

Sustainability of the local stakeholder network in semi-steppe rangelands in southern Iran

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ABSTRACT

Sustainable land management (SLM) as a holistic method seeks to combine ecological values with socio-cultural and policy concepts, through which local populations play a significant role in achieving this management. Qasr Yaqoub village was selected for the present study, which is located in Safashahr city in Fars province, south of Iran. The common method of herding in Qasr Yaqoub village is participatory and in the form of assistance systems. Therefore, in order to have a comprehensive evaluation of the stability of the local stakeholder network in different dimensions of sustainability and social networks, two methods of indicators analysis including social network analysis (SNA) and sustainability barometer model (SBM) were used. The index values for trust and social cooperation ties among stakeholders in the local stakeholders' network in Qasr Yaqoub village, consisting of 42 individuals, were found to be 63.1% and 59.8%, respectively. These values indicate a stable density in the trust network and an average density in the cooperation network among stakeholders in the region. In addition, the social network index, which measures the extent of connections, is 1086 for trust and 1030 for social cooperation, both covering more than 50% of the expected ties. This signifies a significant level of interaction between stakeholders regarding relevant issues, facilitating the promotion of social cohesion in the study area. These findings highlight the positive dynamics within the stakeholder network, fostering trust, cooperation, and social cohesion in Qasr Yaqoub village. This study showed that the combination of network analysis and sustainability barometer model could be a useful tool in the sustainability analysis of local communities in rangeland ecosystems.

1. Introduction

Natural resources in Iran are the fundamental components for the sustainable development of agricultural activities in rural areas (Schlesinger et al., 2015). The Sustainable Development Strategy is described as "an organized, inclusive, and ongoing process of ideas and actions to accomplish balanced and integrative economic, environmental, and social goals" (Goli et al., 2023)." It has recently been suggested as a method for evaluating and interpreting the values of economic and social growth and the use of natural capital in the world (Chenoweth et al., 2018; Holtkamp & Weaver, 2018; Mofidi Chelan, Alijanpour, et al., 2018; Mofidi Chelan, Barani, et al., 2018).

One of the most important parts of natural resources is rangeland, which is of great importance in the conservation of water and soil sources in each country. Therefore, there is a need for sustainable exploitation and scientific management of natural resources, especially in rangelands (Mofidi Chelan & Sheidai Karkaj, 2022; Sheidai-Karkaj et al., 2022). Attempts to improve the sustainable management of rangelands include a duty to devise a flexible, locally contextualized, and scientific land policy (Hoang et al., 2019). The process of sustainable development is of particular importance which requires the productivity and growth of the natural resource sector, especially rangelands, to be continuously promoted in development programs. In other words, sustainability in the management of natural resources and rangelands and

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their preservation are essential pre-conditions for sustainable agricultural and rural development (Mofidi Chelan, 2016; Motamedi et al., 2022; Haghiyan et al., 2022).

The science of rangeland management has progressed dramatically over the last couple of decades (Azadi et al., 2009). However, to adequately develop and ensure a sustainable future for rangelands, there is a need for a modern system for rangeland management and pastoral growth strategy, which will consequently raise the need for alternative approaches to sustainable rangeland management (SRM) (Khedrigharibvand et al., 2019). Sustainable land management (SLM) is described as “a system of technologies and/or planning that intends to combine ecological, socioeconomic, and political principles in the planning of land for agricultural and other activities in order to accomplish intra- and intergenerational equity” (Hurni et al., 2008; personal communication, modified from Eswaran & Blum, 2011). SLM is thus composed of three development components including ‘technology’, ‘policy’, and in particular, ‘land use planning’ (Bouma, 1997). Sustainable land management (SLM) aims to maintain and improve ecosystem services (productivity), reduce production risk (security), conserve natural resources (conservation), and be economically viable and socially acceptable (Thomas et al., 2018). Quantifying the effect of SLM activities on rangelands is difficult since conflicting findings can be seen in numerous ecosystem services. Humans profit from a wide range of ecosystem services given by the natural world and healthy ecosystems. Agroecosystems, woodland ecosystems, pasture ecosystems, and aquatic ecosystems are examples of such ecosystems (Hasan et al., 2020). There are social and economic dynamics that have an impact on the long-term viability of interventions in the management of rangelands (Marques et al., 2016). In this regard, social network analysis (SNA) is the method of studying social formations by the usage of networks.

SNA is used to analyze social networks and the relationships between stakeholders. This approach has been the focus of researchers in recent years (e.g., Bacău et al., 2020; Bergsten et al., 2019; Jiren et al., 2018; Sayles et al., 2019). Rockenbach and Sakdapolrak (2017) argued that a resilient social network ecosystem where rural communities are embedded in social networks and hence direct the flow of wealth, data and knowledge across regions. Krupa et al. (2018) stated that SNA is an efficient, measurable, and understandable method to identify stakeholders. Groce et al. (2019) have noted that the usage of SNA in the management of natural resources is expanding quickly. In order to describe the function of social networks in achieving desired environmental and social outcomes, the stakeholders’ society must presently create a more reliable database.

SNA method will help researchers to analyze the interaction between individuals and their environment by measuring the relationships between individuals and the impacts of these relationships on human communities. As a result, creating and making available indicators for integrated land management can assist managers and planners in achieving effective management.

There is no data on whether rangeland pastoral components are socially, economically, or environmentally sustainable, and there has not been any study on utilizing the SNA approach to assess the sustainability of rangeland pastoral units. A location’s internal and external circumstances, the requirements of the local population, and the availability of human and natural resources should all be taken into consideration when making development decisions. It is critical to have a clear grasp of the presently accessible resources and the possibilities for employing them in order to attain economic, social, and environmental viability. This may be performed by using proper evaluation models to appreciate the existing state of affairs and society’s current situation in terms of sustainability. By analyzing the advantages, downsides, possibilities, and external risks related to the growth of these sectors, researchers may give this insight into the existing quo and the society’s current position in terms of sustainability. In other words, evaluating sustainability enables us to more clearly define sustainable development goals and monitor our progress toward achieving them.

None of the development theories and models can be implemented in the rural areas of the country. Although it is useful to use theories and patterns of development and to learn about them, the country’s rural development model should be a local model. The sustainability of rangeland areas is realized when the utilizers of such areas are managed by knowing all the effective factors in the rangeland ecosystems and respecting the sustainability of all these factors. The experiences gained in the world have shown that the sustainability of the management of natural areas is directly related to the economic, social, and cultural sustainability of the user communities (Salam et al., 2005). The need of the users for the immediate provision of their livelihood and the lack of a forward-looking culture and a sustainable and permanent view on the economy of rangelands, which originates from economic weakness along with cultural weakness, are among the important problems governing most of the customary systems of rangelands. In the ecosystem cycle of rangelands, this is dominated by all environmental and human factors. The sustainability of social, economic, and cultural conditions, along with the sustainability of environmental conditions, are considered the basis for the sustainability of rangeland pastoral units, and this by itself evokes the issue of sustainable development in the mind (Esther & Ndaluhwa, 2003; Hosseininia et al., 2013). Sustainable rangeland management is a dynamic process that depends on rapid response to permanent changes in economic, biological, climatic, and political conditions. Therefore, continuous monitoring of rangeland ecosystems and recognition of the ecological capacity of exploitation units, along with establishing a balance between livestock and rangeland, will cause the stability of these ecosystems. In this regard, studies show that due to the increasing population growth, technological development, and provision of food resources and housing for the growing population, the process of destruction of rangeland and then the destruction of the environment have increased in the last few decades. In many of these cases, this destruction is the result of unreasonable and unscientific human performance in exploiting these resources rather than natural factors such as drought and changing weather conditions. Therefore, one of the world’s concerns and challenges is the protection of these renewable resources, and it is necessary to take steps toward sustainable development in the management of the country’s rangelands.

Due to the participatory methods of herding and assistance systems that exist in this village, in this research, an attempt was made to make a complete and accurate assessment of the sustainability of the local stakeholder network, related to rangelands, in various dimensions of sustainability and social networks. As a result, the following objectives were pursued in this study: introducing indicators and components of sustainability assessment in various dimensions of sustainable development, analyzing the social relations network of rural stakeholders in the study area, identifying effective factors in stakeholder cooperation and trust, and introducing an integrated SNA and sustainability barometer model (SBM) approach to assess sustainable management components in the study area.

Yazdani et al. (2019) defined the SBM as a two-dimensional analytic technique that evaluates well-being in human and natural aspects of a fair and methodical system without data duplication and without concealing the results and findings in a well-being indicator. In this regard, Frondel et al. (2023) used the SBM and analyzed a variety of attitudes and their temporal evolution. Then, it measures sustainability based on two variables including ecosystem welfare and human well-being (Table 4) (Prescott-Allen, 1997). The results of economic and social sustainability assessment indices were used to calculate human well-being, and the results of environmental-ecological management evaluation indices were used to calculate the ecosystem welfare.

The existing human and physical resources, the internal and external circumstances of the place, and the demands of the locals should all be taken into account while making development decisions. The adoption of proper evaluation models is necessary to understand the current state of affairs and the sustainability of society. This is because achieving economic, social, and environmental sustainability requires having a

firm understanding of the resources that are already available and the opportunities for using them. By analyzing the advantages, disadvantages, opportunities, and external threats connected with the expansion of these places, it is possible to investigate the sustainability levels for rangeland grazing units and get information on the status quo and the society's current position in terms of sustainability. In other words, evaluating sustainability enables us to more clearly define sustainable development goals and monitor our progress toward achieving them. Furthermore, efficient planning based on principles and thorough execution are required to achieve sustainable growth at any scale or with any purpose. For various economic, social, and environmental plans, it is essential to develop development strategies, achieve planning and executive plan success, assess and recognize capabilities and shortcomings, and gauge the level of development of local residents using a set of superior indices. Accordingly, the aim of this study was to evaluate the land sustainability assessment in semi-steppe rangelands in southern Iran by the following questions:

- 1) How can the sustainability of the local stakeholder network be accurately measured?
- 2) Can the SNA-SBM approach be effective for evaluating the components of sustainable management and biodiversity in rural areas?
- 3) Is the rural stakeholder social network effective in cooperation and trust between stakeholders?

2. Materials and methods

2.1. Study area

For the present study, Qasr Yaqoub village was chosen as the study area. It is situated in Safashahr city within Fars province, southern Iran. The village's spatial location is represented by a range of latitude and longitude coordinates. Specifically, Qasr Yaqoub village is positioned between 53°08' E and 30°31' N (see Fig. 1). It is located at an altitude of 2170 m and experiences a temperate climate during spring and summer, while autumn and winter are characterized by cold weather conditions. The study area is about 1025 ha, with about 208 inhabitants based on national enumeration in 2016 (Afzali et al., 2019). Most of the people in the village are involved in animal husbandry and agriculture. The village, formerly a temporary settlement for nomads, is more than 100 years old. Valuable historical monuments close to the village, however, are older than the current village (Zucco et al., 2020). The rangelands of

the village are managed by the council and animal husbandry, and the rangeland usage methods have retained their traditional form. However, these traditional practices have become obsolete in many surrounding villages, over the past thirty years (Pakrah et al., 2020). Therefore, some villages have become uninhabited and the villagers have migrated to urban areas by handing over rangelands and selling livestock. Therefore, Qasr Yaqoub village was selected as a village that still maintains its ancient methods in cooperation and rangeland management to study the role of social networks in SRM.

In the study area, the stakeholders bring their livestock into the rangeland in several herds for 9 months for grazing. Mentioning this case is important because this cooperative method represents the unique lifestyle and livelihood of these people. These stakeholders have social links and form a social network whose stability depends on rangelands' and resources' stability and vice versa. The management type of the region is called "Chakaneh", which is a participatory type of management and is a part of the social culture of the village, in which rangeland utilizers bring their livestock to the rangeland in small groups, and each time, one of those utilizers would be in charge of the herd. In other words, each herd belongs to several people (for example, five or six or more people). This is an ancient and traditional method of animal husbandry that leads to maintaining social structures in the village and improving cooperation among them so that there is no individual benefit in the management and utilization of natural resources and the benefits of all utilizers are dependent on each other. It should be noted that, in this way of management, each person would be responsible for grazing the herd proportional to their animals and this rotational trend would be done for 9 months of the year (Rasekhi, 2014).

In the village and every herd, individuals have different contributions based on their duties and economic and social conditions, and by performing their duties in whatever position they are, they shape the social structure of the village to manage livestock. These roles are assigned to individuals in different ways, sometimes inherited and attributed to a particular character, and sometimes the experience and knowledge of the person play the role. The process of milking and producing dairy products in the village is up to the women in the village, and women form groups called "shirdan" and borrow milk in a rotating manner. Shirdan (as a local term) is a social institution among rural women. This cycle follows the mechanism of the ancient tradition. One of the most essentials of these cooperatives in the management of livestock among stakeholders in Iran is "Vareh", which is an ancient, informal organization with the main focus on female cooperation. In

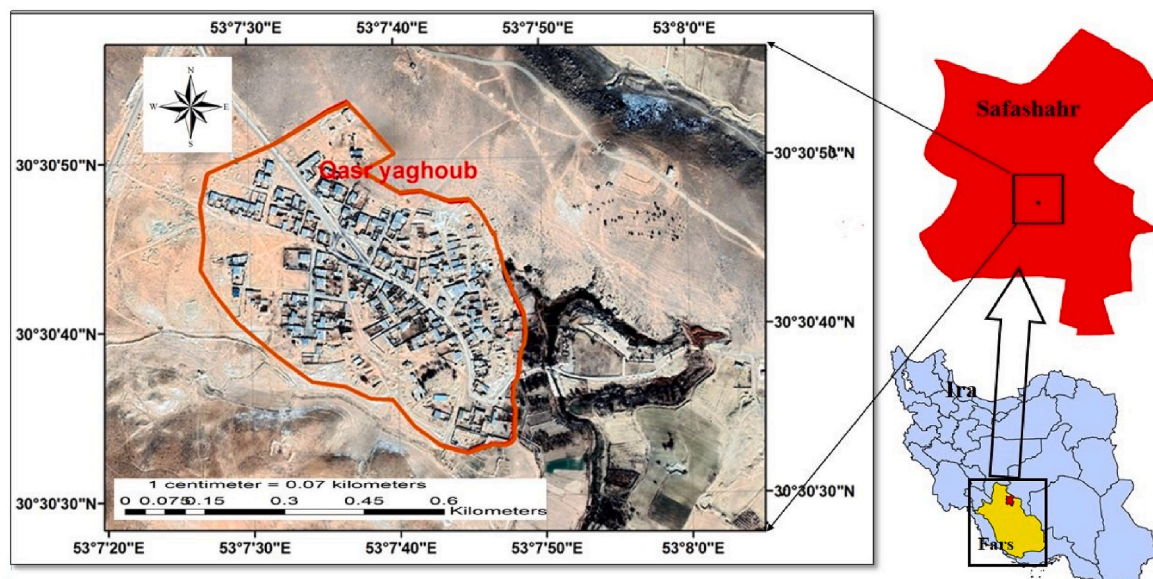


Fig. 1. Geographical location of Qasr Yaqoub village in Iran.

Iran, Vareh has more than 130 different names in different regions. Although the main focus of the trade is on the constant exchange, there are other economic, social, and psychological exchanges on the periphery. These organizations are derived from the local knowledge of the region, are a form of social capital for the beneficiaries, and play an essential role in maintaining and strengthening the social cohesion and sustainability of the economic components of the inhabitants of the region. Apparently, as with other traditions of assistance in the local communities of Iran, Vareh has been used as a social and cultural solution for the participatory use of higher productivity resources (Farhadi et al., 2018; Rasekhi, 2014; Rasekhi & Ghorbani, 2016).

2.2. General introduction

In Qasr Yaqoub village, direct observation, semi-structured interviews, and participatory observation were used to obtain information related to local knowledge and local tradition, collect information, and determine the number of stakeholders. For this purpose, researchers used the snowball sampling method to distinguish all the stakeholders. Finally, they determined that in general, 42 stakeholders were engaged in livestock husbandry in the village of Qasr Yaqoub.

Stakeholders and rangeland utilizers (ranchers, landholders, etc.) were identified between 2018 and 2019. On this basis, 42 stakeholders utilize the rangelands of Qasr Yaqoub village in a corporative manner. They feed their livestock in 6 herds in the rangelands for nine months of the year. The beneficiaries have also had social links with each other, namely social networking, among which sustainability plays a crucial role in rangeland utilization and meeting the economic needs of rural households in the area. All these users were finally questioned through the SNA questionnaire and a scoring method in terms of social trust and social cooperation.

2.3. Social network analysis: data collection

This technique is now an important instrument for researching, analyzing, and modeling local stakeholders' social and economic systems. Data for rangeland-related utilizers were collected using a network analysis technique in this research. The data in this technique are of the relationship type, which means that the unit of study is the connection rather than the person. As a result, the material gathered depicts the interpersonal relationships (by the questions about the amount of current level of cooperation, or the probability or willingness of the person to cooperate in the future). The whole network data approach was used in this study to identify nodes and actors in network analysis. As a result, no sampling was performed, and all actors involved in participation in rangeland management at the local level were considered so that the results to be cited and reliable, and to provide a complete picture of relationship issues within the population.

The collected data are finally displayed as two-dimensional matrices (M),¹ where each row of this matrix (x_{ij})² represents the relationship between node i ³ and node j .⁴ Furthermore, the weighting method was used to describe the amount, intensity, and repetition of the investigated relationships, and the SNA questionnaire method was used to collect the data of the network. Finally, the relationships between the actors were extracted from the recorded information of the network. In the network analysis method, also, matrix algebra theory is used for mathematical calculations.

Data were then analyzed in UCINET 6.0 software. Data analysis was performed based on quantitative and mathematical indices. It is worth mentioning that all the indicators measured in accordance with the

defined goals of this research are mentioned in the table in Appendix 1.

In the present study, the social boundary of the studied networks is rangeland-related utilizers, and the ecological boundary is the Qasr Yaqoub rangeland unit network. In this study, the coherence of the two links of trust and cooperation was measured as perceptions by the individuals of the regional stakeholder network. In addition, "coherence" has been used to describe the combination of density, centrality, reciprocity, and geodesic indices. This study examines the coherence of two ties, including trust and cooperation in the local stakeholder social network, on the regional scale, by measuring the density, centrality, reciprocity, and geodesic indices of the whole network in order to analyze the social cohesion and sustainability. The density index is related to the ratio of all existing ties to all possible links. Density, therefore, relates to the number of ties connected with a node. A general definition of each indicator could be found in Appendix 1.

2.4. Developed and validated indices for assessing sustainability

The validation and development of sustainability assessment indices are based on face-to-face surveys by specialists and researchers. Face-to-face surveys are characterized by the fact that an interviewer calls on, or meets, the respondent and conducts the interview. The interviewer reads out the questions and records the respondent's answers (Groves et al., 2009; Loosveldt, 2008). In the first stage, unstructured interviews were performed with researchers, executives, and local elites on rangeland pastoral units' sustainability assessment indices. Following that, a set of indices connected to the sustainability assessment of rangeland pastoral units that are more practical and relevant to rangeland pastoral units were determined based on the findings of said interviews and the literature analysis of the sustainability assessment indices. The reference group reviewed and rated the indices chosen in the previous step in order to achieve more operational and limited indices. They were asked to express the important coefficient of each index using a five-point Likert scale in this stage.

The "convenience sampling method," which is regarded as one of the non-probability sampling techniques, was used to choose reference group participants for the validation of sustainability evaluation indicators. In this regard, 45 individuals were chosen, including 20 experts from universities who are professors or graduates with at least a master's degree in rangeland sciences, geography, or rural planning, 15 experts from the executive affairs of the natural resources departments, and 10 local elites who use rangelands.

Then the mode, mean value, standard deviation, and coefficient of variation for each feature were calculated. Considering that the five-point Likert scale was used to score the indicators by the members of the reference group and that in this scale, a score of 3 indicates relative agreement, this number is considered as the minimum mean value to select the indicators. Moreover, the threshold numbers for mode, standard deviation, and coefficient of variation are considered according to the data structure. In the next step, based on the scores provided by the reference group, the indices with mode, median, and mean value greater than 3, standard deviation less than 1, and coefficient of variation less than 0.3 were chosen. Then, the Kruskal-Wallis test was applied to define the degree of agreement between the opinions of experts from natural resource agencies, members of faculty, specialist researchers, and local elites about the appropriateness and inappropriateness of each feature. Ultimately, indices with good validity were chosen and introduced to evaluate the sustainability of rangeland utilizers (Mofidi Chelan, 2016; Mofidi Chelan, Alijanpour, et al., 2018; Mofidi Chelan et al., 2018b; Mofidi Chelan et al., 2022) (Tables 1–3).

A questionnaire was used to examine the selected indices (research variables) which were completed by local stakeholders. The questionnaire consisted of four sections. The first part was related to the descriptive information of the respondents, including age, experience in livestock husbandry, household size, number of livestock, and rangeland area. The second section is related to the questions of estimating the

¹ - (M): Two-dimensional matrices.

² - (x_{ij}): Represents the relationship between node i and node j .

³ -Node.

⁴ -Node.

Table 1
Indices of economic sustainability assessment for rangeland owners.

Sustainability components	Sustainability assessment indices	Sustainability components	Sustainability assessment indices
Activity and employment	Job satisfaction Job loss probability Rate of continuity and expansion of livestock husbandry among the young generation	Financial Stability	Income satisfaction Net income Percentage of households having insurance support Percentage of livestock and rangeland insurance
Utilization	Value of household existing livestock Income from dairy products sales Income from sales of wool Livestock feed costs Livestock herding costs Livestock loss ratio livestock drugs and veterinary services costs Level of interest in collective exploitation system Level of interest in private exploitation system	Productivity Economic welfare Efficiency Economic justice	Diversity of products Productivity of all production inputs Cost of living Median household income Efficiency ratio (expenses/revenue) Dependency ratio Income stability Bank loans receiving rates
		Governmental services	The ratio of households with oil quota The ratio of households with gas quota

social sustainability indices, the third section is related to the questions of the economic sustainability indices, and finally, in the fourth section, the questions related to the ecological sustainability assessment indices were evaluated. Standard measurement methods were used to estimate quantitative indices, and survey and Likert scale were used to estimate qualitative indices. In order to analyze the validity, a variety of specialists in the field of sustainability evaluation were provided with the questionnaires in line with the aims, conclusions, and analysis subjects and were invited to offer critical feedback on the questionnaires. As a result, the questionnaire problems were identified and validated by

correcting the questionnaires. The alpha coefficient of Cronbach was then used to assess the reliability of the questionnaires. In this study, Cronbach's alpha coefficient for different parts of the questionnaires was 78% on average, which is in the desired range (Cronbach, 1951). Finally, the questionnaires were completed for all the 42 rangeland stakeholders and the indices were determined using standard techniques (Zucco et al., 2020). When various indices are used to evaluate sustainability levels, it is not possible to say that all of the indices have the same value and significance. As a result, appropriate weights must be given to the indices in order to regulate the differences between them. Due to the

Table 2
Indices of social sustainability assessment for owners of the rangelands.

Sustainability components	Sustainability Assessment indices	Sustainability components	Sustainability assessment indices
Population dynamic	Relative population density Population mortality rate Working age population Gender ratio Average household size	Services	Satisfaction rate with educational services Satisfaction rate with promotional services Percentage of livestock and rangeland insurance Satisfaction rate with health services Percentage of household insurance
Education	The existence of a teacher and educational facilities The rate of children reaching the fifth grade of elementary school The ratio of literate people – writing and reading skills Adults' literacy rates	Human capital	The age of the utilizers Experience of utilizers Indigenous knowledge level of utilizers
Health	Percentage of smokers Working hours per day for the head of the household Percentage of households with safe, healthy water	Social security	Percentage of households having insurance support The degree of social solidarity The degree of harassment of strangers (tourists)
Cultural capital	Traditional culture preservation Tourism conflict with local communities	Social participation	Participation rate in household affairs Participation rate in rangeland improvement practices The level of responsibility Female labor force participation
Psychological security	The degree of interaction with neighboring households Hope for the future Job satisfaction rate Satisfaction rate with relevant government agencies and relevant officials Satisfaction with Life	Social justice	Households living below the poverty line Access to welfare facilities Social deprivation rate
Hygiene	The mortality rate of children less than five years and mothers Healthcare access Attention to health and management of livestock diseases The level of meeting hygienic principles in the production of livestock products	Social relationships	The level of cooperation and collaboration The level of social cohesion The level of social labor division
		Technology	Percentage of mobile phone use Percentage of novel energy use (solar water heater, flashlight, etc.)

Table 3

Environmental-ecological sustainability assessment indices for the owners of rangelands.

Sustainability component	Indices for evaluating the sustainability of pastoral units	Sustainability component	Indices for evaluating the sustainability of pastoral units
Grazing management	Premature grazing rate Surplus livestock in rangelands	Rangeland management	Road construction rate in rangeland
Rangeland properties	Grazing period Rangeland area Rangeland stocking rate	Environmental health	The adherence rate to the principles of rangeland conservation Waste materials and wastewater management level
Water sources	The multiplicity of drinking resources for livestock Satisfaction rate with quality of drinking water Livestock corral and water sources distance in rangeland	Soil properties	Rain splash protection Soil cover (Patches) Percentage of bare soil Percentage of litter

wide range and substantial number of sustainability evaluation indicators employed in this study, pairwise comparisons were performed to determine the relative weight of the indices using the Analytic Hierarchy Process (AHP), and surveying was used to determine the weights of the components individually. As a consequence, 20 university experts and related professionals determined the importance of sustainability components and characteristics, which were then computed using Expert Choice software.

Comparing sustainability elements in each sustainability dimension and sustainability levels across dimensions was carried out using analysis of variance and Duncan tests.

2.5. Sustainability measurement data analysis with SBM

The Barometer model consists of two main elements, namely ecosystem welfare and human welfare, both of which must be improved to achieve sustainable conditions. This model was proposed by Prescott Allen and it divides sustainability into five levels. Then, it measures sustainability based on two variables including ecosystem welfare and human well-being (Table 4) (Prescott-Allen, 1997). The results of economic and social sustainability assessment indices were used to calculate humans' well-being, and the results of environmental-ecological management evaluation indices were used to calculate the ecosystem's welfare.

The steps for calculating the barometer model are as follows:

- 1 Preparing the table for the same scale data: Each of the indices in the data matrix has different units, so it is possible to compare them by no-scaling. Explanations on how to select sustainability assessment indicators have been added, and indicators related to economic, social, and environmental dimensions are listed in Tables 1–3. The indices introduced for sustainability assessment have different units. Some indices are quantitative and some are qualitative. Therefore, it was necessary to proceed without scaling the values of the indices.

$$x_{ij} = \frac{(x_{ij} - x_{min})}{x_{max} - x_{min}}$$

where x_{ij} is equivalent to the i_{th} index value, x_{max} is equivalent to the i_{th} index maximum value, and x_{min} is equal to the i_{th} index minimum value.

- 2 Preparing the final data table: At this point, the value of each index is multiplied to determine the final value of each index by the

coefficient of the importance of that index. The data obtained show the actual and final value of each index. The data states that the data obtained for each indicator are in the range of zero to one and that the classification of Prescott Allen can determine the sustainability class. Fig. 2 shows the general flow chart of research steps and methods.

3. Results

3.1. Structural analysis of social trust and cooperation

3.1.1. Indices of density, size, and cohesion rate

Based on the results of the density index in Table 5, the index value for the ties of trust and social cooperation among the stakeholders in the local stakeholders' network in Qasr Yaqoub village (42 people) was 63.1% and 59.8%, respectively. This indicates the stable density in the trust network of the stakeholders and the average density in the cooperation network of the stakeholders in the region, which shows the high level of trust in the stakeholder's network in each other and various matters. Regarding the cooperation network, although the percentage of density was slightly lower, it was moderate and acceptable. Therefore, the level of cohesion based on the density index in Qasr Yaqoub village is at a moderate to intense level, which shows the high level of social capital in the region. In this regard, Moghfeli et al. (2021) demonstrated that improving the quality of dialogue between people in a network and players from other networks and communities improves the nature of relationships in social networks. This can boost social network productivity, resulting in higher-quality resources, greater support, the exchange of valuable information among networks, and an improvement in farmers' adaptive ability.

Another indicator is the size of the social network. The index, which shows the number of ties in the stakeholders' network, is equal to 1086 and 1030 for trust and social cooperation, respectively, and covers more than 50% of the expected ties; in other words, they have assigned a medium to large percentage, which proves the interaction between stakeholders in related matters, which in turn paves the way for the promotion of social cohesion in the study area.

3.1.2. The reciprocity index and the transitivity of ties in the local stakeholders' network

The results of Table 6 show that the levels of mutual trust and mutual cooperation based on the degree of reciprocity between the local stakeholders are 49.59 and 48.84% in the links of trust and cooperation (on average). The reciprocity and transitivity indices indicate the level of sustainability and balance of the existing networks. It is noteworthy that the rates of transitivity of trust and cooperation ties in the study area are 39.69% and 35.71% (low to medium) in trust and cooperation ties, respectively. According to the reciprocity and transitivity indices, it can be stated that although the rate of reciprocity and transitivity indices are low to medium, due to the high level of existing ties, the sustainability and balance of the examined social network are at medium to

Table 4

Classification of sustainability from Prescott Allen's viewpoint.

Levels	Sustainability status	Sustainability values
First level	Bad: Unsustainable	0–20
Second level	Poor: Potentially unsustainable	20–40
Third level	Medium: Intermediate	40–60
Fourth level	OK: Potentially sustainable	60–80
Fifth level	Good: Sustainable	80–100

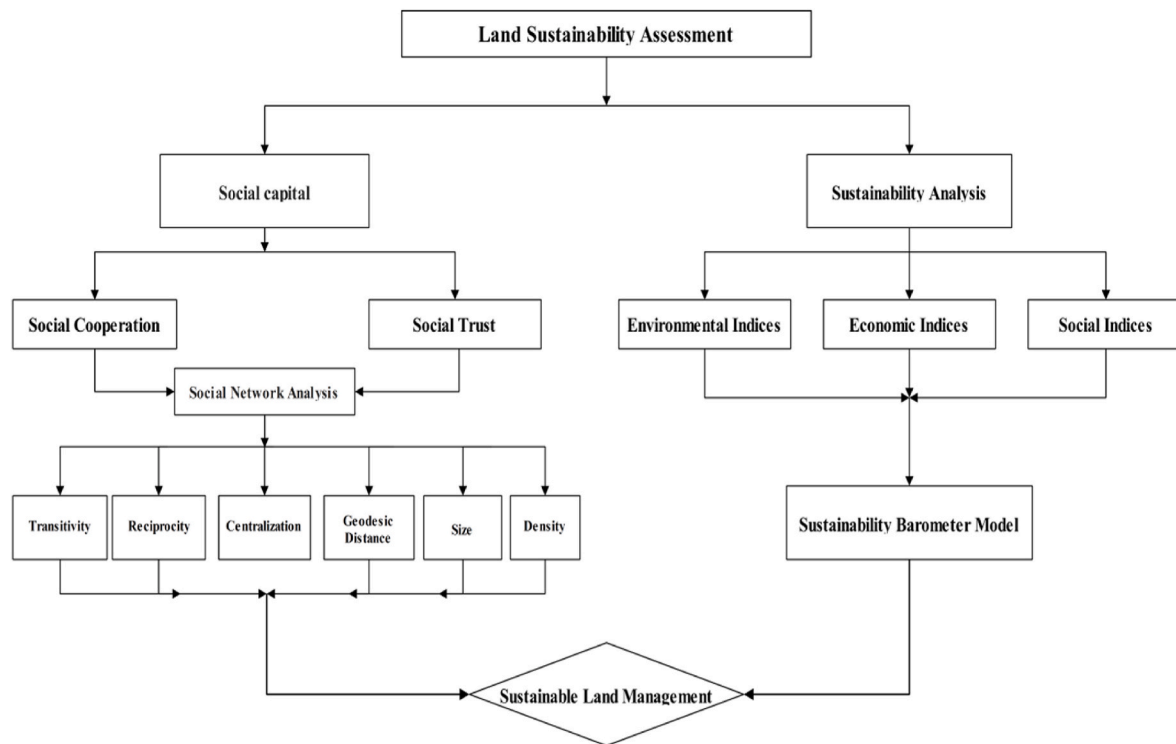


Fig. 2. Flow chart of the methodology.

Table 5

The value for density and size indices in the local stakeholders' network in the studied area.

Ecological border	Tie	Population	The expected ties number	Density (%)	Network size
Qasr Yaqoub village	Social Trust	42 people	1722	63.1	1086 tie
	Social cooperation	42 people	1722	59.8	1030 tie

Table 6

The value for reciprocity and transitivity indices in the local stakeholders' network in the studied area.

Ecological border	Tie	population	Reciprocity (%)	Transitivity (%)
Qasr Yaqoub Village	Social Trust	42 people	49.59	39.69
	Social cooperation	42 people	48.84	35.71

relatively good levels. In general, however, by increasing trust and mutual cooperation, social capital has also increased, and a more cohesive social network can be expected. Such a network has a higher resilience and capability in the face of environmental crises. Considering that the dominant occupation of the local communities living in the village is Rangeland-based Livestock Husbandry in the form of using free forage. Therefore, any decrease in forage production and changes in the quality of rangelands can affect the economy and livelihood of the local stakeholders and ultimately cause changes in the level of economic and social stability of village stakeholders. Therefore, according to our results and also as shown by Smith et al. (2021), reducing the quality of rangelands has been effective in the stability of the village. However, the evaluation and results were based on social indicators and comparing the general conditions of the village with the surrounding villages. As

Table 7

The value for centralization index based on in-degree and out-degree ties in the rangeland stakeholders' network.

Ecological border	Tie ^a	In-degree (%) ^b	Out-degree (%) ^c
Qasr Yaqoub village	Social Trust	35.33	20.34
	Social cooperation	36.16	21.17

^a Tie: The ties throughout which each particular social unit is connected indicate the convergence of different social contacts of that unit.

^b The number of nodes received by an actor is extremely indicative of a person's status or authority.

^c In fact, the number of nodes left by a high-level actor reflects the impact of the actor, which is mostly considered in the network of data transmission.

mentioned, despite the geographical conditions, today, most of these villages are uninhabited. Therefore, the current situation of this village can be related to the traditional methods used and the existing social capital.

3.2. Centralization index in the local stakeholders' network

As mentioned earlier, the calculation of this indicator is based on the network's degree and degree ties.

Based on the findings in Table 7, the network's centralization (in-degree) is less than 50 based on trusted network relationships, which indicates that gaining trust in the network is less focused. Furthermore, reducing the centralization based on out-degree ties compared to in-degree ties means that the development of trust has been spread at the network level because with the reduction of out-degree ties, the focus on trust distribution increases. Furthermore, according to the results of Table 3 for cooperation ties, it can be stated that receiving cooperation ties in the mentioned network has a lower focus. Low centralization based on out-degree ties means that the focus is less on the distribution of cooperation. In other words, most people are involved in the distribution of partnerships and cooperation in the region, and the division of power and responsibility in the studied networks has been achieved

relatively, which is itself the basis for the sustainability of a society as much as possible.

3.3. Average geodesic distance between linking trust and participation in the local stakeholder network

The average geodesic distance was used to determine the relationship between trust and participation in the local stakeholder network. The average geodesic distance measure is the sum of the shortest gap of a pair of actors and is used to measure the speed of circulation and exchange (trust and cooperation) in the network. This indicator also shows the level of unity and integrity between individuals in a society. In order to achieve this index, the mean geodesic distance between local rangeland stakeholders in the studied area and in the trust and cooperation ties has been measured. According to the results, this index is 1.07 in the trust tie and 1.1 in the cooperation tie. The results show that the speed of exchange and circulation of information and resources among local stakeholders is good. The results also show a higher rate of exchange of trust compared with cooperation with little difference in society. Thus, it can be said that the resilience of the local community in this village when encountering environmental stresses is high. Therefore, the social infrastructure has higher strength (Table 8).

3.4. Sustainability analysis

Variance analysis was employed to evaluate the mean sustainability variable values, and Duncan's comparison test was used to observe the sources of the intragroup changes. Findings of analysis of variance show that the average values of economic components are notably varied. The results of Duncan's test indicate that economic components are categorized into 5 different groups. Productivity with a value of 0.67 has the highest average value of components, and the lowest average of components is economic sustainability with a value of 0.45. Therefore, it can be said that the utilizers of the Qasr Yaqoub village rangelands have a low economic income and are not satisfied with their income. Also, a low percentage of households have insurance support. The results show that the mean values of the social components have a significant difference. The results of Duncan's test indicate that social components are categorized into 7 different groups. The component of social participation with a value of 0.79 had the highest average, and the component of psychological security with a value of 0.41 had the lowest average among the components. In this regard, field observations showed that the utilizers are not satisfied enough with the livestock husbandry job. Also, government agencies and relevant officials have not been able to provide adequate services to the utilizers. Findings of the mean variance of the environmental-ecological component show that the environmental-ecological components are significantly different and the component of the environmental health component has a maximum average of 0.72 among the environmental-ecological components. The lowest level is related to the soil characteristics with 0.38 values. The result of Duncan's test indicates that environmental-ecological components are categorized into 4 different groups. The results of the variance analysis of comparing sustainability in different dimensions show that the social, economic, and environmental-ecological sustainability of Qasr Yaqoub village had significant differences from each other. The social dimension had the greatest level of sustainability with a value of 0.68, and the economic dimension with a value of 0.45 had the lowest level of sustainability. The field observations and the outcomes of the prediction of sustainability indices revealed that the utilizers' weak

economic base, low average annual income, lack of diversity of economic activities and reliance on livestock husbandry, low level of productivity, low level of government services, and low level of using new technologies are the main factors reducing the utilizers' economic sustainability (Fig. 3).

Various letters indicate a notable variation at the level of $P < 0.05$.

The results of the sustainability measurement with the SBM showed that in the social dimension, Qasr Yaqoub village is in a state of fine sustainability. In the economic and environmental-ecological dimensions, this unit is in a state of medium sustainability, and finally, in terms of total sustainability, it is in medium sustainability with a value of 0.45 (Fig. 4).

Undoubtedly, reducing the quality of rangelands has been effective in the stability of the village. However, the evaluation was based on social indicators and comparing the general conditions of the village with the surrounding villages. As mentioned, despite the geographical conditions, today, most of these villages are uninhabited. Therefore, the current situation and conditions of this village can be related to the traditional methods used and the existing social capital.

4. Discussion

Strategic development plans focused on the sustainability framework have been considered in recent years at the village level. The beginning point is called strategic preparation for pastoral units to clarify the existing scenario and what the real pastoral units are in the current situation. Pastoral groups face several challenges at the moment, yet, at the same time, are facing different choices for the future. Therefore, to understand the units of pastoral status in terms of sustainability and to recognize components and indicators explaining appropriate sustainability models for measuring sustainability, the present study was conducted coherently and systematically in the village of Qasr Yaqoub.

4.1. Sustainability analysis

The results show that the mean components of sustainability assessment in different dimensions of sustainable development are mutually meaningful, which is consistent with the results of Mofidi Chelan, Alijanpour, et al. (2018) who reported that in Sahand summer rangelands, the economic components of sustainability are significantly different from other components. The components of productivity in the economic dimension, social participation in the social dimension, and the grazing management component in the environmental-ecological dimension have the highest value. It seems that the average standard of Qasr Yaqoub village is related to the diversity of dairy products in this unit and the average level of productivity for the factors of production. Therefore, due to the traditional milking system (shirvareh) among women in this pastoral unit, women in the village are in charge of dairy production and milking process, and a variety of dairy products are produced, including butter, yogurt, oil, curd, and cheese (Rasekhi & Ghorbani, 2016). The high level of social participation indicates the high level of participation, family affairs, and rangeland restoration affairs. The high level of social participation shows the high level of responsibility of the local people of the village and the high share of women in the total workforce.

Regarding environmental sustainability, the ecological component of rangeland health and rangeland management had the highest value among the components. It seems that according to the social structure of this pastoral unit, the cycle of traditional management of livestock grazing, and assistance methods, cultural beliefs and thoughts in herding and local environmental knowledge in rangeland management are the indicators of the continuity degree of basic resources (adherence to rangeland protection principles), and the level of waste and wastewater management has high average values that ultimately increases the components of environmental health and rangeland management. Ulambayar et al. (2017) confirmed promoting community-based

Table 8

Average geodesic distance in trust and cooperation ties.

Ecological border	Tie	Average geodesic distance
Qasr Yaqoub village	Social Trust	1.07
	Social cooperation	1.1

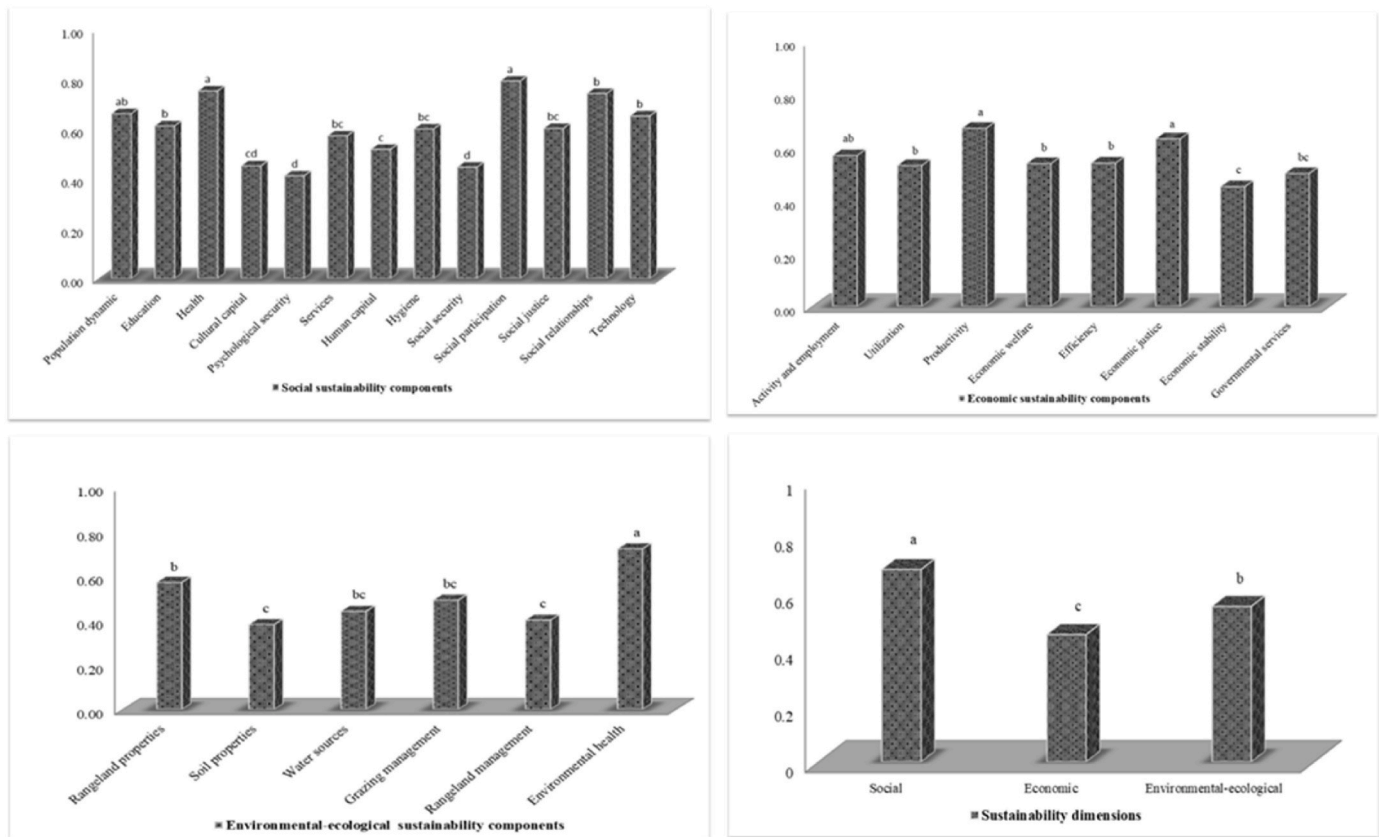


Fig. 3. Mean and Duncan test results from the components of sustainability dimensions of Qasr Yaqoub community.

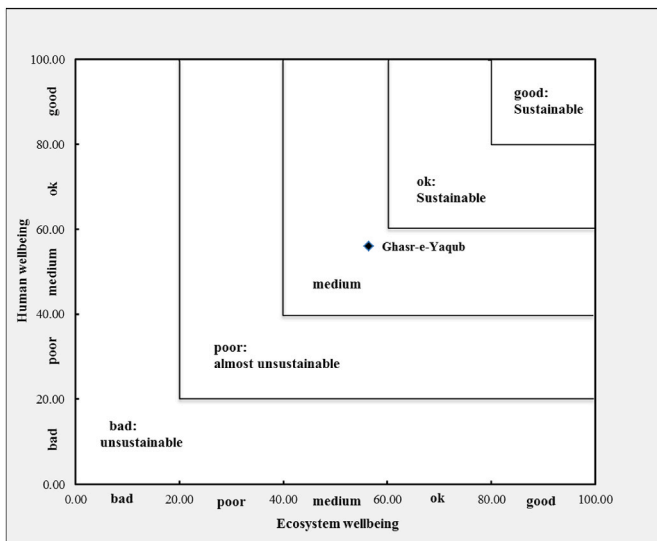


Fig. 4. Sustainability assessment with SBM in Qasr Yaqoub village.

rangeland management (CBRM) as a viable alternative to achieve the conservation of both the rangeland and community well-being. According to the results of sustainability assessment with barometer model, although in the social dimension, the village of Qasr Yaqoub is in a potentially sustainable state, the low sustainability value of the economic and environmental dimensions has caused this unit to be in a state of medium sustainability in terms of total sustainability. The individual questions, field data collection, and economic resilience evaluation outcomes in the research range revealed that the economic vulnerability

of stakeholders, low level of employment, lack of variety in economic activities, pure reliance on husbandry, low level of employment, low competitiveness, lack of policy funding, household size, and low level of exposure to the emerging technologies are the core elements of stakeholders' economic deprivation. In this respect, the focus must be given to the reality that, over the last decades, the quality of rangelands in the study area has decreased significantly, which is due to two important natural and human reasons. The fundamental reason, as mentioned, is the intensification of drought in the region and the reduction of water resources, which has gradually reduced the quality of rangelands. Another reason related to the human community is youth unemployment and lack of ancillary jobs to provide household livelihoods. Despite the circumstances, the participatory approach in the studied area and the achieved social capital and cohesion have strengthened the structure of the village so that it can be considered the most important reason for social sustainability and rural life.

4.2. Structural analysis of social trust and cooperation

As mentioned, from the past until now, the management of herds and rangelands has always been done collectively and collaboratively in Qasr Yaqoub village. There are currently 42 ranchers in the area with 6–11 herds. Each of these participatory herds is a kind of social institution or network, and the type of relationship that governs it is the social capital of this institution, which provides the ground for maintaining and sustaining this system. In this regard, the present study used the SNA approach to analyze the data. [Hanson et al. \(2016\)](#) state that using network analysis and the exact components of size, form, and density, the network can be positioned and its coherence could be examined (quoted by [Mir Mohammad Sadeqi, 2012](#)).

Based on the findings of this report, there is a high density of stakeholder trust and engagement in the network, which indicates the

high richness of social capital and people's adherence to local customs. It is obvious that a society that is bound by these traditions will work harder and more empathetically to manage its local resources and will not seek to destroy and exploit these resources. It should be noted that increasing social capital has an impact on reducing social exclusion and increasing the social welfare of actors, and in such circumstances, SLM will be more welcomed and successful. In some other studies, it has been noted that increasing the density of trust ties also increases the level of collaborative activities and mutual communication (Pretty & Ward, 2001).

In the survey conducted in the herdsmen's network, the network's centralization was studied based on the centrality of the in- and out-degrees, and the results showed that the trust and cooperation ties are scattered in the network and among all actors. In other words, most individuals are involved in distributing trust, cooperation, and collaboration in the region. In such a society, with low centrality and distribution of trust and cooperation, the activity and collaboration of all people have increased, and each person in the network is able to play a role and exert an influence. In this way, there will be no restrictions on distributing or receiving trust and cooperation. Proper network centralization also increases network homogeneity and reduces network diversity. As a result, the number of people with high potential in the network will increase and power is given to more people with the same characteristics, and thus the resilience of society against environmental factors increases. In this regard, Bodin et al. (2006) stated that the distribution of trust and cooperation ties in the network of stakeholders' coordination is more appropriate to start a process of natural resources co-management.

These results were confirmed in the studies by Bodin and Prell (2011) and Ghorbani et al. (2012).

The results of the study of the average geodesic distance index in the ties between cooperation and trust have shown that the speed of collaboration among individuals and the speed of access to each other among rangeland stakeholders in the study are at high levels representing the high level of unity and solidarity, which is one of the main goals of sustainable development.

Based on the above-mentioned results, it can be stated that in general, the network of Qasr Yaqoub village herders has a high level of cohesion in terms of trust and cooperation ties, which will lead to more cooperation and collaboration of stakeholders in line with SLM, and this process will be less costly and time-consuming.

High social capital will lead to an increase in the flexibility and adaptive capability of individuals. Resilience in social systems is the human capacity to anticipate and plan for future crises and changes. The adaptive capacity of social systems also includes the tolerance of different conditions without disrupting their process. Undoubtedly, the high adaptive capacity of social systems results from the rich social capital of these systems. In this sense, it can be argued that the greater the social capital in the human system, the greater the adaptive capacity of that society will be to adapt to changes outside the system (e.g., changes in the ecological system). If this adaptive capacity is at a high level, social systems will be more in tune with the course of change in these systems, and as a result, they will be more resilient to changes (Thomas et al., 2018). There will be more protection of natural resources, as well as resolving disputes and conflicts among stakeholders of resources, which confirms our findings in this section. This might be an intriguing and timely topic for future investigation.

4.3. Policy implications

The policy governing a complex social landscape recognizes the necessity of considering the interplay between social, economic, and ecological factors when implementing any policy within that landscape. In this study, the researchers used the social network analysis and sustainability barometer model to evaluate the sustainability of the social network and local community resilience in Qasr Yaqoub village in Iran.

The study aimed to assess the stability of the local stakeholder network in different dimensions of sustainability and social networks. The study utilized a holistic approach that considers the interrelationships between social, economic, and ecological factors in the context of the local community. The use of the social network analysis and sustainability barometer model provides a comprehensive assessment of the sustainability of the local stakeholder network, evaluating different dimensions of sustainability and social networks. This approach aligns with the principles of the policy governing a complex social landscape. Therefore, the approach used in this study can be considered a reflection of the policy of a complex social landscape. By evaluating the sustainability of the social network and local community resilience, the study provides valuable insights into how this approach can deal with the impacts on society and the environment.

5. Conclusion

In summary, this study utilized social network analysis and sustainability measurement to evaluate the social capital and sustainability of rangeland management in Qasr Yaqoub area. The results showed that there is a significant socio-ecological continuity in the area due to the existence of cooperation and assistance systems and the use of natural indigenous knowledge in rangeland management. The study also revealed the challenges and opportunities facing sustainable rangeland management in the study area. The suggested policy implications of this study include the expansion of a settlement model that encourages the use of resources related to rural regions and the adoption of participatory methods of stakeholders. The results of this study can be generalized to similar regions in the country and the world through sustainable land management.

Based on the previous analysis, reasonable management strategies for the sustainable development of rangeland in the study area include the implementation of policies that promote the use of natural indigenous knowledge, the adoption of participatory methods of stakeholders, and the expansion of settlement models that encourage the use of resources related to rural regions. These policies can help reduce rangeland degradation and make greater use of the environment. Future research should focus on the usage of integrated indicators and models to measure and evaluate sustainability in other rangelands of the country and the study of strategies to improve human and socio-economic development indicators in rangeland communities.

Author contributions

S.R and M.M.C performed the study and developed the main text; H. A.; G.S and R.V contributed to the first draft manuscript and enriched it up to the final version.

Availability of data and material/data availability

Once the manuscript is accepted, the data will be archived in the repository of the Science and Research Branch, Islamic Azad University, Tehran, and a link will be made available.

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Code availability

Not applicable.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.apgeog.2023.103093>.

Appendix1

The measured criteria in participatory management of natural resources in the SNA method and related indices.

Measure	Index	Application	References
Social trust	Density	The number of ties in the network relative to all possible ties in the target network. This index represents the degree of correlation or coherence in the network.	Hanneman & Riddle, 2005 Granovoter, 1993
Social cooperation	Size	The number of ties in a network of relationships. This index has a direct relationship with network density. The greater number of social ties in the network increases collaborative activities.	Bodin et al. (2006)
	Centralization	The percentage of the network that is controlled by a number of limited actors with a central location in the network (In-degree: Ties receiving rate/Out-degree: Ties distribution rate)	Pratti and Ward, 2001
	In-Degree	The relationship between cohesion and centralization in the network is an inverse relationship. In order to properly understand the degree of cohesion in the network, it is necessary to measure the density and centralization indicators together.	Bodin et al. (2006)
	Out-Degree		Bodin and Prell (2011)
	Reciprocity	The degree of network sustainability which is obtained by examining the mutual relations of network actors.	Henmann, 2001
	Transitivity	If actor A has a link with actor B and B has a link with actor C, then transitivity is the chance that A has to link with C. This index determines the quality and balance of the network	Bodin and Prell (2011)
	Geodesic distance	The shortest path between two pairs of actors based on the data exchange links. This index indicates the speed of circulation and spread of trust and cooperation ties among people, and the degree of unity and unity in the society. It shows the success rate of cooperative management in the society.	Henmann and Riddle, 2005 Ghorbani, 2012

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