frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 03 November 2022
DOI 10.3389/fsufs.2022.1003128

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Land, Livelihoods and Food Security, a section of the journal Frontiers in Sustainable Food Systems

RECEIVED 25 July 2022
ACCEPTED 03 October 2022
PUBLISHED 03 November 2022

CITATION
Abedi M, Hayati D and Valizadeh N (2022) A conceptual model for adaptation to climate variability in rangelands.
Front. Sustain. Food Syst. 6:1003128.
doi: 10.3389/fsufs.2022.1003128

A conceptual model for adaptation to climate variability in rangelands

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Exploiting medicinal plants on rangelands is a climate-sensitive strategy in Iran. In other words, there is an urgent need for the transition toward resilience under current climatic pressures and risks. In addition, a deep understanding about awareness, risk perceptions, and adaptation strategies of different rural groups can play a significant role in the mitigation of climate change impacts and the development of the adaptation capacity. Therefore, the development of a conceptual model for adaptation to climate variability in rangelands was determined as the main purpose of the present study. To this end, we used analysis of awareness, risk perceptions, and adaptation strategies of medicinal plant exploiters toward climate variability. This research was carried out in Sought Khorasan province of Iran, which is one of the climate-sensitive and leading areas for the exploitation of medicinal plants in the country. Required data for this study were gathered through 13 focus group discussions. The number of members of these focus groups was between 4 and 12 people. The total number of participants in the focus groups was 91 medicinal plant exploiters. The results revealed that exploiters have a relatively favorable awareness of the current climate situation. However, they perceived huge constraints in financial supports and resources which lead to increasing social conflicts, decreasing social relations, leaving the job, increasing migration, unemployment, and psychological impacts. As expected, various adaptation strategies were used aiming at conserving, developing, improving, and managing income resources, but many of them are short of resilience orientation. Finally, research findings were articulated in the form of a conceptual model and some practical recommendations were presented to enhance adaptation of rangelands' exploiters.

KEYWORDS

climate variability, awareness, perception, adaptation strategies, medicinal plants exploiters

Introduction

The world's climate is changing in an alarming rate (Adger et al., 2003; Esham and Garforth, 2013; Valizadeh et al., 2022). Climate change is regarded as one of the most important issues of the twenty-first century (Vincent, 2007; Jürkenbeck et al., 2021). So that, it has exposed the highest risk to arid and semi-arid regions of the world (Keshavarz et al., 2014).

This is particularly true in developing countries like Iran whose rural livelihood is highly sensitive and vulnerable to climate changes (Adger et al., 2003; Haji et al., 2020; Valizadeh et al., 2021b). Since the beginning of the twenteeth century, unfavorable intensified variability has severely eroded natural resources in Iran (Karami, 2009; Hayati et al., 2010; Sharafi et al., 2021; Valizadeh et al., 2021a). The rangelands which are covering 25% of Iran's land area (FRW, 2016) are being destroyed because of the severity of climate change impacts (Karimi et al., 2017). That is while the rangelands are among the main sources of rural livelihoods in the country. For example, Iran's rangelands are habitat of many medicinal plants, and villagers use these plants as an important source of livelihood. In this regard, the exploitation of bio-products of medicinal plants, including seeds, gums, fruits, and leaves, is highly valued by many Iranian rural households (Shahraki et al., 2015). More specifically, the exploitation of medicinal plants is the main and (in many cases) the only source of income for some rural households in South Khorasan, Kerman, Fars, and Yazd provinces. However, rapid climate changes and their subsequent impacts have posed major challenges to the survival of these plant species and villagers depending on these plants. Therefore, medicinal plant exploiters need to be adapted to climate changes by employing suitable adaptation and risk-reducing strategies. The extreme economic dependency of these communities on the exploitation of these plants and the limited ability to intervene in rangelands necessitate the development of measures to achieve maximum resilience. In contrast, the policy of prohibition of exploitation on rangelands in some years has been the dominant effort of policy-makers (Bijani et al., 2017; Valizadeh et al., 2019, 2020). Although this policy has made some adjustments on rangelands, it has created more difficulties for exploiters (Ministry of Agriculture-Jahad of Iran, 2020). It is apparent that such a policy overlooks the socio-ecological resiliency of the exploitation systems. Moreover, the process of adaptation becomes more difficult as the pace of climate change increases.

Risk management is generally considered as one of the best approaches to overcome such perturbations. However, it is poorly used in Iran (Zarafshani et al., 2012). Scientific reports illustrate that the crisis management has been dominant approach in recent years (Keshavarz et al., 2013; Yazdanpanah et al., 2016); as a result, effective adaptation and increased socio-ecological resilience are not feasible (Mahmood et al., 2021; Valizadeh and Hayati, 2021; Hawkins et al., 2022). According to Juana et al. (2013), understanding the awareness of communities toward climate change and analyzing its risks for their livelihoods and adoption of the adaptation strategies are crucial factors to effective adaptation toward climate change. Climate change awareness is defined as "conscious about the issue of climate change" (Jürkenbeck et al., 2021). The perception of risk in the field of climate change is a subjective construct and is influenced by human factors, such as personal experiences, memories of climate events, and various biases (Patt and Schröter, 2008). The adaptation strategies against climate variabilities are a set of measures that are consciously used by people at the production and income unit level of rural households to mitigate the negative effects of climate change or even prevent its impacts. More specifically, investigating the awareness is assumed as a start point to make effective adaptation (Fosu-Mensah et al., 2012; Gandure et al., 2013; Yaro, 2013; Le Dang et al., 2014; Farrokhi et al., 2020; Mahmood et al., 2021). Since climate change management also needs some information about perceived risks (Gandure et al., 2013; Azadi et al., 2019a; Mahmood et al., 2021) and potential and in-action adaptation strategies (Smit and Wandel, 2006; Gandure et al., 2013; Dumenu and Obeng, 2016; Azadi et al., 2019a; Esfandiari et al., 2020; Mahmood et al., 2021) to attract required financial supports.

Studies addressing the issues of climate change awareness, perceptions, and adaptation in Iran (Zarafshani et al., 2005; Fatemi and Karami, 2010; Hayati et al., 2010; Keshavarz et al., 2013; e.g., Azizi Khalakhili and Zamani, 2014; Zobeidi et al., 2016; Azadi et al., 2019a,b; Jamshidi et al., 2019; Esfandiari et al., 2020; Farrokhi et al., 2020; Delfiyan et al., 2021; Ghazali et al., 2021) are basically focused on farmer groups. Therefore, exploiters of medicinal plants have not been studied so far. This is one of the most important originalities of the present study. While their activities play an important role in sustaining their livelihood and Iran's rural economy, the lack of such studies over the years has led to the adoption of some inappropriate policies, such as prohibition of exploitation. Moreover, most of these studies (Deressa et al., 2009; Fatemi and Karami, 2010; Hayati et al., 2010; Fosu-Mensah et al., 2012; Esham and Garforth, 2013; Yaro, 2013; e.g., Gandure et al., 2013; Antwi-Agyei et al., 2014; Azizi Khalakhili and Zamani, 2014; Baudoin et al., 2014; Le Dang et al., 2014; Dumenu and Obeng, 2016; Zobeidi et al., 2016; Azadi et al., 2019a,b; Jamshidi et al., 2019; Esfandiari et al., 2020; Farrokhi et al., 2020; Ghazali et al., 2021; Mahmood et al., 2021; Hawkins et al., 2022) have turned a blind eye to the resilience orientation of the adaptation strategies. Therefore, the second originality of the present study is that it is focused on the resilience aspects of the adaptation strategies. This is an innovative perspective that has not been investigated by the pervious researchers. Due to the fact that different strategies have unequal ability to create resilience (Hawkins et al., 2022), it is necessary to identify the best strategies and background affecting their adoption. Being insider or outsider in the villages and continuance of application are of great importance in identifying the best adaptation strategies and resilience-building measures. Therefore, the investigation of the continuance of the application of climate adaptation strategies is the third originality of the present study. The best adaptation strategies and resilience-building measures are more crucial for exploiters of medicinal plants as they are critically exposed to

climate events. To fill these gaps, the present study, therefore, investigates the climate change awareness of exploiters and its alignment with the ability to mitigate the impacts and adopt more appropriate adaptation strategies. The focus then shifts into the investigation of different perceptions of climate change risks and their severity. In this regard, the perceived effects are also studied according to the previous type of climate awareness. Finally, the adaptation strategies were identified and investigated according to their resilience orientation. To this end, the selection of the adaptation strategies was analyzed with respect to the antecedent variables and climate change awareness and risk perceptions. At the end, a conceptual framework was developed and presented for livelihood adaptation to climate variability in rangelands. In general, the main questions of this study are as follows:

1. How Do Medical Plant Exploiters see Climate Variability?
2. What Are the Risks of Climate Variabilities Understood by Medicinal Plant Exploiters?
3. How Do Medicinal Plants Exploiters Assess the Severity of Risks Related to Climate Variabilities?
4. What Is the Role of Medicinal Plants Exploiters' Climate Awareness in the Formation of Perceptions (About the Impacts and Their Severity)?
5. What Strategies Do Medicinal Plants Exploiters Choose to Reduce the Impacts of the Climate Variabilities?
6. In What Classes can the Strategies of Medicinal Plant Exploiters be Classified?
7. Which Strategies Are the Most Used Among Medicinal Plant Exploiters?
8. Which Strategies Have a Higher Ability to Increase the Resilience of Medicinal Plant Exploiters Against the Impacts of Climate Variabilities?
9. What Strategies Should Climate Risk Management Programs use to Reduce Vulnerability From Climate Risks?

Methodology

The study area

The study area was Tabas County, located in the west of the Sought Khorasan Province in Iran (Figure 1). This county has a desert climate. It is about 960 meters above the sea level. Same to the most part of Iran, this county has experienced a dramatic drop in rainfall and increase in temperature over the past years. Climatological reports from 1984 to 2014 reveal that the average precipitation dropped by about 20 mm and temperature mean increased about 2°C in Tabas (Omidvar and Taleb-zadeh, 2015). The same result has been repeated in another recent research that was conducted by Ghazavi and Moosavian (2017). The results of this research showed that between 2010 and 2019, the temperature increased and the rainfall decreased. This county has always been considered as a leading region in exploiting medicinal plants. The area of rangelands in this region is 140,000 hectares (Khosravi and Mehrabi, 2006). In addition, these pastures are steppe and desert type. Due to the special ecological conditions of Tabas, rangeland-based exploitation of medicinal plants is of particular importance to the rural livelihoods. In the other words, the lack of sufficient water and suitable agricultural soil has led to the use of medicinal plants in rangelands as the main source of income over the years. Exploiters earn their living by extracting bio-products from local medicinal plants. In some case, they have small-scale livestock keeping and agriculture activities. Most of the medicinal plants' bio-products such as leaves, flowers, and gums are sold by local traders in the country or abroad. Asafoetida (*Ferula assa-foetida*) is the most popular exploited plant. Thyme (*Thymus vulgaris*) and Caraway (*Carum carvi*) are also exploited in the study area. Considering the importance of medicinal plants exploitation activities in employment and exports and the need to sustain the dependent rural livelihoods, Tabas was selected as the study area.

Population and sampling

The statistical population of the current study was all the medical plant exploiters in Tabas County ($N = 400$). The study area was first divided into thirteen villages according to the Country Divisions Report. Then, using an interactive dialog with the rural councils and local informants, all the heads in exploiting households were identified and listed separately for each village. At the third stage, the exploiters invited to participate in the Focus Group Discussions (FGDs) and participatory observation processes voluntarily. Taken together, 91 exploiters participated in FGDs. In the simplest definition, an FGD is a type of interview with the presence of a facilitator–interviewer who guides the discussion toward the research questions using a pre-arranged and semi-structured guide. This method is the most suitable way to understand how a society thinks as a whole.

Data collection and analysis

A deep understanding about farmers' awareness and perceptions of climate change requires analyzing insiders' (farmers') perspectives using a qualitative research method. In this regard, data gathering was done through the FGD and participatory observation. Sharing ideas and perceptions in the FGDs and following participatory observation enabled the in-depth, context-based, and detailed investigation of goals. According to Le Dang et al. (2014), in the first step, the main topics were drawn up from relevant studies to be discussed in meetings. These topics included the awareness of climate variability, the perceived effects, and the climate change adaptation strategies. In the second step, FGDs were

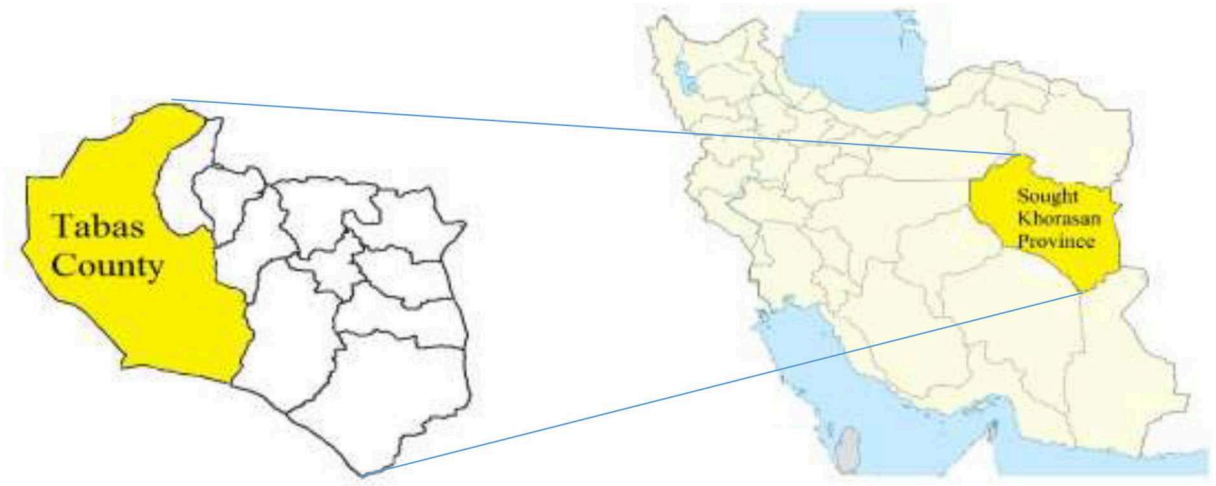

FIGURE 1
Geographic position of the study area.

conducted at least with four and maximum with 12 exploiters. The time for these meetings was one and half to 2 h. The most important open-ended questions in this section were as follows: (1) How do you perceive climate change? (2) What are your personal experiences in climate change? (3) What risks do you think climate change has on your life? (4) What are you doing to adapt to climate change? (5) In which area are the activities of adapting to climate change more? (6) How do you know what measures are appropriate to adapt to climate change? During conducting FGDs, the researchers tried to guide the discussions toward the goals of the research. Also, the exploiters were requested to spend more time on the more important issues. For the purpose of documentation of the results, all discussions were recorded. In the third step, the documentation phase began with transcribing verbatim. Then, thematic categorization using case study method was employed to form the basis of the coding process. Each code and its related concepts were put together. In addition to the recorded FGDs, the researchers' notes were used to evoke the concepts. Also, in the coding process, the frequency of references in the interviews, the emphasis and focus of the users on the concepts, and the results of participatory observations were used as coding aids. The best expressions of each concept were written in the final qualitative manuscript. Tag cloud was employed to represent the importance and priority of the concepts. These tag clouds were visualized using the online-free tag clouding software. In this way of representing the results, concepts or words with a larger size and thickness have more importance or priority from the respondents' point of view.

Results and discussion

The awareness about climatic variations

Based on the findings, the awareness about climatic variations consisted a wide range of decreasing rainfall amount, increasing interval of rains, decreasing snowfall, late precipitation, increasing annual warmth, and increased duration of the warmth. These concepts are categorized in the form of two general variables entitled precipitation and temperature (Table 1).

Decreasing rainfall was pointed by most of the participants. They believed in insufficient annual rainfall. It should also be mentioned that increasing the interval of the rains was discussed by most of the samples and acknowledged as the main root of droughts. These results also highlighted the importance of decreasing snowfall over recent years. Moreover, late precipitation was characterized as another element of the awareness about climatic variations. Increasing the annual warmth and duration of the warmth were the two most important factors which were emphasized by exploiters in temperature variability and change dimension. In their view, temperature changes of seasons (especially between summer and autumn) are less perceptible than before. Such awareness is raised due to high dependence on natural resources. In the case of medicinal plant exploiters, the compulsion to continuously monitor the status of rangelands and climate makes them have a relatively wide range of climatic awareness. These findings are in line with the meteorological results of Omidvar and Taleb-zadeh (2015).

TABLE 1 Medicinal plant exploiters' awareness about climate variability and change.

Variables	The concepts of awareness	Exploiters' quotations	Support in the literature
Precipitation	Decreasing rainfall amount	Raining was often 24 hours a day in the past. Now it's an hour or minutes (FGD 13). After raining, the land gets wet a little and dries up very soon. It is not enough for us (FGD1).	Deressa et al. (2009), Fatemi and Karami (2010), Fosu-Mensah et al. (2012), Yaro (2013), Antwi-Agyei et al. (2014), Azizi Khalakhili and Zamani (2014), Jamshidi et al. (2019) and Mahmood et al. (2021)
	Increasing interval of rains	These years, the rainfalls' interval seems to be longer than before. It is the main root of drought in our region (FGD7).	Fatemi and Karami (2010), Yaro (2013), Baudoin et al. (2014), and Le Dang et al. (2014)
	Decreasing snowfall	In the past, sometimes snowing was that much that we could not take our sheep out. Now, there is no such snowing (FGD 11).	Azizi Khalakhili and Zamani (2014)
	Late precipitation	It is now the 12th month of the year, there is still no raining (FGD 8).	Gandure et al. (2013)
Temperature	Increasing annual warmth	The autumn and winter are not cold like before (FGD 4).	Fatemi and Karami (2010), Fosu-Mensah et al. (2012), Esham and Garforth (2013), Yaro (2013), Antwi-Agyei et al. (2014), Azizi Khalakhili and Zamani (2014), Le Dang et al. (2014), Jamshidi et al. (2019), and Mahmood et al. (2021)
	Increasing duration of the warmth	It seems that the autumn couldn't be felt, because the air is still warm. The duration of the warmth period has also increased (FGD 6).	

Reference: Findings of the research.

The effects of climate changes

According to the results, risk perceptions of extreme climate events have manifested through some initial environmental and economic impacts, which in turn lead to some other social and psychological consequences. Although exploiters were well aware of the fluctuations and trends of climate change, it seemed that the risks of climate change on their livelihoods were wide-ranging. According to Ghazali et al. (2021), in such a situation, it is expected that a proper understanding of the severity of climate risks will lead to favorable and effective adaptation. Figure 2 shows an overview of the perceptions of exploiters suffering from the negative impacts of climate variability in the form of a tag cloud. Phrases existing in this figure are demonstrating the perceived risks of climate change. The impacts such as rangeland weakness, reduced income, reduced financing power, leaving the job, and unemployment which have been shown by bigger font sizes were more highlighted in the results.

Environmental–economic risks

These risks refer to the visible consequences in rangelands (the main source of income for the users of medicinal plants) and small-scale agricultural and livestock units (subsidiary sources of income) along with the economic and financial losses attached to them.

Rangeland weakness

In comparison with the past, exploiters had more clear ideas about the trends of rangelands' degradation. Accordingly, they claimed that decreasing rainfall and increasing temperature generally lead to the coverage reduction of the medicinal plants on rangelands. In this case, a special emphasis was on Asafoetida—the most important and profitable medicinal plant in the area—that have had a huge decline on rangelands (Table 2). They have clear perceptions of reducing the number of plants suitable for exploitation and reducing the number of exploiters in each region. They also consider the decrease in the number of their livestock as a direct result of the reduction of bushes and trees in pastures due to climate change and drought. In such a situation, rangelands are no longer able to provide services to medicinal plant exploiters. In other words, rangelands cannot be considered as a supporting source for their livelihood.

Reduced water for agriculture

Sufficient agricultural water resources in rural area could be a driver of villagers' attachment and dependence to village. The reduction of groundwater resources is a serious challenge for the regions dealing with extreme climatic variations. As

FIGURE 2
Word cloud of the perceived risks of climate variability.

mentioned earlier, a small group of exploiters have secondary income sources, including agriculture and livestock husbandry. Based on the findings (Table 2), the farmers studied pointed out lack of water and drying of gardens as one of the main problems. They do not even see their efforts to extract more water from underground sources very fruitful. Therefore, perceiving this issue as a problematic and stressful situation is inevitable.

Reduced income

The present study revealed that climate change risks have negatively and impressively affected the income of exploiters. Since climate change has decreased the annual yield. Given that exploiting medicinal plants is the main livelihood strategy of the participants, income reduction is the most tangible effect of extreme climate events. The decline in revenue is generally due to the constraints that climate change imposes on adaptation. The loss of complementary income sources is another factor limiting the use of the adaptation strategies. Agriculture and livestock husbandry sectors, which enhance households' feedings and subsequently raise their income, are heavily influenced by climatic variations (Table 2). Therefore, the sharp decrease in the income from the exploitation of pastures along with its negative effects on the income from other sources increases the economic pressure and vulnerability.

Reduced financing power

Based on Table 2, the inability of exploiters to recover and make a living is the first result of the continuation of adverse climatic events and destruction of income sources. It is apparent that meeting the basic needs, including education, health, and nutrition, will be faced with serious problems within the households of the medical plant exploiters. It highlights their inability to support the education of their children. Also, some of exploiters do not pay much attention to their health due to the lack of money. Therefore, the quality of their life remains to be far from its standards.

Social–psychological risks

Climate changes have social–psychological risks. These social and psychological factors may act as psychological inhibitors or drivers of adapting to climate change. Table 3 shows the socio-psychological risks identified from the point of view of medicinal plant exploiters.

Increased social conflicts

Current extreme climatic events increase the social conflicts (Table 3). Common pool resources lead to intensified competition to maximize resource utilization and create egoistic and individualistic behaviors in communities. Individualistic behaviors basically exacerbate the inequality in access to resources. Inequality in the exploitation of pastures leads to conflicts among exploiters (Table 3). Social conflict among medicinal plant exploiters generally has one main source: Customary and informal ownership of pastures lead to the exploitation of pastures under each other's possession without their permission. The utilization of pastures under climatic conditions is not very dependent on customary rules governing communities. In other words, financial benefits and the ability

TABLE 2 Medicinal plant exploiters' perceptions about environmental–economic risks.

The concepts of perceptions	Exploiters' quotations	Support in the literature
Rangeland weakness	"In the past, it rained a lot and heat was not so intense. There was Caraway, Thyme. Now, it is about four or five years that we have not seen them as much as before." (FGD 12) "In our region, only 3 of us were able to exploit this year. I remember we were 30 in 2006. We were used to exploit approximately 4,000 Asafoetida plants by each person. Now this number reduced to 1,500." (FGD 11) "Wild Almond[a] and Mt. Atlas mastic trees[b] may be about 15 years that are not greened. There is no more vegetation and bushes to feed livestock in the pastures." (FGD 6) "We had over 10,000 to 15,000 sheep in this village, now they may be 500. If you take the statistics of the Ministry of Agriculture or Veterinary Office, you can understand how drought could endanger us." (FGD 13)	
Reduced water for agriculture	"Because of the drought, the water of the fountain in our village has reduced. Five to six years ago, water was enough for agricultural necessity, but now it is not responsive." (FGD 3) "Here, we have an aqueduct that is drying up. We are trying to dredge it by taking governmental budgets, but there is no good result." (FGD 9) "Due to the scarcity of water and status of fountains, our gardens are drying up." (FGD 1)	Fatemi and Karami (2010), Azizi Khalakhili and Zamani (2014), Jamshidi et al. (2019), Hawkins et al. (2022)
Reduced income	"These days, due to the drought conditions, the harvest of Asafoetida has decreased from 100 kilos to 20 kilos." (FGD 7) "In the past, exploiters of Asafoetida were able to earn 10 or 15 million tomans[c]; however, there is no more than 3 or 4 million tomans[d] at present time, unless they go somewhere else." (FGD 5) "Lack of water has dried up gardens and pastures and fodder is scarce. With these conditions, what income can be expected for agriculture and animal husbandry?" (FGD 1)	Fatemi and Karami (2010), Hayati et al. (2010), Keshavarz et al. (2013), Yaro (2013), Azizi Khalakhili and Zamani (2014), Baudoin et al. (2014), Le Dang et al. (2014), Hawkins et al. (2022)
Reduced financing power	"If a fruit seller or someone else came to our village in previous years and we wanted to buy something, we could pay him/her immediately. Now we have to make time to pay." (FGD 8) "Asafoetida has been scanty in these years. Our income has dramatically decreased. We don't have money to spend for our wife and children. Over these years, it has been the same for all of us." (FGD 4) "Two of my children are now students. Providing their education costs is really hard to me." (FGD 9)	Fatemi and Karami (2010), Hayati et al. (2010), Keshavarz et al. (2013), Le Dang et al. (2014)

[a]The scientific name is *Amygdalus scoparia Spach*.
[b]The scientific name is *pistacia atlantica*.
[c]It is *about one thousand US dollars*.
[d]It is *about three hundred US dollars*.
Reference: Findings of the research.

to make a living are more important than other behavioral stimuli. Therefore, increasing social conflicts between exploiters for access to limited rangeland resources are very common.

Decreased social relations

Regarding the fact that exploiters are facing seriously with the climate changes, the decline of social relations is not unexpected (Table 3). Although this effect was observed to a small extent in the sample, the decline of social relations is a double-edged sword, because on the one hand it leads to individuals' effort to improve the relations and on the other hand it causes more rupture in relationships. It is noteworthy that the existence of such social gap could limit the ability of social networking, which enables the exchange of required information and knowledge of adaptation.

Unemployment

From the perspective of the exploiters (Table 3), the risks of climate change are not limited to reducing social capital, because unemployment is also in most cases rooted in climate change. Due to the reduction of medicinal plant cover in the pastures, many exploiters have not been able to harvest any products over the past several years. Although there is relatively good awareness in the field of climate fluctuations and the transition of climate change among medicinal plant exploiters (Table 1), the extent of other economic and social risks has caused an increase in unemployment.

Leaving the job

Medicinal plant exploiters mainly highlighted the loss of rangelands and its economic consequences as one of the most important reasons for quitting their jobs. Leaving the job may

10.3389/fsufs.2022.1003128

TABLE 3 Medicinal plant exploiters' perceptions about social–psychological risks.

The concepts of perceptions	Exploiters' quotations	Support in the literature
Increased social conflicts	"Over the past few years, we have seen and heard a great deal about property disputes. For example, a person has usurped an area for exploitation; but someone else has claimed that he owns the land." "Such conflicts, which are due to lack of Asafoetida in rangelands, were much less in the past." (FGD 13)	Fatemi and Karami (2010), Keshavarz et al. (2013)
Decreased social relations	"We are now dealing with issues that we can no longer see our neighbors as in the past. We used to have a soiree every night; but now we don't have such soirees." (FGD 10)	Zarafshani et al. (2005), Fatemi and Karami (2010), Hayati et al. (2010), Keshavarz et al. (2013)
Unemployment	"Many people in the area were not engaged in agriculture in the warm seasons and were unemployed in the winter." (FGD 7) "In the past, no exploiter was seen in the village during the exploitation season; but this is no longer the case." (FGD 7)	-
Leaving the job	"Exploiters generally leave their jobs due to the inadequacy of Asafoetida, Caraway, and Thyme. Whereas in the past this was not the case." (FGD 12) that "exploiters are turning to other jobs because they cannot afford to pay living expenses." (FGD 7)	-
Increased migration	"The migration of the people is increasing now. The reason why other farmers do not migrate is the small farm or livestock they have in the village." (FGD 12) "There were exploiters in our village who sold all their property and migrated to the city. I am sure that they will never return." (FGD 6)	Fatemi and Karami (2010), Hayati et al. (2010), Keshavarz et al. (2013), Yaro (2013)
Anxiety	"Nowadays people are not as happy as they used to be. Everyone is anxious." (FGD 1) "In recent years, we have not only suffered financially, but also broken spiritually." (FGD 11)	Fatemi and Karami (2010), Hayati et al. (2010), Keshavarz et al. (2013)
Frustration	"We villagers now have very little income. Sometimes it is necessary to pay 100,000[a] Tomans to educate children in school; but we really do nor have a red cent. In such cases, we do not know from whom we should borrow this money." (FGD 5) "We are really worried about our children more than ourselves. As the current situation continues, our concern increases." (FGD 9)	Keshavarz et al. (2013)

[a]It is *about 8 US dollars*.
Reference: Findings of the research.

be a consequence of potential harmful factors; regardless of this, it is an important agent in terms of system sustainability and its resilience.

Increased migration

The results showed that the lack of exploitation resources and other livelihood constraints has slightly intensified migration from rural to urban areas. In such circumstances, migration from the countryside to the urban areas is inevitable. Based on the exploiters' perceptions, migration is slowly raised among them due to the lack of economic resilience. According to Table 3, in some cases, the exploiters sold all their property and migrated due to their difficult conditions in terms of income. Therefore, the rate of resistance in village is now falling.

Anxiety

Damages to the natural-economic resources have led to the decline in the income and quality of life; this has removed joy and happiness from the lives of the exploiters. Rural jobs are not just jobs; they are also a means of subsistence for the villagers. Based on Table 3, the loss of productive resources and its consequences might cause a lot of mental and subjective stress for the exploiters. In such a situation, they will experience more anxiety. This rising concern as a consequence of climate variability indicates the widespread psychological vulnerability caused by climate events in Iran.

Frustration

The risk of climate change on rural livelihoods has prevented villagers from meeting some of their basic needs, such as children's education and daily expenses. This issue has resulted in huge frustration among exploiters (Table 3). They had a

worrying view of the livelihood and future of their families and children. Such a view about climate change and its effects can ultimately deprive the household of labor.

Adaptation strategies to variations in climate

Climate change has led to the formation of some adaptation strategies among exploiters (Figure 3). As mentioned earlier, some small-scale agricultural and livestock activities are considered as auxiliary sources of income for exploiters. Therefore, the adaptation strategies of the exploiters were very diverse in terms of nature, purpose, location, and time of use. These strategies were grouped in the form of four categories, including maintaining and developing rangeland-based income, maintaining and developing non-rangeland income, improving agricultural and livestock income, and cost/money management strategies. According to Ghazali et al. (2021), people who are exposed to greater risks of climate fluctuations are more likely to go toward adaptation strategies.

Strategies related to revenues of rangelands' maintenance and development

These strategies refer to forms of strategies that can be applied at the rangeland level. The purpose of using such strategies is the care and sustainability of medicinal plants. Changing climate has caused poor vegetation of the rangelands. Due to the high dependence on rangeland resources and proper knowledge of climatic trends, medicinal plant exploiters have mainly focused their first adaptation efforts on rangeland conservation activities and development of revenues. Factors such as simplicity, low cost of use, and future-oriented benefits have led to the widespread use of this group of adaptation strategies.

More care of Asafoetida in the exploitation process is the first and most widely used conservation strategy which can be adopted by the exploiters. As a resilience-oriented strategy, it represents a conservation practice protecting medicinal plants from being exploited unless they look well in terms of age and size. In relation to the application of this strategy, one of the exploiters in FGD 8 stated that "*Small plants have no effect on increasing our income. They will be very economical if they are exploited in the following years, especially during these droughts.*" Similar to the previous one, rangeland rehabilitation has been mainly done through Asafoetida sowing. Its application aimed at reducing the damage driven by droughts and unprotected exploitation activities of Asafoetida in the past. It was also found that exploiters usually try to allow rangelands to lie idle during the growing season. They believed that the rangelands should not be exploited unless the proper condition be provided in terms of favorable coverage especially of Asafoetida. One of the participants in the FGD 6 mentioned that "*if we used to harvest Asafoetida in a certain area once every three years, now it might be five years because of the droughts.*" Reducing the number of harvests has been adopted by the exploiters as another frequently used conservation activity. This strategy improves the revival of Asafoetida by accelerating the root generation. One of exploiters in FGD 5 described this strategy in detail: "*we used to harvest Asafoetida 15 or 17 rounds each year, but now we are trying to do 12 times or less.*" Seasonal migration as an adaption strategy (Yaro, 2013; Baudoin et al., 2014; Le Dang et al., 2014) was adopted by some of the exploiters. This strategy is mainly difficult to implement and less available. The exploitation of other medicinal plants such as thyme and Caraway was another strategy to adapt to climate change. This strategy can relatively compensate the reduced income of Asafoetida. As a risk-sharing strategy, exploiting part of others' land is also an adaptation option used by a small number of exploiters. Although the need to share benefits in rangelands has limited the use of this strategy, its adoption reduces the pressure on some weak and vulnerable people.

Strategies related to the development of non-rangeland income sources

Strategies related to the development of non-pasture sources of income include income-generating activities outside the pastures. To adapt to the impacts of climate change and compensate for financial losses resulting from exploitation, exploiters are looking for temporary and sometimes alternative income sources. Non-agricultural revenue-generating activities involve a number of strategies that might be either temporary or permanent. It should also be mentioned that these income sources (auxiliary sources of income) might be inside or outside of the village. The common feature of these strategies is creating new revenue for exploiters. The most frequently used strategy of this category is providing labor force for construction jobs in cities. These sources of income will undoubtedly have positive effects in non-agricultural seasons and low rain years, but it accelerates the migrating from the villages and leaving the exploitation activities. In contrast, there are less common strategies increasing the economic resilience of rural households and the survival of rural populations. Out of them, investment in small-scale livestock husbandry programs has attracted more exploiters than the other strategies. This is a result of rangeland shortages and the consequent reduction in the number of herds, which aims to meet their needs and generates more income through greater control of animal feed. The benefits of implementing these two strategies have not been able to satisfy the exploiters to compensate for the failures caused by severe climatic events. According to the results, some women also slightly helped to adapt to climate change through activities, such as carpet weaving. The need for the participation of other family members has led to the development of this strategy.

FIGURE 3
Word cloud of the applied adaptation strategies.

Agricultural laboring, laboring in governmental projects, and mining were other adaptation strategies identified in the FGDs. Similar to construction laboring, high-rate application of these strategies may lead to leaving the village.

Cattle breeding was the last adaptation strategy in this category. Despite the fact that this strategy is a suitable strategy for increasing resilience, it has been used less than other strategies of this group. An exploiter in the FGD 1 stated that "*since shepherding is not economically viable at the moment (it is even harmful), some people have turned to cattle breeding.*" Here, financing seems to have prevailed over other prerequisites, such as climate information, simplicity of application, and perceived benefits. Therefore, the using rate of this option is very low.

Strategies related to improvement of agricultural and livestock incomes

These strategies include the changes made by the farmers of the pasture medicinal plants in their micro-scale agricultural and livestock units. Although agricultural and livestock activities are less important for exploiters, it is believed that strategies can, to some extent, help the adaptation of the exploiters to climate change. Because, these activities are considered as auxiliary income-generating activities for medicinal plant exploiters, and the main source of income is the same medicinal plants. According to the results, to support the livelihood of exploiters, small-scale agriculture and animal husbandry have undergone some changes. Some exploiters (who have better access to the suitable water and soil resources) made adjustments in their farm lands by planting trees. From their perspective, gardening has the potential to generate more income than farming. Since water shortage is considered as an important issue for agriculture, gardening seems to be more appropriate due to less water consumption. One of them in the FGD 5 mentioned that "*in addition to medicinal plants, most people used to grow barley and wheat, but now they are gardening; because it has a better income and needs less water*." In addition, livestock breeding has been an adaptive response to climate change used by a small group of exploiters. The reason for such a change is related to the arrival of more productive livestock breeds in the region, which are more desirable than the natives. Besides, adaptation in farm land was mainly considered by exploiters who own this subsidiary income source. Unlike previous studies (Fosu-Mensah et al., 2012) in which "increasing" crop diversity or change in agricultural products was proposed as a strategy for adaptation to drought and climatic events, the present study revealed that "reducing" crop diversity can also be adopted as an adaptation strategy. This result has been supported by Gandure et al. (2013). In recent years, farmers have slightly turned to some lucrative and commercial products, such as saffron and garlic. Less water consumption is another benefit of planting these crops, which improves the adaptation capacity of the exploiters. Managing ecological stresses in the agricultural and livestock sectors was another strategy for adapting to the climate change that was emphasized in FGDs. Due to the growing importance of agriculture and animal husbandry in the livelihood of the households, faster and better management of environmental stresses (such as pests) has recently grown slightly. In other

words, the exploiters see coping with ecological stresses as a key strategy for adapting to climate change. The households are trying to preserve their productive resources to increase the tolerance of agricultural/livestock income resources.

Cost/money management strategies

Money and cost management strategies are also measures outside the exploitation and production units that are done to manage or meet the financial needs of the household. Some of the adaptation strategies identified in this study were specifically related to the issue of liquidity and financial constraints of medicinal plant exploiters. The role of reducing the living consumptions was highlighted as a frequently used in this study. This strategy seems to be a low-cost and easy-to-use strategy. This strategy also can serve as an appropriate response to climate change, as long as it does not harm people's standard of living. It is a sign of the efforts of exploiters to foster greater adaptive capacity in future. Along with this, using loans has become a widely used strategy in response to the lack of income from exploiting, livestock husbandry, and farming. The increase in the use of this strategy (loan) is probably related to the greater dependence of production on the climate and the high sensitivity to its fluctuations (Ghazali et al., 2021). However, there is a risk of debt for individuals due to insufficient productive income. Therefore, the problems with receiving loan contributed to borrowing money from other people. The deterioration of the current climate situation has made receiving help from others an important strategy for adapting the rural communities of Iran to climate change (Azadi et al., 2019a). The use of these two strategies (loan and borrowing money from others) has also been documented in the research of Hawkins et al. (2022).

Conclusion and recommendations

Pervious adaptation studies have generally focused on farming communities in rural areas. Therefore, there is no scientific documentation of medical plants' exploiters community on how to deal with the climate change. Also, the study of the orientation of the selected strategies to achieve socio-ecological resilience has been neglected in previous adaptation studies. That is, the extent of this tendency varies between different strategies. This study, therefore, investigated the awareness, perceptions, and adaptation strategies to climate variability to strengthen and support the adaptation capacities of exploiters. Research finding has illustrated in the shape of conceptual model (Figure 4). According to the results, the exploiters' awareness about climatic events has been satisfactory. Considering the observation of such knowledge among exploiters, it seems that they are well monitoring and understanding the current climate transition. The exploiters' awareness was mainly focused on their ideal and expected conditions for exploitation. For example, their emphasis on reducing rainfall is due to the threats and destruction that have affected their rangelands. According to the exploiters' perception, rangelands and related livelihoods have been subjected to dramatic impacts of climate change. Severe economic and environmental impacts have led to damage on the social dimension and more severely on the psychological dimension. More specifically, environmental and financial constraints have caused unemployment, migration, social conflicts, leaving the job, reduced social relations, and anxiety and frustration. Considering the undeniable relations among perceptions, adaptation strategies, the nature of the effects, and underlying antecedent variables, it is expected that exploiters adopt strategies with maximum resilience orientation. On the contrary, a large number of frequently adopted strategies are lacking the capacity to strengthen resilience (see Figure 4). Although the adaptation strategies of rangelands' conservation are widely used, other strategies such as animal husbandry and planting new trees and crops have also been chosen to some extent. In addition, strategies with short-term effects such as job diversification have been used to a greater extent. It should be noted that most of these solutions are outside the village and therefore increase the possibility of leaving the village. Commonly used strategies such as loans and borrowing also accelerate the migration process due to the inability to improve the financial situation. Therefore, it cannot be said that having proper knowledge about climate change definitely leads to the use of proper strategies. This is because there are different and widespread perceptions of the impacts and severity of climate change among exploiters. In this regard, the following suggestions are provided.

It is suggested that social networks be developed among climate affected groups. Because, some government policies (such as banning exploitation) may not only improve the current unfavorable situation, but also create social conflicts within exploiter communities. In such cases, these social networks can play a key role in reducing negative effects. Of course, such networks must have bargaining power.

According to the results of this study, having a correct understanding of the climate will never lead to optimal adaptation. Therefore, it is necessary to coordinate strategies with effective adaptation processes. In this regard, it is suggested to use financial aid and motivational activities at first, and then try to select the adaptation strategies that are in line with the goals of sustainable rural environment and help to increase resilience. In the case of medicinal plants, these strategies included strategies adopted in pastures and other strategies in agricultural and animal husbandry activities.

In addition, it is suggested that other sources of income and the costs of implementing the income diversification strategy mentioned by many respondents should be evaluated. This can reduce the effects of climate change. To do this, the basic conditions of adopting livelihood strategies should be

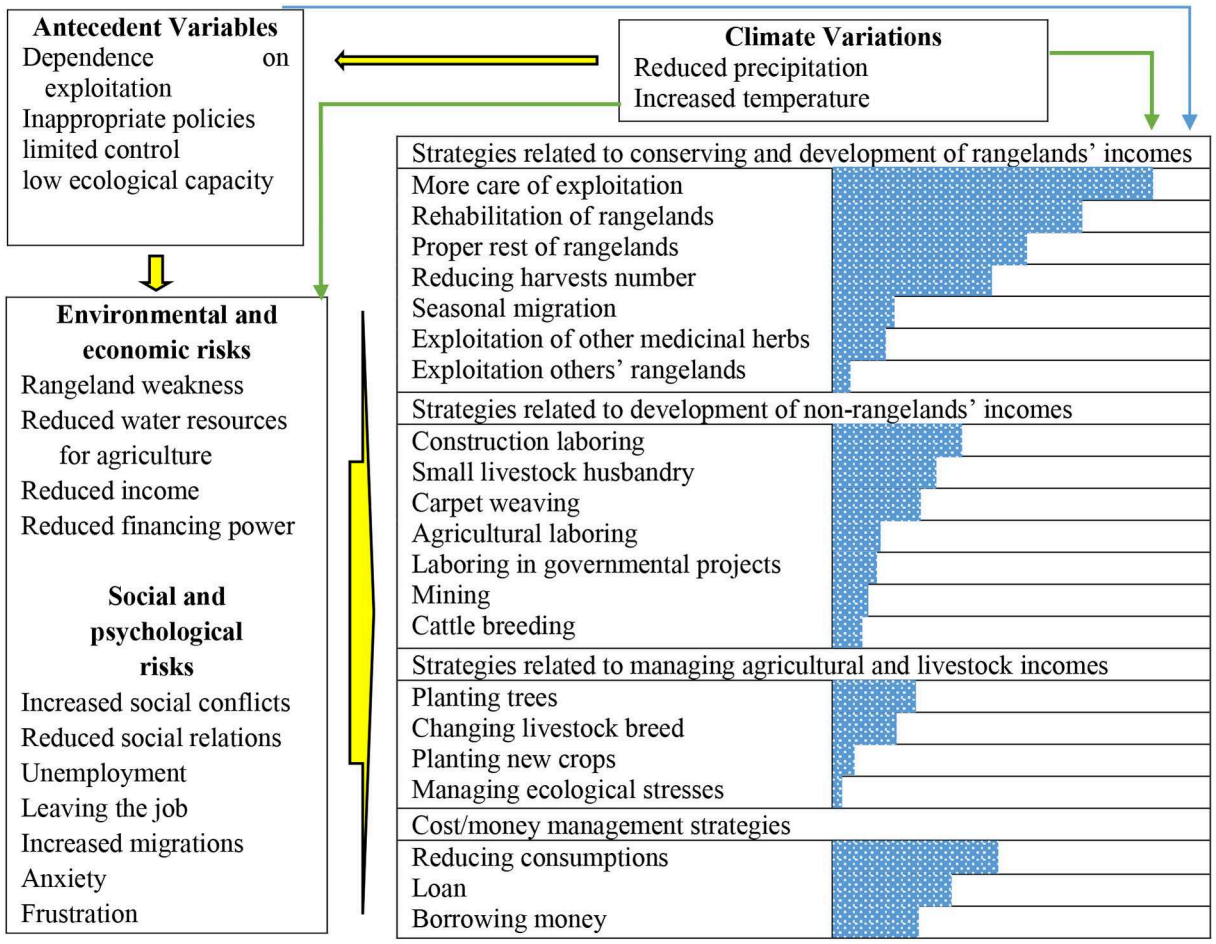

FIGURE 4
Conceptual model of adaptation to climate variability and its pathway based on awareness and perceptions of medicinal plant exploiters.

considered to increase the visibility and sustainability of the medicinal plant exploitation system.

The most important contribution of this study to the theory is the conceptual model for the livelihood adaptation to climate variability in rangelands which provides new insights about the adaptation of medicinal plant exploiters to climate change. In addition, the current research provides some strategies and recommendations for adapting to climate change that can be used by medicinal plant exploiters, policy-makers, managers of rangelands' conservation programs, and other users.

In general, the main take-home message of this research is that proper awareness of climate change and its impacts does not necessarily lead to the adoption of the long-term adaptation strategies at the levels of production and livelihood units. In other words, this hypothesis is rejected in many cases due to the strong dependence of the exploiters on the products and some other factors, such as incorrect policies. Therefore, based on the conceptual framework presented, adopting a suitable risk management system can play a key role in reducing the vulnerability of exploiters against climate change.

The present study faced two main limitations. Awareness of these limitations can pave the way for future researchers who are interested in working in this area. The first limitation was related to the dispersion of the community and the studied sample in different villages of Tabas County. In other words, this limitation made it a challenge to access the statistical population to form focus group discussions. The second limitation is related to the validation of the conceptual framework developed in this study. This research used the qualitative research method approach to develop the conceptual framework. However, it is suggested that future researchers use quantitative methods to validate the framework presented in this study. Also, considering that the use of strategies with more

appropriateness or more consistency with increasing the climate resilience of rural livelihoods can significantly help decision-makers in this field, it is suggested that future researchers focus on the feasibility of using these strategies in macro-climate policies. Examining strategies in terms of difficulty and cost can show the shortcomings of the process of choosing more suitable strategies.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Funding

This research was financially supported by Graduate School of Shiraz University.

Acknowledgments

The authors would like to thank all exploiters of medicinal plants for their participation.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer MB declared a past co-authorship with the authors NV and DH to the handling editor.

Publisher's note

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