Journal of Arid Environments 192 (2021) 104540

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Sustainable Co-Management of arid regions in southeastern Iran: Social network analysis approach

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ARTICLE INFO

Keywords:
Social network analysis
Social assets
Co-management
Green landscapes rehabilitation
The degraded land plan

ABSTRACT

Co-management requires two or more organizations that collectively manage natural capital. This study aimed to explore the function of social capital in the cycle of establishing co-management in southeastern Iranian rural communities (who participated in the Rehabilitation of Forest Landscapes and Degraded Land (RFLDL) project). Since measuring social capital is important and difficult, and one of the most promising and accurate methods for evaluating this capital is Social Network Analysis (SNA), it has been used as a research method in this research. The results showed an increase in the observed network characteristics of the RFLDL data, which indicates the positive effect of the social mobilization in RFLDL on bonding social capital. In addition, it suggested that the assessment of the success of community based natural resource governance solely based on a relational perspective of social capital is too narrow. Especially, traditional forms of community organization are not taken into account explicitly. Therefore, more research needs to be undertaken on how to incorporate differences in cultural organizations, traditional knowledge, and practices into the perspective of community empowerment.

1. Introduction

The impact of human activities worldwide on the natural environment is on a planetary scale touching and overstepping planetary boundaries. We are about to leave the relatively stable geologic age of the Holocene, which gave rise to human civilization toward the Anthropocene, where humans will have to take on much more responsibility for the stability of natural systems that are out of balance (Rockstrom et al., 2009; Virapongse et al., 2016). Adverse changes in environmental systems, such as desertification or anthropogenic climate change, are complex problems on multiple temporal and local scales, characterized through a high level of uncertainty and affecting multiple stakeholders including individual actors, agencies, and institutions (Fatemi, 2018; Reed, 2008; Basupi et al., 2019; Brandt et al., 2014). The complex character makes it virtually impossible to tackle these wicked problems in a top-down manner.

Forming groups of local resource users are widely considered as a promising approach to improve the sustainable use of local resources. These activities are called new modes of natural resource governance (Evans, 2012; Hogl et al., 2012; Schultz et al., 2017). They rely on the main idea to allow communities to develop and exchange knowledge of good practice and alternative livelihoods having less environmental impacts and build institutions that allow for sustainable cooperative solutions that are not overusing the environment and improve the communities' wellbeing at the same time. Decentralization allows actions that are accessible to the citizens involved, encouraging more transparency and responsibility. It will help decision-makers leverage more precise time- and place-specific information regarding natural resources (Stern and Baird, 2015). Another advantage of local co-management is efficiency because of competition and evolution of ideas among the groups. Lemos and Agrawal (2006) highlight that local stakeholder groups do not question centralized authority if rules and competencies are clearly separated and are not contradictory. On the contrary, they work together with various other stakeholders across organizational levels – from the community level to the global and multinational levels, including various stakeholders from government organizations, NGOs, scholars, and local cooperatives.

Due to the interaction of a local community and its surrounding

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https://doi.org/10.1016/j.jaridenv.2021.104540
Received 21 July 2020; Received in revised form 4 April 2021; Accepted 12 May 2021
Available online 29 May 2021

ecological systems, the local management schemes need to be able to adapt to changing environmental conditions. The capacity to do this is discussed as socio-ecological resilience. As future change happens under uncertainty, resilience can be improved by building and systemizing knowledge of ecosystem dynamics and promoting flexible local institutions (Rapp, 2020). It can be concluded that adaptive co-management should focus on incentivizing local populations' participation in new institutions to govern community resources. In other words, adaptive co-management facilitates social changes that are able to sustain socio-ecological systems (Labeyrie, 2014). Bodin and Prell (2011) highlight that successful adaptive co-management needs actors to build social relational ties with a diverse set of other stakeholders. These ties can be drawn upon in times of need or during the realization of projects. They are the sum of all ties connecting organization and stakeholders' institutions across all levels. Through these ties, information flow, lack of knowledge, and expertise can be communicated and used (Oubenal et al., 2017). The capacity of a community or group of people to harness their social bonds and norms as a basis for livelihood or other projects is captured in Social Capital Concept (Emery and Flora, 2006).

Social capital, in essence, recognizes the significance of social ties and is interpreted as "networks of common norms, values, and understanding that promote cooperation within or between communities" (Barnes-Mauthe et al., 2015). Social ties are described as interpersonal connections that allow people to share information, knowledge, feelings, and experiences (Qian et al., 2017). Wide-ranging research suggests that strong social ties are linked to a longer life (Luu and Ngo, 2019). The ties can be weak, strong, or latent based on the extent of exchanges and interactions between two nodes (Alexander et al., 2017). The World Bank took 'Social Capital' as a useful organizing idea, claiming that social stability is the key to economic growth for economies and sustainable development (World Bank, 1999). The key idea is that 'social networks are a precious asset.' A social network, according to Miller and Mundey (2020), is a social structure consisting of a group of social actors (such as individuals or organizations), a set of dyadic ties, and other social interactions among actors. The social network perspective offers a set of tools to analyze the structure of entire social entities, as well as a variety of theories to explain the patterns that can be seen in them (Block et al., 2020). The study of these structures uses SN to identify local and global patterns, locate influential entities, and examine network dynamics (Sun et al., 2018). In social network, more interaction between individuals will lead to greater participation, better and more effective communication, and thus contribute to the cohesion of group structures (Morrison-Smith and Ruiz, 2020). It is suggested that a sense of identity and the practical understanding of social networks (and the confidence and empathy partnerships that might be involved) may offer tremendous benefits to citizens. In other words, whereas physical capital refers to tangible resources and human capital refers to individual property, social capital refers to interpersonal relationships – social networks and the standards of reciprocity and trustworthiness that derive from them (Liu et al., 2020; Immanuel et al., 2017). Human capital refers to health, nutrition, education, knowledge and skills, ability to work, and adaptive capacity (Asian Development Bank, 2017; UNDP, 2017), which enable individuals to pursue different livelihood strategies and achieve their livelihood goals. Moreover, there is a factor of quantity and quality of available labor at the household level that varies depending on household size, skill level, leadership potential and health status (UNDP, 2017), but generally it is a tool to achieve livelihood outcomes (Lenihan et al., 2019; Xu et al., 2019). In this way, social capital is directly linked to what others have named "civic virtue." The difference is that "social capital" refers to the concept of being embedded in a single network with shared social relations. A culture with many good yet alienated citizens is not inherently abundant in social resources (Labeyrie et al., 2014). The theoretical foundations of SNA can be found in the work of early sociologists such as Georg Simmel and Émile Durkheim, who wrote about the importance of studying social interaction trends.

Since the early twentieth century, social scientists have used the term "social networks" to refer to complex sets of relationships between members of social systems on all scales, from interpersonal to international. In the 1930s, Jacob Moreno and Helen Jennings developed basic empirical approaches (Freeman, 2004). In 1954, John Arundel Barnes began regularly utilizing the word to describe structures of relations, adopting terms commonly utilized by the public and those employed by social scientists: confined classes (e.g., nations, families) and social distinctions (e.g., class, ethnicity). The usage of systemic social network research was extended by scholars such as Ronald Burt, Kathleen Carley, Mark Granovetter, David Krackhardt, Edward Laumann, Anatol Rapoport, Barry Wellman, Douglas R. White, and Harrison White (Freeman, 2006). Anheier, Gerhards, and Romo (Anheier et al., 1995), Wouter De Nooy (De Nooya, 2003), and Burgert Senekal used network analysis only in the review of literature (Senekal, 2012). Social network research employs methodologies from a branch of mathematics called Graph Theory (Scott and Stokman, 2015). Different measures of network structures were theoretically derived by sociologists and mathematicians to quantify and order the preferability of network structures. In social network, the graph representing all ties and nodes is referred to as the whole network. The following characteristics are defined for the whole network and relate directly to the community it represents. The most commonly used are investigated here, namely density, reciprocity, transitivity, and geodesic distance.

SNA is the method of using networks and graph theory to investigate social structures (van der Hulst, 2009). It classifies networked structures as nodes (individual actors, people, or things in the network) and ties, edges, or links (relationships or interactions) that connect them. Social media networks are one type of social structure that can be visualized using social network analysis (Grandjean, 2016; Hagen et al., 2018) memes spread (Nasrinpour et al., 2016) information circulation (Grandjean, 2017) friendship and acquaintance networks, business networks, knowledge networks (Brennecke and Rank, 2017) and working relationships (Brennecke, 2019). Socio-grams, in which nodes are represented as points and ties are represented as lines, are frequently used to visualize these networks. These visualizations allow you to assess networks qualitatively by changing the visual representation of their nodes and edges to reflect different attributes (Ghanbarnejad et al., 2019). These are the most important elements of a social network. There are many case studies that are undertaken to assess the impact of social capital on natural resource governance (Ghorbani, 2016; Hearne and Powell, 2014; Seferiadis et al., 2015; Meaza et al., 2017; Okello and D'Amour, 2008). The perspective of embeddedness goes further and is proposed as an alternative social theory, underlining the importance of the social context within which individual actors operate (Virapongse et al., 2016). Pinkerton (1989) makes clear the value of co-managing social partnerships. She goes on to write that " … It is important to note that effective co-management activity essentially depends on the partnerships between human actors allegedly fostered by structured structures and informal agreements that render such ties possible" (Pinkerton, 1989). Highly applicable to this essay are the attempts made by the development of social capital to grasp the complexities of social interactions in the control of wealth. Initially, Ostrom (1992, 2001) defined concepts such as shared understanding, confidence, and reciprocity as qualities that enhance the probability of self-organization. It is understood that social capital is both significant and difficult to quantify (Woolcock and Narayan, 2000; Côté, 2001; Seferiadis, 2015). Social network analysis (SNA) is a promising approach to social capital assessment (Bodin and Prell, 2011; Salpeteur et al., 2017) which was used as a testing tool and will be defined in depth in the following section. Today, the concept of social capital is widely applied to rural communities in most countries, and the SNA methodology is used to assess it based on a social relational approach (Salpeteur et al., 2017). Therefore, the aim of this study was to investigate and analyze the role of intra-group social capital through the method of SNA in two time

periods before and after the implementation of RFLDL (Rehabilitation of Forest Landscapes and Degraded Land) initiative in Sarayan city in South Khorasan province (located in Eastern Iran).

2. Materials and methods

2.1. Background: rangelands and land degradation in Iran

Iran is one of the largest countries in the Middle East with an area of 1.64 million km^2, being part of the global arid belt. This means that 85% of Iran's territory can be classified as drylands with larger evaporation than precipitation for more than 6 months per year. Of these areas, 20% are classified as desert areas that are of very limited economic potential and 55% as rangelands (Amiraslani and Dragovich, 2011) which equals about 90 Mio hectares (Abolhassani, 2011). The remaining 25% consists of cities (6%), agricultural land (11%), and forests (8%). According to Heady (1975) (cited in Abolhassani (2011)), rangelands are 'shrublands, grasslands, and open woods, where warm, sandy, or muddy soils, steep topography, and rocks hinder commercial and woodland crops from developing.' In Iranian rangelands, the vegetation is limited by lacking precipitation and the salinity of the soil. Nevertheless, rangelands are an important source of income and livelihood and contribute greatly to the economy. According to Abolhassani (2011), livestock-production on the rangelands makes up about 6% of total Iranian GDP. Especially on the rural subsistence level, about 3 Mio Iranians solely live from animal husbandry as their only source of income – with nomadism and semi-nomadism accounting for the biggest mode of livestock farming. About 83 Mio livestock (mainly sheep and goat) rely on the rangelands for more than 7 months per year. Other economic factors are honey production and medical plant harvesting for make-up production (Abolhassani, 2011).

Iran is a young country with a population having an average age of 27 years (Iran, 2011). In the past 40 years, the population increased from 34 Mio in 1976 to about 75 Mio in 2011 (Iran, 2011), leading to an increasing demand for large quantities of rangeland products, like meat, milk products, and wool. Growing cities, infrastructure construction, and agricultural development cut into rangelands. Additionally, Iran has been the destination for many refugees from the nearby conflicts of Afghanistan, Syria, and Iraq; many of them bringing their own herds.

Such factors contribute to strain on the current rangelands gradually. The amount of livestock is projected to be around 2.5 times the viable carrying ability of rangelands (Badripour et al., 2006). This overstocking leads to an overexploitation of the rangelands through untimely grazing and overgrazing and ultimately to their degradation. The ultimate transformation to an unproductive land is referred to as desertification, a mechanism described by the United Nations Convention on Counter Desertification (UN, 1994) as: "land loss in arid, semi-arid, and dry sub-humid regions resulting from numerous factors, including climate change and human activity."

The connection of intensification of land use, agricultural production, and desertification was investigated by Moghaddam and Saghafi (2006) in a study of a salt playa, a closed watershed whose water is lost with no visible outlet like a lake or river in the Birjand region, South Khorasan, in Eastern Iran. It was found that, using remote sensing techniques, there was an increase of 5061 ha in agricultural land between 1988 and 2002, which amounts to a net annual increase of 15%. Further experiments have found that the total salinity in the playa-lakes is specifically related to habitat trends, clearings, and climate change. The authors of the study region conclude: "Areas that have experienced major changes in the recent past are regarded as especially vulnerable to possible salinity rises and therefore pose an extreme salinization threat" (Moghaddam and Saghafi, 2006) and they correlate the adverse effects of land degradation directly to human activities. Some pictures of sand dunes and rangelands can be found in Fig. 1.

Damage to Iran's economy due to desertification can be partially offset by the use of payment for ecosystem services (PES). Because PES policies compensate individuals or communities for undertaking actions that increase the provision of ecosystem services such as water purification, flood mitigation, carbon sequestration, oil stabilization, recreation, cultural values, among others (Le et al., 2017). Therefore, this method allows a monetary value to products and services that nature provides free of charge to the economy (Barbier and Burgess, 2015). Badripour et al. (2006) estimate the value of ecosystem services of Iranian rangelands with pollution control (US$87/a ha) and the production of raw-material (US$57/a ha) as the two largest contributors, at about US$232/year per hectare. In a recent news report on the dimension and economic problems of land degradation in Iran, IRNA estimates the annual economic loss at about US$1 billion (IRNA, 2015). Given that natural resources play a role in economic, social, and environmental conditions, careful planning and management of their exploitation can help ensure environmental sustainability (Olalekan et al., 2019). PES can be a cost-effective way to conserve natural resources (Tyack et al., 2020). Payments for ecosystem services are a novel conservation strategy that is increasingly being used in both developed and developing countries, including Iran. Although there is no single definition of PES, it can be broadly defined as "the benefits of nature to families, communities, and economic systems" or simply "the good things that nature provides to us." Payments for environmental services are promoted as a long-term solution to reduce environmental degradation. The benefits of this method include the cooperation of stakeholders and local communities, as well as an increase in their income (Romero-Sánchez Arriola-Padilla, 2020; Zare Chahouki and Sanaei, 2018). Desertification is by no means a new phenomenon in Iran. Policy efforts to address this have been ongoing for some 50 years. The Desert Relations Department, now part of the Woodland Rangeland and Wetlands Agency of Iran (FRWO), in its first phase (between 1968 and 1988) aimed to control desert encroachment and desertification of rangelands by technical methods with sand dune fixation using oil mulch and reforestation efforts. Special attention was given to the types of vegetation appropriate for reforestation. These experiences were used to develop technical plans during the period from 1989 to 2003. Additional attention was given to run-off control and an increase in success evaluation and documentation

Fig. 1. Pictures prepared during the research of sand dunes and pastures of the study area.

(Amiraslani and Dragovich, 2011). Nevertheless, the results lacked sustainability, and re-degradation could not be prevented. Golmohammadi (2013) points out that technical methods for combating desertification need to be accompanied by rangeland management practices as well as soil and water conservation measures, including the prevention of over-grazing.

2.2. Study area

Sarayan is one of the cities of South Khorasan province which has an area of about seven thousand square kilometers (Fig. 2). The center of this city is Sarayan, which is located 160 km southeast of Birjand city (the center of the province). The city is located at 58° and 31 min east longitude and at 33° and 51 min north latitude and its average elevation is 1484 m above the sea level. The city has an area of about 9342 square kilometers. The average rainfall in this city is about 124 mm per year and its average temperature is 18.5 °C. The city has mostly cold winters and dry summers. According to the 2012 census, the population of this city is about 32493 people in urban areas and 10248 people in rural areas. The city consists of three districts, named Sarayan, Isik, and Se Qaleh, and 52 villages, and all parts of the city are less developed. Its most important villages are Bostaq, Zangoii and Dust Abad (Sarayan County Development Document, 2012).

In this city, like other dry and desert areas, due to low rainfall, there is no permanent river full of water. According to the report of the General Department of Natural Resources of the province, the area of natural resources of the city is so low, and it does not benefit from dense and semi-dense forests (Department of Natural Resources South-Khorasan, 2016). In the past, the forests of Tagh, Gaz, Skanbil, Qich, and many other parts of the city have been covered, but population growth, drought, overgrazing, Afghan settlement, and negligence have destroyed most of these forests. Of course, the attention of the authorities and the implementation of projects such as RFLDL (Earth Ecosystems and Polluted Property Regeneration) have to some extent prevented the destruction of pastures and we can be optimistic about the future.

RFLDL is a collaborative effort of the United Nations Agriculture Organization (FAO), the Iranian Woodland, Rangeland, and Wetlands Protection Organization (FRWO), and the Global Environmental Facility (GEF), which is used as a financial tool to enact the United Nations Convention on Fighting Desertification. On two project sites in the Iranian Provinces of Kerman and South Khorasan, during a period of 5 years (between March 2011 and February 2016), a total of 462.068ha of land were targeted for an ambitious program to develop a scalable process that ensures at the same time the protection of biodiversity to limit desertification and, therefore, increases carbon storage, and to help local people to improve their livelihood (RFLDL, 2014).

This project site is in close proximity to the Dasht-e Lut, which is one of the driest and hottest places on the earth and has been subject to desertification and droughts for many years (Fig. 1). RFLDL's key goal is the introduction of interconnected sustainable land and forest management (SLFM) frameworks, involving the local population in a participatory process (RFLDL, 2014).

2.3. The establishment of village development committee, village development groups (VDG) and micro credit finance in RFLDL

One of the goals of the RFLDL project is to institutionalize the concept of participatory management among local communities and to develop a model of participatory management of natural resources in arid and semi-arid regions. Indeed, the development of this model requires shifting the direction of participatory approaches, i.e., decision-making, planning, and implementation from the bottom to the top, with the goal of removing key barriers to sustainable land and forest management and increasing the capacity of degraded lands and forest landscapes to create sustainable livelihoods, food security, and desertification. The most important principle in public participation activities is capacity building and the mobilization of local communities through social structuring and the creation of popular organizations accepted by rural communities. In this regard, one of the methods that has been used as a successful experience in developing countries and also in this project is the formation of resource management committees, rural development and sustainable development funds of local communities.

Rural committees are the main and most popular participatory institutions in rural communities that, if successful and stable, can be a strong support, guarantee of stability and success of the goals in public participation projects. The formation mechanism of these organizations is by holding joint meetings first with Islamic councils, Dehyar and key people of the target villages and then with local communities to introduce the project, its goals and implementation approaches and thinking about how these organizations and finally the formation of committees and rural funds have been perceived by local communities (one

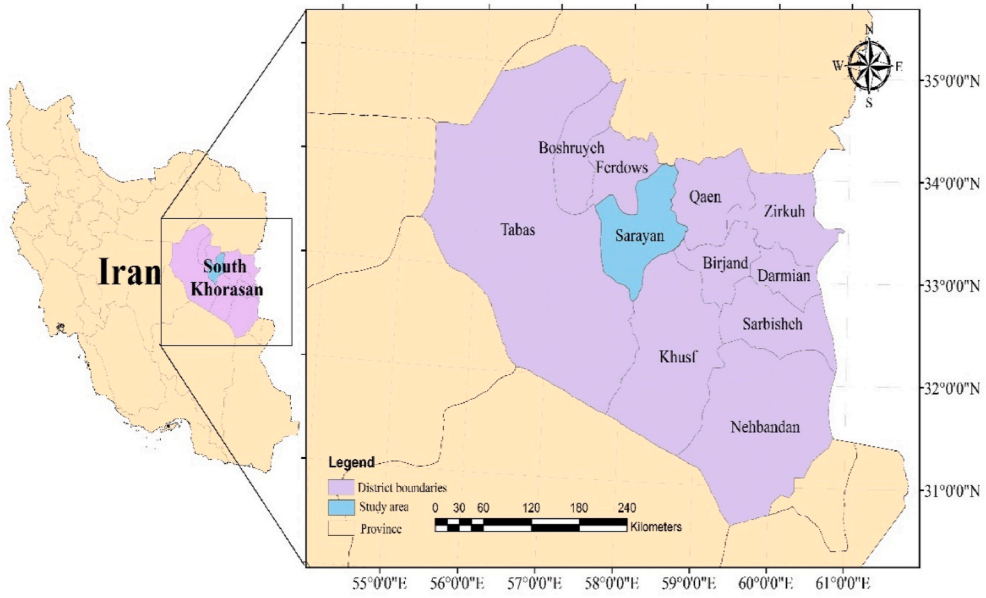

Fig. 2. Map of the study area.

committee and one fund in each village). The main purpose of forming rural development committees, social mobilization and organizing people for participatory planning and management is to preserve and rehabilitate degraded lands, environment and natural resources, to create environmentally friendly livelihoods and natural resources, and to carry out rural development activities. Each village committee consists of 13 people (men and women) who are elected by people as the representatives of the villagers. Also, in order to follow up the executive affairs in each committee, 3 people are selected as the executive board (secretary, accountant and the chairman of the committee). The members of the Rural Development Committees and the executive committees of these committees, who work voluntarily, hold regular meetings at least twice a month to discuss, decide and plan for the problems of the village. Local Community Sustainable Development Funds also aim to mobilize and manage the financial resources available through rural development committees, to preserve and rehabilitate degraded lands, the environment and natural resources, to create environmentally friendly livelihoods and natural resources, and to carry out activities.

Village development has been launched in each of the target villages. The Sustainable Development Funds of local communities consist of groups of 20–25 people. Each member of the Rural Development Committee as the head of the group will be responsible for forming the group and collecting funds. A bank account is opened for each of the rural funds in the name of the village development committee in the nearest bank and is managed by the executive board of the committee. Rural fund members also hold monthly meetings to raise monthly savings. In these monthly meetings, in addition to receiving savings, the issues and problems of the village and its solutions are also discussed and decided. These funds include people's savings, the income from environmental activities and services, attracting government funds, donations and loans. The RFLDL project has organized workshops and training courses in order to achieve appropriate and efficient strategies for empowering and capacity building of local communities and increasing people's participation in rehabilitation activities after social restructuring with the participation of such grassroots organizations and communities. Local people can manage their own local resources and gain the capacity and self-confidence to influence project implementation policies, and eventually rehabilitate areas destroyed by the communities themselves (Ghorbani, 2016).

2.4. Methodology

In fact, SNA is a quantitative tool developed from a socio-relational surveying methodology whose big advantage is that it unites holistic and individualistic perspectives (Bodin and Prell, 2011). SNA reflects a distinctive collection of methodologies to track, evaluate, and assess social ties between persons, teams, and organizations. It encourages the analysis of trends and types of relationships among actors, where these actors (which may be individuals, groups, or organizations) are visually defined by systemic nodes in a network chart and relationships (ties or links) between these nodes. You can see the summary of relevant measures for the network and nodes in Table 1. It should be noted that these measures are commonly used in similar studies such as Bodin and Crona (2009), Bodin and Prell (2011), and Ghorbani and Azadi (2021) with different objectives. Given the general goal of this study, which is to analyze social network measures, five measures (density, reciprocity, transitivity, geodesic distance and group density) were used.

Depending on the research focus, nodes may also be used to represent events, ideas, or actions. SNA allows the study of the position and effect of the actors in a network; it can also define and chart network interactions and examine framework structures (Salpeteur et al., 2017). SNA offers a systematic method for analyzing the role of participants in a network and a context for examining hypotheses of group actions and social roles (Wasserman and Faust, 1994) which is able to evaluate the characteristics of a network before and after the implementation of a project.

Table 1
Summary of relevant measures for the network and nodes.

Measure	Description
Density	Density describes the number of links within a network as measured by the number of possible connections. Relations per node are often suggested for use in combination with depth to avoid the risk of performance score misinterpretation (Hoppe and Reinelt, 2010).
Reciprocity	The reversibility of ties is investigated by the reciprocity measure (Borgatti et al., 2013). Like density, it can be measured as a probability, i.e., if actor A states a relation with actor B, the reverse (B to A) is also true. The level of analysis is dyad-based, which means pairwise on the actor level. In the case of a trust network, this allows to characterize the equality of power interactions. Reciprocity is closely connected to in-degree centrality and out-degree centrality. With low levels of reciprocity, a village's social structure may be described as hierarchic. The benefits of reciprocity are simultaneous exchanges of information and long-term obligations between people because of repeated interactions (Pretty, 2003).
Transitivity	Transitivity extends reciprocity by investigating the relationships of all three actors, referred to as a triad. Borgatti et al. (2013) explained that the main idea is answering the question if A is related to B and B is related to C, what is the probability that A is related to C? If there is a relationship between A and C, a triad is transitive. If networks have high transitivity, they have a clumpy structure of areas with interconnected ties. Borgatti et al. (2013) point out that transitivity of about 50% is a rather high value.
Geodesic distance	The length of the shortest walk between two nodes in a given network is equal to the number of edges that need to be passed on the way between them. This measure is called the geodesic distance. Geodesic distance in the trust network is a useful measure for the speed of information flow. A trust-relationship makes a submission of information likely, while its absence or a great geodesic distance might hinder the transmission of information between two individuals. Low geodesic distance measures indicate the high speed of response to an external impulse and serve as a characteristic of socio-ecological resilience.
Group density	Group density is similar to the whole network density but on a sub-group level. It is measured for pre-defined groups in UCINET (Borgatti et al., 2002). For the measurement, each sub-group is considered as its own network. A high density in collaboration indicates a well-functioning sub-group, while a high level of trust indicates an optimal precondition for a sustained group structure.

Development in SNA has been closely related to the rise in computational power and the application of personal computers (Schweizer, 1989) allowing to analyze larger and more complex networks in a reasonable time. As the measures of Graph Theory are very formal, network characteristics can be assessed using algorithms implemented into different software packages (Borgatti et al., 2013; Scott and Stokman, 2015). One of these software packages is UCINET (Borgatti et al., 2002). UCINET operates on the adjacency matrixes that are coding the relations between the two nodes of the network data. There is extensive documentation available that explains stepwise procedures (algorithms) and the application of the software to calculate network characteristics. However, because UCINET is a closed source system, the software implementation of algorithms cannot be verified. The researcher has to trust the program to work right, but needs to reflect if the results are plausible.

It is essential to understand that UCINET has not been developed for measuring social capital in natural resource governance. Borgatti is interested in organizational research (Borgatti and Foster, 2003). The interpretation of the network characteristics obtained and their implications for successful governance are neither mathematically defined nor trivial. On the contrary, they have to be explained based on the theory of social capital. In the following sections, different levels of networks and some network measures are introduced theoretically and then related to successful community activation.

2.5. Methods of data analysis

2.5.1. Questionnaire and data collection

To assess the network characteristics, a structured questionnaire was conducted in the study areas. The data used in this study have been collected through the Social-Ecological-Systems Modelling Lab (SESM) at the University of Tehran, Iran. The qquestionnaires were completed based on the "complete network" (Ghorbani and Azadi, 2021) of 754 stakeholders (215 from 14 groups of Zangoii, 190 from 13 groups of Bostaq, 168 from 17 groups of Dust Abad and 181 from 19 groups of Se-Qaleh city). The "complete network" indicates that the empirical data for this study was obtained from every member of the VDGs in the target areas. Trust and collaboration ties have been measured by asking close-ended questions on a Likert scale from 0 to 5. This simple design was selected to be understood by the rural population who are often illiterate (Ghorbani, 2016).

The questions used in the questionnaire¬ for each measure are as follows:

1) Trust: On a scale from zero to five, to what extent do you trust people in the rural areas?
2) Collaboration: On a scale from zero to five, to what extent do you practically cooperate with the people in activities related to rural sustainability, conservation, and sustainable use of natural resources?
1) Trust: On a scale from zero to five, to what extent do you trust people involved in the rural sustainability activities emphasized by the International Carbon Sequestration Project (after the implementation of the RFLDL?
2) Collaboration: On a scale from zero to five, to what extent do you practically cooperate with the people in activities related to rural sustainability, conservation, and sustainable use of natural resources?

To assess the long-term effects of the social mobilization activities, it is necessary to analyze longitudinal data considering the social capital before and after the implementation of the RFLDL project. If the project was successful, the change of structural characteristics of the trust and collaboration networks could be considered as a representative of the desired change in social capital. Therefore, in Sarayan, data were collected by the SESM-Lab staff as part of an assessment of the social dimension in the ongoing RFLDL project. The data were taken from a report of the SESM lab. This report assessed the changes in the network characteristics for the three villages of Bostaq, Zangoii and Dust Abad, and Se-Qaleh city. The first data collection was in 2011 (during the formation stage of VDGs and micro credit finance) and the second one was in 2015 (after RFLDL).

2.5.2. Data processing and graphical representations

In order to improve the reliability of the results, the raw data were simplified. Dichotomization is a process that reduces the complexity of the measured values (Borgatti et al., 2013). Afterward, only binary data, respectively the existence or non-existence of a tie, are investigated. Dichotomization can be easily achieved using the corresponding UCINET-method routine. As the ties were measured on a scale from 0 to 5, a cut-off value of 3 was selected. All ties with a value of 3, 4, or 5 were given the value one, while all other ties, including 0, 1, and 2, were given the value zero. To analyze the RFLDL data collected by the SESM-Lab, the UCINET software (Borgatti et al., 2002) was used to calculate network characteristics, using implemented algorithms. The results were stored using Microsoft Excel and a UCINET specific format. To accompany the network characteristics, plots were prepared using the NETDRAW (Borgatti, 2002) package of UCINET.

3. Results

3.1. Dynamics in SNA data - longitudinal comparison before and after RFLDL

3.1.1. Density

The RFLDL data set allows to study the dynamics of networks comparing the characteristics before and after project implementation. The density of Sarayan District, collaboration, and trust networks (Table 2) could be improved by RFLDL. The changes were almost the same in magnitude for both collaboration and trust networks with an absolute increase from 7% (Se-Qaleh trust network) to 19% (Zangoii collaboration network). The highest density was observed for Zangoiis trust network with a score of 84%. This high trust score is also reflected in much stronger collaboration which could be improved by 35.2% in Zangoii, now having the highest density (73%) among the observed villages. In Se Qaleh, the rate of change is much more moderate, scoring the lowest improvement in absolute (7% in trust and 8% in collaboration) and in relative numbers (11.1% in trust and 15.4% in collaboration).

In the networks of village leaders (Table 3), the absolute magnitude of change appears to be greater than that of the whole village networks. Especially remarkable are the high densities of the trust networks with Bostaq leader's network reaching the highest possible score of 100% and Zangoii with 87%, having achieved a relative change of 45% (27% difference). The scores of collaboration show a large increase from 17% (Bostaq) to 29% (Zangoii). Bostaq leader's network density is very high, reaching 91% after RFLDL, contrasted by only 64% in Se Qaleh where there are further opportunities for improvement.

3.1.2. Reciprocity

The change in reciprocity scores is positive in Sarayan District. The improvements for networks that scored lower before RFLDL, received larger improvements compared to networks that already scored high before RFLDL. All villages scored between 65% and 70% for both collaboration and trust networks after RFLDL, requiring a relative change between 40.9% (Zangoii collaboration network) and 14.8% (Bostaq trust network). This smaller change for villages that already were successful indicates that the maximum feasible reciprocity on the whole village level might be around 70% (Table 4).

The largest reciprocity for the Sarayan leader networks (Table 5) was 82% for the collaboration network and 100% for the trust network in Bostaq. There were big improvements in Zangoii, and the collaboration reciprocity increased by 29% and reached the second highest level (72%). Trust reciprocity also increased by 36% (a relative increase of 92.3%). Se Qaleh leaders had very low reciprocity after RFLDL, scoring only 52% for collaboration and 60% for the trust network. Interestingly, the transitivity of trust ties between leaders is lower for some villages than the overall transitivity (Se Qualeh, 53% compared to 58%). This might indicate unresolved conflicts between the leaders that could be

Table 2
Sarayan district – density.

Village/ city	Network	Before RFLDL	After RFLDL	Difference	[%]-Change
Zangoii	Collaboration	54%	73%	19.00%	35.2%
Bostaq	Collaboration	61%	71%	10.00%	16.4%
Dust Abad	Collaboration	58%	66%	8.00%	13.8%
Se-Qaleh	Collaboration	52.00%	60.00%	8.00%	15.4%
Zangoii	Trust	72%	84%	12.00%	16.7%
Dust Abad	Trust	65%	74%	9.00%	13.8%
Bostaq	Trust	73%	81%	8.00%	11.0%
Se-Qaleh	Trust	63.00%	70.00%	7.00%	11.1%

Table 3
Sarayan district - leader density.

Village/ city	Network	Before RFLDL	After RFLDL	Difference	[%]-Change
Zangoii	Collaboration	52%	81%	29.00%	55.8%
Se Qaleh	Collaboration	41.00%	64.00%	23.00%	56.1%
Bostaq	Collaboration	74%	91%	17.00%	23.0%
Dust Abad	Collaboration	69%	76%	7.00%	10.1%
Zangoii	Trust	60%	87%	27.00%	45.0%
Bostaq	Trust	81%	100%	19.00%	23.5%
Se Qaleh	Trust	54.00%	68.00%	14.00%	25.9%
Dust Abad	Trust	66%	80%	14.00%	21.2%

Table 4
Sarayan district – reciprocity.

Village/ city	**Network**	**Before RFLDL**	**After RFLDL**	**Difference**	**[%] -Change**
Zangoii	Collaboration	44%	62%	18.00%	40.9%
Bostaq	Collaboration	51%	66%	15.00%	29.4%
Dust Abad	Collaboration	53%	66%	13.00%	24.5%
Se-Qaleh	Collaboration	53.00%	66.00%	13.00%	24.5%
Zangoii	Trust	51%	67%	16.00%	31.4%
Dust Abad	Trust	57%	67%	10.00%	17.5%
Se-Qaleh	Trust	57.00%	67.00%	10.00%	17.5%
Bostaq	Trust	61%	70%	9.00%	14.8%

Table 5
Sarayan district - leader reciprocity.

Village/ city	Network	Before RFLDL	After RFLDL	Difference	[%]-Change
Zangoii	Collaboration	43%	72%	29.00%	67.4%
Se Qaleh	Collaboration	24.00%	52.00%	28.00%	116.7%
Bostaq	Collaboration	60%	82%	22.00%	36.7%
Dust Abad	Collaboration	58%	65%	7.00%	12.1%
Zangoii	Trust	39%	75%	36.00%	92.3%
Bostaq	Trust	68%	100%	32.00%	47.1%
Dust Abad	Trust	52%	66%	14.00%	26.9%
Se Qaleh	Trust	51.00%	60.00%	9.00%	17.6%

addressed.

3.1.3. Transitivity

The change trend in transitivity is positive. The magnitude of change is similar for both collaboration and trust data. The largest transitivity was calculated for Dust Abad's collaboration network (69%) and Zangoii's trust network (67%). This indicates good progress in the empowerment of the beneficiaries in these two villages. The largest relative change was observed in Zangoii, with a 40.9% increase in collaboration transitivity and a 31.4% increase in trust transitivity (Table 6).

The largest transitivity for the Sarayan leader networks (Table 7) was 83% for the collaboration network and 100% for the trust network in Bostaq. There were big improvements in Zangoii, and the collaboration transitivity increased by 30% and reached the second highest level (66%). Trust transitivity also increased by 40% (a relative increase of 102.6%). Se Qaleh leaders had very low transitivity after RFLDL, scoring only 42% for collaboration and 53% for the trust network.

Table 6
Sarayan district – transitivity.

Village/ city	Network	Before RFLDL	After RFLDL	Difference	[%]-Change
Dust Abad	Collaboration	50%	69%	19.00%	38.0%
Zangoii	Collaboration	44%	62%	18.00%	40.9%
Bostaq	Collaboration	45%	55%	10.00%	22.2%
Se-Qaleh	Collaboration	40.00%	48.00%	8.00%	20.0%
Zangoii	Trust	51%	67%	16.00%	31.4%
Bostaq	Trust	51%	65%	14.00%	27.5%
Dust Abad	Trust	51%	62%	11.00%	21.6%
Se-Qaleh	Trust	50.00%	58.00%	8.00%	16.0%

Table 7
Sarayan district - leader transitivity.

Village/ city	Network	Before RFLDL	After RFLDL	Difference	[%]-Change
Zangoii	Collaboration	36%	66%	30.00%	83.3%
Bostaq	Collaboration	53%	83%	30.00%	56.6%
Dust Abad	Collaboration	53%	62%	9.00%	17.0%
Se Qaleh	Collaboration	39.00%	42.00%	3.00%	7.7%
Zangoii	Trust	39%	79%	40.00%	102.6%
Bostaq	Trust	62%	100%	38.00%	61.3%
Dust Abad	Trust	48%	65%	17.00%	35.4%
Se Qaleh	Trust	38.00%	53.00%	15.00%	39.5%

3.1.4. Geodesic distance

RFLDL succeeded in reducing the average geodesic distance; in all four villages, the trend was positive for collaboration and trust networks. The greatest improvements were made in Zangoii with 16.6% for the trust network and 14.2% change for the collaboration network. Generally, the geodesic distance declined by between 0.09 and 0.25, which is a big improvement, compared to the maximum possible improvement of 0.55 (Zangoii collaboration network) and 0.33 (Dust Abad trust network) (Table 8).

In the leaders' network, there are also larger improvements of geodesic distance measures; again, the trend is positive for all four villages and all three analyzed networks. The greatest changes are in the scores of Bostaq and Zangoii. Very impressive is the fact that the trust networks between the leaders reached the maximum value of 100% in Se Qaleh, Bostaq, and Zangoii, suggesting big improvements in the leaders' trust in each other. This certainly represents high levels of linking social capital for this group of leaders (Table 9).

The findings suggest that confidence, collaboration, unity, and social capital were low prior to the implementation of the RFLDL project, whereas those indexes increased and reached moderate rates after the implementation of RFLDL. In other words, the steps taken by RFLDL

Table 8
Sarayan district - average geodesic distance.

Village/ city	Network	Before RFLDL	After RFLDL	Difference	[%]-Change
Zangoii	Collaboration	1.55	1.33	−0.22	−14.2%
Se-Qaleh	Collaboration	1.54	1.39	−0.15	−9.7%
Bostaq	Collaboration	1.37	1.26	−0.11	−8.0%
Dust Abad	Collaboration	1.41	1.30	−0.11	−7.8%
Zangoii	Trust	1.51	1.26	−0.25	−16.6%
Bostaq	Trust	1.36	1.18	−0.18	−13.2%
Se-Qaleh	Trust	1.38	1.28	−0.10	−7.2%
Dust Abad	Trust	1.33	1.24	−0.09	−6.8%

Table 9
Sarayan district - average geodesic distance leader.

Village/ city	Tie	Before RFLDL	After RFLDL	Difference	[%]-Change
Se Qaleh	Collaboration	1.91	1.58	−0.33	−17.3%
Zangoii	Collaboration	1.43	1.18	−0.25	−17.5%
Bostaq	Collaboration	1.40	1.25	−0.15	−10.7%
Dust Abad	Collaboration	1.31	1.23	−0.08	−6.1%
Zangoii	Trust	1.35	1.05	−0.30	−22.2%
Dust Abad	Trust	1.43	1.20	−0.23	−16.1%
Bostaq	Trust	1.16	1.00	−0.16	−13.8%
Se Qaleh	Trust	1.45	1.40	−0.05	−3.4%

facilitated the creation of more durable and cohesive networks among the members and increased mutual confidence and cooperation.

4. Discussion

4.1. Role of trust and collaboration network in the success of RFLDL project

The restoration and rehabilitation of natural resources requires careful planning, implementation and monitoring of RFLDL projects. As discussed, one of the goals of the RFLDL project is to strengthen the resilience of forest sites, improve land use management and protect it for the future. As a result, constructive programs and policies must be implemented in order to increase flexibility and improve land management. The results of this study showed that achieving a strong network of trust and cooperation as a major gap requires more attention in policy making. Achieving to a point where natural resource demand is less than population growth is the simplest way to relieve pressure on these resources (Table 2). Iran would generally move toward this turning point (the high level of trust and collaboration network in rehabilitation and restoration programs). This process could happen in a form of a catastrophe or in a desirable way (Fatemi et al., 2018). If the present trajectory persists without any policy adjustments, the amount of natural use would be greater than the population density. This can lead to the destruction of natural resources and reduction of ecological diversity. Conversely, with the RFLDL project, effective environmental protection practices will occur in a desirable and reasonable manner (Fatemi et al., 2018). Today, rangeland protection, restoration and development will not be possible without the active participation of stakeholders. Trust is the starting point for participation and the facilitator of this process among natural resource actors. SNA helps researchers to identify challenges related to trust, partnerships, and how they interact across social network. The results show that there is a high correlation between trust and participation of people in social network. Also, the study of trust links between actors shows that there is a close relationship between members in the studied networks. These results are consistent with the findings of Scholz (2011), Ghafari (2008), Prell et al. (2009), Ghorbani et al. (2012) and Ebrahimiazarkharan et al. (2020). As a result, trust must be emphasized in order to enhance natural resources management. Because it is the most critical aspect of all sustainable social interactions and a core component in the beginning of collaboration activities. Based on the findings of this study (Table 3), the level of collaboration showed a large increase. Compared to the lower level (64%) in Se Qaleh that showed opportunities for further development, the network density of Bostaq's leader was very high (91%) after the implementation of RFLDL project. As collaborators move from broad statements to specific management practices, developing a collaborative network is critical to the success of rehabilitation projects. (Urgenson et al., 2017). This is similar to the shared theory of change in the integrative framework for collaborative governance (Emerson and Nabatchi, 2015).

According to Ryan and Urgenson (2019), collaborative capacity built on trusted leaders assists collaborations in overcoming barriers to developing natural resource management, but a lack of trust can pose challenges to landscape restoration programs. The results of the density index show that this rate is moderate to high in the studied networks and consequently the cohesion in terms of trust, participation, and social capital will increase at the same rate among the networks. Therefore, based on the results of this index, a dense network can be expected among the studied links. The results of some studies on the use of social network in participatory management of natural resources also confirm this. In this context, Gašević et al. (2019) has stated that the higher density of social networks, the greater the participation of people in that network will be. This can be a way to develop and improve the social capital of the members of that network. Also, according to the findings of Zhang et al. (2017), in social networks with low density, the rate of participation and social learning will be significantly reduced. As a result, with increasing the density in a social network, better social results will be seen.

4.2. SNA and enhancing natural resources governance

SNA was widely used to investigate the governance and management of natural resources (Bodin and Prell, 2011). This is because natural resource management usually includes a wide range of actors who are rooted in different organizations and engage on various scales and in heterogeneous ways, e.g. through power relationships, mutual assistance, etc. As the findings of this study showed, SNA dynamics contributed to assessing the changes in reciprocity and transitivity scores in terms of trust and collaboration network in Sarayan District (Table 4). These results indicate that the changes in the Sarayan region have been positive and significant. This means that the progress of networks that had lower scores before RFLDL has been significant and high, and both cooperation and trust networks have achieved high scores. In this context, Calvet-Mir et al. (2015) studied the informal network of collaboration between the stakeholders involved in the management of a natural park in Spain. By comparing the informal exchange of knowledge between a wide variety of institutional and non-institutional actors and the formal participatory bodies of the natural park, they show how the SNA makes it possible to recognize key stakeholders in participatory bodies and thus potentially help strengthen participatory governance of protected areas. According to Levesque et al. (2016), when members' power is distributed, trust can develop across core interests, and social learning can lead to shared understanding and joint solutions. Nunes and Abreu (2020) argued that one of the major challenges in project management is to understand the extent to which dynamic interactions between different people - through formal and informal collaboration networks - affect the outcome of the project. Because of the enormous impact on economic, environmental, and social sustainability, this challenge has caused growing concern among the organizations that implement and oversee these projects. As shown in Table 5, the largest reciprocity was 82% for the Sarayan leader networks' collaboration network, and 100% for the trust network in Bostaq. In such a context where the social network appears to be vertical in order to enhance the trust and collaborative network, we normally expect the implementation of formal rules, regulations and procedures for collective action interventions. The findings of the study show that formal relationships are important in cost, quality, and labor protection; however, they are even more important in improving coordination, safety, and environmental protection. This also confirms the role of leaders' network (Tables 6 and 7) in achieving big improvements in the level of trust. Leaders should be well connected, according to the findings, and can be identified through network measurements. Multiple mechanisms, such as leaders' providing advice and support to one another, have been shown to influence change efforts through network structure (Daly, 2010; Coburn et al., 2012; Finnigan and Daly, 2012; Penuel et al., 2012). Leaders with ties to one another contributed to the

success of these change efforts in these networks. Leadership is required to create widespread change according to Elrod and Kezar's work on the Kaleidoscope project in 2014. These individuals serve as champions, members of the organization who can rally support for an innovation and overcome obstacles to its adoption (Knaub et al., 2018). When it comes to promoting reform programs, a good hero or leader should have qualities such as the ability to create or change conditions to work better with others (e.g., Foote et al., 2016; Knaub et al., 2016). Where formal rules, leaders, and committees work to promote collective action, but mutual trust is low and collaborative initiatives are undervalued, Krishna (2000) argues that collective action interventions are needed to build trust and willingness to collaborate and create relational social capital. The findings of this study will serve as a basis for future research that combines a more nuanced understanding of trust with an available trust and collaborative network theory. Potential RFLDL collaborators, for example, should carefully consider how to build a project and plan relevant stakeholders, balancing the need to be inclusive with the need to develop a shared commitment among stakeholders. According to Senga (2016), the presence of relational trust among network actors can facilitate collective action and improve natural resource management collaborative practices. The results of Senga's (2016) study also show that the desire of actors in SN and their communication and connection with others is very important for natural resource management. Because by influencing management decisions, it will play an important role in selecting, maintaining or dissolving the relationship of trust between RFLD actors.

4.3. Problems associated with the SNA method

Today, SNA is as a method broadly applied in different research fields and practical applications. It is not only applied to individuals but also to organizations and agencies (Borgatti et al., 2013; Scott and Stokman, 2015). For example, to prevent terror attacks, social networks based on meta-data of social media websites like facebook.com and phone-networks are used by machine learning algorithms to identify targets for potential drone strikes (Grothoff and Porup, 2016; Scott and Stokman, 2015). However, there are reasons to be skeptical about the advances in SNA methodology and the decisions that are based on seemingly highly precise measurements of network characteristics. In the case of automated kill-decisions the risk and cost of a false positive needs to be seriously considered. Grothoff and Porup (2016) highly doubts the reliability and suggests that the threat of suspicious individuals identified by SNA should be further investigated using other methods.

The same criticism might be considered for the application of SNA to measure social capital in community natural resource governance. It needs to be considered that the other calculated factors could lead to a certain network configuration and what would be the implications of getting the wrong impression based on a false perception of reliability implied by the highly precise network measure calculations. It needs to be critically assessed if the assumption of the relational approach can be upheld in a culturally very different background from the Western countries. In many recent case studies using SNA to assess social capital in natural resource governance this is not the case (Barnes-Mauthe et al., 2014; Guarnacci, 2016; Henry and Vollan, 2014). Many conclusions are derived but the limitations of their methodology and the underlying assumptions of these studies are hardly discussed by the authors (Kocho-Schellenberg and Berkes, 2015; Salpeteur et al., 2017). Another problem is the "dark side" of the social capital approach (Haynes, 2009). When focusing on building social capital of leaders and brokers, the individuals in the periphery of the network are easily discarded. In the long-term, SNA may contribute to reiterating the status quo. Already powerful people that are targeted for community activation measures may use the resources given to them to further improve their status in the community. The implications of these asymmetries of power are not at all addressed by SNA. Social capital appears to be a too narrow lens. Cultural capital does also have a strong influence and potential to improve natural resource governance. However, the resilience of traditional communities cannot be investigated through the SNA lens only. Ultimately, better measures of success of community activation are needed. The measure of social capital remains hypothetical and no causal relations about its impact on natural resource governance can be established.

Moreover, failing to acknowledge additional factors influencing the SNA needs to be seen in the con-text of the geometries of power (Scott, 2015). The perspective of the researcher normatively introduces a concept of good governance and an intact community that may co-determinate the judgment about good and bad network structures. Scott (2015) raises the point that SNA is rooted in a positive social science view that its application can improve governance. However, with taking the critics of Haynes (2009) about the dark sides of SNA research into consideration, more doubts about the method arise. SNA appears to involve every stakeholder's preferences, but does not allow them to speak for themselves. This may reproduce injustice in the long term and intensify competition for access to resources.

5. Conclusion

Due to the lack of access to longitudinal data in the analysis of social networks in natural resources in most of the researches and the difficulty of collecting longitudinal data, less attention has been paid to this issue. Also, it is important to highlight the application of social network analysis and the effective role of this data in demonstrating the trend of changes over time. Therefore, the innovation of this research is the generation of longitudinal data that shows changes over time using quantitative and mathematical metrics.

The increase in observed network characteristics of the RFLDL data indicates a positive effect of the social mobilization in RFLDL on bonding social capital. For example, after the implementation of RFLDL, the data show that the density of the Sarayan District villages' trust and collaboration networks has been improved between 10% and 20%. This implies a higher capacity of the local population to engage in joint actions. However, some hotspots in the form of villages with low network densities may be identified for further social mobilization activities. Special consideration should be given to the villages' cultural constraints. It would be interesting to have more secondary data that could then explain the differences in network densities.

The density of trust between village leaders grew even more strongly which is directly related to the increased linking social capital within the villages. At the time of the data collection, the density of the leader network was very high, but it remains to be seen if these results can be sustained over time.

A major opportunity for the SNA approach in community-based sustainable development research for future applications lies in tracking the progress of ongoing social mobilization initiatives over time. Using SNA-software like UCINET, the data can be easily analyzed using a structured questionnaire survey that could be performed at many points in time. However, attention can be given to other metrics for the mobilization activities and the performance of resource consumer groups. In the end, a more straightforward indicator of progress is the increase in the human development score or the sum of saved capital and productive programs. The value of the rangeland is quickly measured with economic or environmental metrics. The SNA methodology can be helpful when it comes to researching issues about why planning projects struggle. Graphical patterns can easily be used in the realistic implementation of such research to determine the effectiveness of the mobilization steps for growing groups. The project will spend additional research to expand its activities in communities with poorly defined network systems.

The creation of sustainable communities is an important part of the growth agenda. Methodologies ought to be built and implemented in this context to determine the effectiveness of programs promoting the

participation of local actors in sustainable natural resource co-management. SNA is successively used by several scholars to evaluate the well-being of rural communities in non-western countries.

Structural aspects of group social capital were analyzed using the SNA method in the examined case studies. The structural characteristics of the investigated Iranian villages indicate an improvement in the parameters of the social network which could be linked to the positive results during the RFLDL group activation processes. The partnerships were not distinguishable in terms of sensitivity. You may classify key players to be involved using their strategic role. More work is needed if these actors really have an important role to play and how well they use their ability to achieve positive outcomes.

In addition, financial wealth and social participation may be seen to have risen to double the rates and would further help the elimination of social exclusion. Following the project's adoption, outer community social capital has risen across the four communities, which in effect claims a decrease in social inequality, improves social security, and strengthens citizen involvement. This can be inferred, based on the survey methods and findings, that network research will assess and analyze valuable metrics relating to social variables impacting sustainable local growth and empowerment. The creation and expansion of civic associations also culminated in improved social services and stronger participation in policymaking. In order to achieve positive social empowerment, it is important to further create local economic growth and combat social inequality, social resources, and social stability, with a focus on confidence and cooperation. Certainly, even the standard of life in the project region would improve with the development of social resources. Stronger trusted relations between the committees in the four areas promote sustainable rural growth and would be a significant move towards enhancing the spirit of collaboration between them, which is the opposite of social isolation and an essential contributor to socio-ecological resilience.

In the end, the most significant drawback of this quantitative analysis is that any relation between structural features and values of the citizens remains theoretical. Therefore, any assessment of social capital focused solely on institutional features remains incomplete. Structural features provide essential means for the production of social capital, but they are not adequate to justify its appearance.

CRediT authorship contribution statement

Mehdi Ghorbani: Conceptualization, Methodology, data collection and analyses, Writing – original draft. **Hossein Azadi:** Conceptualization, Methodology, Writing – review & editing. **Kristina Janečková:** Writing – review & editing. **Petr Sklenička:** Writing – review & editing. **Frank Witlox:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Abolhassani, L., 2011. Rangeland Management in Iran - A Socio-Economic Analysis and Case Study of Semnan Rangelands. (Ph D), Albert-Ludwigs-Universität Freiburg I. Brsg., Germany.

Alexander, S.M., Armitage, D., Carrington, P.J., Bodin, O., 2017. Examining horizontal and vertical social ties to achieve social–ecological fit in an emerging marine reserve network. Aquat. Conserv. 26 (6), 1209–1223.

Amiraslani, F., Dragovich, D., 2011. Combating desertification in Iran over the last 50 years: an overview of changing approaches. J. Environ. Manag. 92, 13.

Anheier, H.K., Gerhards, J., Romo, F.P., 1995. Forms of capital and social structure of fields: examining Bourdieu's social topography. Am. J. Sociol. 100 (4), 859–903. https://doi.org/10.1086/230603.

Asian Development Bank, 2017. Sustainable infrastructure for future needs. https://www.adb.org/documents/adb-annual-report-2017.

Badripour, H., Eskandari, N., Rezaei, S.A., 2006. Rangelands of Iran, an Overview: Ministry of Jihad-E-Agriculture, Forest Range and Watershed Management Organization, Technical Office of Rangeland, Tehran, Iran.

Barbier, E.B., Burgess, J.C., 2015. Sustainable development: an economic perspective. Int. Encycl. Soc. & Behav. Sci. 23, 823–828.

Barnes-Mauthe, M., Gray, S.A., Arita, S., Lynham, J., Leung, P., 2014. What determines social capital in a social–ecological system? Insights from a network perspective. Environ. Manag. 55 (2), 392–410. https://doi.org/10.1007/s00267-014-0395-7.

Barnes-Mauthe, M., Gray, S.A., Arita, S., Lynham, J., Leung, P., 2015. What determines social capital in a social-ecological system? Insights from a network perspective. Environ. Manag. 55, 392–410. https://doi.org/10.1007/s00267-014-0395-7.

Basupi, L.V., Quinn, C.H., Dougill, A.J., 2019. Adaptation strategies to environmental and policy change in semi-arid pastoral landscapes: evidence from Ngamiland, Botswana. J. Arid Environ. 166, 17–27.

Block, P., Hoffman, M., Raabe, I.J., et al., 2020. Social network-based distancing strategies to flatten the COVID-19 curve in a post-lockdown world. Nat Hum Behav 4, 588–596.

Bodin, Ö., Crona, B.I., 2009. The role of social networks in natural resource governance: what relational patterns make a difference? Glob. Envinron. Change. 19, 366–374.

Bodin, Ö., Prell, C., 2011. A social relational approach to natural resource governance. In: Bodin, O., Prell, C. (Eds.), Social Networks and Natural Resource Management - Uncovering the Social Fabric of Environmental Governance. Cambridge University Press, Cambridge, pp. 3–28.

Borgatti, S.P., 2002. NetDraw: Graph Visualization Software. Analytic Technologies, Harvard, Ma.

Borgatti, S.P., Everett, M.G., Freeman, L.C., 2002. Ucinet 6 for Windows: Software for Social Network Analysis Harvard. Analytic Technologies, MA.

Borgatti, S.P., Everett, M.G., Johnson, J.C., 2013. In: Seaman, J. (Ed.), Analyzing Social Networks. Sage Publications Ltd, Thousand Oaks, Ca.

Borgatti, S.P., Foster, P.C., 2003. The network paradigm in organizational research: a review and typology. J. Manag. 29 (6), 991–1013.

Brandt, M., Romankiewicz, C., Spiekermann, R., Samimi, C., 2014. Environmental change in time series – an interdisciplinary study in the Sahel of Mali and Senegal. J. Arid Environ. 105, 52–63.

Brennecke, J., 2019. Dissonant ties in intraorganizational networks: why individuals seek problem-solving assistance from difficult colleagues. Acad. Manag. J. 63 (3), 743–778.

Brennecke, J., Rank, O., 2017. The firm's knowledge network and the transfer of advice among corporate inventors—a multilevel network study. Res. Pol. 46 (4), 768–783.

Calvet-Mir, L., Maestre-Andrés, S., Molina, J., van den Bergh, J., 2015. Participation in protected areas: a social network case study in Catalonia, Spain. Ecol. Soc. 20 (4), 45. https://doi.org/10.5751/ES-07989-200445.

Coburn, C.E., Russel, J.L., Kaufman, J.H., Stein, M.K., 2012. Supporting sustainability: teachers' advice networks and ambitious instructional reform. Am. J. Educ. 119 (1), 137–182.

Côté, S., 2001. The contribution of human and social capital. ISUMA 2 (1), 29–36.

Daly, A.J., 2010. Social Network Theory and Educational Change. Harvard Education Press, Cambridge.

De Nooy, W., 2003. Fields and networks: correspondence analysis and social network analysis in the framework of Field Theory. Poetics 31 (5–6), 305–327. https://doi.org/10.1016/S0304-422X(03)00035-4.

Ebrahimiazarkharan, F., Ghorbani, M., Malekian, A., Bressers, H.T.A., 2020. Analyzing stakeholders' network to water resources Co-management at a watershed scale: a case study from the taleghan watershed in Iran. In: Fischer, M., Ingold, K. (Eds.), Networks in Water Governance. Palgrave Studies in Water Governance: Policy and Practice. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-46769-2_9.

Emerson, K., Nabatchi, T., 2015. Collaborative governance and collaborative governance regimes. In: Emerson, K., Nabatchi, T. (Eds.), Collaborative Governance Regimes. Georgetown University Press, Washington, DC, pp. 14–35.

Emery, M., Flora, C., 2006. Spiraling-up: mapping community transformation with community capitals framework. J. Comm. Dev. Soc. 37 (1), 19–35.

Evans, J.P., 2012. Environmental Governance. Routledge, London.

Fatemi, M., Rezaei-Moghaddam, K., Wackernagel, M., Shennan, C., 2018. Sustainability of environmental management in Iran: an ecological footprint analysis. Iran Agric. Res. 37 (2), 53–68.

Finnigan, K.S., Daly, A.J., 2012. Mind the gap: organizational learning and improvement in an underperforming urban system. Am. J. Educ. 119 (1), 41–71.

Foote, K., Knaub, A., Henderson, C., Dancy, M., Beichner, R.J., 2016. Enabling and challenging factors in institutional reform: the case of SCALE-UP. Phys Rev Phys Educ Res 12 (1), 010103.

Freeman, L., 2006. The Development of Social Network Analysis. Empirical Press, Vancouver.

Freeman, L.C., 2004. The development of social network analysis: a study in the sociology of science. Empirical Press, Vancouver, B. C. https://www.researchgate.net/publication/239228599.

Gašević, D., Joksimović, S., Eagan, B.R., Shaffer, D.W., 2019. SENS: network analytics to combine social and cognitive perspectives of collaborative learning. Comput. Hum. Behav. 92, 562–577.

Ghafari, Gh, 2008. Trust: A Sociological Theory, Shirazeh Press, p. 376 (In Persian).

Ghanbarnejad, F., Saha Roy, R., Karimi, F., Delvenne, J., Mitra, B., 2019. Dynamics on and of Complex Networks III Machine Learning and Statistical Physics Approaches. Springer International Publishing: Imprint: Springer, Cham, ISBN 9783030146832. OCLC 1115074203.

Ghorbani, M., 2016. Report of the Project of Analysis and Assessment of the Social-Policy Networks of Grassroots Association, Institutions and Sustainable Development Funds RFLDL Project (Sarayan District- South Khorasan). University of Tehran, Persian.
Ghorbani, M., Azadi, H., 2021. A social-relational approach for analyzing trust and collaboration networks as pre-conditions for rangeland Co-management. Rangel. Ecol. Manag. 75, 170–184. https://doi.org/10.1016/j.rama.2020.10.008.
Ghorbani, M., Azarnivand, H., Mehrabi, A.A., Bastani, S., Jafari, M., Nayebi, H., 2012. Social network analysis: a new approach in policy-making and planning of natural resources co-management. J. Range. Water. Manage. 65 (4), 553–568.
Grandjean, M., 2016. A social network analysis of Twitter: mapping the digital humanities community. Cogent Arts & Humanities 3 (1), 1171458.
Golmohammadi, F., 2013. Desertification through Rural People Participation (Experience of International Project of Carbon Sequestration in South Khorasan Province – East of Iran). Paper Presented at the 6th International Conference on Information and Communication Technologies in Agriculture, Food and Environment (HAICTA 2013), Corfu Island, Greece.
Grandjean, M., 2017. Complex structures and international organizations" [Analisi e visualizzazioni delle reti in storia. L'esempio della cooperazione intellettuale della Società delle Nazioni]. Memoria e Ricerca (2), 371–393.
Grothoff, C., Porup, J.M., 2016. The NSA's SKYNET program may be killing thousands of innocent people. Ars Technica, retrieved from web:. on. http://arstechnica.co.uk/security/2016/02/the-nsas-skynet-program-may-be-killing-thousands-of-innocent-people/. (Accessed 10 April 2016).
Guarnacci, U., 2016. Joining the dots: social networks and community resilience in post-conflict, post-disaster Indonesia. Int. J. Dis. Risk Red. https://doi.org/10.1016/j.ijdrr.2016.03.001.
Hagen, L., Neely, S., Robert-Cooperman, C., Keller, T., DePaula, N., 2018. Crisis communications in the age of social media: a network analysis of zika-related tweets. Soc. Sci. Comput. Rev. Social Science Computer Review. 36 (5), 523–541.
Haynes, P., 2009. Before going any further with social capital: eight key criticisms to address. In: INGENIO (CSIC-UPV) Working Paper Series, 2009/02.
Heady, H.F., 1975. Rangeland Management. Mc Graw-Hill, New York.
Hearne, D., Powell, B., 2014. Too much of a good thing? Building social capital through knowledge transfer and collaborative networks in the southern Philippines. Int. J. Water Resour. Dev. 30 (3), 495–514.
Henry, A.D., Vollan, B., 2014. Networks and the challenge of sustainable development. Annu. Rev. Environ. Resour. 39, 583–610.
Hogl, K., Kvarda, E., Nordbeck, R., Pregering, M., 2012. Legitimacy and effectiveness of environmental governance - concepts and perspectives. In: Hogl, K., Kvarda, E., Nordbeck, R., Pregering, M. (Eds.), Environmental Governance - the Challenge of Legitimacy and Effectiveness. Edward Elgar, Cheltenham, UK, pp. 1–28.
Hoppe, B., Reinelt, C., 2010. Social network analysis and the evaluation of leadership networks. Leadersh 21, 600–619.
Immanuel, Sh, Sivakumar, P.S., Prakash, P., Jaganathan, D., 2017. Livelihood analysis of tuber crop farmers in Kerala. J. Root Crops 43 (1), 111–115.
Iran, 2011. Selected Findings of the 2011 National Population and Housing Census. Teheran: Statistical Center of Iran.
IRNA, 2015. FAO prepared to assist Iran counter land degradation. Retrieved from. http://www.irna.ir/en/News/81614466/.
Knaub, A.V., Henderson, C., Fisher, K.Q., 2018. Finding the leaders: an examination of social network analysis and leadership identification in STEM education change. Ij Stem Ed 5, 26.
Knaub, A.V., Foote, K.T., Henderson, C., Dancy, M., Beichner, R.J., 2016. Get a room: the role of classroom space in sustained implementation of studio style instruction. Int J STEM Educ 3 (1), 1–22.
Kocho-Schellenberg, J.E., Berkes, F., 2015. Tracking the development of co-management: using network analysis in a case from the Canadian Arctic. Polar Rec. 51, 422–431. https://doi.org/10.1017/S003224.7414000436, 04.
Krishna, A., 2000. Creating and harnessing social capital. In: Dasgupta, P., Serageldin, I. (Eds.), Social Capital a Multifaceted Perspective. The World Bank, Washington, DC.
Labeyrie, V., Rono, B., Leclerc, C., 2014. How social organization shapes crop diversity: an ecological anthropology approach among Tharaka farmers of Mount Kenya. Agric. Hum. Val. 31 (1), 97–107. https://doi.org/10.1007/s10460-013-9451-9.
Le, J.T., Levin, L.A., Carson, R.T., 2017. Incorporating ecosystem services into environmental management of deep-seabed mining. In: Deep Sea Research Part II: Topical Studies in Oceanography.
Lemos, M.C., Agrawal, A., 2006. Environmental governance. Anu. Rev. Environ. Resour 31, 297–325. https://doi.org/10.1146/annurev.energy.31.042605.135621.
Lenihan, H., McGuirk, H., Murphy, K.R., 2019. Driving innovation: public policy and human capital. Res. Pol. 48 (9), 103791.
Levesque, V.R., Calhoun, A.J.K., Bell, K.P., Johnson, T.R., 2016. Turning contention into collaboration: engaging power, trust, and learning in collaborative networks. Soc. Nat. Resour. 30 (2), 245–260.
Liu, W., Li, J., Ren, L., et al., 2020. Exploring livelihood resilience and its impact on livelihood strategy in rural China. Soc. Indicat. Res. 150, 977–998.
Luu, N., Ngo, L.V., 2019. Entrepreneurial orientation and social ties in transitional economies. Long. Range Plan. 52 (1), 103–116.
Meaza, H., Frankl, A., Poesen, J., Zenebe, A., Deckers, J., Eetvelde, V.V., et al., 2017. Natural resource opportunities and challenges for rural development in marginal grabens – the state of the art with implications for the Rift Valley system in Ethiopia. J. Arid Environ. 147, 1–16.
Miller, B.J., Mundey, P., 2020. Emerging SNS use: the importance of social network sites for older American emerging adults. J. Youth Stud. 23 (5), 613–630.
Moghaddam, M.H.R., Saghafi, M., 2006. A change-detection application on the evolution of Kahak play (South Khorasan province, Iran). Environ. Geol. 51, 565–579. https://doi.org/10.1007/s00254-006-0352-8.
Morrison-Smith, S., Ruiz, J., 2020. Challenges and barriers in virtual teams: a literature review. SN Appl. Sci. 2, 1096.
Nasrinpour, H.R., Friesen, R., McLeod, R.D., 2016. An Agent-Based Model of Message Propagation in the Facebook Electronic Social Network. arXiv:1611.07454.
Nunes, M., Abreu, A., 2020. Applying social network analysis to identify project critical success factors. Sustainability 12, 1503.
Okello, M.M., D'Amour, D.E., 2008. Agricultural expansion within Kimana electric fences and implications for natural resource conservation around Amboseli. National Park. Kenya 72 (12), 2179–2192.
Olalekan, R.M., Adedoyin, O., Williams, E.A., Christianah, M.B., Modupe, O., 2019. The roles of all tiers of government and development partners in environmental conservation of natural resource: a case study in Nigeria. MOJ Ecol Environ Sci 4 (3), 114–121.
Ostrom, E., 1992. The rudiments of a theory of the origins, survival, and performance of common-property institutions. In: Bromley, D. (Ed.), Making the Commons Work. ICS Press, San Francisco.
Ostrom, E., 2001. Reformulating the commons. In: Burger, J., Ostrom, E., Norgaard, R.B., Policansky, D., Goldstein, B.D. (Eds.), Protecting the Commons. Island Press, Washington, DC.
Oubenal, M., Hrabanski, M., Pesche, D., 2017. IPBES, an inclusive institution? Challenging the integration of stakeholders in a science-policy interface. Ecol. Soc. 22 (1), 11. https://doi.org/10.5751/ES-08961-220111.
Penuel, W.R., Sun, M., Frank, K.A., Gallagher, H.A., 2012. Using social network analysis to study how collegial interactions can augment teacher learning from external professional development. Am. J. Educ. 119 (1), 103–136.
Pinkerton, E., 1989. Attaining better fisheries management through co-management prospects, problems and propositions. In: Pinkerton, E. (Ed.), Cooperative Management of Local Fisheries: New Direction in Improved Management and Community Development. University of British Columbia Press, Vancouver, BC.
Prell, C., Hubacek, K., Reed, M., 2009. Stakeholder analysis and social network analysis in natural resource management. Soc. Nat. Resour. 22, 501–518.
Pretty, J., 2003. Social capital and collective management of resources. Science 302, 1912–1914.
Qian, L., Xiuwu, L., Jiapeng, L., 2017. A social ties-based approach for group decision-making problems with incomplete additive preference relations. Knowl. Base Syst. 119, 68–86.
Rapp, C., 2020. Hypothesis and theory: collaborative governance, natural resource management, and the trust environment. Hypothesis and Theory. https://doi.org/10.3389/fcomm.2020.00028.
Reed, M.S., 2008. Stakeholder participation for environmental management: a literature review. Biol. Conserv. 141, 2417–2431.
RFLDL, 2014. RFLDL: Key Activities & Achievements 2011-2014. Birjand. RFLDL Project Office, South Kohrasan, Iran.
Rockstrom, J., Steffen, W., Noone, K., Persson, A., Chapin, F.S., Lambin, E.F., Foley, J.A., 2009. A safe operating space for humanity. Nature 461 (7263), 472–475.
Romero-Sánchez, M.E., Arriola-Padilla, V.J., 2020. The payment of environmental services as an economic and governance mechanism for the conservation and management of natural protected areas. In: Ortega-Rubio, A. (Ed.), Socio-ecological Studies in Natural Protected Areas. Springer, Cham.
Ryan, C.M., Urgenson, L.S., 2019. Creating and sustaining collaborative capacity for forest landscape restoration. New Era Collab. For. Manage. 3, 78–95. https://doi.org/10.4324/9781351033381-5.
Salpeteur, M., Calvet-Mir, L., Diaz-Reviriego, I., Reyes-García, V., 2017. Networking the environment: social network analysis in environmental management and local ecological knowledge studies. Ecol. Soc. 22 (1), 41. https://doi.org/10.5751/ES-08790-220141.
Sarayan County Development Document, 2012. http://www.sk-sarayan.ir/dorsapax/Data/Sub6/File/s anad%20%20.pdf.
Scholz, R.W., 2011. Environmental Literacy in Science and Society: from Knowledge to Decisions. Cambridge University Press, Cambridge, p. 631.
Schultz, C., McCintyre, A., Cyphers, K., Ellison, L., Kooistra, A., Moseley, C., 2017. Strategies for success under forest service restoration Initiatives. Available online at. https://ewp.uoregon.edu/site s/ewp.U oregon.edu/files/WP_81.pdf. (Accessed 22 November 2019). accessed.
Schweizer, T., 1989. Netzwerkanalyse mit dem Mikrocomputer. In: Schweizer, T. (Ed.), Netzwerkanalyse Berlin: Dietrich Verlag, pp. 201–222.
Scott, M., 2015. Re-theorizing social network analysis and environmental governance: insights from human geography. Prog. Hum. Geogr. 39 (4), 449–463. https://doi.org/10.1177/0309132514554322.
Seferiadis, A.A., 2015. Producing social capital as a development strategy: implications at the micro-level. Prog. Dev. Stud. 15 (2), 170–185.
Seferiadis, A.A., Cummings, S., Zweekhorst, M.B.M., Bunders, J.F.G., 2015. Producing social capital as a development strategy: implications at the micro-level. Prog. Dev. Stud. 15 (2), 170–185. https://doi.org/10.1177/1464993414565530.
Senekal, B.A., 2012. Die Afrikaanse literêre sisteem: ŉ Eksperimentele benadering met behulp van Sosiale-netwerk-analise (SNA). LitNet Akademies 9 (3).
Senga, M., 2016. 'In local collaboration we trust': the dynamics of trust network relationships in collaborative natural resource management in Tanzania. Tanzania J Sociology 2&3 (7), 31–46.
Stern, M.J., Baird, T.D., 2015. Trust ecology and the resilience of natural resource management institutions. Ecol. Soc. 20, 14. https://doi.org/10.5751/ES-07248-200214.
Sun, H., Geng, Y., Hu, L., Shi, L., Xu, T., 2018. Measuring China's new energy vehicle patents: a social network analysis approach. Energy 153, 685–693.
Tyack, N., Dempewolf, H., Khoury, C.K.T., 2009. He potential of payment for ecosystem services for crop wild relative conservation. Plants 2020, 9, 1305.van der Hulst, R.C.

Introduction to social network analysis (SNA) as an investigative tool. Trends Organ. Crime 12, 101–121.
UN, 1994. United nations convention to combat desertification in those countries experiencing serious drought and/or desertification. In: Particularly in Africa. United Nations, General Assembly, New York.
UNDP, 2017. The truth and nothing but the truth. https://www.undp.org/content/undp/en/home/blog/2018/truth-a-nothing-but-the-truth–the-impact-of-media-communication.html.
Urgenson, L.S., Ryan, C.M., Halpern, C.B., Bakker, J.D., Belote, T.R., Franklin, J.F., et al., 2017. Visions of restoration in fire-adapted forest landscapes: lessons from the collaborative forest landscape restoration program. Environ. Manag. 59, 338–353. https://doi.org/10.1007/s00267-016-0791-2.
Virapongse, A., Brooks, S., Metcalf, E.C., Zedalis, M., Gosz, J., Kliskey, A., Alessa, L., 2016. A social-ecological systems approach for environmental management. J. Environ. Manag. 178, 83–91.
Wasserman, S., Faust, K., 1994. Social Network Analysis: Methods and Applications. Cambridge University Press, Cambridge, UK.
World Bank, 1999. What is social capital?', PovertyNet. http://www.worldbank.org/poverty/scapital/whatsc.htm.
Xu, D., Deng, X., Guo, S., et al., 2019. Sensitivity of livelihood strategy to livelihood capital: an empirical investigation using nationally representative survey data from rural China. Soc. Indicat. Res. 144, 113–131.
Zare Chahouki, M.A., Sanaei, A., 2018. Payment for ecosystem services as an economic instrument for natural resources conservation. Strategic Research Journal of Agricultural Sciences and Natural Resources 3 (2), 123–134.
Zhang, S., Liu, Q., Chen, W., Wang, Q., Huang, Z., 2017. Interactive networks and social knowledge construction behavioral patterns in primary school teachers' online collaborative learning activities. Comput. Educ. 104, 1–17.

Update

Journal of Arid Environments

Volume 193, Issue , October 2021, Page

DOI: https://doi.org/10.1016/j.jaridenv.2021.104597

Journal of Arid Environments 193 (2021) 104597

Contents lists available at ScienceDirect

Journal of Arid Environments

journal homepage: www.elsevier.com/locate/jaridenv

Corrigendum to "Sustainable co-management of arid regions in southeastern Iran: Social network analysis approach" [Journal of Arid Environments 192 (2021) 104540]

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The authors regret that the name of the second corresponding author not included in the paper. The correct order of the co-authors of this paper is as follow:

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Furthermore, we found that the full phrase of the abbreviation (FRWO) was not correct mentioned in two parts of the materials and methods section in pages 3 and 4. The correct full phrase of (FRWO) is "Forests, Range and Watershed Management Organization".

The authors would like to apologise for any inconvenience caused.

DOI of original article: https://doi.org/10.1016/j.jaridenv.2021.104540.

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https://doi.org/10.1016/j.jaridenv.2021.104597

Available online 22 July 2021