Analysis and Prioritization the Effective Factors on Increasing Farmers Resilience Under Climate Change and Drought

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FULL-LENGTH RESEARCH ARTICLE

Analysis and Prioritization the Effective Factors on Increasing Farmers Resilience Under Climate Change and Drought

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Abstract California is severely exposed to drought and damage due to the climate change and drought belt, which has a major impact on agriculture. So, after the drought crisis, there are various reactions from farmers. The extent of the damage caused by the socioeconomic, environment and the extent of the resistance of farmers to this crisis is manifested in a variety of ways. Recognizing the population's resilience and the involved human groups is a tool for preventing a catastrophe-based increase in life-threatening areas in high-risk areas. Sometimes the inability to manage this phenomenon (especially under the climate change) leads to farmers' desertification and agricultural land release, which itself indicates a low level of resilience and resilience to the crisis. The recent drought under the climate change condition in California and the severity of the damage sustained by farmers continue to be vulnerable. The present study seeks to prioritize and prioritize resilience of farmers to the crisis under the climate change. This study simulated drought condition with using PDSI value for current and future time period. In order to calculate PDSI values, the climatic parameters extracted from CMIP5 models and downscaled under the scenario of RCP 8.5. Also in order to understand the resilience of the agriculture activities under the climate change, this study was performed using statistical tests and data from the questionnaire completed in the statistical population of 320 farmers in the Tulare region in California. The findings of the research by t test showed that the average level of effective factors in increasing the resilience of farmers in the region is low. This is particularly significant in relation to the factors affecting government policies and support. So that only the mean of five variables is higher than the numerical desirability of the test and the other 15 variables do not have a suitable status for increasing the resilience of the farmers. Also, the results of the Vikor model showed that most of the impact on their resilience to drought and climate change was the development of agricultural insurance, the second important impact belongs to drought monitoring system, climate change and damage assessment, and variable of attention to knowledge is in third place of the important factor.

Keywords Resilience · Climate change · Drought · *t* test · Vikor model · California

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Introduction

The economies of villages of varying dimensions today face a great deal of danger. One of these economic dimensions is rural agriculture, due to the location of California on a belt of drought with hazards such as desertification, land use change, land release and land degradation. The main reason for this crisis is the lack of attention to the dimensions of drought crisis management and the promotion of resilience and the flexibility of farmers against such dangers. The dangers of drought and climate change have the potential to turn into disastrous and devastating powers for human communities in the absence of risk reduction systems [33]. Living among natural hazards does not necessarily mean damage and vulnerability, but the lack of resilience and the amount of knowledge and perception of a population independent of the degree of the type and the risk of causing damage [22, 23]. This is why world-class changes in risk perceptions are evolving so that the dominant approach has been to deconstruct and reduce vulnerability to increased resilience to disasters [24, 45]. Based on this approach, hazard reduction programs should seek to build resilience in communities and focus on disaster management in the sense of local community resilience. Resilience is one of the most important factors in the realization of sustainability. The introduction of the concept of resilience to disaster management issues was raised since 2005, and gradually became more important in both the theoretical and practical aspects of reducing the risks of accidents [22, 23]. In recent years, concepts such as resilient societies and resilient livelihoods are commonly used in scientific studies. Droughts and climate change are one of the most important natural disasters, which have a huge impact on the agricultural sector and water resources, from a wide range of hazards that human societies are exposed to Singh [43]. For this reason, the drought, due to its geographical size and range, is more complex than other natural disasters and therefore affects more populations. In other words, the most costly natural disaster is considered by farmers as a reduction of agricultural production and suffering. The damage done to farmers and the consequences of their periodic droughts indicate the lack of preparedness and resilience of farmers to this risk and its consequences, as well as the effectiveness of crisis management systems in these cases. In other words, the first step necessary to deal with droughts and to mitigate its consequences is to understand and accurately understand the vulnerability and resilience dimensions of individuals in order to promote the resilience of its flexibility, which has been neglected in most regions such as California. In most arid and semiarid areas like California, the continuing drought in the last decade has led to drought-induced crises in the agricultural sector due to climate change, which has a profound dependence on water production. Droughts can lead to negative effects beyond the normal drought risk among rural farmers, which can be due to their level of resilience against this risk. Therefore, reducing the vulnerability of rural farmers by increasing the resilience plan and improving the resilience to the adverse effects of climate change and drought can be one of the special tasks of management and agricultural development planning by identifying the exact factors influencing the strengthening of the resilience [15]. Accordingly, the purpose of this research is to answer the key question that factors affecting the increase and increase of farmers' resilience to drought risk and its status among the samples of the study area and, finally, which of these factors are of high priority.

Several dimensions of drought and drought crisis management in California which did not consider in previous works:

A. Droughts in California's can provide long-term problems. The current drought emphasized the dependence of California's agriculture on groundwater in dry episodes and led to considerable legislation needing more effective local groundwater organization. Some developments in water accounting, urban water preservation and other parts were accelerated by the drought

B. A varied economy with deep global connections considerably buffers economic impacts of drought. California and most modern economies depend on abundant water resources. Agriculture is California's most water-dependent industry, about 80% of human water consumption. High values for major export crops greatly depend on irrigated land during the drought. Urban regions (which support most of the people and economic activity) should develop in terms of resiliency during the California drought

C. Major drought and climate alteration can considerably influence on irrigated water systems with diversified supply resources, particularly groundwater, and flexibility in operations with water networks and markets. California's extensive and diverse water infrastructure allowed more than 70% of lost water supplies to be substituted through pumped groundwater for agriculture, needing bigger recharge of groundwater in the long term. Although costly contrasted with dryland agriculture, California's irrigation infrastructure and network of reservoirs and canals greatly should mute the impacts of drought, and should be particularly effective for protecting the most economically valuable crops and economic activities

D. Ecosystems were most influenced through the drought, given the weak situation of many native species, even in wet years, because of decades of losses of habitat and water and the growing abundance of invasive species. With each drought, humans should be better at weathering drought; however, effective institutions and funding still are weak to improve ecosystem management and preparation for drought. Forests are mainly vulnerable and difficult to defend from droughts. Dedicated environmental water rights and renewal and migration programs can help support ecosystems

E. Rural water systems are particularly vulnerable to drought. The systems often have problems in normal years, lack economies of scale, typically have only a single vulnerable water supply, and commonly lack sufficient organization and finance; and so it needs to improve for better resilience

F. Every drought is different. Droughts are hydrologically unique happenings that occur under various historical, economic and ecosystem circumstances, and increasingly with different climate circumstances. But all droughts can provide opportunities and incentives to develop and adjust water organization to altering economic and environmental circumstances and priorities. In well-managed systems, each drought should greet with developed preparations from previous droughts

Theoretical Basics

Resonance is often referred to as the return to the past, which is derived from the Latin root of the "resilio" jump to the past. This term was first introduced in 1973 as the ecological concept of Holling [29]. Baggio et al. [7] in social systems, Cosens and Gunderson [12] in the environmental human systems, Folke et al. [16] used in the ecological social systems, Ortiz-de-Mandojana and Bansal [35], in managing short-term crisis and Woodward et al. [52] in long-term phenomena such as climate change. Indeed, in the context of the resounding of many studies in the field of various sciences, the concept of resilience is an interdisciplinary concept that is presented in the field of ecology science in the psychology of social sciences and economics and other sciences (Table 1).

Resilience in the context of hazards can be considered a common concept between ecology and sociology and economics [34]. Because the risks are events that, with the threat of a community, its various members, as well as the environment, have implications [7]. Resilience in various aspects such as socioecology of the economic psychology of other dimensions of science can be arranged. The definition of social resilience among them is the ability of a group or community to deal with external pressures and external interventions resulting from sociopolitical and environmental changes Javadinejad et al, 2020 [21]. In other words, resilience increases the capacity and ability to cope with stress and pressure, and this is considered a rule or antithetical solution to vulnerability. Critical conditions also have a distinct concept of vulnerability [14]. Critical situations point to a situation in which the extent or degradation rate of the environment impedes the continuation of the current use of systems for the welfare and human welfare and attempts to increase the adaptability and adaptation of the community's ability to cope with that crisis (Fig. 1). Actually this figure explains that before making resilience, risk factors (both environment and human factors)should have been known and also before measuring and doing processing on resilience, the effects and weight of resilience factors on ecosystem and human s' spiritual and human s' physical should analyze.

Resilience to the Dangers of Drought and Climate Change

Many researchers consider resilience and vulnerability to be at the two ends of a spectrum, and believe that some people are more likely to suffer disasters than others. As Besnard and Albrechtsen [9] explain in the health theory, the health dynamics create a spectrum from heath to diseases based on the adaptation of the situation in different parts of the spectrum. Resilience is a form of spectrum that experiences varying degrees between two resilient points and vulnerabilities (Fig. 2).

Therefore, community vulnerability to threats is largely influenced by the resilience and the ability of the local community to respond to events. It is necessary to define the concepts of vulnerability and flexibility to understand why a natural occurrence is changing to a catastrophic. According to Mac, the term "resilience" in the context of the security of the people, the ability to stand, resist, discount, deal with it and improve and modernize the resulting damage and reduce the proportion of the severity of the damage that threatens them. Given the role of governments, local institutions, residents and local households in responding to hazards, a strong link between these factors and the conditions of their activities can be identified. Although the scope and extent of flexibility and responsiveness are high, there are many factors in social vulnerability. Capacities for coping and improving affairs against crises are dependent on structural conditions and are not merely dependent on the individual characteristics and circumstances of the inhabitants. The structural vulnerability was analyzed by the Paton and Johnston [36], which can be expressed in the following form with the help of the PAR model based on pressure and release. Henly-Shepard et al. [20] believe that the vulnerability of residents is in contradiction with the sustainability of their resistance. In fact, here the concept of flexibility and sustainability is synonymous and contradictory to vulnerability (Fig. 3).

Table 1 The examples of studies about resilience in different fields

Field	References	Investigation
Psychology	Shi et al. [41]	Relationship between resilience and satisfaction of life
Ecology	Altieri et al. [3]	Create farmer s' resilience
Medical	Persily et al. [38]	Relationship between job stress and resilience with job exhaustion in the female nurses
Sociology	Aldrich and Meyer [2]	Economic–social resilience
Natural hazards	Kelman et al. [26]	Resilient communities and vulnerable people: flood response study

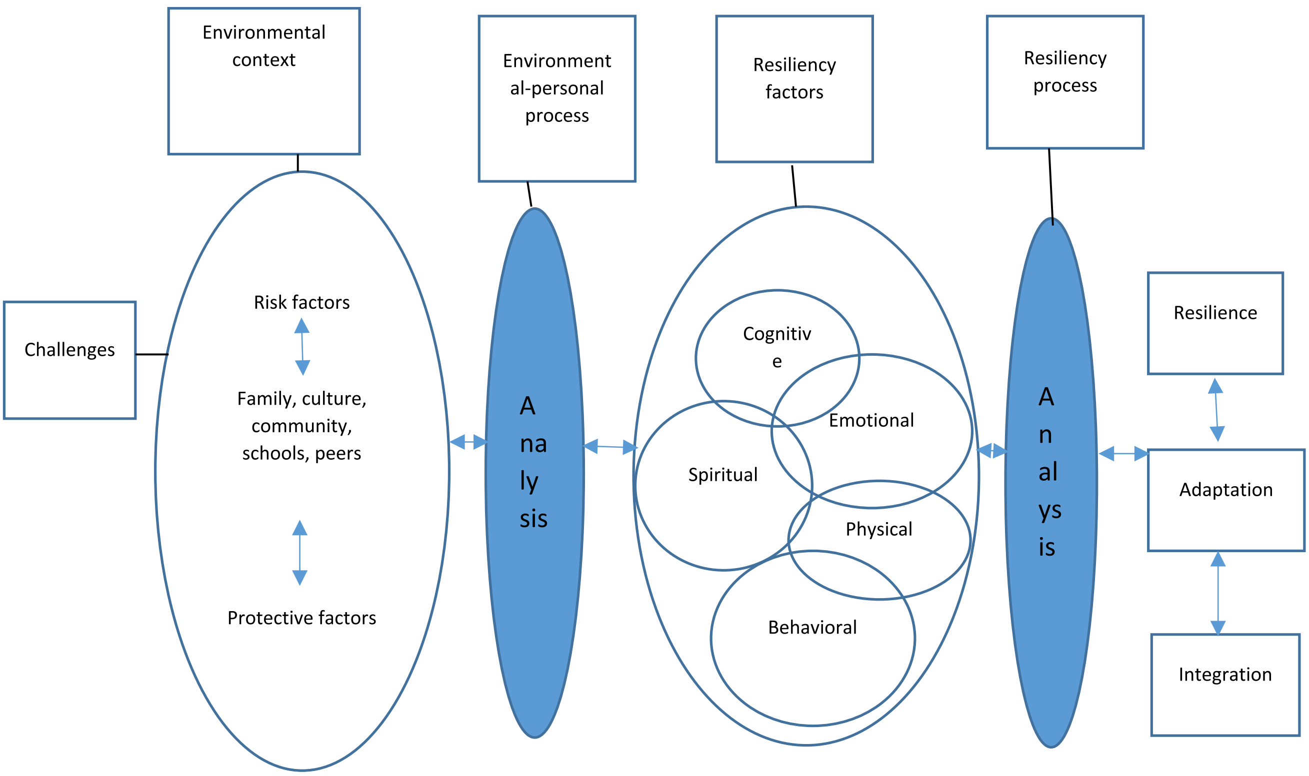
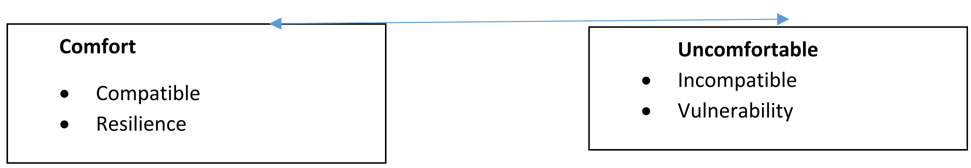


Fig. 1 Theory of resilience [44]

Fig. 2 Salutogenesis theory [17]



Also the direct and indirect effects of drought hazards and climate change on agriculture are shown in Fig. 4. This figure explained that in hazard conditions because of extreme drought and high degree of temperature the direct effects like decreasing in volume of crop production, fire and so on will appear and also indirect impacts such as most of farmer will lose their jobs and their income will decrease and so for a little amount of crop, people should pay more and the cost of crop production will increase.

Drought has plummeted over the past half century, causing loss of crops and the emergence of various disasters such as widespread famine. The drought is a network of effects that has affected many sectors of the economy, and has produced a far greater impact than the physical drought experienced. In general, the effects of drought can be divided into direct and indirect dangers. The severity of these effects depends on the flexibility and resilience of the farmers' communities, and varies from one community to another, from group to group, from region to region. Some communities have a higher degree of readiness to deal with hazards because of prevention. In any case, droughts have long and prolonged consequences that have an impact on all aspects of human life. This phenomenon is the result of climate change and global change, and the other side of the resilience caused by them can be measured by various factors. Occasionally, many human functions increase the effects of drought and thus reduce resilience to it. Recent socioeconomic and social impacts of drought in California indicate the low resilience of these communities to the dangers of drought. In order to enhance the level of resilience of individuals, especially local communities, against natural hazards, it is necessary to have a clear understanding of the factors that contribute to increasing endurance and resilience to risk. In Fig. 5, the cycle of drought effects can be observed.

Components and Resilience Indicators

Many factors can be attributed to the promotion of resilience. As stated in the studies, the economic, social, environmental and ecological dimensions of the mental health state are considered as factors influencing the

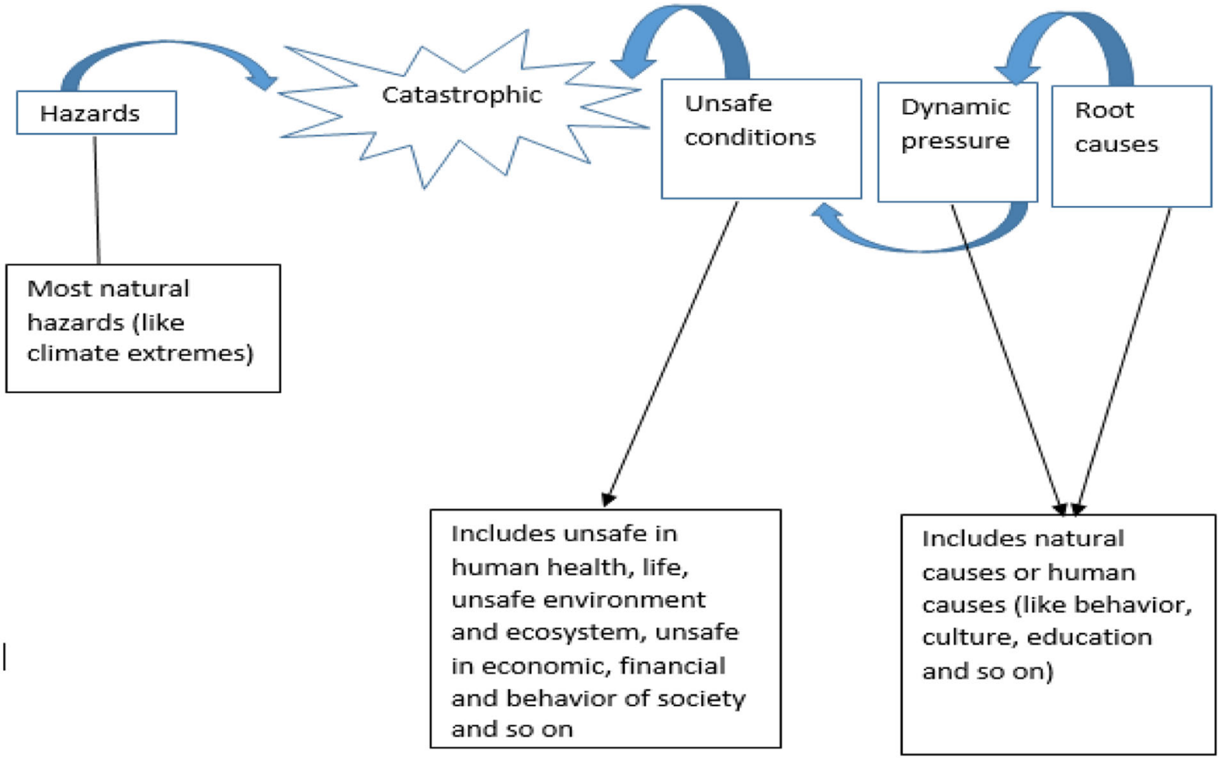


Fig. 3 The steps for occurring a catastrophic and the role of structural conditions in the management [11]

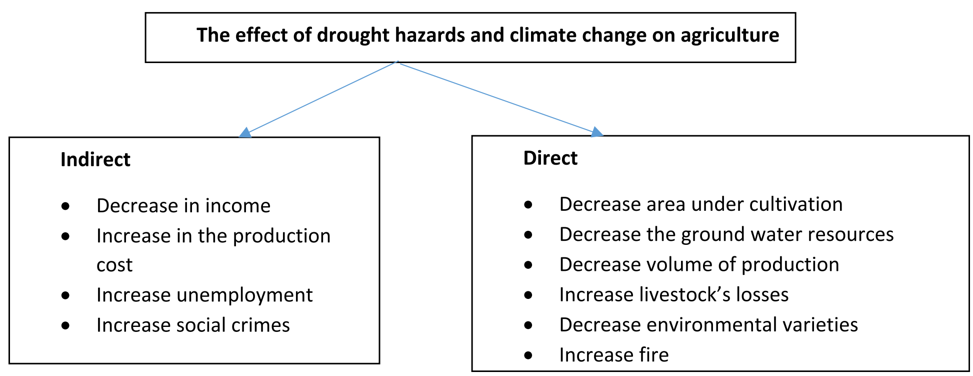


Fig. 4 The direct and indirect effects of drought hazards and climate change on agriculture

promotion of resilience to risks. From the Aldrich and Meyer [2] viewpoint, the availability of household and local residents to resources to address the perils of community standards for survival and modernization, the protection of organizations and institutional conditions that affect the distribution of resources are very significant in terms of community resilience. The vulnerability and flexibility of communities and groups vary in terms of economic and social conditions [16]. This difference in vulnerability is due to variables such as social class, economic status of gender, age, religion, social networks, access and resources, climate change, income diversification, infrastructure constraints, poor market access, market capitalization, etc. In other words, high vulnerability causes reducing the resilience indicators. One of the key factors in economic resilience is the rate of economic growth and sustainability and distribution of income among the population. Dependence on a limited range of natural resources can increase income variance and thus reduce sustainability and economic stability. This is due to a variety of reasons: first, dependency on resources for business activities due to the prosperity or bankruptcy of the market resulting from resource utilization, technological threats to sustainable economic activity, especially during the globalization era. For example, Townshend et al. [47] have shown that communities that are solely dependent on mineral resources have a high incentive to diversify the economy and away from the cyclical circulation of

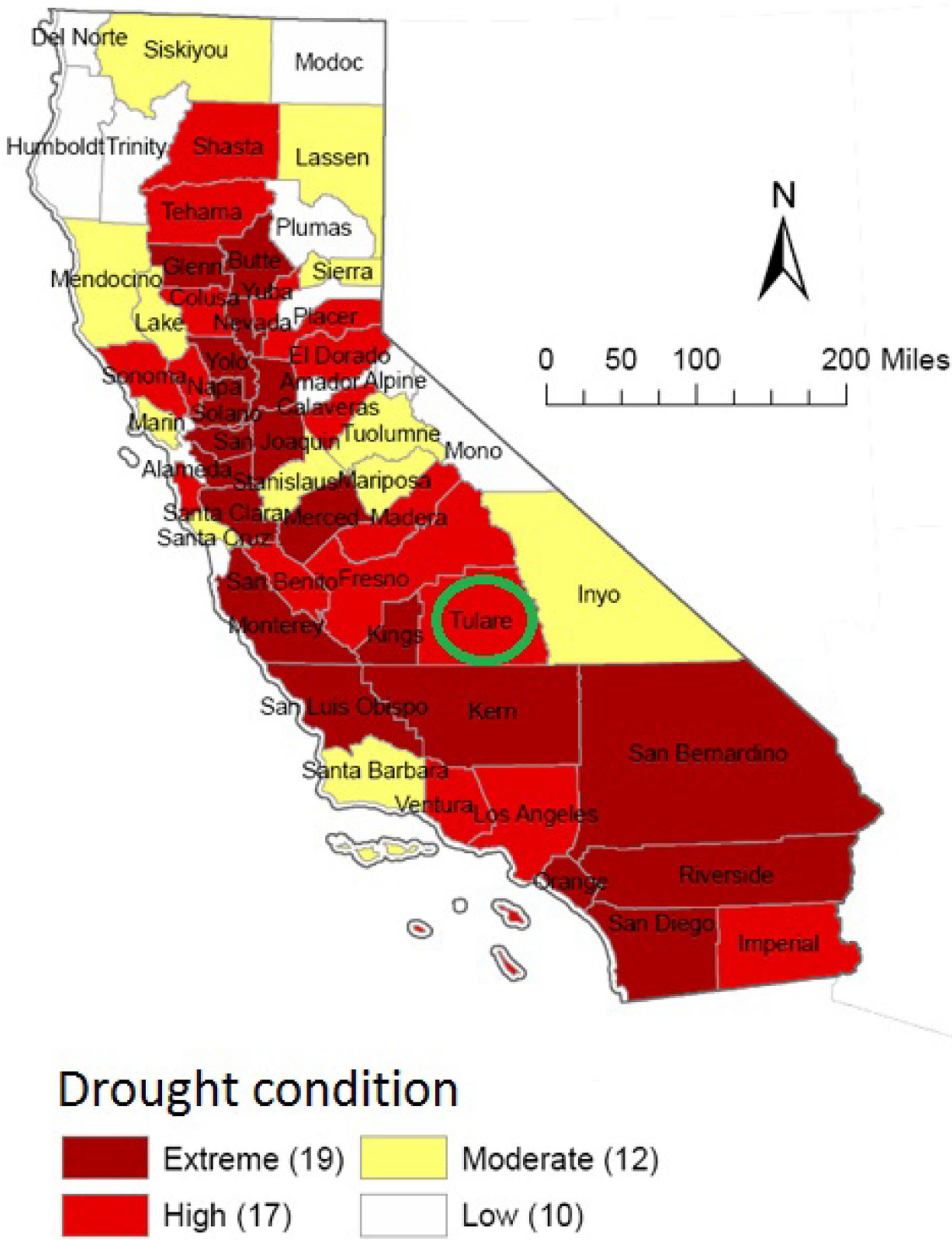


Fig. 5 Location of the study area (edited from American Veterinary Medical Association [4])

their dependent economy with the collapse of exchange conditions. As has been said, technology, resource allocation across the earth, labor mobility and education all contribute to this dependency and lack of flexibility. Secondly, environmental changes can increase the risk of dependence on specific resources through severe natural hazards near drought, flood and the effects of disease and insects on agricultural systems. Another aspect is social resilience, sustainability and stability, especially in livelihoods. Insecurity cannot affect the growth of the source of income in a sustainable economy, but the theory of many contemporary economies is based on the idea that growth depends on institutional and social infrastructure. The sustainability of its social systems can be seen as a factor in encouraging innovation and technology development. Evidence suggests that sustainable economic growth will be enhanced by explaining the equivalents of assets in this population with the goal of achieving economic ties. Other resilience elements at community levels are visible through representatives such as the official employment sector, registered crime rates, demographic factors or other defined cultural variables. But at individual levels, livelihoods and social investment can be expressed by income and other variables such as immigration, which represents the population-level stability of the stakeholder level. Accordingly, in the case of dangers such as drought, climate change, the resilience of farmers, especially rural farmers, can be attributed to various factors and factors:

- Geographical location of the establishment and production.
- Production conditions.
- Access to water resources, land, labor and capital.
- Support from the government, NGOs and the public.
- Mutual supportive networks.
- Institutional capacity building of government and local organizations in response to drought.
- The relationship between social unions.
- Government measures to reduce drought, manage natural resources, social security and reduce poverty.

As agriculture is considered as one of the main sources of employment for villagers, as most domestic and foreign studies also show, there are various consequences of climate change and drought in rural areas. In addition, the wider effects of drought are the effects of the agricultural sector and the rural households have a significant dependence on the agricultural sector, with the economic capacity of this rural economy not to be compromised, and it will lead to further consequences. Shiferaw et al. [42] have also sought to investigate the factors that reduce farmers' vulnerability to drought crisis, economic factors such as access to banking facilities and the amount of non-agricultural incomes, land levels, product insurance, capital ratios of major economic factors and factors such as dependency on the government has examined cooperative activities among members, membership in companies and corporations, religious beliefs, social status and so on as socially effective factors in reducing vulnerability. Reducing the vulnerability can be expressed as a kind of counterpoint to the resilience spectrum, which is to achieve an increase in resilience. Weichselgartner and Kelman [50] in a study entitled Conceptual Explanation of Resilience and its indicators in community-based disaster management classified the effective indicators in increasing resilience to disasters in four dimensions: social, economic, institutional and environmental–physical. In addition to these factors, the impact of technology and information technology should not be ignored as factors influencing climate change and drought and creating resilience among farmers to counteract it. Mac and colleagues have also investigated the factors influencing the attitude of wheat farmers toward using technology to reduce wheat losses in periods of water stress and drought, as one of the ways to create resilience. In another study by Kachergis et al. [25], the resilience and flexibility of drought are affected by factors such as ethnicity, race, social class, gender, age and the level of resources and power.

In this study, according to the indicators of the research background, a set of indicators has been identified as indicators that affect farmers' resilience to drought risk. These indicators can be classified into three general formats of government policy indicators, socioeconomic capacity and environmental permeability, each containing several variables (Table 2).

One of the important dimensions in increasing the amount of resilience is considering the impact of macroeconomic policies of the government on various social and economic environments in dealing with the risks of this aspect.On the other hand, the existence of some socioeconomic capacities among their people makes them more resistant to the risks and coping with the effects of others. In some circumstances, it is possible to reduce the severity of the vulnerability through creativity and innovation in relation to making environmental changes in the environment, and as a result of the resilience among farmers. Sustainable farming society has general characteristics such as maintaining motivation and continuity of agricultural activity, lack of incentive to migrate from the countryside, lack of job change, increase and maintain agricultural productivity, increase hopes for the future of agriculture, search for drought-tolerant methods in agriculture, which can improve the factors that can help rescue farmers is to improve.

Study Area

Tulare is a city in Tulare County, California. The population is 59,278 in the year of 2018. Tulare is placed at 36° 12′ 24″ N and 119° 20′ 33″ W. Tulare is located among Fresno and Bakersfield. Tulare is placed in the middle of the Central Valley. Figure 5 shows the location of Tulare. The total area of the Tulare is 21.0 square miles (54.38 km^2), that 20.9 square miles (54.13 km^2) contains land and 0.1 square miles (0.26 km^2) (0.41%) contains water. The economy of the area based on agriculture activities.

Table 2 Important indices for farmers' resilience in drought conditions

Index	Variable
Government policies and support	Agricultural insurance development
	Granting credits and loans to hazardous persons
	Coordination of agricultural-related acting government forces
	Reduce tax or delay in deadline payment
Capacity of economic–social	Increase saving
	High area of land
	Increase knowledge about drought
	Increase income of non-agriculture and economic diversity
	Development of local organizations in the field of agriculture
	Enhance local farmers' participation
	Attention to the local and nations' knowledge
	Drought prognosis and assessment of damage
Local activities	Improve the methods of irrigation and water management
	Increase the varieties of crop
	Increase spatial continuity in agriculture lands
	Improve control of soil erosion
	Improve drought resistant species
	Attention to the suitable time for cultivating
	Attention to the cover of irrigation channel
	Deep plowing in rainy seasons

The climate of the area is fluctuated, with cool and damp winters with an average temperature of 45 F; however, the region usually experiences very hot dry summers, with an average temperatures of 95–110 F. The mean average rainfall is 10 inches prior to the drought that started in 2012 and continues ongoing as of February 2018. Average annual of rainfall now is just 1–2 inches. The area usually faces air pollution, and air quality is the worst in the USA as a result of both geographical circumstances (hemmed in valley, weak winds) and the frequency of diesel fuel consume from farming and truck traffic on the highways. Also farming can exacerbate this since it boosts tremendous quantities of dust, particularly in the late summer and autumn months.

Materials and Methods

For analyzing the factors influencing the level of drought variability of farmers in this study, at first the conditions of drought need to analyze, therefore PDSI used in this study as a drought index to understand the wet or dry year during current and future time period. So, the climate parameters include precipitation, temperature, evapotranspiration, humidity extracted from climate explorer and climate models of CMIP5 reached and are downscaled statistically. PDSI has greatest capacity to monitor the evolution and characteristics of drought in the arid region. Also PDSI is more spatially comparable than the other drought indices like SPI, SPEI and so on. In addition, PDSI can better show soil moisture and evapotranspiration conditions during dry years [49].

Climate Change Simulations

Generally, climate change predictions made by models are not aligned with the "real" natural environment because of uncertainties and data errors in the models. Recently, CMIP5 results tried to fill this gap with a finer resolution for the models and also with new climate change scenarios. In this research, different outputs from climate models were utilized monthly output from 38 GCM which participated in the CMIP5 was applied. These new models are more nuanced, more developed vis-a-vis the CMIP3. In addition to the CMIP5, new models for predicting climate change using different scenarios such as "representative concentration pathways" (RCP) developed by Stöckle et al. [46] and Van Vuuren et al. [48] exist. This model can be used to predict GHG mitigation potential [18].

Model scenarios applied in this study include historical simulations and future projections. The historical simulations were forced by observed natural and anthropogenic atmospheric composition changes spanning 1971–2005; they are applied to make a baseline against which to determine climate change in future projection. The future projection is obtained by forcing from the RCPs. Unlike the Special Report on Emission scenarios (SRES) that announced the climate projections for the previous CMIP experiment (CMIP3), the CO_2 concentration in RCP2.6 is below B1, in RCP6.0 is a little above A1B and in RCP8.5 surpasses A2. In this study, the RCP8.5 scenario (which is the severest one) is applied for 2006–2100. The severest potential GHG path for the twenty-first century is selected to make the strongest planning adaptation to mitigate the potential climate change impacts on droughts, supply availability and water demands.

Multiple ensemble members are available for each CMIP5 scenario for the given model. Assuming that there are enough models in the ensemble to approach reliable estimates of a potential climate change signal, in this study only one ensemble from each CMIP5 model (total 38 models) and scenario RCP8.5 is applied. The variables applied are: precipitation, temperature, relative humidity and wind speed. However, in the results section only precipitation and temperature, the most important variables, are represented and analyzed. The aim of providing 38 coupled GCMs in the scenario of RCP8.5 is to show the uncertainty in climate impacts growing from future climate modeling.

Moreover, biases in climate variables such as precipitation should be taken care of; otherwise, they will extend into the computations for subsequent years. Possible sources which cause errors and bias are:

- Partial ignorance about some geophysical processes.
- Assumptions for numerical modeling.
- Limited spatial resolution.
- Parameterization.
- Bias on resolved scales.
- Additional bias can occur on smaller scales (sub-grid/station).

In order to solve the resolution problems and possible errors in GCM outputs, they are downscaled statistically to each of the meteorological stations. However, to decrease the model's error and increase the resolution precision we use a simple downscaling technique to increase the accuracy of the model as summarized by Hawkins et al. [19]. Some downscaling techniques attempt to improve daily timescales. In this study, because the drought characteristic analysis cases and water evaluation and planning models are used on monthly resolution, just monthly average climate data are necessary and so resolving the high-frequency variability (the intent of more complex approaches) is not necessary.

In order to remove bias between the GCM and reality, monthly precipitation and temperature time series from GCM and observations for a specific location for the same reference period is needed, which is denoted by $X_{\mathrm{p,\ gcm}}$ and $X_{\mathrm{p,\ obs}}$ respectively.

Furthermore, output from the GCM for some future period of the same length as the reference period, $X_{\mathrm{f,\ gcm}}$ is needed. This study considered a general approach, namely change factor. This is similar to delta change methods used for weather generators. However, the approach taken here is simpler, as a shifted and scaled version of the observed time series is applied for the future rather than a series taken from a weather generator.

The change factor methodology uses the observed monthly variability and changes the mean and monthly variance as simulated by the GCM [5]. In the simpleset case, this is the "delta method", where the monthly variability is assumed to have the same magnitude in the future and reference periods, and the corrected monthly data can calculate follow by the equation in below:

$$X_{\mathrm{DEL}}(t) = X_{\mathrm{p,obs}}(t) + \left(\bar{X}_{\mathrm{f,gcm}} - \bar{X}_{\mathrm{p,gcm}}\right) \quad (1)$$

where the time mean is denoted by the bar above a symbol and the result of the bracket $(\bar{X}_{\mathrm{f,gcm}} - \bar{X}_{\mathrm{p,gcm}})$ in Eq. 1 known as climate signal.

However, in a more general case, considering changes in variance is [40],

$$X_{(\mathrm{f,obs},m,y)} = \left[\bar{X}_{\mathrm{f,gcm}_m}\right] + \left[\bar{X}_{\mathrm{p,obs}_m} - \bar{X}_{\mathrm{p,gcm}_m}\right] \times \left[\frac{\bar{\sigma}_{\mathrm{f,gcm}_m}}{\bar{\sigma}_{\mathrm{p,gcm}_m}}\right] \quad (2)$$

$X_{(\mathrm{f,obs},m,y)}$ in Eq. 2 represents the unknown future observations value of variable X for a given month, m, and period of years, y. The variables contain temperature, rainfall, relative humidity and wind speed; $\bar{X}_{\mathrm{f,gcm}_m}$ indicates the mean future simulation for a specific month and period of years (such as 2006–2040). $\bar{X}_{\mathrm{p,obs}_m}$ is the mean present-day observed climate for a specific month averaged across all years of the historical period (1971–2005), as measured from the meteorological stations in the study area; $\bar{X}_{\mathrm{p,gcm}_m}$ indicates the mean simulation from GCM for a specific location for the reference period (e.g. 1971–2005); $\bar{\sigma}_{\mathrm{f,gcm}_m}$ and $\bar{\sigma}_{\mathrm{p,gcm}_m}$ represent the standard deviations of the raw model output for the future and present-day period for a specific month.

PDSI

The palmer drought severity index (PDSI) applies temperature and precipitation data in order to measure relative dryness. It is a standardized index that ranges from − 10 (dry) to + 10 (wet). It is able to model long-term drought successfully. Because it can use temperature data and a physical water balance model, it can capture the basic impact of global warming on drought through alterations in potential evapotranspiration.

The Factors Affecting the Level of Resilience of Rural Farmers to Drought and Changeable Risk

This study, with descriptive-analytical approach and applied nature, seeks to prioritize and prioritize the factors affecting the level of resilience of rural farmers to drought and changeable risk, which includes three basic steps:

First step Determination of agricultural irrigation index and variables in order to determine the agricultural resilience to drought hazards. First, the study and research background were used to extract indicators and agricultural resilience variables, which generally showed indicators in three aspects: government policies and support with four operational variables, socioeconomic capacities were grouped with eight operational variables and local actions with eight variables, and a total of 20 operational variables were categorized.

Second step Determine the effect of each of the factors on agronomic agronomy through t test one sample: for this purpose, based on the statistical section of the research question, a hypothesis was developed: in the studied area, the farmers' average level of resilience to drought risk is not significant.

Third step Prioritization is an effective factor affecting the resilience of rural farmers to the dangers of drought through the decision-making process of Vikor. Different methods and models have been used to measure and prioritize factors that have contributed to resilience so far, using multi-indicator methods is more important. In this regard, the Vikor method is based on similarity to a more perfect solution. The Vikor means multi-criteria optimization of the concerted steps. One of the methods of decision making is a multi-criteria application, whose efficiency is high in solving discrete problems. This approach is based on agreed planning, in which a consensus solution determines the solutions that are justifiable, which is close to the ideal solution and has been created through agreement with special decision makers' credits. Hence, options closer to the ideal solution to options beyond that are more credible. Usually, the criteria are ranked according to several criteria and then ranked. In this method, emphasis is placed on the ranking and selection of the set of options and the identification of solutions to the problem with conflicting metrics. An agreement solution is an option that is closer to the ideal. Integration index is known as a measure of proximity. The development of Vikor approaches based on the relation 1 as the aggregation function began. In this model, $L_{1,j}$ is used as the S_j and $L\infty$ as the R_j to formulate the ranking.

$$Lpj = \left\{ \sum \left[wi(fi * - fij)/(fi * - fi^{-}) \right]^{p} p \right\}^{1/p} \quad 1 < p < \infty i \quad j = 1, 2, \ldots j \tag{3}$$

where $L_{p,j}$ shows the distance between the option of A_j and the ideal solution. The compensatory solution of $F^c = (f_1^c, \ldots, f_n^c)$ is possible solution, and it is close to the ideal solution of F^*. Hence, the offsetting means that an agreement with the parties of the parties, as presented $\Delta fi = fi^* - fi^c$, $i = 1, \ldots, n$, is obtained (Fig. 6).

This method is used to solve discrete decision problems based on the choice of the optimal option among available options based on ranking. In order to carry out the construction of the methods proposed in the study area in order to continue the phenomenon of drought in this agricultural area, as in most parts of California in recent years, was selected. A total of 3176 households with agricultural livelihoods were included as the statistical population. A total of 320 samples were selected through Cochran's equation at alpha-0.05 level. To collect the data, a questionnaire was developed in the form of a Likert spectrum, in which the collected data were analyzed for obtaining the results.

In other words, farmers over time, according to the principle of compliance with existing conditions, have undertaken activities to reduce the negative effects of drought on livelihoods and activities. This is despite the fact that the government still does not take serious action and measures to reduce the effects of drought and promote the adaptation of farmers and accelerate the process of compliance, and is weak. Also, based on the desired aspects for each matrix, raw data indicators represent each of the criteria, based on the analysis based on the Vikor model, to determine the most important factor in the resilience of rural farmers to drought risk.

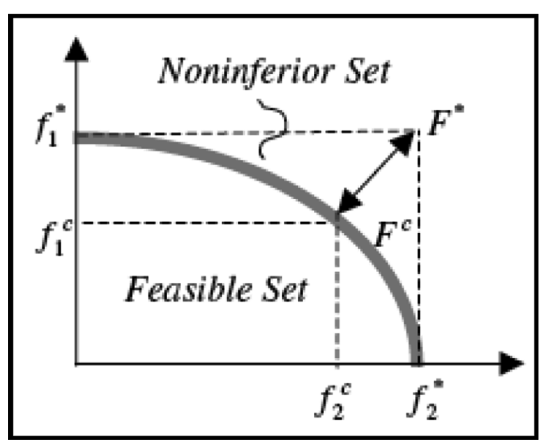


Fig. 6 The agreement and ideal solution

Formation Decision Matrix Assume that there are m options and n features. There are also various alternatives that are represented by xi. There is also a set of criteria for each option, the value of which is displayed as xij. In other words, Xij is the value of the j property. In this column matrix, the criteria used in the field of agricultural agronomy and in the rows are also influential factors, and the raw data of each criterion are related to the effective factors derived from the questionnaire extracted from the table houses.

Calculation of Normalized Values To normalize the values of the time when xij is the initial value of option i and after j, use the following equation:

$$F = \frac{xij}{\sqrt{\sum_{j=1}^{n} x^2}} \quad i = 1, 2, \ldots, m \quad j = 1, 2, \ldots, n \tag{4}$$

where xij is the initial value and fij is the normalized value of the i option and then j. The result of the normalized data is the normal matrix.

Determine the best and worst value for all criterion functions: if the criterion function is positive, the best and worst values are calculated based on the following equation.

$$Fi* = \max fij, \quad fi^{-} = \min fij \tag{5}$$

The criterion function represents the cost (negative), the worst and best article is calculated based on the following equation.

$$Fi* = \min fij, \quad fi^{-} = \max fij \tag{6}$$

In this way, we can determine the best and worst values for the criteria.

Determination of the weight and degree of importance of the properties To express the relative importance of the properties and criteria, their relative weights should be determined. For this purpose, there are various methods such as Linmap, AHP, ANP and special vector, which can use with regard to the research requirements. In this research, the ranking power function is used which is shown in below:

$$(n - ri + 1)^2 \tag{7}$$

Calculate the distance values of options with the ideal solution At this stage, the distance between each option is calculated from the ideal solution and then computed the aggregation based on the following equation.

$$Si - \sum \frac{w(fij * - fij)}{fj * - fj^{-}} \tag{8}$$

$$R = \max[wi(fij * - fij)/(fj * - fj^{-})] \tag{9}$$

where Sj is the distance between the option i and the ideal solution way (the best one) and Rj is the distance between the option i and the negative ideal solution (the worst). Awesome ranking based on Sj, and bad ranking based on Rj's values. In other words, Rj and Sj represent the $L1$ and $L1i$ symbols.

Calculation of the value of Qi in Vikor for $i = 1, 2, \ldots, m$

$$Qi - v\left[\frac{si - s*}{s^{-} - s*}\right] + (1 - v)\left[\frac{Ri - R*}{R^{-} - R*}\right] \tag{10}$$

$$S* = \min sj, \quad S^{-} = \max Sj$$
$$R = \min Rj, \quad S^{-} = \max Rj \tag{11}$$

where v is strategy weight (Most criteria) or maximum group utility. $\frac{si-s*}{s^{-}-s*}$ is the distance from the positive ideal solution of i option. $\frac{Ri-R*}{R^{-}-R*}$ is the distance from the negative ideal solution for I option. While $v > 0.5$ the index of Qi has maximum agreement, and when $v < 0.5$ the index shows the maximum attitude. In general, when $v = 0.5$, it means group agreement is equal.

Results

PDSI

In order to estimate the conditions of drought in the area, PDSI values are calculated for historical and future time period under the climate change conditions (Figs. 7, 8). As it is shown in Fig. 8 because of more drought in future, the trend of PDSI value will decrease from − 1.5 to − 2.87 for the year of 2020 to the year of 2100.

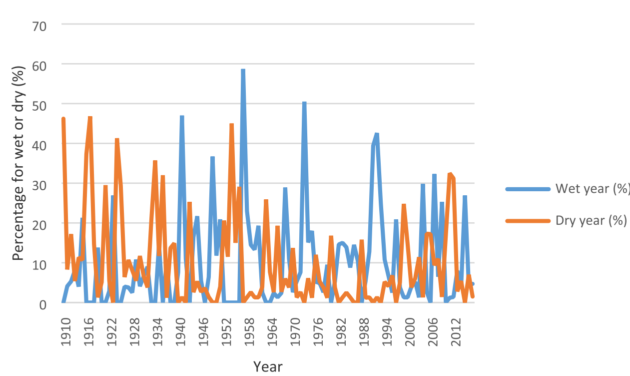


Fig. 7 The percentage of wet and dry for historical time period

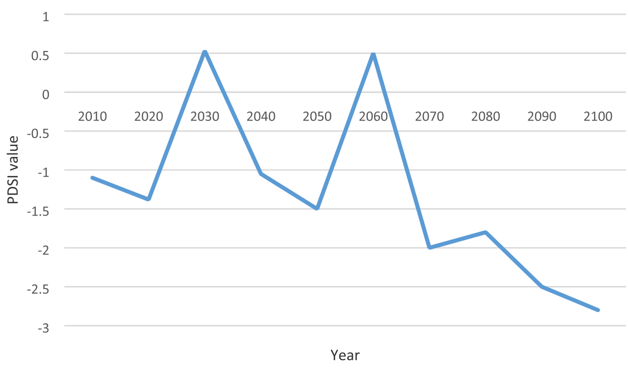


Fig. 8 PDSI value for future time period

Factors Influencing the Level of Drought Variability of Farmers

For analyzing and identifying the present status, factors influencing the level of drought variability of farmers were first analyzed using T-single sampling, the effect of each of the factors, and then through the multi-indicator decision-making model of the Vikor. Prioritizing the factors influencing farmers' resilience to drought risk was discussed. In the present situation, it seems that the factors that affect the resilience of the situation are not favorable conditions for increasing the level of resilience of farmers.

The mean numerical analysis of the research variables indicates that most of the variables are not in desirable conditions, and the results show that only the mean of 5 variables is higher than the numerical desirability of the test, which is 3, and the test statistic is also positive. Therefore, due to the significant level, only variables corrected for irrigation and water management practices, increasing the variety of cultivated products, accuracy in the timing of crop production, attention to the cover of irrigation channel and performing deep plowing in rainy seasons, have a good status in terms of it has an impact on increasing farmers' resilience to the dangers of drought. Therefore, 15 other identified variables do not have a proper status in order to influence the farmers' resilience to the dangers of drought in the region and confirm the individual's research. Only five variables are mentioned that the research hypothesis is rejected and only a small effect on the resilience of farmers is observed. Among the most influential meanings, the greatest influence on the variables is the observance of the principles of deep plowing in rainy seasons with an average of 3.2 (Table 3).

Therefore, increasing the resilience of farmers to flood risk depends on local action indicators that can affect resilience factors. Therefore, as shown in the results of single-sample *t* test, local measures are the highest among farmers with respect to government policies and support and economic and social capacities (Table 4).

Actually, farmers over time, according to the principle of compliance with existing conditions, have undertaken activities to reduce the negative effects of drought on livelihoods and activities. This is despite the fact that the government still does not take serious action and measures to reduce the effects of drought and promote the adaptation of farmers and accelerate the process of compliance, and is weak. Also, based on the desired aspects for each matrix, raw data indicators represent each of the criteria, based on the analysis based on the Vikor model, to determine the most important factor in the resilience of rural farmers to drought risk.

Ranking of Options Based on Values of *Qi*

Based on the *Qi* values, the options that were calculated in the previous steps can be used to rank the options. Options with higher values of *Qi* are placed in a higher priority, and the values of *Qi* smaller mean low rank (Table 5).

The results of the multi-index decision-making model can be obtained, but, in terms of farmers, most of the factors affecting their resilience to the dangers of drought and climate change and increasing their compatibility with the drought conditions are the development of agricultural insurance, monitoring and estimation of damage is in second place, and the variable of attention to indigenous knowledge and the rate of utilization of it is in the third place.

Discussion

California's location on a dry belt and the persistence of droughts in recent years due to climate change has led to the formation of drought-induced crises, especially for farmers who have a deep dependence on water for production. Droughts in the area have not been excluded from this rule and have led to negative effects beyond the normal state and drought risk among farmers, which can be due to their low level of resilience to this risk. The deep recognition of the population's resilience and of the involved human groups is considered as a step toward preventing an increase in the ecological disaster in high-risk areas. In the field of drought management, the first step that societies will take is the sale of livestock, early cultivation, livestock diversification, plant protection, forage and crop resistant plants [13]. While the first step to confront drought and modifying its effects is to recognize the drought reality, especially the context and causes of the occurrence and the effects of its consequences and its multiple causes, it is the next step to adopt strategies and to choose the solutions that can be used to deal with the consequences of this phenomenon and harnessed or reduced their harmful effects.

Table 3 The mean and level of significance were lower than the desirable variables of increasing the vibrations of farmers against drought

Numerical utility test = 3							
						Confidence interval (95%)	
Variables	Average	*t* test	Free degree	Significant value	Difference between desirable	Lower	Upper
Development of insurance of agricultural products	1.46	− 47	19	0	− 1.55	− 1.62	− 1.49
Granting credits and loan to suffers against natural hazards	2.35	− 2.7	19	0.015	− 0.66	− 1.16	− 0.143
Coordination of agricultural-related acting government forces	2.37	− 3.20	19	0.005	− 0.73	− 1.20	− 0.249
Reduce tax or delay in deadline payment	2.83	− 0.80	19	0.038	− 0.18	− 0.65	− 0.29
Increase saving	2.49	− 2.20	19	0.042	− 0.52	− 1.00	− 0.025
High area of land	2.27	− 3.3	19	0.006	− 0.74	− 1.22	− 0.256
Increase knowledge about drought	2.33	− 3.2	19	0.007	− 0.68	− 1.14	− 0.23
Increase income of non-agriculture and economic diversity	2.54	− 2.13	19	0.048	− 0.47	− 0.91	− 0.0076
Development of local organizations in the field of agriculture	2.40	− 2.74	19	0.014	− 0.61	− 1.07	− 0.141
Enhance local farmers' participation	2.43	− 2.43	19	0.026	− 0.58	− 1.07	− 0.079
Attention to the local and nations' knowledge	2.42	− 2.40	19	0.028	− 0.585	− 1.10	− 0.074
Drought prognosis and assessment of damage	1.79	− 72.7	19	0	− 1.22	− 1.26	− 1.19
Improve the methods of irrigation and water management	3.02	0.009	19	0.995	0.0011	− 0.318	− 0.320
Increase the varieties of crop	3.07	0.293	19	0.775	0.0628	− 0.388	0.513
Increase spatial continuity in agriculture lands	2.39	− 2.478	19	0.024	− 0.612	− 1.13	− 0.095
Improve control of soil erosion	2.29	− 3.147	19	0.005	− 0.713	− 1.19	− 0.329
Improve drought resistant species	2.39	− 2.438	19	0.026	− 0.616	− 1.14	− 0.871
Attention to the suitable time for cultivating	3.08	0.417	19	0.683	0.0703	− 0.283	0.424
Attention to the cover of irrigation channel	3.13	0.731	19	0.476	0.1297	− 0.243	0.5015
Deep plowing in rainy seasons	3.23	1.37	19	0.190	0.23	− 0.119	0.57

Table 4 The mean and level of significance were lower than the desirable variables of increasing the vibrations of farmers against drought

Numerical utility test = 3							
						Confidence interval (95%)	
Variables	Average	*t* test	Free degree	Significant value	Difference between desirable	Lower	Upper
Politics and governmental supports	2.23	− 4.57	19	0	− 0.775	− 1.13	− 0.420
Capacities of economic–social	2.33	− 3.48	19	0.003	− 0.671	− 1.08	− 0.268
Local activities	2.82	− 1.139	19	0.028	− 0.182	− 0.517	0.153

Hence, one of the main strategies for reducing vulnerability in social systems and, as a result, strengthening the sustainability of societies against environmental crises such as droughts, is to increase the resilience of these communities to the disturbances created by ecological systems [8]. Increasing resilience to crises can lead to increased adaptability and sustainable livelihoods of the community [39]. The results of various studies confirm the above. Boeri et al. [10] have been studying the characteristics of resilient communities about responding to crises.

The results of the measurement of the resilience of the rangeland users in the face of the drought phenomenon

Table 5 The ranking of effective factors in resilience farmers based on the distance from the ideal solution

Factors	*S*	*R*	*Q*	Rank	Factors	*S*	*R*	*Q*	Rank
Development of insurance of agricultural products	1	0.5	1	1	Attention to the local and nations' knowledge	0.59	0.27	0.55	3
Granting credits and loan to suffers against natural hazards	0.24	0.13	0.12	15	Drought prognosis and assessment of damage	0.87	0.37	0.87	2
Coordination of agricultural-related acting government forces	0.5	0.15	0.25	11	Improve the methods of irrigation and water management	0.24	0.10	0.08	17
Reduce tax or delay in deadline payment	0.17	0.09	0.01	19	Increase the varieties of crop	0.24	0.11	0.08	16
Increase saving	0.32	0.16	0.21	12	Increase spatial continuity in agriculture lands	0.43	0.22	0.37	6
High area of land	0.43	0.19	0.33	8	Improve control of soil erosion	0.47	0.19	0.35	7
Increase knowledge about drought	0.47	0.18	0.33	9	Improve drought resistant species	0.44	0.22	0.37	5
Increase income of non-agriculture and economic diversity	0.39	0.17	0.28	10	Attention to the suitable time for cultivating	0.31	0.13	0.17	14
Development of local organizations in the field of agriculture	0.36	0.13	0.20	13	Attention to the cover of irrigation channel	0.21	0.11	0.08	18
Enhance local farmers' participation	0.47	0.24	0.43	4	Deep plowing in rainy seasons	0.16	0.09	0	20

indicate that the resilience of the exploiters was 2.95, which was lower than the average, indicating that the exploiters are vulnerable to the degradation of the pasture [6]. Accordingly, according to the results of the t test, these individuals had the highest resilience in terms of socio-cultural, economic and natural components, but in terms of institutional component, they had a low level of resilience.

In a researcher's study, researchers have researched and evaluated the dimensions and components of resilience in some major cities, and stated that these cities have the highest degree of resilience in terms of sociocultural component [51].

In another study, the authors reviewed the resilience of communities to earthquakes in two different areas in Nepal [32]. The results indicated a low resilience in both regions. However, in the B area, resilient in terms of economic and infrastructural dimensions was better than the A area, and it was recommended that institutional and human social conditions be improved in order to increase community resilience in countering future earthquake hazards.

Other authors of the study assessed the resilient capacities in urban areas in Iran and stated that this city had the highest degree of resilience in terms of social component, but its institutional and physical components had low resilience and should be prioritized [27].

So far, little research has been conducted on adaptation to natural hazards and climate change. Alam et al. [1] have focused on adaptation strategies for farmers with drought, but the severity and frequency of drought and its relation with agricultural land management, land use and individual and family characteristics have not been provided.

Another research is to determine the difference in the effectiveness of two indigenous and new knowledge on reducing the vulnerability of rural communities to natural disasters. The results show that there is a significant difference between the effectiveness of two knowledge in reducing the vulnerability of natural disasters. Also, from the perspective of the sample population, effectiveness of indigenous knowledge is more in comparison with modern knowledge in reducing the vulnerability of natural disasters in the study area [28].

Given the importance of influencing the effects of climate change on livelihoods of communities and resilience and adaptation to these conditions, this research has been carried out.

The ranking of resilience for different factors completely depends on the area of study. For example as it shown by the results in California the factors of agricultural insurance, the drought monitoring system, climate change and damage assessment, and variable of attention to knowledge have the highest important. However, in other regions (developing countries) like Iraq, Afghanistan, Pakistan or so on, probably local activities are more important [30, 31, 37].

It is generally seen that the values for all dimensions as well as the average resilience of exploiters in the California area tend to be vulnerable to drought. According to the results, it can be suggested that consideration of indicators and criteria that increase the level of resilience is one of the most essential activities for planning the current and future status of water resource users to deal with drought.

Conclusion

One of the natural hazards that, in addition to natural aspects, is partly influenced by human actions, is the dangers of drought and climate change, which, due to the slowness of its development and learning process, have mentioned this kind of risk as a progressive threat. Drought, because of its nature, affects mostly human societies and economic activities, which are closely linked to the environment, and in particular the water factor. Meanwhile, human communities with farming activity have deep links with the environment and water resources, more than other human strata affected by drought hazards. Therefore, today, in addition to applying the drought prevention approach, the emphasis is on rehabilitation approach and increasing drought compatibility. Accordingly, the debate about resilience and resilience farmers against drought risks is very important. To increase the level of human population fluctuations in confronting drought hazards, several factors can be affected, which can increase the level of agility and adaptability to drought conditions in farmers, in order to prevent migration to the countryside and the abandonment of agricultural land. Since the California area is one of the drought-belt areas and in times of drought and its development, it can lead to serious damage to farmers, the damage in semiarid regions is more than in very dry areas. Therefore, it is very important to pay attention to increasing the level of resilience of farmers in the region in coping with the drought phenomenon. Accordingly, in this study, in the theoretical framework, efforts were made to identify the factors affecting farmers' resilience and were classified into three groups of government policy and support, socioeconomic needs and local actions. Then, through the *t* test, the mean of each factor was studied in the existing conditions of the study area. The results showed that most of the variables are not in desirable conditions and the results show that only the mean of 5 variables is higher than the numerical utility of the test, that is, the number 3 and the test is positive. Therefore, due to the significant level, only irrigation and water management modification variables, attention to the cover of irrigation channel, accuracy in the cropping timing, increasing the variety of cultivated products, performing deep plowing in rainy seasons, have a good status in terms of impact it is aimed at increasing farmers' resilience to the dangers of drought. Therefore, fifteen identified changes are no longer a good condition for influencing farmers' resilience to the dangers of drought in the region. Also, using Vikor's multi-index decision-making models, it was attempted to prioritize effective indicators on farmers' resilience to drought risk based on 6 agricultural regeneration indices. In this regard, the results showed that, in terms of farmers, most of the factors influencing their resilience to the dangers of drought and increasing their adaptability to climate change and drought were the development of insurance of agricultural products, the second was the establishment of a system for monitoring and drought forecasting and damage assessment, and the variable of attention to native knowledge and the rate of its use are also in the third place, which is the shortest distance from the ideal and the farthest distance from the negative idea. According to the results, it can be suggested that consideration of indicators and criteria that increase the level of resilience of farmers is one of the most important activities of planning the current situation for agriculture to deal with drought. In this regard, the role of government support will be very significant.

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Author's Contributions SJ designed this research, she wrote this paper and she collected the necessary data, and she did analysis of the data. RD participated in drafted the manuscript, and he contributed in the collection of data and interpretation of data and edited the format of the paper under the manuscript style. FJ participated in the data collected and data analysis.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no serious conflict of interest. However, the authors faced the problem in finance, but regional water authority supported us and helped the authors.

Ethical Approval There is ethics approval in the results of this study.

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