



# Indigenous knowledge about climate change and sustainability of nomadic livelihoods: understanding adaptability coping strategies

Samane Ghazali<sup>1</sup> · Hossein Azadi<sup>2,3</sup>  · Kristina Janečková<sup>3</sup> · Petr Sklenička<sup>3</sup> · Alishir Kurban<sup>4,5,6,7</sup> · Sedef Cakir<sup>8</sup>

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## Abstract

Indigenous knowledge about climate change that makes adaptability necessary by coping strategies leads to the sustainability of nomadic livelihoods. This paper proposed a new adaptability approach, an association coping strategy (ACS), which is established based on the association rules' recommendations. The adaptability was empirically analyzed using 12 coping strategies used by Kashkooli nomads in Sepidan plain, Fars province, Iran. Required data were gathered both in the form of time series from November 1988 to February 2020 and cross section during June–July 2019. Household perceptions of climatic and environmental variables, supported by meteorological data, revealed that climate change was negatively impacting the Kashkooli nomadic livelihood in Sepidan plain. The findings also indicated that taking simultaneous coping strategies resulted in selling livestock surplus, saving water consumption, livestock insurance, rangeland regeneration schemes, and immigration to more suitable rangelands. Therefore, Kashkooli nomadic livelihood survived climate changes using ACSs. The association rules were useful for recommending anticipatory coping strategies that were adopted based on indigenous knowledge about climate change by nomads to establish appropriate adaptability.

**Keywords** Association rules · Coping strategies · Data mining · Household perceptions · Kashkooli nomads

## 1 Introduction

Climate change adaptation is one of the goals considered by nomads (Aryal et al., 2020; Bierbaum et al., 2013), and it appears to be a viable realistic solution (Saboochi et al., 2019; Yan et al., 2011). In fact, nomadic coping strategies are better suited to extreme weather conditions and changing climate (Adger et al., 2003; Pei et al., 2019). Adaptation refers to interacting and managing one system to compensate for the losses caused by climate change (IPCC, 2001). The choice of coping strategies is done locally, regionally, and

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✉ Hossein Azadi  
hossein.azadi@ugent.be

Extended author information available on the last page of the article

globally, and its actors can be a household, firm, and government (Henry et al., 2018; Smit & Skinner, 2002; Wadgyamar et al., 2017). It is necessary to explore indigenous knowledge about climate change on how nomads adopt suitable coping strategies (Makondo & Thomas, 2018). Indigenous knowledge about climate change refers to understandings and philosophies developed by long-established nomad communities on climate change, and this knowledge has a strong link with the natural environment (Orlove et al., 2010). Thereby, indigenous knowledge helps nomad communities cope with climate change (Saboo et al., 2019).

The first step towards reducing vulnerability to climate change is to properly understand the climate of the region and anticipate the climatic hazards before their occurrence (Abdul-Razak & Kruse, 2017). Thus, understanding the climate and climatic conditions of the region based on indigenous knowledge is valuable. Such knowledge of the region's climate is very effective in managing the vulnerability of indigenous individuals (Mekonnen et al., 2018). In this way, after recognizing the climate situation and correctly predicting climate events, nomads plan to incorporate coping strategies. Coping strategies contribute to increasing nomads' resilience to climate change (Stammler & Ivanova, 2020). Such strategies must be planned to manage future climate risk. To achieve effective coping strategies, climate risk must be considered as part of nomads' decision to adopt a strategy (Rahut & Ali, 2018). Therefore, the adaptation of nomads to climate change leads to sustainable livelihoods and improved incomes (Zeweld et al., 2019).

Selecting an appropriate coping procedure (ACP) to climate change is very important. Changing climate affects various sectors, including the natural ecosystem. On the other side, nomads live in environmental surroundings, and their main source of livelihood is traditional ranching on natural rangelands. They are severely affected by climate change. Nomadic livelihood is sustainable when it can cope with and recover from climate change and maintain or enhance its capabilities both now and in the future without undermining natural rangeland resources (Gongbuzeren and Li, 2016). Therefore, the sustainability of nomadic livelihoods requires appropriate coping strategies to climate change (Kariuki et al., 2018; Wilder et al., 2010). As a result, for the nomads that their livelihoods are dependent on ranching, the pressure on the natural resources of the rangeland will be reduced (Martin et al., 2016). Glantz (1992) classified coping strategies as (1) anticipatory options, which refer to proactive measures to preserve and protect systems against climate change impacts, and (2) reactive measures, which are adopted after observing the climate change impacts (Nasso et al., 2019; Peterse et al., 2013). If nomads have good indigenous knowledge about climate change, they choose a set of anticipatory strategies that are often indigenous knowledge-related strategies. Otherwise, the reactive measures are adopted based on the advice of other nomads and experienced experts from government agencies (Bradford et al., 2018; Son et al., 2019). Most nomads cope with climate variations after climate change occurred by reactive coping strategies.

Adaptive capacity refers to the potential success of a system in responding to climate stimulus (Adger et al., 2005). Adaptation will be easier if policymakers consider climate changes in their decision-making. Thus, in order to mitigate the consequences of climate change, there is a need to develop a new approach that will ultimately be adopted by using indigenous knowledge (Suberi et al., 2018). The approach based on indigenous knowledge can introduce anticipatory coping strategies before climate change damages nomadic livelihoods. Hence, the implementation of coping strategies will contribute to the sustainability of nomadic livelihoods.

Perception is described as the process of creating experiential feelings in the real world (Lindsay & Norman, 2013) and highlighting an individual's ability to take advantage of his

experience of nature and natural variables (Hartig et al., 2001). In order to examine household perceptions about climate change, to assess climatic and environmental variables on traditional livelihood, and to discover coping strategies to climate change, the previous studies employed descriptive statistics in their analyses. Science should, therefore, be integrated with people's perceptions and indigenous knowledge in order to achieve a real solution to climate change and its variability impacts on traditional livelihoods and to adopt coping strategies with climate conditions. The concept of "climate variability" is used to define climatic statistical variations over a given period of time (e.g., a month, season, or year) as opposed to long-term averages for the same year. Such variations, which are typically considered anomalies, are used to measure climate variability (Craine et al., 2009). As Thornton et al. (2014) have stated, climate variability already has significant influences on social systems and on many smallholders, communities, and countries. Improved awareness of the full range of climate change impacts on food systems and rural livelihoods is a critical step towards being able to efficiently address extreme weather events and climate variability impacts on human vulnerability. Climate change contributes to a statistically significant trend that persists for a prolonged period of time, in either the mean or variability of the climate state. Climate change may be due to natural internal processes or external factors, such as frequent changes in weather or land use (ARCC, 2014). In addition, climate change impacts human health in ways sometimes ignored. Awareness of these impacts encourages public engagement and effective adaptations, which mitigate negative effects and exploit opportunities for more positive change. All these activities are considered as perceptions of climate change (Ardey Codjoem et al., 2013). Thus, indigenous knowledge is referred to as traditional knowledge or local ecological perceptions, which has received much attention in climate change discussions and adaptation mechanisms.

Special attention has been paid to climate change in Iran as well as in other nations. Over the last decade, a significant part of climate research has concentrated on studying climate change and its consequences (e.g., Jamshidi et al., 2020; Samadi et al., 2012). Many papers have been published over the past decade based on precipitation patterns across Iran (e.g., Modarres & Sarhadi, 2009; Razinei et al., 2012). The analysis of station level precipitation data showed a decreasing trend in annual rainfall at 6% of the stations, while Modarres and Sarhadi (2009) and Razinei et al. (2012) observed an increasing trend in the median rainfall in 24 h at 50% of the stations. While Iran is subject to a variety of climatic conditions, it is mainly geographically located in a dry region of the Earth where precipitation is significantly lower than the global average, and the country is expected to get drier due to decreased precipitation and increased temperature (Jamshidi et al., 2020). The Intergovernmental Panel on Climate Change (IPCC, 2014) estimated that Iran's temperature will increase by 0.5–1.5 °C in the next decade (from 2020 to 2029). Iran's Climatology Research Institute expected a 9% decrease in precipitation in the period 2010–2039, and the temperature of nearly all provinces will rise in the following decades. In addition, it is expected that the temperature in the country will rise between 2.4 and 5 °C by the end of the twenty-first century.

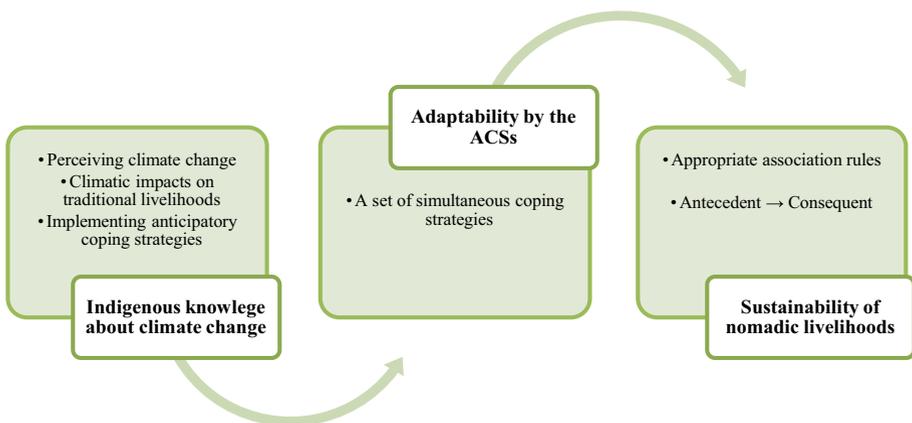
Hence, it is necessary to gather empirical data from nomadic households and detect coping strategies in a specific location, taking into account different perceptions of climate change and mitigating it. Given the nomadic dependence on rangelands and the adaptation of their traditional livelihoods to climate changes, their responses to such changes and the choice of ACP are important. The proposed approach in the current study discovered the most abundant reactive coping strategies that were simultaneously adopted by sampled nomads. In fact, the reactive coping strategies can be considered anticipatory for other nomadic households who have not faced severe climate impacts yet.

The new adaptability approach, i.e., the choice of association coping strategy (ACS), was built on the instructions of the association rules. This is a pattern that represents the relation between item sets in the data mining analysis, e.g., coping strategies. The ACSs were developed by implementing candidate coping strategies with a higher lift value, in which when classifying cases, the lift value is a measure of the success of an association rule. Therefore, the ACSs contain a specification, and nomads may rely on the internal empirical process of data mining techniques to take item sets, e.g., coping strategies, rather than arbitrary choices.

In sum, the purposes of the current study are the analysis of the Kashkooli nomads' perception of climate change, the investigation of the climatic and environmental impacts on their traditional livelihoods, and the detection of the association rules among coping strategies in Sepidan plain. Notably, the ACPs have interior linkages that can be discovered by data mining in the association rules. The empirical results of the paper suggest useful new evidence for policymakers and try to answer the following questions: How Kashkooli nomads perceive climate change? Which climatic variations affect traditional nomadic livelihoods? Which ACP is suggested to combine the planning process and sustainable livelihoods?

## 2 Literature review and conceptual framework

Various studies have extensively explored indigenous knowledge and adaptation to climate change through a set of coping strategies for farmers and natural resource users (Latulippe & Klenk, 2020; Makondo & Thomas, 2018; Son et al., 2019; Syahputra, 2019). However, the adaptation of the nomadic community whose main livelihood is based on livestock activity has rarely been studied. As shown in Fig. 1, in this study, in order to have a clear review on the previous studies, the literature review was performed based on two main aspects as follows:



**Fig. 1** An appropriate process to achieve the sustainability of nomadic livelihoods. Adopted by Aguilera et al. (2020) and Mekonnen et al. (2018)

1. Indigenous knowledge about climate change: A group of studies focused on indigenous knowledge about climate change and individuals' perceptions of climatic and environmental variables (Abate, 2016; Aniah et al., 2019; De Sousa et al., 2018; Kusakari et al., 2014; Latulippe & Klenk, 2020; Mapfumo et al., 2015; Mekonnen et al., 2018; Syahputra, 2019). These studies commonly discussed that indigenous knowledge-related strategies should be adopted by communities as anticipatory coping strategies before the occurrence of climatic events.
2. Adaptability by association coping strategies (ACSs): The other group of studies focused on adaptation and increasing the resistance of communities to climate change impacts (Aguilera et al., 2020; Devisscher et al., 2018; Dhungana et al., 2020; Jamshidi et al., 2020; Sarker et al., 2020; Struelens et al., 2017; Tesfaye & Seifu, 2016; Treydte et al., 2017). These studies generally discussed the adoption of coping strategies at the same time.

## 2.1 Indigenous knowledge about climate change

Many communities make decisions based on indigenous knowledge. This knowledge is important in terms of cultural perspective and policymaking to the community's livelihood (Latulippe & Klenk, 2020; Mapfumo et al., 2015). The knowledge is derived from the experiences of the past generations (Syahputra, 2019). Based on this knowledge, the indigenous community is connected to environmental conditions (Nyong et al., 2007). In the context of community resilience, it is unlikely that coping strategies will be effective without understanding indigenous knowledge of climate change.

Accordingly, it is important to review relevant case studies on indigenous knowledge about climate change and their anticipated coping strategies. In this regard, Alam et al. (2017) examined indigenous knowledge of vulnerable households on adaptation to climate change in Bangladesh. Based on their results, individual perception of climate change is similar to those observed in meteorology data. Their findings showed that individuals have perceived the effects of climate change on their livelihoods, which leads to increased vulnerability. To reduce the vulnerability, households have adopted a range of coping strategies including changes in planting date, tree planting, and cultivating local rice, spices, and oil seed. In Central America, De Sousa et al. (2018) analyzed farmers' climate knowledge, their perceptions on the variation in climate patterns, and their adaptation strategies of farming practices. According to their findings, reforestation was identified as a preferable adaptation strategy among households. There were two effective drivers for adopting farming practices including education and farmland size. They concluded that while the illiterate farmers with smaller arable lands tend to use more inputs, literate farmers selected soil management and new crop varieties. Aniah et al. (2019) investigated farmers' responses to climate change impacts on their livelihood activities in two rural communities in the Savanna agroecological zone of Ghana. Their findings suggest that households apply various coping, on-farm, and off-farm adaptation strategies to climate change. The on-farm coping strategies such as changing planting dates, use of resistant varieties, and soil conservation strategies were based on indigenous knowledge. They concluded that to ensure the sustainability of coping strategies, there is a need for exchanging knowledge between farmers and formal institutions by recognizing local and common measures.

In southern Ethiopia, Abate (2016) investigated a sample of nomadic households to evaluate their perception of climate change and their adaptation to its effects. Based on his study, there was a decrease in rainfall and an increase in drought intensity. Nomads

have adopted a variety of coping strategies including changing crop production, grazing, and herd management. He concluded that among various strategies, the sale of livestock is recognized as the most effective coping strategy. In Wa West District of north Ghana, Kusakari et al. (2014) investigated individuals' livelihood activities, which were affected by their indigenous knowledge about climate change hazards such as drought and flooding. In another study, Mekonnen et al. (2018) assessed households' perceptions of long-term climate change and concluded that these perceptions were a fundamental pre-indicator in undertaking adaptation processes in Arsi Negele district of Ethiopia. They further concluded that such climatic perception could mitigate the climate change impacts and uncertainty of the households' livelihoods.

## 2.2 Adaptability by association coping strategies (ACSs)

Coping strategies are selected to increase the community's resilience against climate change and extreme weather events (Aguilera et al., 2020). Selecting a set of coping strategies at the same time can mitigate the risks of climate change which is called the adaptability by the ACSs. In fact, communities are adapting to climate change through the prioritization, coordination, and adoption of the ACSs which have the potential to reduce future economic, social, and environmental costs (Bedeke et al., 2019).

To understand ACSs, several case studies and their coping strategies that were adopted at the same time are reviewed. Schroth et al. (2009) have modeled environment-related livelihoods exposed to climate change and developed coping strategies in the mountainous regions of southern Mexico. Their findings showed that for conservation of ecosystem services and livelihoods exposed by climate change, the main ACSs which were adopted consist of (1) promoting coffee growing methods, (2) forest restoration payments, (3) diversification of income earning activities, (4) coherent fire management, (5) crop insurance, and (6) strengthening local capacity. In eastern Ethiopia, Tesfaye and Seifu (2016) identified a set of simultaneous coping strategies adopted by farmers. Their findings showed that in response to climatic adverse effects, the major coping strategies adopted by farmers included cultivating various products, growing different crop varieties, altering cultivation dates, applying water and soil protection methods, agricultural conservation practices, and engaging in various income earning activities. Their results also showed that in addition to adopting the ACSs, government support is effective when providing credit resources, information, and promotional services on coping strategies and investing in climate smart and resilient projects. Sarker et al. (2020) investigated the ACSs for riverine island residents against the risks of climate change in Bangladesh. Their findings indicated that vulnerable residents who adopted a set of the ACSs resulted in enhancing livelihood resilience. This study also displayed that homestead gardening, altering cultivation patterns, tree planting, and migration were some of the most usual coping strategies selected by residents. In addition, their results illustrated that development programs and disaster management projects must be implemented through effective monitoring to increase the livelihoods resilience of the residents. In the mid-hills of Nepal, Dhungana et al. (2020) studied rural communities that have adopted the ACSs for the conservation of their natural forest resources and livelihoods. In their study, firstly, main climatic risks were explored, and then simultaneous coping strategies were determined based on perceptions of rural individuals. According to Dhungana et al.'s (2020) findings, the set of the ACSs in the drought incidents included plantation of trees, water sources conservation, construction of the conservation ponds, protection of forest, construction of irrigation channel, planting drought-resistant crops,

and maintaining a clean environment. Their findings indicated that the set of simultaneous coping strategies against the occurrence of floods were as follows: construction of check-dam, bamboo plantation, bio-engineering, plantation of trees, and protection of forest. Finally, as their results show, to deal with forest fires, simultaneous coping strategies were adopted such as construction of fire line, use of water, control grazing, and use of fire tools. In Iran, Jamshidi et al. (2020) examined the adaptability of farmers' households against climate changes and identified their simultaneous coping strategies. Their findings showed that farmers had a better perceiving of climate change if the dry seasons were longer and a lower perceiving of climate change if more rainfall and water resources were available. Based on their results, the most effective ACSs adopted by farmers include (1) using new irrigation methods and system, (2) shifting to drought tolerant crops and varieties, (3) diversifying household income resources, (4) optimized water resource management, and (5) optimal use of chemical pesticides and fertilizers.

Common simultaneous coping strategies adopted by nomads in Afar, Ethiopia, comprise supplementary feedstuff, combining different types of herds, including goats and sheep, and collecting weak livestock for sale (Treydte et al., 2017). During severe drought periods in Bolivia, nomads change their herd composition from sheep to goat as the feed requirements of the latter are less than the former (Struelens et al., 2017). While some coping strategies (such as borrowing money, occupation in other jobs, and reducing unnecessary expenses) are economically viable, others also consider the sustainability of natural rangeland resources. Nomads reduce the pressure on natural rangeland resources in several ways, such as rangeland evacuation and immigration to more suitable rangelands. The latter is seasonally circulating in cold and tropical regions and is a kind of traditional ranching management to protect natural rangelands (Devisscher et al., 2018; Struelens et al., 2017).

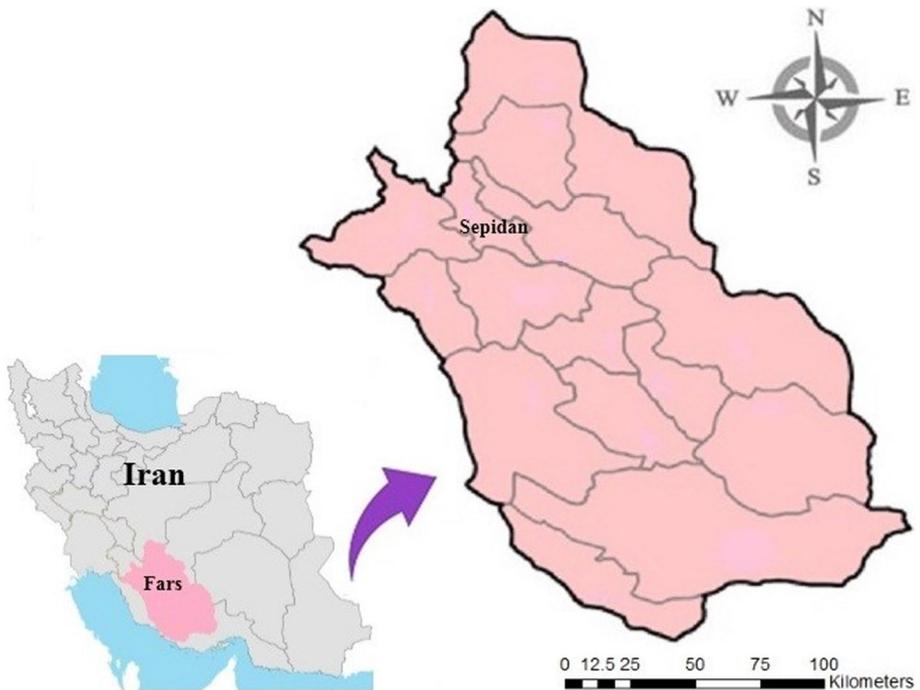
Based on the presented literature review, a conceptual framework should be created that provides an appropriate process to achieve the sustainability of nomadic livelihoods (Fig. 1). To develop the conceptual framework, indigenous knowledge about climate change should first be incorporated in terms of perceiving climate change, assessing impacts on traditional livelihoods, and implementing anticipatory coping strategies (Kusakari et al., 2014; Mekonnen et al., 2018; Sklenicka, 2002). Furthermore, indigenous communities develop a variety of coping strategies that reduce their vulnerability to climate change (Abate, 2016; Alam et al., 2017). In fact, after perceiving climate change and its effects on traditional livelihoods, communities adopt a set of simultaneous coping strategies (Aguilera et al., 2020). Applying several appropriate coping strategies at the same time can adapt communities to climate change and provide them with sustainable livelihoods. However, previous studies focused only on the adoption of different coping strategies but did not identify the relationships that exist between the adoption of those strategies. This means that adopting a set of antecedent coping strategies can lead to selecting a set of consequent coping strategies. Discovering the relationships between the adoption of coping strategies can provide new knowledge to adapt to climate change. The current study has identified those relationships using appropriate association rules.

### 3 Methodology

#### 3.1 Study area

Sepidan plain is located in the southwest slopes of Zagros mountains, northwest of Fars province, south of Iran, in a mountainous and forested region mostly covered with oak trees (Fig. 2). While Sepidan is mainly visited for its nature and countryside, it can be a destination for historical and archeological tourists. A number of Qashqai tribes, such as Kashkooli Bozorg and Kashkooli Koochak nomads, also live in the area.

The study area from north reaches to Yasuj basin, from south to Beyza plain, from west to Noorabad plain, and from east to Bakan plain. The maximum altitude in the region is 2300 m, and its area is 375 hectares, which is placed in latitude  $30^{\circ}15'N$  and longitude  $51^{\circ}59'E$ . The annual mean temperature is  $14.8^{\circ}C$ , and the total annual precipitation is 678 mm. Moreover, the plain is classified as a semiarid and cold region, upon to the Amberger climate scale.



**Fig. 2** Map of the study area in Sepidan plain, Fars province, Iran

### 3.2 Data

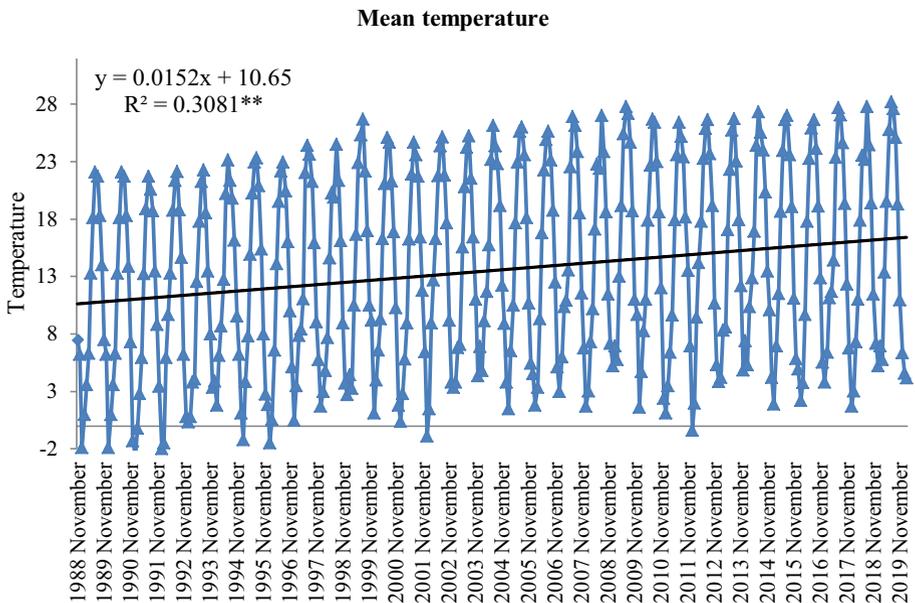
The statistical population consisted of Kashkooli nomads. The simple random sampling method was applied to determine the sample size using Eq. 1 (Scheaffer et al., 2012):

$$n = \frac{Npq}{(N-1)D + pq} \text{ where } q = (1-p) \text{ and } D = \frac{B^2}{4} \quad (1)$$

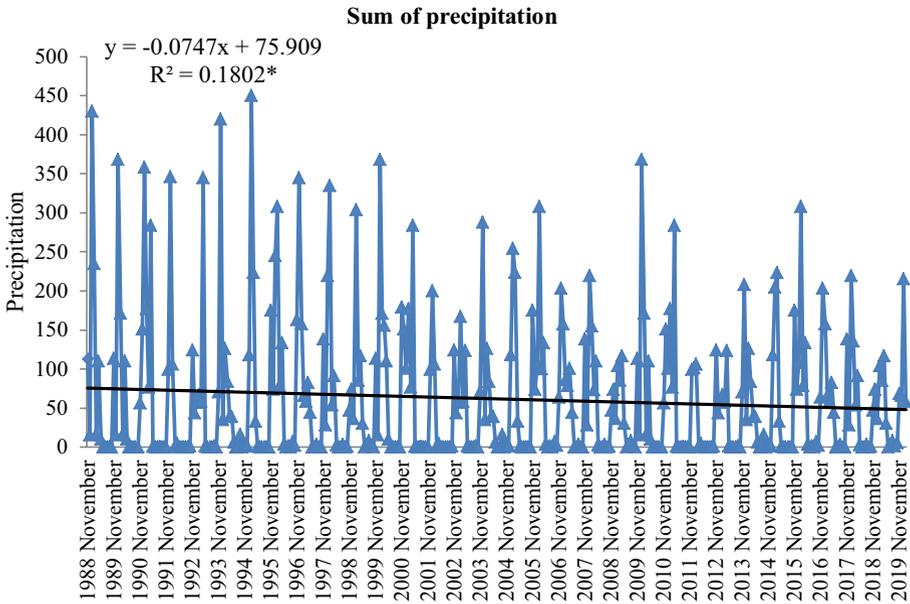
where  $n$  shows the sample size,  $N$  represents the nomadic population of Kashkooli in Sepidan plain (Fars province, Iran),  $p$  expresses the population proportion of Kashkooli nomads who have adopted a coping strategy against climate change, and  $B$  is bound on the error considered 10% in the study. Accordingly, 225 nomadic households were selected. Sample surveys were conducted by face-to-face interviews during June–July 2019.

In addition, historical meteorological data (including monthly mean temperature and sum of monthly precipitation data) were collected from the local weather station in Sepidan from November 1988 to February 2020. The trend linear regression analysis was used to monitor climate variations (Yihui et al., 2007; Zarei & Masoudim, 2019). The linear trend has allowed a precise study of the inter-monthly changes in climatic data. Thus, Figs. 3 and 4 were prepared to show trends in climate data.

Finally, time series data were compared with local perceptions of changes. This comparison provided an indication on whether and how recent climate change and coping strategies have occurred and have been implemented. This approach incorporated qualitative experience with quantitative measurements by distributing sampled households among different coping strategies.



**Fig. 3** Trend of monthly mean temperature (in °C). *Source:* Department of Meteorology, Fars province, Iran



**Fig. 4** Trend of sum of monthly precipitation (in mm). *Source:* Department of Meteorology, Fars province, Iran

### 3.3 Association rule

The association rule detects the probability of co-occurring items in a dataset. The findings show the relationships among the co-occurring objects. The association rule must explicitly show multiple association relationships, one of the methods most widely used to identify and extract valuable information from the database. This rule has been defined and introduced by Agrawal et al. (1993) for the first time and is as follows:

An association rule is in the form of  $A \Rightarrow B$ , where  $A$  and  $B$  are two disjoint sets of options in the database. The analysis refers to option  $A$  as the left (Lhs) side and option  $B$  as the right (Rhs) side of the association statute. Help (i.e., % of cases listed in data containing both  $A$  and  $B$ ), trust (i.e., % of cases listed in data containing both  $A$  and  $B$ ), and lift (i.e., confidence ratio to the percentage of cases that contain  $B$ ) are the three most commonly used measures for selecting interesting rules. These are the formulas used to calculate these steps (Dahbi et al., 2017):

$$\text{Support}(A \Rightarrow B) = \text{probability}(A \cup B) \tag{2}$$

$$\text{Confidence}(A \Rightarrow B) = \frac{\text{probability}(A \cup B)}{\text{probability}(A)} \tag{3}$$

$$\text{Lift}(A \Rightarrow B) = \frac{\text{probability}(A \cup B)}{\text{probability}(A) \cdot \text{probability}(B)} \quad (4)$$

In the current study, the elevator value of the association rule was used to take the candidate options for an adaptability approach. For the study of data mining association rules, a classic "a priori" algorithm was used (Kotu & Deshpande, 2019). It is the first algorithm commonly used for counting transactions and determining the percentages of products according to various rules. The a priori algorithm was implemented by IBM SPSS Modeler18 software.

## 4 Results

### 4.1 Demographic profile of nomads

Table 1 shows the general information of the nomadic respondents. The mean age of the household head was 53 years. The standard deviation of this set of values was 13.24. The minimum and maximum of literacy of household head were respectively 0 (illiterate) and 4 (higher education). Survey of nomadic literacy illustrated that nomadic households had a median of 2 (secondary education) and dispersion of 0.46. Finally, the median number of household's livestock and monthly household income was 140 stocking rates and 3152 thousand Iranian Toman (about 200 USD), respectively, with a standard deviation of 66.28 head of livestock and 600 thousand Iranian Toman. The results showed that nomadic households are well aware of climate change due to mean descriptive variables such as age, education, number of household livestock, and monthly income.

**Table 1** General information of nomadic respondents. *Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran

	Min	Max	Median	SD <sup>a</sup>
Age of household head (years)	20	90	53	13.24
Literacy of household head (education level)	0	4	2	0.46
Number of household livestock (livestock heads)	18	450	140	66.28
Monthly income of household (thousand Iranian Toman)	269	7815	3152	600

<sup>a</sup>Standard deviation

**Table 2** Perceived changes in temperature over 1988–2018 (in %). *Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran

	Not at all	Mildly	Moderately	Significantly
Mean temperature of spring and summer has increased	0	3.56	23.55	72.89
Mean temperature of autumn and winter has decreased	0	2.67	18.67	78.66
Overall, the temperature pattern has changed as mean temperature	0	1.78	2.67	95.55

## 4.2 Changes in climatic variables and climate change

### 4.2.1 Changes in temperature

According to the trend of monthly mean temperature, linear regression was significant at a level of 0.05 (Fig. 3). Linear trend analysis showed that the tendency rate (slope) using least squares was 0.0152 °C. Therefore, the monthly mean temperature increased in the Sepidan plain over the period from November 1988 to February 2020. Maximum/minimum peaks of the graph also indicated mean temperatures in hot/cold months that had increasing trends.

The severity of the impacts was perceived from "not at all" to "significantly". Nomadic perceptions in the context of changes in mean temperature were in admission with observed meteorological changes. Both indicate a significantly changing mean temperature. Survey data analysis (Table 2) indicates that 215 out of 225 Kashkooli nomadic households answered positively on having a significant change in overall temperature pattern as mean temperature. Moreover, 72.89% of nomads perceived significantly that mean temperatures of spring and summer have increased. In addition, 78.66% of nomads perceived significantly that mean temperatures of autumn and winter have decreased. Therefore, most nomads perceived that the mean temperatures of hot and cold seasons have increased and decreased, respectively. According to Fig. 3, meteorological data also showed that the monthly mean temperatures have increased. Therefore, nomads perceived correctly that mean temperature has increased in hot seasons. However, their perceptions were found to be in disagreement with meteorological mean temperature trends in cold seasons. The reason for it may be that Sepidan was located along Zagros mountains in a cold climate.

### 4.2.2 Changes in precipitation

Figure 4 shows the trend of the sum of monthly precipitation for the last 30 years. The trend analysis based on linear regression showed that the tendency rate (slope) was  $-0.0747$  mm and significant at a level of 0.10. Therefore, the sum of monthly precipitation became less in the Sepidan plain over the period from November 1988 to February 2020.

Based on the results, 65.78% of the Kashkooli nomadic households noted a significant change in precipitation patterns as severe rain, snow, and hail over the last 30 years (Table 3). There was also a perceived decrease in the amount of sum of rainfall which is in agreement with the climate measurement observations. 75.56% of the respondents

**Table 3** Perceived changes in precipitation over 1988–2018 (in %). *Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran

	Not at all	Mildly	Moderately	Significantly
Amount of sum of rainfall has decreased	0	4.00	18.22	77.78
Length of the rainy period, from the first day of rainfall to the last, has decreased	0	5.33	19.11	75.56
The rainy period has become more erratic in unexpected times	0.89	19.11	73.33	6.67
Overall, precipitation pattern has changed as severe rain, snow, and hail	0	1.33	32.89	65.78

perceived that the length of the rainy period, from the first day of rainfall to the last, has decreased significantly. The perceived change in the length of the rainy period also implies the perception of changes in the timing of the rainy period. In particular, 99.11% of the respondents perceived that the timing of the rainy period has become more erratic in unexpected times.

#### 4.2.3 Perception of climate changes in future

The survey on gathered data indicates that 219 of the 225 nomadic households have believed that climate change will persist in the future. Therefore, climate changes are happening more than before. This means that Kashkooli households were more likely to be exposed to the risk of changing climate. Hence, most nomads perceived climate change strongly.

### 4.3 Climate change impacts on traditional livelihoods

Perceived changes of climatic and environmental variables affected nomadic livelihoods. These impacts included temperature pattern changes (e.g., mean temperature) and precipitation pattern changes (e.g., severe rain, snow, and hail and drying of main water sources), and degraded rangelands were detected by 68.44%, 66.67%, 75.56%, and 68.89% of nomadic respondents, respectively (Table 4). On the other hand, moderate impacts of lack of daily access to water and asynchronous floods were realized by 64.44% and 70.22% of Kashkoolis, respectively.

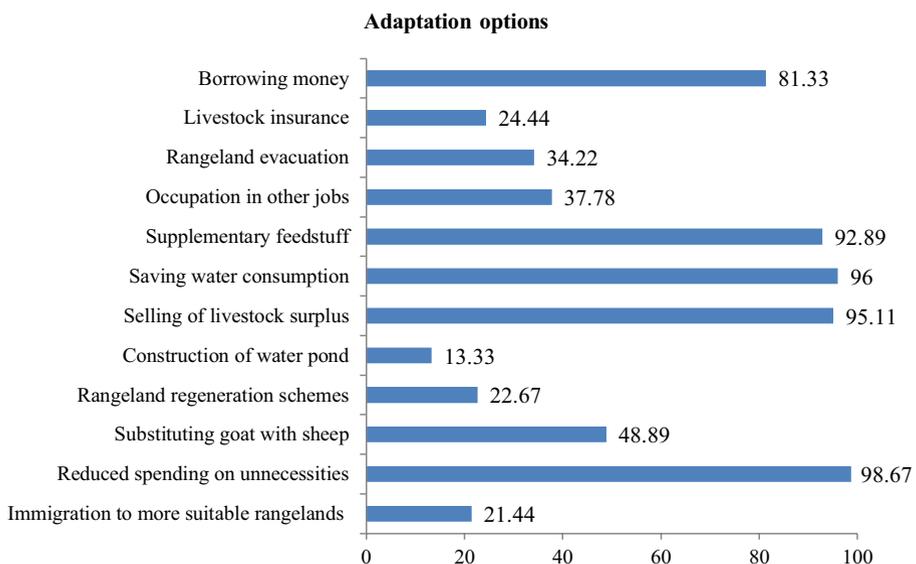
**Table 4** Perceived changes of climatic and environmental variables in traditional livelihoods over 1988–2018 (in %). *Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran.

	Not at all	Mildly	Moderately	Significantly
Temperature pattern changes as mean temperature	0	0.89	30.67	68.44
Precipitation pattern changes as severe rain, snow, and hail	0	0.89	32.44	66.67
Lack of daily access to water	0	4.44	64.44	31.12
Drying of main water sources	0	2.22	22.22	75.56
Degraded rangeland	0	0.44	30.67	68.89
Asynchronous flood	0	4.00	70.22	25.78

#### 4.4 Coping strategies to climate change

Adaptation is now considered as enabling households to cope and improve livelihoods in the light of climate shocks (Assan et al., 2018; Bhatta et al., 2015; Orlove, 2009). Kashkooli nomads have been operating several coping strategies based on their requirements. Nomadic households are concerned with adopting adaptation options. Some solutions during a crisis include reduced spending on unecessities, borrowing money, substituting goats with sheep, selling livestock surplus, supplementary feedstuff, livestock insurance, having other jobs, saving water consumption, and construction of water pond. Sustainable management of ecosystem services needs to be introduced in order to ensure sustainable nomadic livelihoods and avoid further unsustainable use of rangelands through rangeland evacuation and migration to more appropriate rangelands that pursue traditional ranching.

Figure 5 indicates coping strategies to cope with climate change. Most Kashkooli nomadic respondents, equal to 98.67% of households, reduced spending on unecessities under the changing climate. It means that climate change affected their incomes and reduced their purchasing capacity. According to a decline in precipitation in the region, 96% of Kashkooli nomads saved water consumption regarding water shortages. Moreover, 95.11% of sampled nomads sold up the amount of livestock surplus. This adaptation option has several advantages such as producing income, decreasing rangelands pressures, and preventing environmental degradation. Therefore, this is an appropriate adaptation option in terms of economic and rangeland resources conservation. According to climate change influences on rangeland quality and grass production decreases, 92.89% of nomadic households applied supplementary feedstuff for their livestock feeding. It is notable that Kashkooli nomads help each other financially under a climate crisis. 81.33% of respondents borrowed money from relatives, neighbors, and formal institutions. More than half of the Kashkoolis sample was taken from the five explained coping strategies, including reduced spending on unecessities, saving water

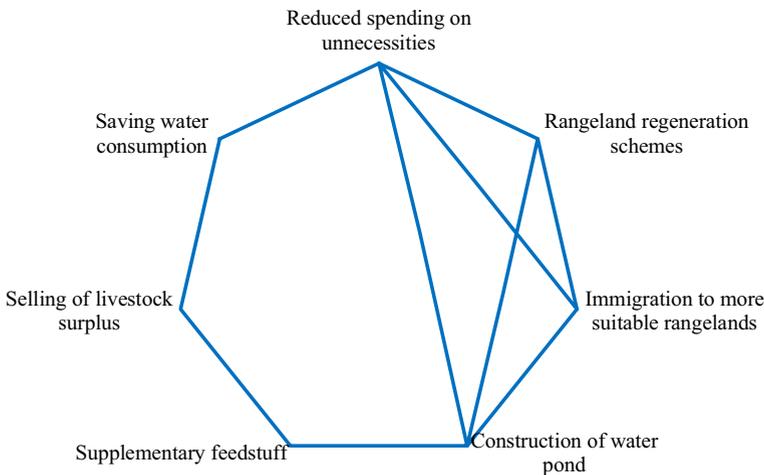


**Fig. 5** Adaptation options to cope with changes observed from 1988 to 2018 (in %). *Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran

consumption, selling livestock surpluses, supplementary feedstuffs, and borrowing money, which are reactive coping strategies to cope with climate change. In addition, four coping strategies for livestock insurance, rangeland regeneration schemes, moving to more suitable rangelands, and water pond construction had the lowest level of acceptance, respectively (24.44, 22.67, 21.44, and 13.33% of the nomads' population). Therefore, these options can be potentially introduced to other nomads as anticipatory options. Especially, the two options of rangeland regeneration schemes and immigration to more suitable rangelands can be used in the environmental protection of rangeland resources.

#### 4.4.1 Association rule mining

Figure 6 displays schematic adaptability based on data mining. The results represent co-occurrence combinations of adaptation options, and more than 95% of the dataset was adopted by the nomads. As the results show, 10 co-occurrence combinations were detected among seven coping strategies in the dataset. If one of the coping strategies in the co-occurrence combination is taken by the nomads, there is more than 95% probability that another option is adopted, too. For instance, the co-occurrence combination of selling



**Fig. 6** Schematic adaptability based on data mining. *Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran

livestock surplus and supplementary feedstuff indicates that nomadic households who adopt the selling of livestock surplus option take the supplementary feedstuff option with more than 95% probability, and vice versa. Other co-occurrence combinations in Fig. 6 have a similar interpretation.

The study sets the help value and trust value to different levels in order to examine the internal associations of coping mechanisms using the data mining technique as shown in Table 5. The mining adaptation data produce 182 rules when the study establishes minimum trust and help with 80% and 10%, respectively (Set 1 in Table 5). When the minimum trust or support is raised, then the number of laws appears to be substantially reduced. In the current paper, the proposed Set 9, which sets the minimum support at 30% and the minimum trust at 100%, will undermine a total of 16 practical association rules. As shown in Table 6, 16 rules are listed according to the data mining results.

As a result of the association rules, five adaptation options, including the sale of livestock surpluses, saving water consumption, livestock insurance, rangeland regeneration schemes, and immigration to more suitable rangelands, have been adopted from a number of other options. For example, rule R1 shows that when supplementary feedstuffs and saving water consumption were taken out, the sale of livestock surplus was accepted.

The mining adaptation alternative leads to the empirical results which follow. First, all 16 association rules that have the highest lift appear in the partnerships that include options being adopted. The findings show that the impacts of adaptation are greater than those of non-adaptation. Second, in general, the livestock insurance, immigration to more suitable rangelands, and rangeland regeneration schemes are consequent of association rules, not an antecedent. That is, other adaptation option selections cause the adoption of these options. Third, the supplementary feedstuff, reduced spending on unecessities, and borrowing money play important roles in the antecedent of association rules.

**Table 5** Number of association rules for adaptation options.  
*Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran

Number of sets	Min. support	Min. confidence	Number of rules
1	0.10	0.80	182
2	0.10	0.90	155
3	0.10	1.00	90
4	0.20	0.80	124
5	0.20	0.90	109
6	0.20	1.00	64
7	0.30	0.80	60
8	0.30	0.90	45
9	0.30	1.00	16

**Table 6** Association rules of adaptation options. *Source:* Household Survey, 2019, Sepidan plain, Fars province, Iran

Rule	Consequent	Antecedent	Support	Confidence	Lift
R1	Selling of livestock surplus = 1	Supplementary feedstuff = 1, Saving water consumption = 1	0.91	1.00	1.07
R2	Selling of livestock surplus = 1	Supplementary feedstuff = 1, Reduced spending on necessities = 1	0.91	1.00	1.07
R3	Selling of livestock surplus = 1	Borrowing money = 1, Supplementary feedstuff = 1, Saving water consumption = 1	0.75	1.00	1.07
R4	Selling of livestock surplus = 1	Borrowing money = 1, Supplementary feedstuff = 1, Reduced spending on necessities = 1	0.75	1.00	1.07
R5	Selling of livestock surplus = 1	Supplementary feedstuff = 1, Saving water consumption = 1, Reduced spending on necessities = 1	0.91	1.00	1.07
R6	Selling of livestock surplus = 1	Borrowing money = 1, Supplementary feedstuff = 1, Saving water consumption = 1, Reduced spending on necessities = 1	0.75	1.00	1.07
R7	Saving water consumption = 1	Selling of livestock surplus = 1	0.93	1.00	1.06
R8	Saving water consumption = 1, Livestock insurance = 1	Borrowing money = 1, Selling of livestock surplus = 1	0.77	1.00	1.06
R9	Saving water consumption = 1, Rangeland regeneration schemes = 1	Supplementary feedstuff = 1, Selling of livestock surplus = 1	0.91	1.00	1.06
R10	Saving water consumption = 1	Supplementary feedstuff = 1, Reduced spending on necessities = 1	0.91	1.00	1.06
R11	Saving water consumption = 1	Selling of livestock surplus = 1, Reduced spending on necessities = 1	0.93	1.00	1.06
R12	Saving water consumption = 1, Immigration to more suitable rangelands = 1	Borrowing money = 1, Supplementary feedstuff = 1, Selling of livestock surplus = 1	0.75	1.00	1.06
R13	Saving water consumption = 1	Borrowing money = 1, Supplementary feedstuff = 1, Reduced spending on necessities = 1	0.75	1.00	1.06
R14	Saving water consumption = 1	Borrowing money = 1, Selling of livestock surplus = 1, Reduced spending on necessities = 1	0.77	1.00	1.06
R15	Saving water consumption = 1, Rangeland regeneration schemes = 1	Supplementary feedstuff = 1, Selling of livestock surplus = 1, Reduced spending on necessities = 1	0.91	1.00	1.06
R16	Saving water consumption = 1, Immigration to more suitable rangelands = 1	Borrowing money = 1, Supplementary feedstuff = 1, Selling of livestock surplus = 1, Reduced spending on necessities = 1	0.75	1.00	1.06

## 5 Discussion

### 5.1 Nomadic perceptions and meteorological data on changing climate

Kashkooli nomads perceived climatic variables comprising temperature and precipitation differently. Most households, 95.55% of nomads, expressed that the overall temperature pattern as mean temperature has significantly changed. A significant increase and decrease in mean temperature in hot and cold seasons were perceived by 72.89% and 78.66% of sampled nomads, respectively. On the other hand, most households, 65.78% of nomads, expressed that the overall precipitation pattern as severe rain, snow, and hail has significantly changed. Moreover, a significant decrease in sum of rainfall and rainy season period was perceived by 77.78% and 75.56% of Kashkooli households, respectively. It is notable that Kashkoolis' awareness of climate change had become strong, although concern has been variable among households. Approximately 97% of nomadic households had regarded that climate change will persist in the future.

Nomadic perceptions and opinions, originating from discussions on changes in climatic variables and in the context of climate change directly, were in admission with observed meteorological changes. Meteorological data in Sepidan plain from November 1988 to February 2020 show that the trend of monthly mean temperature has increased by the slope of 0.0152 °C. On the other hand, the trend of the sum of monthly precipitation has had a negative rate.

The findings of this study about nomadic climatic perceptions and meteorological data are in agreement with other studies. Scientists believe that coping strategies are unlikely to be effective without an accurate understanding of the household perceptions of climate change. Sujakhu et al. (2016) indicate the household perception of hailstorms, landslides, flooding, thunderstorms, and extreme precipitation as climate-related hazards in the Melamchi Valley of Nepal. Alam et al. (2017) demonstrate that the perceptions of the respondents about climate change and extreme climatic events were similar to the climate data observed in Bangladesh. Ayala and Filhob (2017) indicate that more than 80% of households in Ethiopia have felt the different manifestations and effects of climate variability. Their perceptions of temperature fluctuations were recognized with the study of meteorological evidence. Nevertheless, their beliefs were found to be at odds with meteorological patterns in rainfall. Hasan and Kumara (2019) reported a moderate perception of climate change among respondents. The vast majority (98%) experienced a warmer summer and 96% observed a colder winter than before. 91% of households believed that rainfall had risen and 97% believed that the timing of rainfall had improved. Climate data observed were largely consistent with their expectations of temperature, rainfall, floods, and droughts. In short, by involving them in various organizations, the awareness degree of climate change will be increased. It could accelerate the spread of coping strategies between them to cope with the adverse impacts of climate change.

### 5.2 Traditional livelihoods under changing climate

Kashkooli nomads identified how climate change and environmental variables that included temperature pattern changes (e.g., mean temperature), precipitation pattern changes (e.g., severe rain, snow, and hail; lack of daily access to water; and dried main water source), degraded rangelands, and asynchronous floods were affecting their traditional livelihoods.

Changes in temperature and precipitation patterns eradicate the rangeland quality and increase flood risks. An important source of income for nomads is livestock farming. There is a very popular saying that 'sell wool and wear gold', but now the situation has changed according to climate change impacts on traditional livelihoods. Sheep and goat rearing have decreased significantly in recent years due to the decreasing availability of suitable rangelands. Nomads say that rangelands are drying earlier, or instead, the growth of grass is decreasing due to drought.

These findings were confirmed by other studies: Debela et al. (2015) illustrated that most participants perceived climate change and its negative impact on local livelihoods in pastoral and agro-pastoral systems of Borana in southern Ethiopia. In particular, lengthened drought and changing climatic patterns had resulted in a livelihood crisis. Van der Geest et al. (2018) showed that causal relationships between climate changes, such as multi annual drought, and ecosystem services, along with subsequent losses and damages, were often complicated in household livelihoods in West Africa. In sum, the effect of climate change damages on traditional livelihoods could be decreased by appropriate adaptation.

### 5.3 Association of coping strategies with climate change

This is notable that more than 50% of Kashkooli households were coping with climate change by reducing spending on unecessities, saving water consumption, selling the livestock surplus, using supplementary feedstuff, and borrowing money. Current responses were reactive and short-term options (Alvarado et al., 2018; Ihemezie et al., 2018; Mahaaracha, 2019; Smith, 2018). However, long-term coping strategies that consider expected future climate changes, quality of rangeland resources, and broader development goals are also required. The current paper proposed a new adaptability approach, the ACSs, to reach these purposes. Analyzing Kashkooli nomadic responses from local adaptation options, 10 important interior associations were detected among seven adaptation options. Four co-occurrence combinations showed that 95% of sampled nomads who reduced spending on unecessities have practiced one of the coping strategies (saving water consumption, rangeland regeneration schemes, and moving to other rangelands) or have built a water pond, and vice versa. Additionally, three co-occurrence combinations represented that 95% of sampled nomads who moved to other rangelands with better conditions have practiced one of the coping strategies (rangeland regeneration schemes and reduced spending on unecessities) or have built a water pond, and vice versa. Moreover, when the minimum trust and help are set at 80 percent and 10 percent, respectively, there are over 180 rules to mine the data on adaptability. The minimum support was increased by 30% in order to produce acceptable rules, and the minimum trust was increased by 100%, resulting in a total of 16 practical association rules. These association rules distinguished causality effects so that adopting antecedent options, such as supplementary feedstuff, reduced spending on unecessities, and borrowing money caused taking consequent options, such as livestock insurance, immigration to more suitable rangelands, and rangeland regeneration schemes.

## 6 Conclusions

The findings of the current paper provide an overview of the nature of Kashkooli nomadic perceptions of climatic variables fluctuations, climate changes in the future, climatic and environmental variables impact on traditional livelihoods, and local coping

strategies adopted to cope with climate change. Sample nomadic perceptions and experiences, supported by meteorological data, reveal that most Kashkooli households understand climate change at a strong level. Moreover, climate change is negatively impacting the nomadic traditional livelihoods in Sepidan plain.

The current study identifies and strengthens coping strategies for Kashkooli nomads. The findings of this study provide new insights into the linkages of data mining and adaptability theory in a data set application. Given Kashkooli nomads' practical perception of climatic conditions, they are encouraged to adapt their traditional ranching practices through supplementary feedstuff and selling livestock surplus. In fact, this can be said that the good indigenous knowledge of the nomadic tribes about climate change has assisted them in using appropriate coping strategies to improve their livelihoods. Supplementing livestock with complementary feed, in addition to improving livestock nutrition, reduces pressure on natural pastures and improves pasture conditions in the face of climate change. Furthermore, the separation of weak livestock and their sale leads to creating liquidity for nomadic households and increases the purchasing power of households. Therefore, the two mentioned strategies have environmental and economic aspects. However, adopting these two options simultaneously was a reactive adaptation measure providing the nomads with a rangeland regeneration scheme option. Rangeland regeneration is performed in two ways of seeding and planting seedlings, and indigenous individuals can also participate in this project. Indigenous knowledge of plant species is thus used in this coping strategy and results in the restoration and improvement of plant species. Participation in the regeneration of rangelands is an anticipatory option that will improve rangelands in the future to be resilient against climate change impacts.

To address the first research question, it should be highlighted that Kashkooli nomads' coping strategies are mainly to (1) borrow money to cope with climate change impacts, (2) adopt supplementary forage, (3) sell livestock surplus, (4) and move to more suitable rangelands. Thus, diversifying financial sources is greatly recommended to policymakers. Providing cash for nomadic households in the face of climate change is one of the key factors that make it possible to adopt coping strategies and thus help them maintain their traditional livelihoods. To address the second research question, the results showed that changes in temperature and precipitation patterns, degraded rangelands, and asynchronous floods are key climatic and environmental variables that affect traditional nomadic livelihoods. These variables pose a significant risk to traditional ranching activities, which are the major source of Kashkooli nomads' livelihoods. Policymakers must therefore note that understanding the indigenous knowledge of climate change is critical to the development of effective policies to achieve sustainable livelihoods.

To address the third question, the findings showed that the ACPs aim to address sustainable livelihoods in order to increase the adaptive capacity of Kashkooli nomads using the new adaptability approach called ACSs, which incorporate climate change coping strategies. Moreover, the climate change adaptation should focus on viable options, including livestock insurance, securing suitable rangelands as livelihood resources, and finally, strengthening the capacity of nomads through moving to more suitable rangelands to limit the loss impacts resulting from climate changes. Finally, understanding and building on indigenous knowledge and resources will improve the design and implementation of coping strategies to climate change impacts for nomadic livelihoods.

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## Authors and Affiliations

Samane Ghazali<sup>1</sup> · Hossein Azadi<sup>2,3</sup>  · Kristina Janečková<sup>3</sup> · Petr Sklenička<sup>3</sup> · Alishir Kurban<sup>4,5,6,7</sup> · Sedef Cakir<sup>8</sup>

<sup>1</sup> Agricultural Economics, Shiraz University, Shiraz, Iran

<sup>2</sup> Department of Geography, Ghent University, Ghent, Belgium

<sup>3</sup> Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Prague, Czech Republic

<sup>4</sup> Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, 818 South Beijing Road, Urumqi 830011, Xinjiang, China

<sup>5</sup> Research Center for Ecology and Environment of Central Asia, Chinese Academy of Sciences, 818 South Beijing Road, Urumqi 830011, Xinjiang, China

<sup>6</sup> University of Chinese Academy of Sciences, Beijing 100049, China

<sup>7</sup> Sino-Belgian Joint Laboratory for Geo-Information, Urumqi 830011, China

<sup>8</sup> Environmental Research Centre, Cyprus International University, Nicosia-Northern Cyprus via Mersin 10, Turkey