



Analyzing social trust network in human-large carnivores conflict management, Case study: Golestan National Park

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Article Info

Article type:
Research Article

Article history:

Received: August 2024
Accepted: January 2026

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Keywords:

Golestan national park
Human-large carnivore conflict
Protected areas
Social network analysis
Trust network

Abstract

Protected areas (PAs) play a vital role in biodiversity conservation. However, human-large carnivore conflict (HCC) is a common problem in PAs that threatens long-term conservation goals. Socioeconomic factors are a significant aspect of HCC, and addressing these factors is crucial for achieving human-large carnivore coexistence. Trust and appropriate communication between all stakeholders are key factors in the HCC management, but they have remained unclear. The purpose of this study is to investigate stakeholders' social networks in the HCC around the Golestan National Park (GNP), using social network analysis to address this gap. We identified a social trust network in support and information exchange in HCC. The data were collected through a questionnaire and 292 face-to-face interviews with the residents of 30 villages around the GNP from April to November 2022. We analyzed indices of degree of centrality, betweenness centrality, and multi-dimensional scaling (MDS). Our findings indicate that local communities place the greatest trust in family members for receiving support, while rangers are the most trusted source for information exchange. In contrast, villagers and village councils play a negligible role within the social network. The results highlight the significant centrality of rangers in the network, positioning them as important social capital and key actors in human-carnivore conflict (HCC) mitigation strategies. Overall, this research clarifies the interactions within stakeholders' social networks and demonstrates that effective conflict mitigation requires a multidisciplinary approach, emphasizing the need to incorporate diverse social dimensions into conflict management programs.

Cite this article: Ebrahimi Monfared, Z., Mirkarimi, S.H., Mohammadi Kangarani, H., Soofi, M. 2026. Analyzing social trust network in human-large carnivores conflict management, Case study: Golestan National Park. *Environmental Resources Research*, 14(1), 15-27.



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10.22069/IJERR.2026.22245.1428

Publisher: Gorgan University of Agricultural Sciences and Natural Resources

Introduction

Today, protected areas face various types of threats caused by human activities (Ayivor et al., 2020). Considering that the main strategy of managing protected areas is to preserve natural values, prevent the reduction of biodiversity, and maintain the quality and quantity of ecosystem services to humans, trying to reduce possible human-wildlife conflicts is essential (Jepson et al., 2017). Considering that the management of protected areas and surrounding communities are strongly interdependent, managing the interests of all stakeholders and reducing possible conflicts should be a special priority (Von Ruschkowski, 2010). Conflicts in protected areas can cause extensive socio-economic changes, such as the weakening of regulatory institutions, and may lead to overexploitation of natural resources (Mendiratta et al., 2021; Negret et al., 2019). Therefore, reducing conflicts yields conservation benefits for protected areas as well as social and economic advantages for all stakeholders involved (Thorn et al., 2013). Among the various forms of human-wildlife conflict, human-large carnivore conflict is currently one of the main challenges in protected areas. In recent years, due to continuous human population growth and overlapping resource use, the frequency of such conflicts has increased significantly (Penteriani et al., 2016). As a result, both local people and large carnivores may suffer negative consequences (Kansky and Knight, 2014; Treves & Bruskotter, 2014). Harms to humans mainly occur in the form of livestock losses or threats to personal safety (Srivathsa, 2019). As conflicts persist, both the biodiversity goals of protected areas and the livelihoods of local communities are adversely affected. Given that human-large carnivore conflicts are rooted in complex economic, social, political, and environmental issues (Mosimane et al., 2014; Mutanga et al., 2015), the design of conflict reduction activities requires interdisciplinary research bridging human and environmental sciences (Thorn et al., 2013). Therefore, effective management of these conflicts necessitates accurate knowledge of social, economic, and cultural dimensions, as well as an understanding of relationships among the

people involved. It is evident that with the participation of all stakeholders, conflict reduction becomes more feasible (Salvatori et al., 2020).

In the past decade, trust between stakeholders has been recognized as a key factor in natural resource management (Vaske et al., 2007; Stern, 2008). Trust and appropriate communication among all stakeholders are considered essential components of participatory human-carnivore conflict management (Florian, 2019). Research shows that building trust and promoting stakeholder communication is key to resolving conflicts (Morehouse and Boyce, 2017). Conversely, inadequate or inappropriate information exchange in conflict situations often leads to the failure of mitigation measures and fosters high levels of mistrust between stakeholders (Madden, 2004). Salvatori et al. (2021) found that lack of trust between stakeholders and relevant authorities, as well as poor communication, are key features characterizing social conflicts related to large carnivores. Previous studies on human-wildlife conflicts have addressed socio-ecological dimensions, patterns and causes of human-carnivore conflict, and the role of geography in protected area conflicts. However, analyzing the social aspects and communication dynamics among stakeholders remains a scientific gap, which this research aims to fill. Studies indicate that identifying key stakeholders is essential for implementing conservation management plans, and network analysis can effectively reveal key actors in conservation decision-making (Crona et al., 2011; Bodin and Prell, 2011). In this research, the trust network and information-exchange network related to human-large carnivore conflict were evaluated in Iran's first biosphere reserve, Golestan National Park. Weak points in the network were identified, key actors were introduced, and the relationships among local actors were quantitatively and visually analyzed using social network analysis (SNA). This study highlights the utility of SNA as a powerful approach in human-large carnivore conflict management.

Social network analysis is a methodological approach that uses quantitative techniques to

analyze social structures (Romero, 2018). As a useful tool, it enables understanding of stakeholder relations, interactions, and influence through communication networks (Calvet-Mir et al., 2015). By analyzing stakeholder communication networks, it is possible to identify levels of cooperation, communication, and inclusiveness within the network (Feng et al., 2022). The focus on relational patterns distinguishes SNA from other analytical techniques (Bodin et al., 2020). In this study, three large carnivore species in Golestan National Park—the Persian leopard (*Panthera pardus tulliana*), brown bear (*Ursus arctos*), and gray wolf (*Canis lupus*)—were considered as the focal species in conflict analysis.

Materials and methods

Study area

Golestan National Park, the first national park and biosphere reserve of Iran, with an area of 91,895,000, is located on the border of Golestan, northern Khorasan, and Semnan provinces (Darvish Sefat, 1385). Golestan National Park was introduced as a national

park in 1957 and registered as a Biosphere Reserve of Iran in UNESCO in 1976 (Zehzad et al., 2002). Local communities and residents of the villages surrounding the Golestan National Park are composed of different Iranian ethnic groups, including the Turkmen, Fars, Balouch, Sistani, Kermanj, and Tat. Agriculture, horticulture, animal husbandry, beekeeping, and tourism constitute the main economic activities of indigenous communities (Soofi et al., 2016; Ghoddousi et al., 2017; Soofi et al., 2018). This research was conducted in 30 villages around the Golestan National Park. Two villages are located in Semnan Province, 4 in northern Khorasan Province, and 24 in Golestan Province. Given that large carnivores may range up to 5 km beyond their home range (Ghoddousi et al., 2020; Soofi et al., 2018), villages located within 5 km of the national park border were selected. The population of the villages, according to the report of the Iran Statistics Center (general census and housing population of 2015), is 17,684 people.

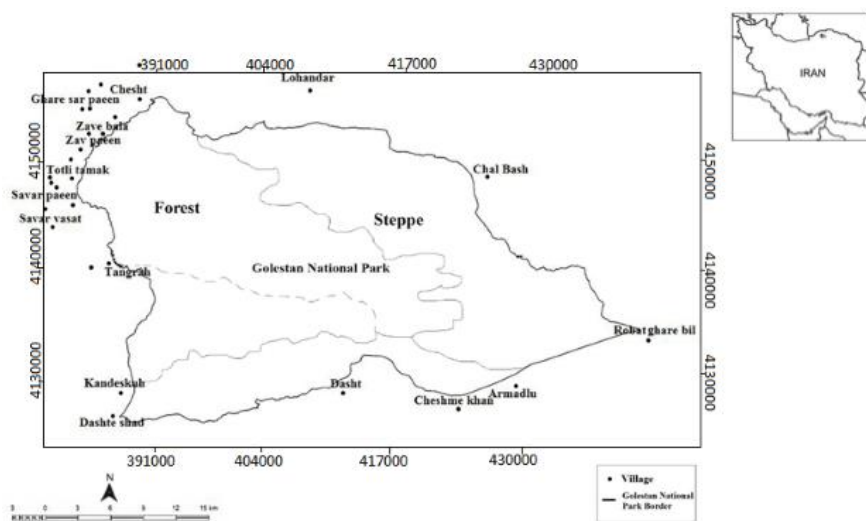


Figure 1. The study area, the Golestan National Park, and the distribution of the villages around the park where the interviews were administered. The map also shows the two dominant vegetation communities (i.e., forest and steppe) in the area.

Data collection

The research was conducted through a field study involving face-to-face interviews with local communities around Golestan National Park. Data were collected between April and November 2022 using a structured

questionnaire administered to 292 respondents across 30 villages. Interviews were carried out in Turkmen (71%, $n = 210$) and Farsi ($n = 82$). To facilitate this, the survey team included one trained Turkmen researcher and a ranger. Although the official

language of Iran is Farsi, which was familiar to all participants, the inclusion of a Turkmen-speaking interviewer ensured clarity and comfort for Turkmen-speaking respondents. Prior to the main survey, a pilot study was conducted with 15 individuals from the selected villages, after obtaining ethical clearance. The research was carried out with official permission from the Golestan Province Environment Department. To protect respondents' rights, all participants were assured that the questionnaire would remain anonymous and that their responses would be used solely for scientific purposes.

Data analysis

In this study, social network analysis (SNA) was employed to examine both the trust-in-support network and the trust-in-information-exchange network related to human–large carnivore conflict. Data analysis was performed using UCINET software. The network was analyzed using degree centrality, betweenness centrality, and multidimensional scaling (MDS). After constructing and entering the data matrix, analyses and diagramming were conducted using UCINET 6 and NetDraw software.

The network analysis indicators used in this research are as follows:

Degree centrality: Degree centrality is a fundamental metric in social network analysis that quantifies the importance of nodes based on their direct connections. It measures the number of links a node has, indicating its prominence within the network. Various centrality metrics, including degree centrality, are essential for identifying key actors in social networks (Mohammadi Kangarani and Mohammadi, 2014; Khaje Naieni et al., 2021).

Betweenness centrality: This metric evaluates individuals' positions within a network by assessing their role in connecting pairs of other individuals along the shortest

paths. An individual with high betweenness centrality is positioned among many others and facilitates communication pathways across the network (Mohammadi Kangarani et al., 2011).

Multidimensional Scaling (MDS): In social network analysis, MDS is a technique used to visualize and analyze relational data by mapping them into a lower-dimensional space while preserving the original relationships between data points. MDS is particularly useful for localizing nodes based on their distances from known reference points (Jäckle et al., 2015).

Results

Over a period of seven months, face-to-face interviews were conducted with 292 individuals (48 women and 244 men) across 30 villages surrounding Golestan National Park, using a structured questionnaire. Table 1 presents the demographic characteristics of the respondents.

Network of trust in support in human–large carnivore conflict

To analyze the network of trust in support, respondents were asked: *"If large carnivores attack your livestock or damage your farm, whom would you ask for help?"* The response options were: (a) ranger, (b) family members, (c) village council, and (d) villagers.

The results indicate that the majority of both men (72%, $n = 176$) and women (77%, $n = 37$) placed the highest level of trust in "family members" for receiving support in conflict situations. Following "family members," the "ranger" was the second most trusted source of support. In contrast, "village council" and "villagers" were the least selected options among both groups, ranking lowest in the support network. Notably, trust in "villagers" and the "village council" was relatively higher among women than among men.

Table 1. Frequency percentage of demographic variables of interviewees

Demographic Variables		Frequency	Percentage
Gender	Female	48	%16
	Male	244	%84
Education	Illiterate	55	%19
	Primary school	112	%38
	Elementary school	94	%32
	academic	31	%11
Age	18-29	37	%13
	30-39	77	%26
	40-49	85	%29
	50-59	50	%17
	≥60	43	%15
Ethnicity	Balouch	5	%2
	Turk	6	%2
	Turkman	210	%72
	Fars	58	%20
	Kord	13	%4

The analysis of the betweenness centrality graph revealed that the "ranger" was most frequently selected by Turkmen people (65%), followed by Fars people (57%). In contrast, Turk, Kurd, and Balouch respondents selected the "ranger" least frequently in the trust-in-support network. Conversely, the highest level of trust in the "villager" was observed among Turk and Kurd people, while the lowest was seen among Turkmen respondents. Across all age groups, "family members" received the highest level of trust for receiving support. The age groups of 50–59 and 60+ predominantly chose "family members." Following that, the "ranger" was the second most trusted source for support across all age groups; however, trust in the "ranger" was highest among younger age groups and lowest among those aged 50–59 and 60+.

The results also indicate that higher education levels (elementary school and academic) are associated with greater trust in the "ranger" for support during conflicts. Conversely, individuals with primary school education or those who were illiterate placed the most trust in "family members."

Figure 2 presents the degree centrality graph of the trust-in-support network. "Family members" and the "ranger" exhibit the highest centrality in the network, with degree centrality values of 21 and 178, respectively.

The "villager" and "village council" rank lowest, with degree centrality values of 45 and 63.

Figure 3, which displays the betweenness centrality graph derived from a one-way row matrix, illustrates the grouping of respondents. This graph shows that, despite "family members" having a slightly higher degree centrality than the "ranger," there are more individuals in the network who trust only the "ranger," and they form a distinct group in the center of the graph. This finding underscores the importance of the ranger within the network. The cluster at the top of the graph, shown in orange, along with the smaller yellow group, represents respondents who chose the "village council" and "villager" as trusted sources for support in conflicts. This highlights the low centrality of these two groups in the trust-in-support network, identifying them as potentially vulnerable points in the network. Overall, the betweenness centrality graph analysis emphasizes the importance of "family members" and the "ranger," with betweenness centrality values of 27,133 and 20,975, respectively, in the trust-in-support network related to human–large carnivore conflict. The numerical results of degree centrality and betweenness centrality analyses for the trust-in-support network are presented in Table 2.

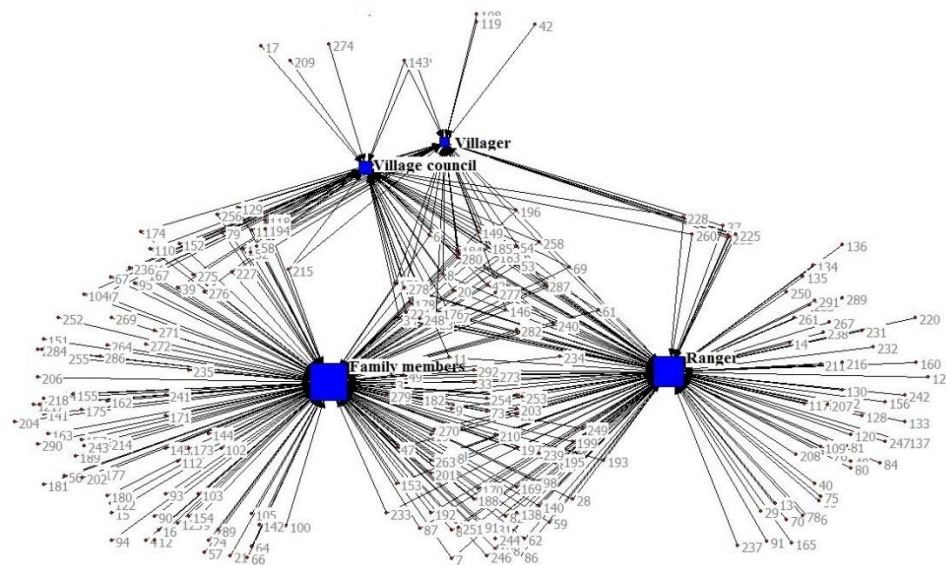


Figure 2. Network of trust in support in the human-large carnivore conflict - Degree centrality

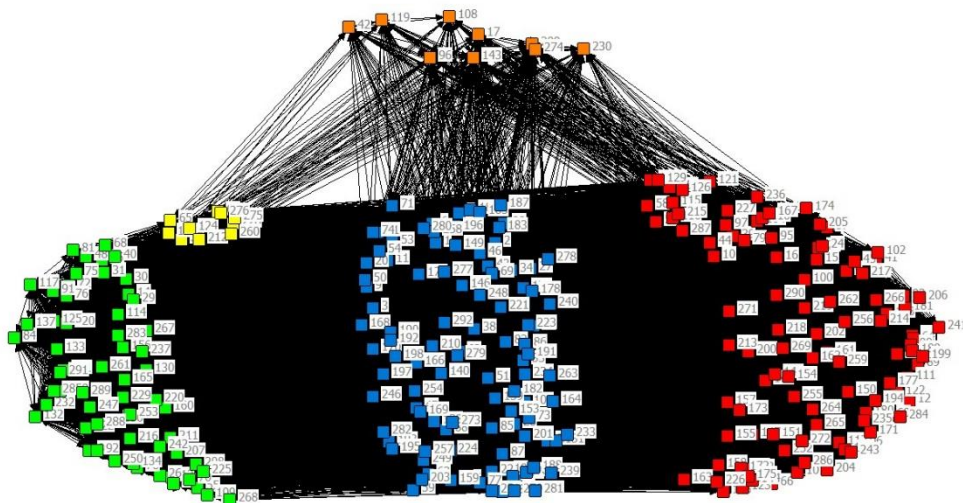


Figure 3. Network of trust in support in human-large carnivore conflict - Betweenness centrality

Table 2. Numerical results of the betweenness centrality and the degree centrality analysis of network of trust in support in human-large carnivore conflict

Indicators	Ranger	Family members	Village councils	Villager
Betweenness centrality	20975	27133	2744	1757
Degree centrality	178	211	63	45

The analysis of the MDS index is shown in Figure 4. In the analysis of the MDS graph, participants are grouped according to the selection pattern into multiple choice groups. The group that chose the “family member” and the “ranger” are placed in the center of the graph, and it emphasizes the high centrality of the “family member” and the “ranger” in the network of trust in support in

human-large carnivore conflict. The group formed on the margin of the graph, with less centrality, had an insignificant role in the network and included people who chose “villager” and “village council” as a trusted group for receiving support in human-large carnivore conflict. The graph of the network of trust in support in the MDS analysis is a re-emphasis on the lack of centrality of

“villager” and “village council” and the high centrality of “ranger” and family in this network.

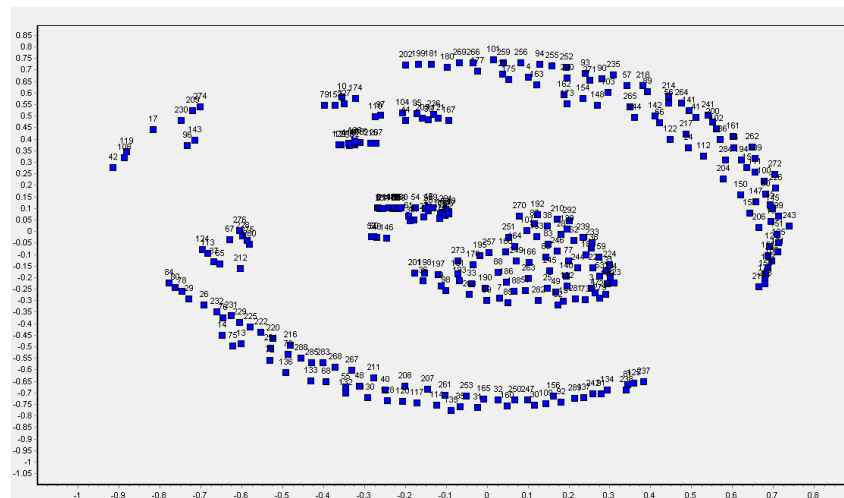


Figure 4. MDS index analysis of the network of trust in support in human-large carnivore conflicts

Trust network in information exchange in human-large carnivore conflict

To analyze the trust network in information exchange, respondents were asked: *"If you need information about large carnivores and conflicts, whom do you turn to?"* The response options were: (a) ranger, (b) family members, (c) village council, and (d) villagers.

The findings indicate that no isolated group exists within the network. Overall, the highest number of selections was for the "ranger" at 65% (n = 190), followed by "family members" at 40% (n = 117), the "village council" at 7% (n = 19), and "villagers" at 4% (n = 9). By gender, men (66%, n = 162) and women (58%, n = 28) placed the greatest trust in the "ranger" for information. After the "ranger," both groups showed the most trust in "family members" (women: 46%, men: 39%). In contrast, trust in "villagers" and the "village council" was the lowest in this network. Ethnically, Turkmen, Fars, and Balouch people placed the most trust in the "ranger," while Turk and Kurd people placed the most trust in "family members."

Across all age groups, the "ranger" was the most trusted source for information exchange regarding conflicts with carnivores. Notably, the youngest age group (18–29 years) expressed the least trust in "villagers" and the "village council" as information sources. The results also show that higher education levels (elementary school and academic education) are associated with greater trust in the "ranger" for information exchange about large carnivores and related conflicts. In contrast, only illiterate individuals trusted "villagers" and the "village council" as sources of information on this topic.

Figure 5 presents the degree centrality of the trust-in-information-exchange network. As shown, the "ranger" and "family members" hold the highest centrality, with degree centrality values of 189 and 116, respectively, indicating that local communities place the most trust in them for information exchange. The "villager" and "village council," with the lowest degree centrality, are positioned at the margins of the graph.

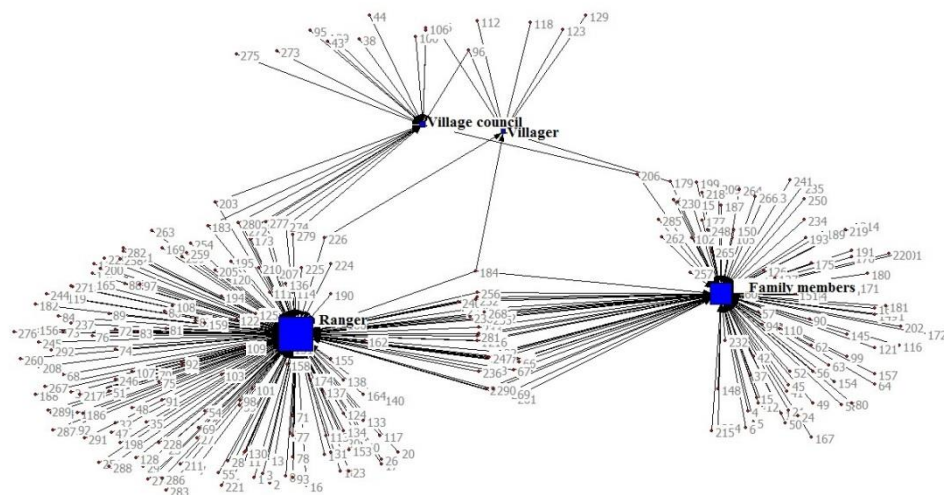


Figure 5. Trust network in information exchange in human-large carnivore conflict - Degree centrality

Figure 6 presents the betweenness centrality graph. The cluster on the left side, indicated by red squares, represents the group of respondents who selected the "ranger." The green cluster includes respondents who made more than one choice, selecting both the "ranger" and "family members" as trusted sources for receiving information. Analysis of this graph further clarifies the influence of the "ranger," which has a betweenness

centrality of 34,720, followed by "family members" with a betweenness centrality of 22,078 in the trust-in-information-exchange network, demonstrating the ranger's controlling power within this network. The numerical results of degree centrality and betweenness centrality analyses for the trust-in-information-exchange network are presented in Table 3.

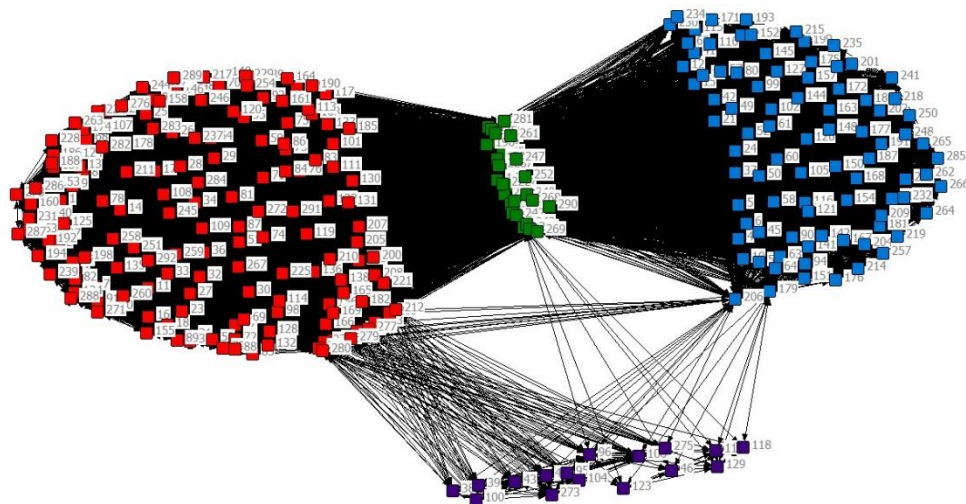


Figure 6. Trust network in information exchange in human-large carnivore conflict - Betweenness centrality

Table 3. Numerical results of betweenness centrality and degree centrality analysis of trust network in information exchange in human-large carnivore conflict

Indicators	Ranger	Family members	Village councils	Villager
Betweenness centrality	34720	22078	1581	3186
Degree centrality	189	116	9	21

The analysis of MDS index is shown in Figure 7. Participants are grouped into family member selection, “ranger” selection, “villager” and “village council” selection, and a multi-choice group including “family members” and “ranger”. The group that chose the family member and the “ranger” are placed in the center of the graph, so it emphasizes the high centrality of the family and the “ranger” in the network of trust in

information exchange. The group in the margin of the graph has a minor role in the network and included people who chose “villager” and “village council” as the trusted people for information exchange in the human-large carnivore conflict. Analyzing the MDS index, re-emphasizes the lack of centrality of “villager” and “village council” and the high centrality of the “ranger” and family in this network.

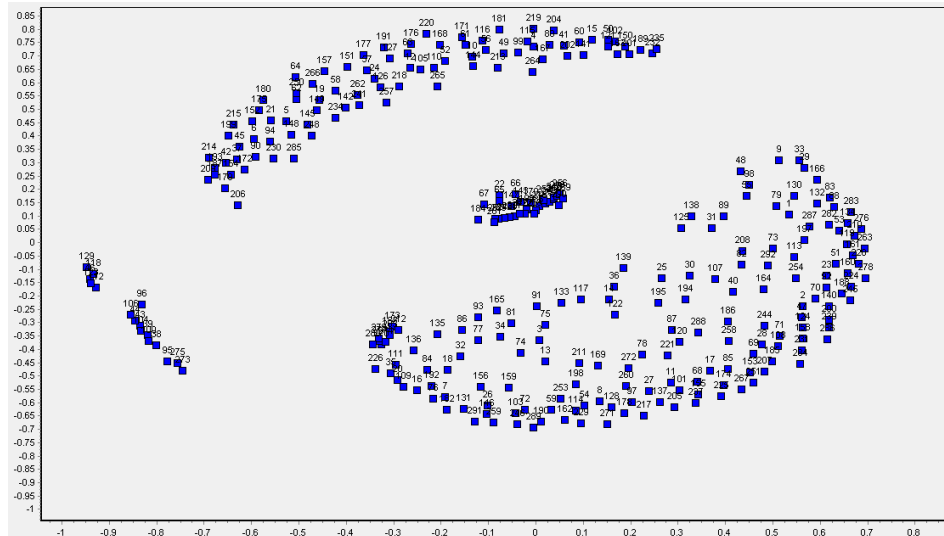


Figure 7. MDS index analysis of the trust network in information index in the human-large carnivore conflicts

The comparison of centrality indices in both networks of trust in support and trust in information exchange is shown in Table 4. In the network of trust in support, the group of

“family members”, and in the network of trust in information exchange, the “ranger” has the most centrality.

Table 4. Comparison of social networks in the human-large carnivore conflicts

Maximum betweenness centrality	Maximum degree centrality	Social network in the human-large carnivore conflict
Family members	Family members	Network of trust in support
Ranger	Ranger	Network of trust in information exchange

Conclusion

The analysis of stakeholder networks supports the design of management strategies to reduce human–large carnivore conflict and contributes to the conservation of large carnivore populations (Grossmann et al., 2020). The size of the stakeholder network and the quality of relationships within it play an important role in advancing conflict management and enhancing the effectiveness of protected areas (Jacobsen and Linnell, 2016; Manolache et al., 2018; Hartel et al.,

2019). In this research, using social network analysis, we examined both the trust-in-information-exchange network and the trust-in-support network in the context of human–large carnivore conflict in Golestan National Park.

The results of the network indicator analysis for both trust networks indicate that villagers and village councils, despite their potential influence, occupy inadequate positions within the social networks. Research by Soleimani et al. (2021) shows that effective

communication between local people and government institutions facilitates knowledge and information exchange (Soleimani et al., 2021). Therefore, by actively highlighting the roles of these two groups within the stakeholder network, they could be introduced to local communities as trusted and reliable sources of support. Grossmann et al. (2020) found that expanding and strengthening stakeholder networks is effective in managing human–large carnivore conflict, and our study similarly underscores the importance of trust and support among stakeholders for conflict reduction.

In the MDS comparison of both networks, the greater number of multiple-choice groups in the trust-in-support network highlights the importance of support in conflict situations with large carnivores, relative to information exchange, among affected local communities. Providing support to local communities can help reduce conflicts and facilitate sustainable coexistence between humans and carnivores. The analysis of the trust-in-support network reveals that local communities place the greatest trust for support in conflict situations first in "family members" and then in the "ranger." Supporting local communities when their primary livelihood sources are at risk of damage or loss is a key conflict management measure in protected areas (Gulte et al., 2023). Conversely, the indicator analysis shows that village councils and villagers occupy inappropriate positions in the stakeholder network, with local communities placing little trust in these two institutions for support. Consistent with Young et al. (2016), our findings indicate that low levels of trust and poor communication between stakeholders and local authorities are key factors that can stall conflict management processes. Similarly, Salvatori et al. (2020) reported low levels of trust and communication among stakeholders, alongside challenges such as insufficient knowledge exchange and limited institutional capacity, as major obstacles in human–large carnivore conflict management. Efforts to establish proper communication, cooperation, and trust between stakeholders are recognized as effective measures for increasing the

success of conflict reduction mechanisms (Barker et al., 2023).

One of the strengths of both networks in this research is the notable centrality of the "ranger" as a significant social capital within the stakeholder network. Stakeholders with high centrality can be regarded as influential actors and important stakeholders in future protected area management planning (Prell et al., 2011). Based on our results, leveraging the capacity of rangers—who are trusted by local communities, particularly in information exchange and support during conflicts—can be integrated into conflict reduction strategies and conservation objectives for the national park. Our findings also highlight the importance of the ranger's role and the need to increase the number of rangers as a recommended management measure. Rizzolo et al. (2021) described rangers as cultural mediators in preventing conflicts in protected areas. Since our results indicate that higher literacy levels are associated with a greater likelihood of choosing the ranger as a source of information about large carnivores and conflicts, planning workshops to enhance local knowledge about human–carnivore conflicts and the ranger's role in the stakeholder network is essential. Increasing local communities' knowledge regarding coexistence with wildlife is an effective strategy in endangered species management (Chynoweth et al., 2016; Bautista et al., 2019). Additionally, workshops focused on human–large carnivore conflicts can strengthen communication between local communities and rangers, fostering broader community support for rangers' efforts in conflict mitigation and control. Given that older age groups (50–59 and 60+) exhibit the highest levels of trust in villagers and village councils and the lowest trust in rangers, villagers and village councils could serve as intermediaries to build trust between these older groups and rangers. Furthermore, our results show that ethnicity influences the choice of the ranger in both trust networks, with the highest level of trust in rangers observed among Turkmen respondents. Therefore, attention to ethnicity in the selection of rangers is important to maximize

interaction among stakeholders in the social network and to strengthen the foundation of trust between local communities and rangers.

Overall, this research is among the first to analyze trust networks within stakeholder networks in the context of human–large carnivore conflict. The analysis of trust networks provided valuable insight into some previously hidden social dimensions of human–large carnivore conflict. Our findings suggest that strengthening the foundation of trust within local communities can serve as a strategic approach in management efforts to reduce conflict. The visual analysis of the trust network clarified interactions within the

stakeholder social network and revealed that conflict mitigation strategies require a broad, multifaceted approach that considers the diverse social aspects of conflicts in management programs.

Acknowledgment

We would like to express our gratitude to the manager, staff, and rangers of Golestan National Park for their invaluable assistance in conducting this research.

This research was funded by Iran National Science Foundation (INSF) under project No.4013560

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