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Analysis of structural characteristics of social capital for increasing the resilience of social- ecological systems (Case study: Kalateh Rudbar, Semnan province)

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Abstract

Researchers studying on adaptation and resilience of systems mainly seek to reduce the vulnerability of extremely complex social-ecological systems against potential changes. Since major portion of natural resources of Iran is interrelated with various users and social groups. Present study focused upon the necessity of studying structural characteristics of social capital of rangeland users in Kalateh Rudbar region of Damghan county. In this way, we used the network analysis method for improving the resilience of social-ecological systems. Accordingly, applying survey method and through interview with target groups and filling in network analysis questionnaire, interpersonal trust and collaboration ties of local beneficiaries were investigated. Applying whole network method for pin pointing local beneficiaries, all rangeland users of three traditional boundaries i.e. Espiro, Goormomenin, and Changi in Kalateh Rudbar region of Damghan county in Semnan province were interrogated. It was found out that the level of social capital among rangeland users of Espiro traditional boundary was high which implies that the resilience of social system against natural system changes is higher. In Changi and Goormomenin traditional boundaries, social capital and cohesion were estimated weak. Therefore, the policy of encouraging people to join to collective activities in order to cope with natural hazards including draught and inappropriate utilization must be put into practice. It can be inferred that the resilience of rangeland users against natural hazards in Espiro traditional boundary was higher than that of the two other boundaries; therefore, implementation of collaborative management in this traditional boundary was facilitated.

Keywords: Resilience; Kalateh Roudbar; Trust; Collaboration; Social capital; Social network analysis

1. Introduction

Nowadays, resilience has emerged as a principal framework for studying the complexity and dynamism of social-ecological systems (Berkes and Folke, 1998; Carpenter *et al*., 2001; Gunderson and Holling, 2002; Anderies *et al*., 2006). According to resilience principle, an environmental-social system does not remain in a steady condition, but is constantly influenced by different shocks which undermine the system foundation and make them change. Thus, as long as a system proves to be more resilient against these shocks or is more flexible, it will enjoy adaptive capacity and will be able to deal with shocks and coordinate its own frameworks and structures (Alcorn and Toledo, 1998; Gunderson and Holling, 2002). In social-ecological systems same as rural environments exploiting natural resources, this capacity depends on the capacity of society for learning and innovation (Walker and Salt, 2006). Exact definition of resilience differs among researchers and all these definitions were presented based on researchers' emphasis either on social or ecological systems. Therefore, resilience and adaptive capacity are applied variably.

Undoubtedly, high level of resilience of social systems derives from rich social capital of these societies. Social capital entails norms and

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trust which enable participants to establish effective relationships with one another and pursue their shared goals. As a matter of fact, social capital, along with economic and human capital, could be regarded as a part of national wealth which lays the foundation for exploiting human and physical (material) capital and it is considered as a path to success (Field, 2005). Besides, there are two types of social capital i.e. bonding and bridging (Putnam, 2000). Present study is focuses upon bonding social capital since community members are regarded cohorts and like-minded members.

Social-ecological systems in arid areas are quite sensitive and fragile faced with natural and human hazards and threats. The smallest negative change leads to the degradation and collapse of systems. Therefore, the stronger the structural features of social capital in social-ecological systems of these regions, the more adaptive that society is to external changes (for example, ecologic system changes). If this capacity is high, social capital of social-ecological systems aligns with the trend of changes in these systems and resilience of these systems for adapting with crises and hazards increases (Folke *et al*., 2003).

On the other hand, collaboration and trust make the fundamental dimensions of social capital. Collaboration, which makes up one dimension of capital, implies the optional and free activity of group members and having a sense of attachment to group activities. Collaboration is a prerequisite for societies' resilience against disorders and chaos of human and environmental systems. Additionally, mutual trust among member's initiates and facilitates their collaboration. Consequently, resilience is directly related to trust so that adaptive and flexible social systems enjoy high interpersonal trust (Cosense *et al*., 2014).

Resilience is typical of the social nature of societies and networks and it is affected by internal and external connections which are activated in different networks (Cassidey and Barnes, 2012). Therefore, Gunderson and Holling (2002) argue that resilience is closely tied with connections in social networks. Even if this is a complex relationship dependent on natural shocks, network indexes are used for its analysis (Janssen *et al*., 2006). Social network brings about a type of relationship which can be correlated with resilience (Hanneman and Riddle, 2005; Webb and Bodin, 2008). The contribution of social networks to sharing natural resources information and knowledge, especially adaptive management of these resources reinforces resilience of systems and this fact is stressed in several studies carried out by other researchers such as; Olsson *et al*. (2004), Crona and Bodin (2006), Janssen *et al*. (2006). Social network analysis was used for exploring the adaptive capacity and resilience of social relationships of rural households residing in coastal area of Botswana against climate change. Research findings show that those households who are connected to one another as a social network are more capable of adapting with the changes of ecological system and they can put their heads together to apply different strategies. They are therefore resilient and have higher adaptability.

Draught and excessive grazing are main factors driving degradation of rangelands in arid areas which endanger the sustainability of rangelands seriously. Meanwhile, how rangeland users take advantage of rangeland reduces or increases the intensity of rangeland degradation. The pilot area of this research was Kalateh Rudbar of Damghan district in which the above mentioned environmental threats are evident (Damghan Natural Resource Office, 2003).

On the other hand, considering the significance of social capital in improving the resilience of social-ecological systems, structural characteristics of social capital of rangeland users were scrutinized in present study. On the other hand, analyzing the social capital of rangeland users is the initial step toward rangeland collaborative management. The findings of present study will fall effective in specifying the opportunities and threats of rangeland collaborative management.

2. Materials and Methods

2.1. The study area

Three rangeland user communities were chosen out of the pilot area for running comparisons. Kalateh Rudbar is situated 42 kilometers northeast of Damghan county in Semnan province. Pastoralism and agriculture are their means of subsistence. Based on field studies and survey research and also through direct observation and interview with target groups and participatory observation, pastoralists and rangeland users of Espiro, Goormomenin, and Changi were identified.

Espiro traditional boundary is located 80 km north of Damghan district, between longitudes 53˚58′ to 54˚1′ and latitude 36˚24′ to 36˚26′. The area of this traditional boundary is 1300 hectares. In this rangeland, which is communally utilized, 7 individuals have the

authorized patent of using natural resources and roughly 906 livestock graze there. Goormomenin traditional boundary is situated at longitude 53˚59′ to 54˚4′ and latitude 36˚24′ to 36˚26′. The area of this traditional boundary is 1430 hectares. Approximately, 14 individuals communally take advantage of Goormomenin rangeland and 2215 livestock graze there. These individuals have patent of exploiting natural resources. Changi traditional boundary is located between longitudes 53˚58′ to 54˚06′ and latitude 36˚24′ to 36˚28′. The area of this rangeland is about 3900 hectares. 43 individuals with patents authorizing the graze of about 7480 livestock communally use this rangeland (Damghan Natural Resource Office, 2003).

2.2. Social Network Analysis Method

Structuralism in social sciences is focused upon the interactions among social actors and it is labeled as social network analysis. Actors may consist of humans, organizations, corporations, countries, etc. The building block of social network approach is this basic idea that the pattern of relations of social actors bears important consequences for them. Therefore, network analysts seek to reveal these patterns, identify how they were formed, and investigate their consequences (Western and Wright, 1994; Nath *et al*., 2010; Akbaritabar, 2010a, 2011b; Chaffin *et al*., 2014). The Action plan of assessment and monitoring of social and policy networks for empowerment of local communities and integrated land management was used for defining social criteria and indicators (Ghorbani, 2015). Following, some indicators measured according to the research specified objectives are outlined;

2.2.1. Network Interests

2.2.1.1. Density

Density is defined as the proportion of all existing ties within a network to maximum possible ties. It ranges from 0 to 100%. In networks of high density, information sharing and coordination in doing tasks and collaboration over resources is done easily. This indicator shows the level of network closure (Western and Wright, 1994).

2.2.1.1. Reciprocity

The reversibility of ties is investigated by the reciprocity measure (Borgatti *et al*., 2013). To define the sustainability of the network of relations and reciprocity of trust and collaboration ties, this indicator is utilized. Highness of this indicator implies high reciprocal relationships among network members. Network sustainability guarantees relations (Hanneman and Riddle, 2005).

2.2.1.1. Transitivity

Transitivity goes one step further than reciprocity and investigates the relationships of each three individuals, one of which acts as a bridge between the two other. The more the number of individuals who transfer ties, the more this indicator increases and consequently relations of actors will be more lasting (Hanneman and Riddle, 2005).

2.2.1.2. Average of Geodesic distance

This indicator shows the length of the shortest walk between two nodes in a given network. Geodesic distance in the trust network is a useful measure for the speed of information flow the higher this indicator, the more the speed of information flow among individuals will be and their social solidarity will also be higher. Thus, coordinating members of the network for implementing co-management will need less time (Rahimi Balkanlou *et al*., 2015b).

2.2.1.3. Centralization

It shows a percentage of the network which is restricted by a limited group and it shows the amount of centralization or density in a graph based on an actor's ties. Like density, centralization is measured as a proportion, where a network with a centralization score of 1 indicates all ties centering around one actor, and a score of 0 reflects a network where all actors have the same number of times (Bodin and Prell, 2011). This indicator is represented as percent and it is called degree of centralization. The higher the degree of centralization in a network, the lower the social solidarity of that network will be (Scott, 2000).

Data used in this study was gathered through direct interview and talk with every one of users of the region. To this end, network analysis questionnaire was constructed and applied and binary matrix of trust and collaboration was created. Whole network method (researcher was an external observer of relationships of individuals) was applied for the network of trust and collaboration ties. Data around trust and collaboration ties was fed as binary matrixes

into network analysis software. Data analysis was carried out in UCINET 6.0.

3. Results

3.1. Analysis of Network Indicators

According to table 1 outcomes, density of trust and collaboration ties among Espiro traditional boundary (including 7 users) was 81 and 57.1%, respectively which is indicative of high density of trust network and moderate density based on collaboration ties among users of this traditional boundary. In Goormomenin traditional boundary (entailing 14 users) this indicator was estimated 32.4% for trust ties and 33.5% for collaboration ties which demonstrates rather weak density of users in this rangeland. In Changi rangeland (consisting of 43 users), the density of trust and collaboration ties was estimated 23.1% and 21.9%, respectively which is indicative of extremely weak density of ties among users of this traditional boundary. Moderate to high density in these boundaries will enhance collective activities of users and it will boost their social relationships. As density goes up, social capital will also enhance among user groups. Accordingly, people will turn more committed to local traditions and customs and conservation of resources will be realized. According to research findings it can be asserted that network closure in Espiro traditional boundary is better.

The level of mutual trust and collaboration based on reciprocity was 70 and 33.3% among users of Espiro traditional boundary which shows high and weak reciprocity of trust and collaboration ties. In Goormomenin traditional boundary, this indicator regarding trust ties and collaboration ties was between 31.1% and 19.6%, respectively which shows reciprocity of trust ties in this boundary is moderate but that of collaboration ties is weak. In Changi rangeland, this amount for trust ties and collaboration ties was 29.9% and 25.7%, respectively and reciprocity of trust and collaboration ties was weak.

Transitivity of ties in Espiro traditional boundary regarding trust and collaboration ties was 73.6% and 39.1%, respectively which was high for trust ties but low for collaboration ones. This indicator shows triad relationships among users in the network. For instance, if in trust network of Espiro users, the person A has trust tie with B and B has trust tie with C, there is a 73.6% likelihood that A establishes trust tie with C, too. As this indicator augments, the balance of network will also increase. The level of this indicator for trust ties of Goormomenin boundary users was about 25.7% and that of collaboration ties was 28%, which is low and weak. In Changi traditional boundary, transitivity was about 17.7% for trust ties and 17.1% for collaboration ties, which was extremely weak.

Table 1. The level of indicators at macro level (network level) of rangeland users

Traditional Boundaries	Relation type	Number of Beneficiaries	Total Expected Ties	Density (%)	Reciprocity (%)	Transitivity (%)
Espiro	Trust	7	56	81	70	73.6
	Collaboration	7	56	57.1	33.3	39.1
Goormomenin	trust	14	182	32.4	31.1	25.7
	Collaboration	14	182	33.5	19.6	28.0
Changi	Trust	43	1806	23.1	29.9	17.7
	Collaboration	43	1806	21.9	25.7	17.1

3.2. Network Centralization in Beneficiaries' level

According to table 2, in Espiro traditional boundary, out degree and in degree centralization of trust ties is 22.2 and 2.8% which shows trust ties are distributed among beneficiaries and in other words; trust ties are well distributed across the network. Regarding collaboration ties, in degree and out degree centralization is 30.6 and 50%. Thus, the level of centralization indicator is higher and collaboration ties are established among few actors. In Goormomenin traditional boundary, centralization of trust ties for in degree and out degree trust ties are 56.2% and 64.5% and the level of centralization of out degree ties in trust network is mostly based on out degree ties. In the collaboration network of Goormomenin beneficiaries, centralization of out degree ties is 63.3% and over 38.5% of centralization belongs to in degree ties. In Changi traditional boundary, the level of centralization in trust network and based on out degree ties is 78.7% which is more than that of in degree ties i.e. 56.8%. It is evident that in the network of relationships of beneficiaries, centralization of trust ties is exclusive to a few actors and these influential actors enjoy higher portion of interpersonal trust ties. In this boundary and within collaboration network of beneficiaries, the level of centralization based on out degree

ties is 79.9% and based on in degree ties it is 45.8%. Again, collaboration ties are exclusive to a limited number of beneficiaries.

Table 2. Centralization at whole level (network level) of rangeland beneficiaries based on in degree and out degree ties

Traditional Boundary	Trust		Collaboration	
	Out degree Centralization(%)	In degree Centralization(%)	Out degree Centralization(%)	In degree Centralization(%)
Espiro	22.2	2.8	50.0	30.6
Goormomenin	64.5	56.2	63.3	38.5
Changi	78.7	56.8	79.9	45.8

3.3. The Level of Social Solidarity Based on Average Geodesic Distance in the Network of Beneficiaries in Trust and Collaboration Ties

Average geodesic distance shows the number of ties between two actors. Based on table 3 results and regarding trust ties, it can be stated that average geodesic distance is 2.2 which is the result of maximum number of ties among two actors (5 ties) and it is indicative of higher speed of link exchange in Goormomenin traditional boundary. Regarding collaboration ties, average geodesic distance is 2.2 based on existing ties (6 ties) and it can be inferred that the speed of exchange of collaboration ties in the network of Goormomenin traditional boundary beneficiaries is less than that of trust ties. This difference is also evident in the case of the two other rangelands. Nonetheless, existing ties in Espiro rangeland and based on table 4 results pass shorter paths among beneficiaries. One-way ties have the highest frequency but in Changi traditional boundary, the frequency of two-way paths is more; therefore, people need to pass two communicative paths to relate with one another.

Table 3. Average geodesic distance based on trust and collaboration ties in the network of relations of rangeland beneficiaries

Traditional Boundary	Average of Geodesic Distance	
	Trust	Collaboration
Espiro	1	1.3
Goormomenin	2.2	2.2
Changi	0.6	2

Table 4. Frequency of lengths of different ties in trust and collaboration ties of rangeland beneficiaries

Changi				Goormomenin				Espiro			
Collaboration		Trust		Collaboration		Trust		Collaboration		Trust	
Frequent	Proport	Frequent	Proport	Frequent	Proport	Frequent	Proport	Frequent	Proport	Frequent	Proport
396	1	417	1	61	1	59	1	24	1	34	1
923	2	957	2	36	2	67	2	12	2	2	2
328	3	379	3	15	3	25	3	6	3	6	3
33	4	53	4	15	4	28	4	-	-	-	-
126	5	-	-	13	5	3	5	-	-	-	-
-	-	-	-	3	6	-	-	-	-	-	-

4. Discussion

As mentioned earlier, the main objective of present study was better recognition of the relationship between ecosystems and human communities so as to reduce the vulnerability of these systems against changes and apply appropriate social strategies for local community of beneficiaries of arid area rangelands. The capacity of systems to restore chaos and disorders and to preserve structures and feedbacks is specified by their resilience. In one hand, creating resilient systems requires creating the capacity for including, conforming, and adapting communities with challenges. Adaptive management of ecosystems necessitates identifying the network of beneficiaries and to adapt them for their protection against probable harms of resource degradation and preserving the integrity of natural ecosystems. On the other hand, the structural nature of social capital causes formation of horizontal and vertical relations within the society and it is a favorable component for facilitating and actualizing in group collaboration. Enhancement of collaboration, trust, and communion among local communities increases social capital, adaptability, and resilience against environmental and human threats and changes (Bodin and Prell, 2011; Ghorbani, 2015).

It was revealed that density, which is a sign of cohesion in social relations and social capital, was higher among beneficiaries of Espiro traditional boundary than other two rangelands. As mentioned previously, more social relations and ties are indicative of high resilience and flexibility of social network against changes and adaptability of members with these changes. Reciprocity and transitivity of ties guarantee

sustainability of relations and they will affect upon social capital, too. If this indicator is significantly high in a network, reciprocal ties among members will be favorably more. Therefore, once a change occurs in group and social or ecological condition of the relevant utilized region, transitivity of ties generate high capacity among individuals for getting adapted. Cohen *et al*. (2001); Bodin *et al*. (2006); Janssen and Ostrom (2006); Ghorbani (2012); Bowen *et al*. (2014); Cosense *et al*. (2014); Ghorbani (2015), have approved this fact in their studies. Besides, if the number of beneficiaries and networks increases, coordination of groups reduces and individuals will not be able to adapt their relations with social and ecological conditions. Therefore, resource degradation will occur. Gholipoor (2010); Ghorbani (2012), Ghorbani (2014a); Rahimi Balkanlou *et al*. (2014) have confirmed this issue in their studies. It was earlier mentioned that when reciprocal relations, communion, and collaboration in collective activities (communal utilization of rangeland is targeted in present study) increases, resilience and coordination of individuals with system changes enhances. These results are approved in other researches including; (Hirschi (2010); Sandstrom and Rova (2010); Bodin and Prell (2011); Bowen *et al*. (2014)). Centralization of relations must be low so that social ties form and distribute appropriately among beneficiaries. This state was observed in the social network of individuals in Espiro traditional boundary but in other two boundaries, the centralization of trust and collaboration ties were high and exclusive to a limited group of beneficiaries. This is in contrast with resilience and group adaptability against probable shocks. Studies carried out by Ghorbani (2012); Chaffin *et al*. (2014); Bowen *et al*. (2014); Ghorbani (2014a); Rasekhi (2014); Rahimi Balkanlou *et al*. (2015b) approve this fact.

As showed by geodesic indicator, in the social network of beneficiaries in Espiro traditional boundary, individuals access to one another very easily and this proves high solidarity in the network of ties and it is a very important factor for adaptability and controlling probable crisis in the process of management and utilization of resources. Whereas, in the beneficiaries' network of Goormomenin and Changi, trust and participation ties are low; therefore, crisis management is more difficult. Average geodesic distance specifies the amount and rate of tie exchange in the network. This indicator is higher in Espiro than two other rangelands. Thus, social capital unconsciously forms faster among beneficiaries of this rangeland and those communities which enjoy considerable social capital are more resilient against social-ecological system changes and have high adaptive capacity. This issue was approved by Hanneman (2005); Ghorbani (2012); Kizos *et al*. (2014); Scott (2014); Ghorbani (2014b); Rahimi Balkanlou (2015a).

5. Conclusion

Last but not least, it can be concluded that beneficiaries of Espiro traditional boundary with higher cohesion and social capital enjoy higher adaptive capacity against changes and threats of social and ecological systems. In Goormomenin traditional boundary, the structural characteristics of social capital is moderately good; however, natural resources planners must pay more attention to establishment and reinforcement of trust and collaboration ties so that these actors have adaptive capability faced with sudden changes of social-ecological systems. In the network of beneficiaries of Changi, the abovementioned components are estimated low; therefore, reinforcement of trust and collaboration ties is recommended for co-management of rangeland in this traditional boundary. Since social conditions change considerably throughout the time, social monitoring in all three traditional boundaries turns necessary for getting informed about changes of social capital structure, social resilience, and adaptive capacity of social groups so that co-management of arid regions' rangeland is implemented successfully. In the other hand denser networks of heterogeneous stakeholders promote bridging of disparate perspectives and formulation of a common view of the ecosystem as well as appropriate management actions is still a sound hypothesis.

The social network analysis is an effective and functional way for getting informed about social capacities and potentials of natural resources beneficiaries and social potentials based on trust building and collaboration of local beneficiaries in co-management of rangeland will be useful.

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