agriculture is still shadowed by uncertainty, there is a general consensus that the agricultural sector of Iran will be significantly influenced (Karimi et al., 2018). Climate change is expected to have a major impact on farming practices through changes in precipitation, temperature, fertilization of carbon dioxide, climate variability, and surface water runoff. Accordingly, the amount of available water is the most affected aspect of farming. In addition, in Iran, the efficiency of irrigation water use varies between 15 and 36% due to the traditional method of irrigation and water transport systems. Consequently, evaporation and percolation lead to the loss of a large fraction of diverted water (Madani et al., 2016).

IPCC (2007) defined vulnerability to climate change as "to what extent a system can or cannot deal with negative climate change effects, including climate variability and extreme weather. Vulnerability is recognized as a component of the character, magnitude, and climate variation's rate to which a system is exposed to a hazard" (IPCC, 2014).

There is a vast body of knowledge on the assessment of vulnerability to climate change, mitigation, and adaptation strategies (Elum et al., 2017), but as Abdul-Razak & Kruse (2017) mentioned, most studies related to climate change are largely centered on farm-level adaptation methods and strategies, and there are only a few studies on the adaptive capacity of smallholder farmers towards the new climate variability.

However as adaptive capacity is one of the main components of vulnerability (Smit & Wandel, 2006), in fact, vulnerability is a component of lack or deficiency of adaptive capacity. Therefore, the adaptive capacity assessments bring the decision table the fundamental information required for the development of a climate change adaptation policy (Abdul-Razak & Kruse, 2017; Adger et al., 2007).

Adaptive capacity has been defined in many different ways, by numerous scholars. For example, adaptive capacity is defined as the ability of a system or an individual to adjust to climate change or climate variability so as to minimize the potential damages or cope with the consequences. IPCC (2014) defined adaptive capacity as the ability of a particular system to accommodate or cope with climate change impacts with minimal disruption. Brooks et al. (2005) revealed that adaptive capacity is the ability of a system to adjust its characteristics or behavior in order to expand its coping range under existing climate variability or future climate conditions. The adaptive capacity of a system is determined by a range of factors that are neither independent nor mutually exclusive but result from a combination of these factors (McCarthy, 2001). In practical terms, adaptive capacity is the ability to design and implement effective adaptation strategies or the ability to react to evolving hazards and stresses so as to reduce the likelihood of the occurrence and/or the magnitude of harmful outcomes resulting from climate-related hazards (Brooks et al., 2005).

It is essential to examine the evidence of climate change in arid regions such as Iran, where dry conditions will increase as a result of global warming (Karandish et al., 2017). In this context, Madani (2014) underlined the water crises in Iran, including water depletion, drying lakes, water supply, and extreme events. Consequently, adapting the agricultural sector to the adverse effects of climate change in Iran will definitely be crucial. Considering that Iran's rural economy is not greatly diversified and is reliant on agriculture, the impact of climate change on farming systems poses major challenges to rural land users. Studies on adaptation strategies in Iran (Hosseini et al. 2009; Hisali et al. 2011; Keshavarz et al. 2010, 2013) have shown that, while facing climate change, the most popular strategy is to improve diversification by adjusting approaches to land use and subsistence, using plant variations and growing crop varieties. Furthermore, another adaptation technique is crop management practices, which are known to be a specific type of change in production systems involving a shift in the length of the growing period, changes in planting time, and changes in crop patterns. Farmers also settle for strategies such as migration, increased use of irrigation, and water conservation strategies to deal with drought (Mansouri Daneshvar et al., 2019). Transformation, as an extreme form of adaptation, is expected to occur when a system faces an unprecedented change and cannot continue to function socio-ecologically or economically (Walker et al., 2004). Transformation is receiving increasing interest from scholars (Pelling, 2010; Marshall et al., 2012; O'Brien, 2012; Manuel-Navarrete and Pelling, 2015) where rural communities are considered particularly important in transformation studies as they are more vulnerable to environmental changes compared with other strata of society. This particular adaptive capacity has been practiced in Iran as well. Khanian et al. (2018) assessed how farmers have recently experienced significant declines in groundwater levels and temperature increases due to climate change in six villages in western Iran. However, due to international sanctions imposed on Iran in recent years, and their impacts on the country's economy, the central government has been unable to mitigate the impacts of drought and support farmers (Zehtabian et al., 2010).

Measuring adaptive capacity is difficult since adaptive capacity is essentially measuring the ‘potential’ to respond to changes in climate or climate related disasters (Byrne, 2014). However different scholars and studies applied a variety of methods and approaches to assess the adaptive capacity. Bouroncle et al. (2017) assessed the adaptive capacity of farmers by some indicators on three dimensions of satisfaction of needs, resources for innovation, and resources for action. Abdul-Razak & Kruse (2017) investigated the adaptive capacity of smallholder farmers to climate change in the Northern Region of Ghana. This study proposed an indicator-based framework for assessing the adaptive capacity along with six main determinants of economic resources, social capital, awareness and training, technology, infrastructure, and institutions, while Nantui et al. (2012) chose knowledge, use, accessibility, availability, and consultations for assessing adaptive capacity of rice farmers. Nakuja et al. (2012) assessed their adaptive capacities by using attributes such as knowledge, use, availability, accessibility, and consultation, while León-Camacho et al. (2014) addressed six dimensions of adaptive capacity including variety, learning capacity, room for autonomous change, leadership, resources, and fair governance. Byrne (2014) argued that at a household or community level, adaptive capacity to climate change depends on "factors such as knowledge base, which may enable [households] to anticipate change and identify new or modified livelihood opportunities, and their access to further resources is required to achieve this."

Much of the work done on adaptive capacity to date, has favored national level assessments that utilize indicators and indices (Byrne, 2014). Currently, however, there are very few studies in Iran that focused on farmers' household level adaptive capacity to climate change. Most researches are mainly on the municipal, provincial, or regional level. Therefore, this study tried to bridge the gap by focusing on the assessment of adaptive capacity at the household level of farmers. The AC of households to climate change may be linked closely to socioeconomic conditions. Hence, the paper provides insights into the factors affecting the adaptive capacity of farmers' households. The effects of climate change on agriculture have called for the need to adopt certain adaptation technologies to cope with its harmful effects (Nantui et al., 2012). Therefore, this study tried to identify different adaption strategies employed by farmers.

2. Materials and methods

2.1 Study area

This study was conducted in Hamadan province, Iran. This province has a total surface of 19.53*103 km2 and is situated in a mountainous area in the center of western Iran which can be seen in Fig. 1. The mean annual precipitation (total rainfall and snowfall) in the study area is about 350 mm with a range of 280 to 550 mm, and the mean annual temperature of the region is 11.8 °C (Jamshidi et al., 2019). It was concluded that the mean temperature of the area will increase by 0.5 to 0.8 ºC, and the annual precipitation will drop off about 23 mm in a short period from 2010 to 2039 compared with the base period from 1976 to 2005. Hamadan was the chosen study site because of climate change and its risks that confront the farmers. Numerous researches showed that this area has experienced climate change in recent years. It is anticipated that the mean temperature of the area will increase, and annual precipitation will decrease. Mohamadkhani and Jamali (2015) concluded that Hamadan and Alborz are the most sensitive provinces to climate change in Iran. Maryanaji et al. (2018) determined that mean annual temperatures of the province showed significant rapid increasing trends. Nazari et al. (2016) found a significant temperature increase and a rainfall decrease, and Zare Abyane et al. (2011) detected significant increasing temperature and decreasing precipitation in most meteorological stations of the province. Therefore, climate change is occurring in the area, and farmers, due to direct dependence on agriculture and limited capabilities and recourses, are considered as the most vulnerable groups.

[Insert Fig 1]

2.2 Analytical framework

The study used a descriptive quantitative method to assess the adaptive capacity of farm households to climate change and investigated the factors affecting them. The current study applied a secondary source of data as well as a primary. The primary data was gathered by a survey, and using Cochran formula, 280 smallholder farmers (out of 82412 as the target population) were selected by cluster random sampling approach. The validity of research instruments was evaluated by a group of agricultural and meteorological experts. In addition, Alpha Cronbach equal to 0.78 indicated the high reliability level of instruments. The secondary data on mean annual precipitation, temperature, and SPI index were obtained from Iranian Meteorological Organization (IMO) for the last 30-45 years. The Statistical Package for Social

Sciences (SPSS) version 18 and Microsoft Excel were used to process and analyze the information.

2.2.1 Method of analysis

This research computed the changing trend of various climatic variables such as precipitation, temperature, and SPI by Man-Kendal statistic for six meteorological stations of the province. Based on IPCC's definition, adaptive capacity is one of the three main components of vulnerability to climate change which has a negative relationship with vulnerability. It means that by increasing adaptive capacity, vulnerability to climate change declines. Therefore, in the current study, the adaptive capacity of smallholder farmers' households to climate change was measured through the Composite Index (CI). The index consists of various determinants and indicators of adaptive capacity. As shown in Fig. 2, adaptive capacity is a function of four determinants, including economic capabilities, social capabilities, human resource capabilities, and institutional capabilities, each of them compromises numerous indicators.

[Insert Fig 2]

2.2.2 Calculating adaptive capacity index

The adaptive capacity index in this study followed closely indicators extracted from some researches including ARCC, 2014; Bennett et al., 2014; Byrne, 2014; Defiesta & Rapera, 2014; Ezra, 2016; Gbetibouo et al., 2010; Gizachew & Shimelis, 2014; Aymone & Ringler, 2009; O'Brien et al., 2004; Pandey et al., 2015; Ranganathan et al., 2009; Varela-Ortega et al., 2013; and Jamshidi et al., 2019. Then, for extracting a set of indicators which are measurable based on the existing data, focus group discussion with the experts was applied. The indicators proposed by them, along with some adjustments which are listed in Fig. 2, have been applied. Because of different scales of indicators, the United Nation Development Program (UNDP) approach for calculating "Human Development Index" is known as a free scale indicator. Then, using principal components analysis, a weight was assigned to each indicator. After aggregating or combining all indicator scores with their weights to create a single index ranging from zero to one, the scores were classified into 4 levels, and high, moderate, low, and very low adaptive capacity levels have been achieved. Since there is no general rule for classifying adaptive capacity levels, this was done by the ISDM method.

3. Results

The descriptive results of the research showed that 81.4% of respondents were household heads, and almost 88% of them were male. The average age of the research sample was 51 years. Regarding the educational level, 11% of respondents held an academic degree, and the mean average of job experience of respondents was calculated as 28.48 years. Regarding the total farm size, it was clear that 88.5% of farmers were small-scale, who had less than 20 hectares. In addition, on average, respondents owned 6.5 hectares of irrigated farmland. The result indicated that about one-third of farmers had only one plot for their farm. While 44% of respondents had only irrigated farms, 33.6% of them had both irrigated and rain-fed farms.

Based on the recall approach of the respondents, the farmers were asked to compare the current situation with 20 to 30 years ago. As shown in Table 1, 69% of farmers perceived an increase in mean annual temperature, while 17.50% considered that temperature remains constant over time, and only 6.8% experienced its decline over time. In addition, about 85% of respondents perceived that precipitation in the region has declined over time, while 8.21% considered precipitation to be constant, and only 3.21% of them believed that it has increased over time. Furthermore, in terms of water resources availability, 86% believed that they have declined over time, 9.29% considered them to be constant, and 2.14% believed that they have increased over time.

[Insert Table 1]

Moreover, household perceptions of climate change and variability were also supported by the observed scientific data. In this study, 3 climatic variables of precipitation, temperature, and SPI have been investigated in six sample meteorological stations of the region. In the case of the annual mean temperature, most stations showed an increasing trend in the study area. In addition, it was found that most stations reported a significant decreasing trend for precipitation and an upward trend for SPI (Table 2).

[Insert Table 2]

To measure farmers' knowledge about climate change, a scale with 15 climate change related questions was applied. Then, the score of each person was calculated in the range of 0 to 30 (each correct response scored 2). For categorizing farmers, a score of 0 to 10 was considered for farmers with low knowledge, 11-20 was considered as a moderate level of knowledge, and 21-30 was considered as a high level of knowledge. The result indicated that only about 15% of the respondents had high knowledge of climate change, 35.35% had moderate knowledge, and 45.71% of them had low knowledge of climate change (Table 3).

[Insert Table 3]

3.1 Analysis of adaptive capacity

As mentioned, adaptive capacity is one of the main dimensions of vulnerability, which in this study, consisted of 4 determinants, including economic capability, social capability, human resource capability, and institutional capability. Fig. 3 depicted the level of indicators of economic capability. As it shows, the indicator of "net farm income" had the highest level. Indicators of social capability are shown in Fig. 4, and based on the analysis, the indicator of "technical advice consulting" got the biggest amount. In addition, indicators of "the highest number of years' education" and "access to infrastructure" got the highest amount for determinants of human resource capability and institutional capability, respectively (Figs. 5 and 6).

[Insert Figs 3,4,5,6]

Overall, 3 indicators of “net farm income”, “access to infrastructure”, and “access to agricultural input”, with an average of 0.70, 0.66, and 0.62, earned the highest score, respectively. On the other hand, 3 indicators of “family members’ participation in social communities”, “parents’ education”, and “technical advice”, with an average of 0.16, 0.19, and 0.20, earned the lowest amount, respectively.

For dividing respondents into different groups based on their adaptive capacity score, the ISDM method was used. The results showed an uneven distribution of respondents under various levels of adaptive capacity (Fig. 7). While only 10% of respondents scored a high level, 26.1% scored a moderate adaptive capacity level, and 36.4% and 27.4% of them were categorized as the low adaptive capacity and very low adaptive capacity, respectively.

[Insert Fig 7]

The comparative analysis of the adaptive capacity of farmers is depicted in Table 4. The result showed that there was no significant difference in adaptive capacity between respondents who were household heads or not, while those with male head households showed significantly higher adaptive capacity levels. The farmers’ household had other sources of income too, but agriculture had a higher level of adaptive capacity. In addition, it was found that farmers who only involved in rain-fed agriculture were more vulnerable and were less adapted compared with those who used both irrigated and rain-fed agriculture. Comparative analysis of farmers living in different counties of the province is shown in the table below.

[Insert Table 4]

The correlation analysis indicated that adaptive capacity of household farmers had a significant relationship with “total farm size”, “irrigated farm size”, “number of agricultural land plots”, “perception”, and “knowledge of climate change” as it is shown in Table 5.

[Insert Table 5]

To identify the climate change adaptation strategies which held relative importance over others, an adaptation index was estimated. As measured by the formula presented below, farmers were asked to assess different adaptation strategies by using the six-point rating scale to rate the importance of each strategy to their agricultural enterprises. The relative importance of adaptation strategies to climate change was calculated based on the following index formula.

$$ASI = AS_n*0+AS_{vl}*1+AS_l*2+AS_m*3+AS_h*4+AS_{vh}*5$$

where

ASI = Adaptation Strategy Index

AS_n = Frequency of farmers who did not use any adaptation strategies at all

AS_{vl} = Frequency of farmers who used an adaptation strategy at a very low level

AS_l = Frequency of farmers who used an adaptation strategy at a low level

AS_m = Frequency of farmers who used an adaptation strategy at a moderate level

AS_h = Frequency of farmers who used an adaptation strategy at a high level

AS_{vh} = Frequency of farmers who used an adaptation strategy at a very high level

The result of farmers' assessment of implementing the adaptation strategy showed that in general, water related strategies scored more than others. For example, "using new irrigation methods and systems", "shifting to drought tolerant crops and varieties", and "diversifying household income resources" were the first priorities of adaptation strategies. The result indicated that although using new irrigation methods and systems were the first priorities in adaptation to climate change, almost 36% of farmers did not use any irrigation methods or systems in their farming at a very low level.

[Insert Table 6]

4. Discussion

The results of the adaptive capacity assessment are useful for generating planning measures, which can increase the adaptive capacity and decrease the vulnerability of Hamadan's household farmers towards the impacts of climate change. The impacts of future climate change on many ecosystem services are uncertain, but it is clear that those who depend mostly on natural resources, like farmers, are likely to be most severely affected (Burton et al., 2002; Reed et al., 2013). Hamadan is one of the most important regions of Iran in producing agricultural products, but rain-fed agriculture is forming the dominant economic activity in the region. Considering the changes in meteorological variables such as precipitation, temperature, and drought, the current study aimed to examine the adaptive capacity of farmers and determine factors affecting and identifying possible adaptation strategies.

Analysing adaptive capacity indicators implied that farmers' condition in terms of variables such as "net farm income", "access to infrastructure", and "access to agricultural input" is more favorable, while in terms of participation, education, and technical advice, the condition is not favorable. Therefore, it is suggested that the relationship between agricultural extension agents and farmers should be improved so that they can use the provided training and expert advice to increase their adaptive capacity.

Scholars have argued that the adaptive capacity of farmers' households depends on natural, physical, financial, human, and social capital (Alam et al., 2017). In this study, 23 indicators within the framework of four determinants of economic capability, social capability, human resource capability, and institutional capability have been taken into account and formed the adaptive capacity composite index. Based on this index, only 10% of farmers had a high level of adaptive capacity, while 27.4% of them had a very low level. Similarly, in the study of Nantui et al. (2012), 27% of farmers were less adapted, and in that of Abdul-Razak (2017), 11.25% of farmers were labeled with a high adaptive capacity.

However, it is important to note that successful adaptive processes to mitigate the adverse effects of climate change depend largely on access to and the judicial use of these capital assets.

The comparative analysis indicated that households with female heads had a lower adaptive capacity. It should be noted that adaptive capacity is linked to women's assets and their ability to have income and common property resources. It also depends on the participation in social communities, benefit from social support, and access to infrastructure. Although gender bias against women's employment in agriculture has been diminished in recent years, the norm that agriculture is a masculine activity is still common and widespread in many parts of the region. In general, female farmers became responsible for households because of the death of their father or husband and rarely because of their desire for agricultural entrepreneurship. This has led them to have lower financial resources and even less owned land, and in some cases, they were deprived of social benefits, which resulted in lower adaptive capacity. Similarly, Pérez et al. (2015) found that this bias makes female-headed households highly vulnerable in terms of adapting their farming practices to economic and climatic risks in Africa.

In addition, it was clear that farmers who had other sources of income than agriculture, scored a higher level of adaptive capacity, and those who were only involved in rain-fed production showed a significantly lower level of adaptive capacity. As different researchers stated, diversity in crops and income sources enables farmers to create a portfolio of livelihoods with different risk attributes so that risks, such as those posed by climate change, can be managed, making recovery easier and faster.

In a comparison of farmers belonging to different cities of the province, it was confirmed that farmers of Hamadan and Kabodarahang had more adaptive capacity, while the ones who lived in Malayer and Asadabad scored a significantly lower adaptive capacity level. Based on additional analysis, there were no significant differences between the cities regarding the productivity of their farming, while farmers of Hamadan and Kabodarahang had significantly larger farms in comparison with others. Therefore, it can be concluded that farm size is a determinant factor in relation to the adaptive capacity of farmers.

Nantui et al. (2012) reported that adaptive capacity varies from farmer to farmer based on certain factors that are peculiar to each of them. In this study, correlation analysis showed that adaptive capacity had a positive relationship with variables such as the total farm size, irrigated farm size, number of agricultural land plots, perception of climate change, and knowledge of climate change.

As we found, the farmers who owned larger farms, scored more adaptive capacity. Similarly, Reidsma et al. (2009) reported that larger farms have been found to increase the adaptive capacity of farmers and hence reduce vulnerability. However, in another study, smallholder farmers with relatively small farms were found to have more adaptive capacity to droughts compared with privately owned large farms due to a range of livelihood options. As Rurinda et al. (2014) argued, even the perceived marginalized households can use a range of options to improve the adaptive capacity and reduce vulnerability.

The study of farmers' perception showed that the majority of the farmers perceived that temperature had been increased and precipitation had been dropped off over the past 30 years. As mentioned earlier, perception is a key component of the adaptation process (Maddison, 2007), and farmers first need to perceive the impact of climate change to take appropriate adaptation strategies in order to mitigate their vulnerability and enhance the adaptive capacity (Alam et al., 2017; Bryan et al., 2009). As Dietz (2015) revealed, if the farmers do not perceive climate change as a threat for their subsistence, they will not implement adaptive strategies. It should be noted that according to the scientific data, farmers have perceived and are informed about the climate change.

In the study of farmers' knowledge, it was found that they mostly had a low level of knowledge on climate change which is contrary to the results of Al Buloshi & Ramadan, 2015; Ogunlade et al., 2014; and Rodriguez-Franco & Haan, 2015; and is similar to the study of Kabir et al. (2016) according to which, only 6.5% of farmers had a high level of climate change knowledge. The result of the study also indicated that knowledge had a significant relationship with the adaptive capacity of farmers. Similarly, Nantui et al. (2012) concluded that the adaptive capacities of farmers depend on their knowledge. Therefore, in planning and implementing adaptation programs, the matter of training of farmers should be taken into account because only knowledgeable farmers could cope with severe climate change impacts.

As Adger et al. (2005) reported, adaptive capacity is about people's ability to convert current and future resources (financial, physical, human, social, or natural capitals) into successful adaptation strategies for the future. Therefore, it is necessary to implement effective adaptation strategies to reduce the effects of climate change on farmers. In fact, due to the nature of agricultural production activity, they are more affected by the climate change phenomenon compared to other groups. The intensity of this effect increases when the adaptive capacity of these farmers is limited. The result of this study revealed that farmers adapt to some strategies which are mostly centered on the optimal management of water recourses. It should be noted that Iran is located in the dry region of the planet, and historically, drought and water shortage were the main environmental issues for this country. However, planning for water resource management has not been very successful. Different studies proposed a vast variety of strategies. For example, Azizi and Zamani (2016) argue that informing and training farmers on the necessity of water resource management is of great importance. According to strategies proposed by Nantui et al. (2012), like using chemical/organic fertilizers, mulching, and farming on fallow land, the highest adaptive capacity has been proposed for rice farmers. It should be considered that every adaptation strategy should be based on environmental, economic, and social conditions of the region, farmers, and communities. Drawing the attention of the officials and planners of the agricultural and rural development to the education of the farmers, as well as an investment increase in water resource management, is also important.

5. Conclusion

There is a great deal of uncertainty about the future of smallholder farmers in the context of climate change. Assessing the potential impacts of climate change on smallholder farmers is imperative, and conducting research on the micro and macro-level adaptive responses to climate change is highly important. This study attempted to fill the gap by concentrating on the adaptive capacity assessment at farmers' household level. Climate change and household adaptive capacity can be closely linked to socio-economic conditions. Since this study was built on a vast range of studies, it can provide insights into the factors that affect the adaptive capacity of farmers' households in Iran.

The main implication of this study is revealing a significant change in precipitation and temperature over time and showing that there was corroboration between farmers' perception and the analyzed scientific weather data. Therefore, it can be stated that the climate of this region is changing, and smallholder farmers have already faced numerous risks posed to their agricultural production including drought and water shortage, pest and disease outbreaks, extreme weather events, and market shocks, which often increase the household farmers' vulnerability.

In addition, by understanding the present and future conditions resulting from climate change and the problems that may affect their subsistence in the future, this study revealed that farmers should be urged to adopt strategies for mitigating and adapting to climate change.

The study also argues that with respect to the surveyed region, although farmers use several adaptation strategies, the farmers' access to new irrigation systems and equipment, drought tolerant crops and seeds, financial resources, new markets, new planting calendar, agricultural products insurance, and consulting and training services still need to be improved. Another important strategy that should be reassured more than ever is the diversification of livelihoods or income sources. Previous studies have emphasized the role of livelihood diversification as a means of adaptation for rural households. Finally, smallholder household farmers are likely to be the most affected by climate change, and although they have developed their own coping strategies, their adaptive capacities in the face of climate change are limited. Thus, they need special attention and support in terms of establishing suitable adaptation strategies.

The main policy implication is that the farming sector should be reformed in terms of environmental, institutional, and economic conditions in order to use specific methods of adaptation that are best suited to specific circumstances.

The optimistic future of farming depends on whether this sector is capable of mitigating the adverse impacts of climate change and managing the irrigation water in a sustainable manner. This would involve a set of actions enabling farmers to access the existing technologies. It is also essential to invest in research to enable land and water management to cope with the uncertainties in the future.

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Table 1. Perceived trend of climate by respondents

Items	Increased over time		Remained constant over time		Declined over time		Do not know	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Mean annual Temperature	194	69.3	49	17.50	19	6.8	18	6.4
Mean annual Precipitation	9	3.21	23	8.21	238	85	10	3.57
Water resources Availability	6	2.14	22	7.86	241	86.07	11	3.92

Table 2. Trend of climatic variations in 6 meteorological samples of the study area

No.	Stations	Precipitation		Temperature		SPI*	
		Q**	Sig	Q	Sig	Q	Sig
1	Ekbatan	-1/87	0.95	2/89	0.99	1/36	ns
2	Malayer	-1/96	0.95	1/67	ns***	3/34	0.99
3	Khomeyngan	-3/33	0.99	-2/58	0.95	2/31	0.95
4	Ghahavand	2/8	0.99	2/35	0.99	3/19	0.99
5	Dargazin	-3/12	0.99	2/88	0.99	-2/07	0.95
6	Kheyrabad	0/087	ns	2/19	0.95	3/45	0.99

*Standardized Precipitation Index **Man-Kendal statistic ***ns: not significant

Table 3. Frequency distribution of respondents, based on the level of climate change knowledge

Rank	Item	Frequency	Percentage	Cumulative Percentage
1	High knowledge	43	15.35	15.35
2	Moderate knowledge	99	35.35	50.70
3	Low knowledge	128	45.71	96.41
4	Not assigned	10	3.59	100
	Total	280	100	-

Table 4. Comparing respondent groups based on adaptive capacity

Variable	Group	Mean	Std. Dev.	t	Sig
Household head	Yes	0.509	0.227	1.79	0.073
	No	0.448	0.271		
Gender	Male	0.508	0.235	2.375	0.018
	Female	0.405	0.248		
Other source of income	Yes	0.545	0.231	4.112	0.000
	No	0.430	0.233		
	Group	**Mean**	**Std. Dev.**	**F**	**Sig**
Type of cultivation	Only rain-fed	0.404a	0.187	6.14	0.002
	Only irrigated	0.531b	0.206		
	Rain-fed and irrigated	0.507b	0.274		
City	Malayer	0.52a	0.211	3.85	0.005
	Asadabad	0.51a	0.233		
	Razan	0.49a	0.222		
	Kabodarahang	0.59b	0.217		
	Hamadan	0.60b	0.218		

Table 5. Correlation between AC and other independent variables

Independent variables	Coefficient	Sig
Age	-0.106	0.078
Education level	0.099	0.097
Job experience (years)	0.093	0.121
Total farm size	0.570	0.000
Irrigated farm size	0.486	0.000
Number of agricultural land plots	0.128	0.032
Perception of climate change	0.120	0.046
Information seeking behavior	0.088	0.134
Knowledge of climate change	0.193	0.001

Table 6. Climate change adaptation strategies used by farmers

Adaptation strategy	N	VL	L	M	H	VH	ASI
Using new irrigation methods and system	28	32	43	67	39	71	830
Shifting to drought tolerant crops and varieties	3	19	132	64	28	34	757
Diversifying household income resources (off farm income, livestock, etc.)	22	43	52	76	53	34	757
Optimized water resource management	14	43	93	64	23	43	728
Cultivation of modified and drought resistance plants	11	47	93	60	41	28	717
Change in planting method	1	48	92	97	25	17	708
Change in planting time schedule	14	64	62	71	50	19	696
Optimal use of chemical pesticides and fertilizers	19	53	100	50	22	36	671
Integrated pest management	20	55	82	84	26	13	640
Establishment of cooperative	16	78	78	55	37	16	627
Migration to another city or village	44	63	57	55	43	18	604
Insuring farm against risks	22	77	94	57	20	10	566
Increase in investment	45	75	60	70	13	17	542
Not doing anything special	41	57	98	57	22	5	537

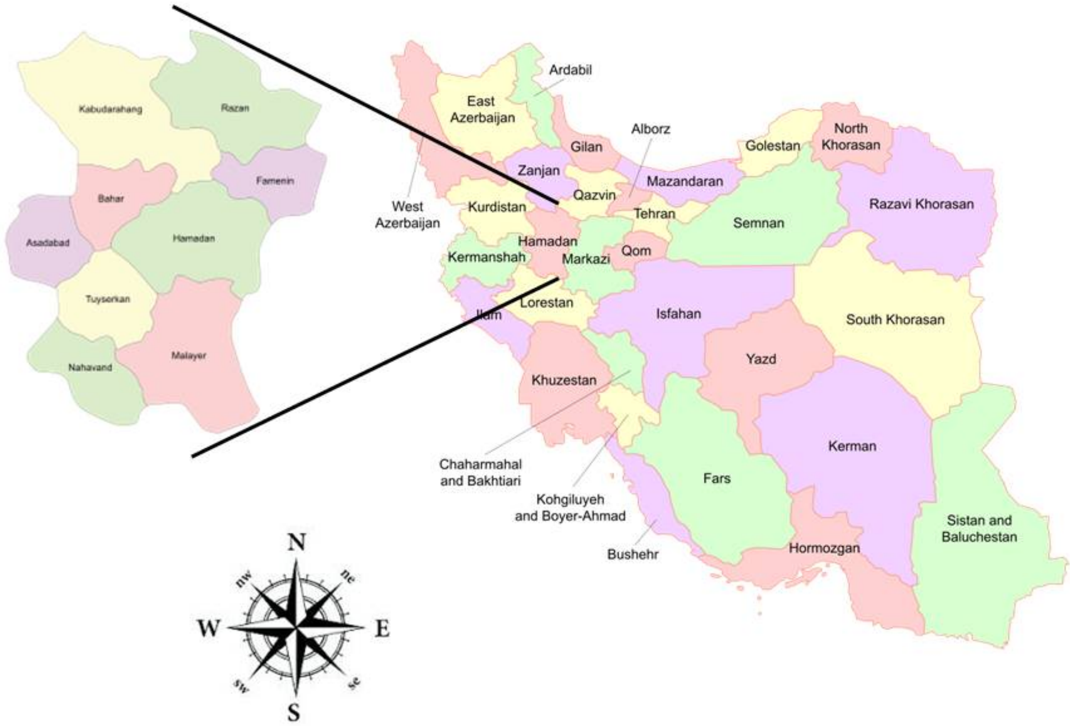

Figure 1.Map of study area

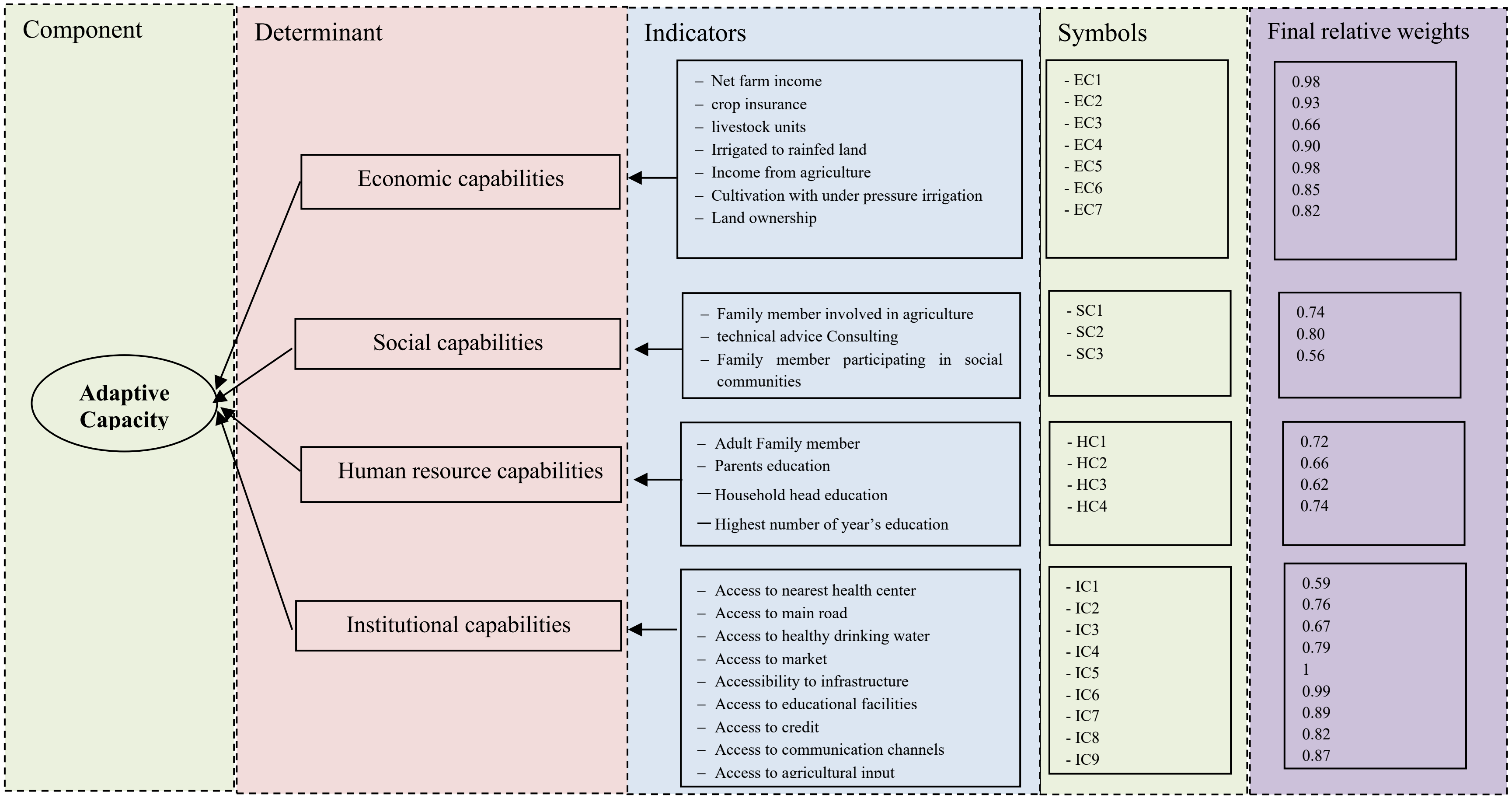

Fig. 2. Adaptive capacity and its determinants and indicators, applied in this research

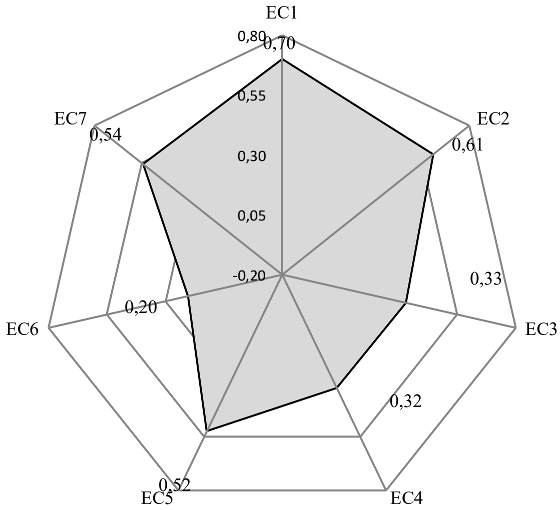

Fig. 3. The level of indicators of determinant of economic capabilities

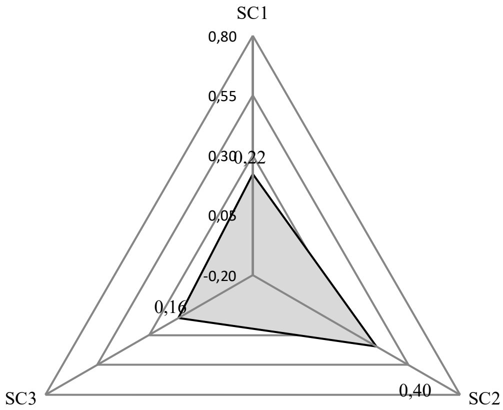

Fig. 4. The level of indicators of determinant of social capabilities

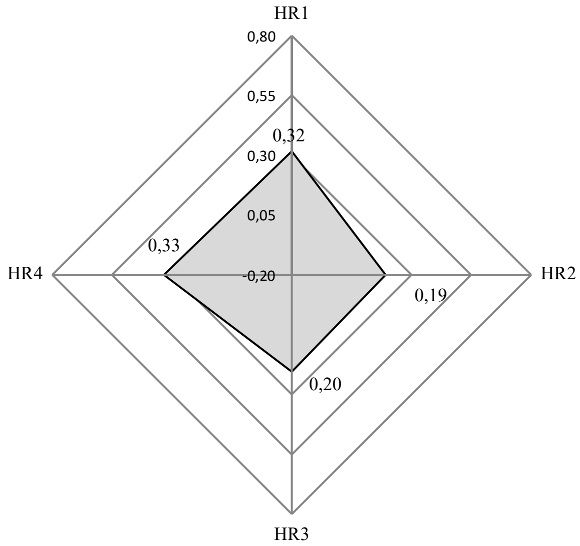

Fig. 5. The level of indicators of determinant of human resource capabilities

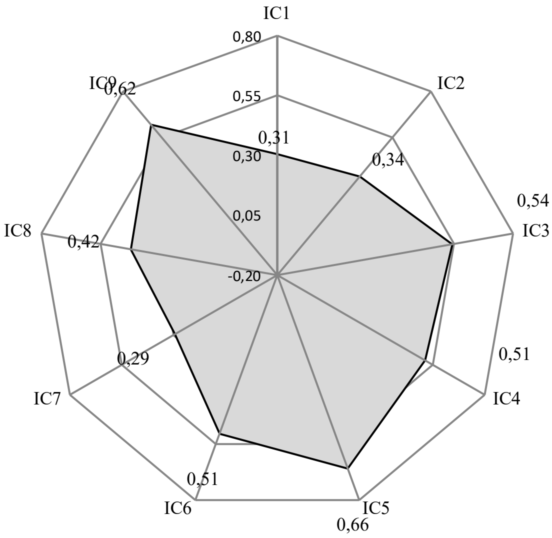

Fig. 6. The level of indicators of determinant of institutional capabilities

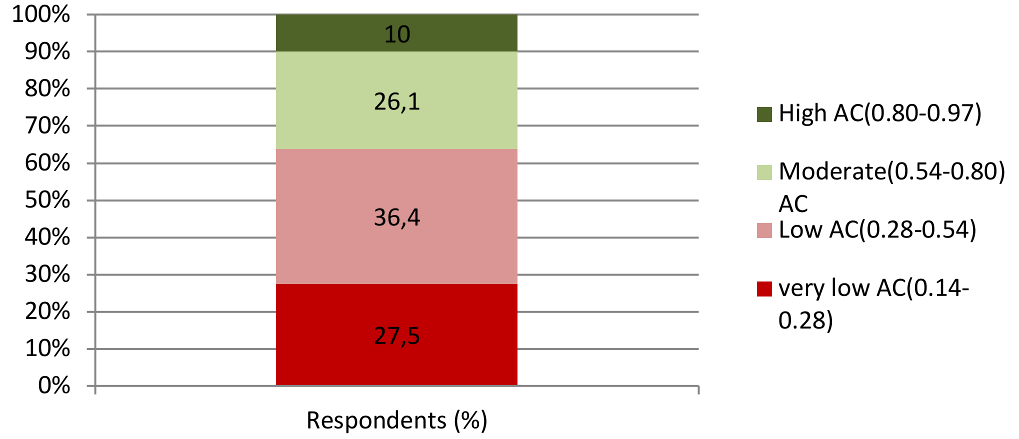

Fig. 7. Distribution of respondents by Adaptive Capacity level