Social Cooperation Networks and Altered Social Groupings Shaped by Drought: A Case Study of the Village of Tutang in Hormozgon Province

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Abstract

A decrease in natural resources and their non-uniform distribution can affect social relationships between residents of watersheds, creating conflict and shifting groupings. The present study used the network analysis method to test the hypothesis that change in hydrologic parameters and water shortages in the village of Tutang has led to the new groupings in the social cooperation network of the local population. Data was gathered by questionnaire. A cooperative network composed of village residents to resolve the water shortage was delineated using UCINET and Visone software. The results showed that past communication patterns based on kinship changed after the water shortage arose and led to the formation of new groupings among residents. Individuals who cooperated in resolving the water shortage experienced higher social power, authority, and status. The results emphasized the need to focus attention on the interactions between subsystems of a social-ecological system. Determined individuals with increased social power can be enlisted to solve the conflicts

Keywords: Homag Catchment; Cooperation Network; Network Analysis; Water Shortage

1. Introduction

Social-ecological systems (SESs) are complex adaptive systems where social and biophysical agents interact at multiple temporal and spatial scales (Janssen and Ostrom, 2006). SES motifs are based on the assumption that a non-trivial SES consists of multiple social actors and multiple ecological resources that are all potentially interdependent (Bodin and Tengo, 2012).

It is the interactions between human and ecological elements that make it a system (Gonzalès and Parrott, 2012). The soul of an SES is the integrated thinking of the natural environment, ecosystem, and human society accentuating the integrity, composition, structural stability, functional synchronization and balance between the ecological processes and components (Zhao and Wen, 2012). Gallopin et al. (2001) argued that the natural analytical unit for sustainable development research is the SES (Renaud et al, 2010).

Social network analysis offers a platform for interaction with qualitative theorists that is useful for those seeking ways to describe the interaction between social and ecological systems using quantitative and qualitative methods (Beilin et al., 2013). A network perspective might be a useful complement to existing analyses because it focuses explicitly on the structure of the interactions between the components of a social-ecological system and the ways in which this

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structure affects the performance of the system. Another benefit of a network perspective is the availability of a uniform language with which to describe complex systems in terms of nodes and links (Janssen et al, 2006).

Kangarani et al. (2009) used network analysis to analyze the networks between the relevant actors in the water and forest. They calculated degree, betweenness and eigenvector centralities to find whether change in the relations and arrangement of state and public institutions for policy-making for Zagros forest can change the quality and quantity of water resources. Results showed that there was no institutional or network attitude in preparing policies for the 4th Development Plan and that public institutions had the lowest status in the networks.

Dawson et al. (2008) examined the intense controversy about the environmental, economic and social effects of a power generator factory on the life and livelihood of residents in the southwest United States. They used social networks to delineate and analyze the conflict network and generating groupings. Their results showed that the local homogeneous community changed into opposition and advocacy groups for economic development on an environmental platform. The advocacy group had the support of project providers and this was the source of the informal power of this group.

Hiwasaki and Arico (2007) emphasized the necessity of understanding specific social and cultural dimensions of the environment to define the multifaceted relationships between local people and the environment. Stakeholders often require different forms of water use that are not always compatible. Analysis of these conflicts makes it possible to gain deeper insight into power relationships and limitations that institutional arrangements and social relationships reflect and engender. This type of information influences decision-making, policy formulation, and the institutional support to facilitate sustainable management of water resources. Carmen et al. (2007) emphasized the relation between residents, water, and the environment. They recommend using methods from a variety of disciplines related to the environment, especially the social sciences.

SESs are defined by Anderies et al. (2004) as social systems 'in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units' (Ostrom and Cox, 2010). Gleitsmann et al. (2007) examined how water scarcity triggered local water wars between villages and conflict between community members over competing priorities for water on the village level.

Iran is an arid and semiarid country (Joneidi-Jafari et al., 2013). Arid and semiarid land comprises about 100 million ha, which is 64% of the area of the Iran (Zandi-Esfahan and Azarnivand, 2013). Iran also is frequently affected by drought, which produces serious economic, social, and environmental effects (Azarakhshi et al., 2011). This makes water one of the most important parameters in the ecology of SESs in Iran. Water shortage can alter the interactions within the social sectors of the SES.

The present research explores the effect of drought and water shortages on the social relations of residents of the village of Tutang. Tutang is located in Homag watershed in Hormozgan province. It has recently experienced drought and a decrease in the groundwater level. This has altered hydrologic parameters as the most influential components of the ecological segment of the SES. These may be lead to changes in social relations among the residents of Tutang, change the existing communication patterns among residents and shape new groupings.

The network analysis method was used to test the assumption that drought and changes in hydrologic parameters in Tutang has resulted in new groupings among its residents.

2. Material and methods

1. Study area

Tutang is located in Homag watershed northeast of the city of Bandar Abbas. It is located at 56°25' longitude and 55°27' latitude at 1380 m in elevation (Geographical Organization of Armed Forces, 2004).

Tutang has 68 households and a total population of 233 people. The occupation of most residents is agriculture and animal husbandry. Tangerines are the dominant agricultural product (more than 95%) of the orchards in this area. Other products, such as dates and oranges are not cultivated for economic factors. (Natural Resources and Watershed Management Organization of Hormozgan Province, 2010). Homag watershed and Tutang are shown in Fig. 1.
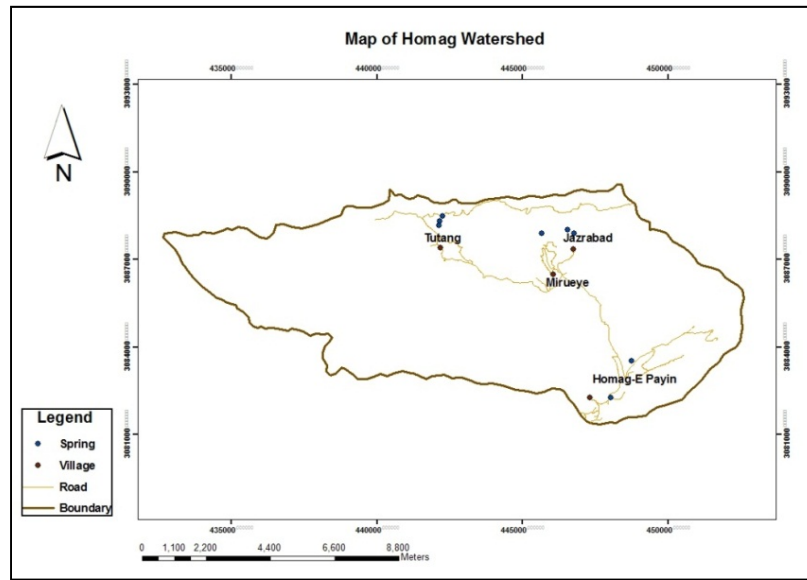
Fig. 1. Tutang and Homag watershed

Because of the sparse vegetation cover, the low permeability of the soil, the mountainous nature of Homag watershed and steep slopes of this region (Natural Resources and Watershed Management Organization of Hormozgan province, 2010), rainfall rapidly runs off and disappears. The region has no surface water resources other than three springs (Mourd, Boc Nar, Boc Shomal). These springs supply water to residents, but have experienced decreased flow after the recent drought (resource: field studies).

Total discharge of these springs is 283, 824 m^3/yr (Regional Water Company of Hormozgan Province, 2009). Although residential drinking water is provided by another village (Miruye), the amount of water from these springs is insufficient to support agriculture and livestock. The amount of water required for these sectors was calculated based on the daily demands for each type of agricultural product and animal and amounted to 2181460.5 m^3/yr. A comparison of the available water and required water reveals the magnitude of the water shortage.

Rainfall in this region tends to be torrential and can precipitate heavy flooding in this region. The Natural Resources and Watershed Management Organization plans to construct levies in the region to control and preserve flood water. The levies can resolve the water shortage in Tutang, but will submerge land belonging to some residents. They oppose construction of the levies, whereas others favor construction to resolve the water shortages. This dilemma prompted selection of this village as a case study.

2. Network Analysis Method

The basic building blocks for modeling a system as a network are nodes and links (Cumming et al., 2010). Nodes are the terminal or intersection points of a graph (vertices). Links are the connections between the nodes and represent the structure of the network over which interaction occurs (Bodin, 2009). Network analysis focuses on the relationships between actors (Prell et al., 2009).

To gather data for network analysis, methods such as interviews and questionnaires are commonly used. The data is imported into a software environment as a matrix and is processed using different methods. The most important concepts in network analysis are grouping, centrality, and power (Hanneman, 2005). A variety of SNA tools are available to develop and visualize social networks, including Netdraw, UCINET, Pajek, and Visone (Liebowitz, 2005).

The emerging importance of social networks as outcomes to natural resource management has resulted in an increase in empirical studies analyzing their structural characteristics (Bodin and Crona, 2009). Grouping and centrality are used to test the hypothesis of this research. The indices of these concepts are described below.

2.1. Multi-dimensional scaling

This index is a grouping index based on similarities within a group; multi-dimensional scaling (MDS) represents patterns of similarity or dissimilarity in the tie profiles between actors as a map in multi-dimensional space. The map demonstrates how close actors are to each other, whether they cluster in multi-dimensional space, and the variation within each dimension (Hanneman, 2005). This index is used to explore the possible creation of new groupings.

2.2. Role equivalence

This is another grouping concept. Briefly, two actors are structurally equivalent if they have identical ties to and from other actors in the network (Wasserman and Faust, 1999). It allows two individuals to be counted as equivalent if they play the same role in different groups, even if they have no common acquaintances (Sparrow et al., 1990). This index is used to explore the possible creation of new groupings based on similar roles.

2.3. Authority

This index relates to the centrality concept. Greater authority acquires a greater entrance relation. If one individual is deferred to more often, his authority will be greater than individuals that are deferred to less often (Kroese, 2011). This index is used to find the individual with more authority.

2.4. Eigenvector centrality

This index is a measure of the centrality concept and determines the central individuals or those in direct contact with central individuals (Landherr, 2010). This index is used to identify individuals with more social power, since more eigenvector centrality is construed as more power.

2.5. Status

Status is another centrality concept and analyzes the status of nodes in the network. Nodes that have higher values denote higher status. If an individual in a social network is selected by more individuals, he/she will have a higher status value and higher social status. This index is used to identify individuals with higher social status.

3. Study Stages

Existing documentation was used to acquire information about water resources, population, occupations, types of agriculture, and social status of village residents. Field studies obtained information about the types of existing relationships and water resource issues. The results of this stage showed that water shortage primarily affected the cooperation relationship.

A questionnaire was used to gather the data to delineate the social cooperation network in Tutang. Respondents were asked: "Which one of the following individuals most endeavored to solve the water shortage problem in Tutang and cooperate with you to solve this problem?" The list of names was developed using the snowball method. This recall list is a good way for residents to express relationships (Erneston, 2008). The recall list for Tutang comprised 22 heads of households. The questionnaire was completed by 32 heads of households.

To delineate and analyze the data for the social cooperation network, it was entered into UCINET in the form of a two-mode matrix of respondents versus individuals from the recall list. The values of a cell were +1 for a cooperative individual, -1 for an uncooperative individual, and 0 for a neutral individual. Analysis of networks was done using UCINET and Visone and by calculating the eigenvector centrality, status and authority centralities, MDS and role equivalence indices.

3. Results and Discussion

Fig. 2 shows the local network for the role equivalence index. The results show that the water shortage has created 4 new groups containing members of the recall list. Group 1 comprises those that most respondents have deemed cooperative. Groups 2 and 3 comprised those with mixed results for cooperation. Group 2 had more uncooperative ratings and Group 3 had more cooperative ratings. Group 4 members are individuals that most respondents rated as uncooperative.

A remarkable result in this figure is that Group 2 includes all the members of the Tutang village council. Most respondents apparently believe that most council members are not motivated to resolve the water shortage.
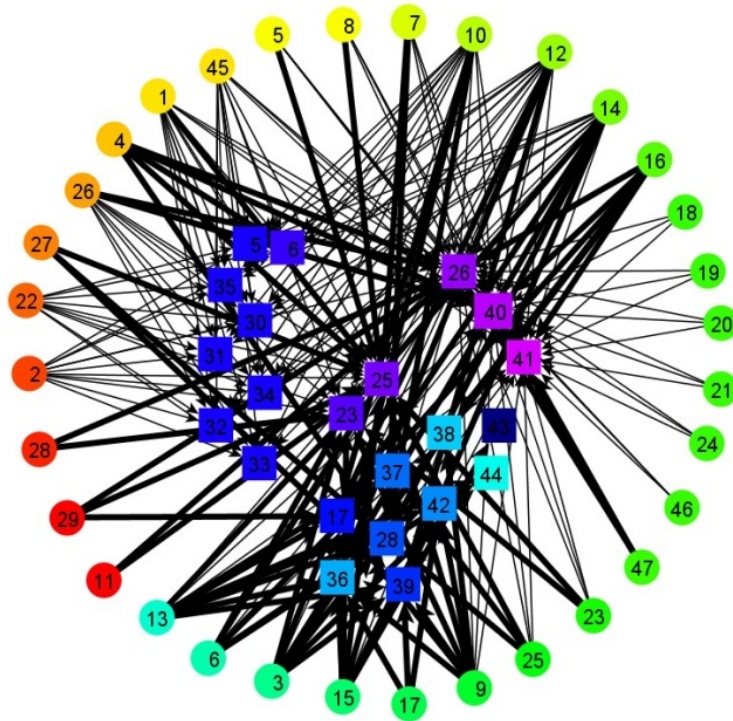
Fig. 2. Social cooperation network in Tutang grouped by role. Circles denote respondents and rectangles denote members of recall list. Bold line denotes cooperation and narrow line denotes lack of cooperation

Table 1 shows the role equivalence index for each individual from Visone. Table 2 shows the groups based on the role equivalence index.

Table 1. Role equivalence index by individual

Number	Roles equivalence	Number	Roles equivalence
41	39	30	33
40	38	5	33
26	37	17	32
25	36	39	31
23	35	28	30
6	34	37	29
35	33	36	27
34	33	38	26
33	33	43	25
32	33	44	24
31	33		

Table 2. Groups based on role equivalence index

Group Number	Index People
1	35, 34, 33, 32, 31, 30, 6, 5
2	41, 40, 26
3	25, 23
4	44, 43, 39, 38, 37, 36, 28, 17

The results show that the water shortage has altered former relations among residents, despite the existence of kinship relationships as revealed by the field study. Opposition to construction of levies has led divisions among them. For example, #25 and #26 are kin, but are in different groups.

Fig. 3 shows the groupings calculated using the MDS index in UCINET. The results of this index confirm the results of the role equivalence index. Groups A, B, C, and D are similar to Groups 2, 1, 3 and 4 in Table 2, respectively.
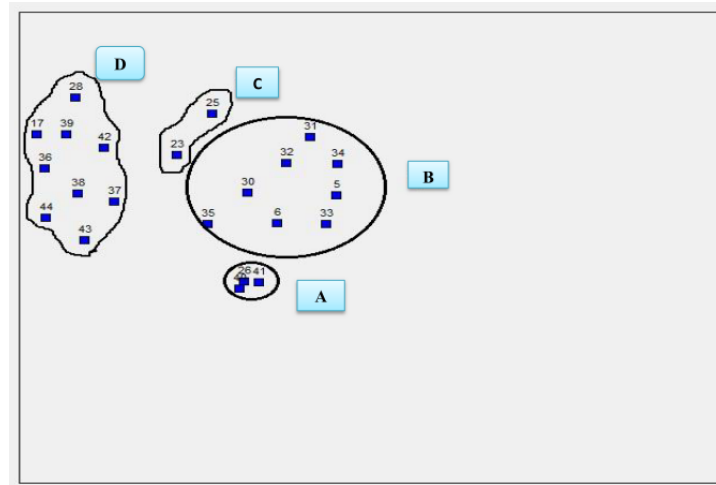
Fig. 3. Groupings based on MDS index

Fig. 4 shows the hierarchical view of the authority index calculated using Visone. Individuals with more authority are located at the top of the hierarchy. Respondents believe them as cooperative in resolving the water shortage. Individuals at the bottom were those deemed uncooperative.

For example, #25 and #23 are former members of the village council and have the greatest authority. Residents are satisfied that they will resolve the water shortage. In contrast, #26, #31 and #43 are current members of village council but are rated as having less authority than #25 and #23. This indicates the dissatisfaction of residents in their performances. Table 3 shows the level of authority for index individuals.
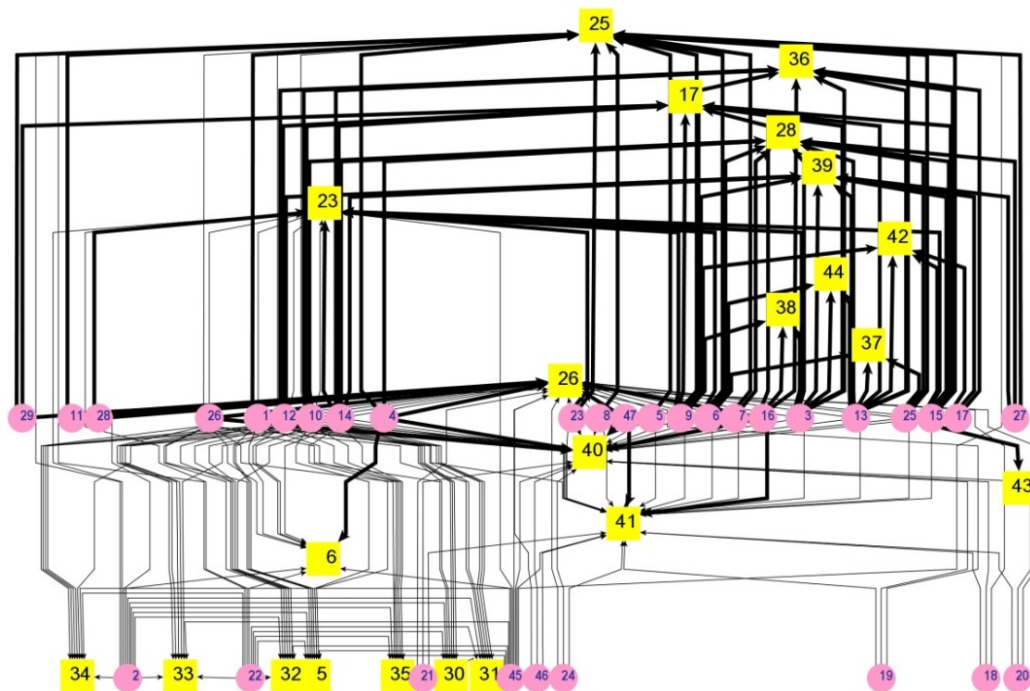

Fig. 4. Hierarchical network of social cooperation based on authority index. Circles denote respondents and rectangles denote members of recall list. Bold line denotes cooperation and narrow line denotes lack of cooperation

Table 3. Authority index for index individuals in social relations network

Index Individuals	Authority	Index Individuals	Authority
25	8.507	40	1.372
36	8.471	43	1.365
17	8.435	41	0.737
28	8.321	6	0.54
39	7.843	5	0
23	6.036	30	0
42	4.412	31	0
44	3.214	32	0
38	2.975	33	0
37	2.551	34	0
26	2.358	35	0

Fig. 5 shows a circular depiction of the social cooperation network in Tutang based on eigenvector centrality as calculated in Visone. As seen, #25 is located at the center of the circle and has the highest eigenvector centrality. Those located on the periphery of the circle (#5, #30, #31, #32, #33, #34, #35) have the lowest values for eigenvector centrality (zero). Table 4 shows the eigenvector centrality values for each individual. A higher value is interpreted as more power and because the network is a social cooperation network. Individuals with greater eigenvector centrality have more social power, with the source of this power being the positive votes of residents.

Results of this index confirm the results of the authority index. In both networks, #25 had the most authority and eigenvector centrality.
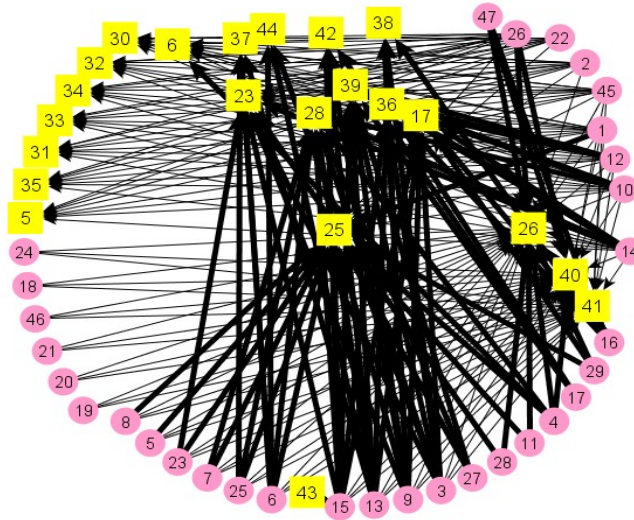

Fig. 5. Social cooperation network based on eigenvector centrality Circles denote respondents and rectangles denote members of recall list. Bold line denotes cooperation and narrow line denotes lack of cooperation

Table 4. Eigenvector centrality values for index individuals in social cooperation network

Index individual	Eigenvector Centrality	Index individual	Eigenvector Centrality
25	16.427	37	3.527
28	11.736	41	2.354
36	10.563	43	1.181
17	10.563	6	1.181
39	9.391	35	0
26	8.218	34	0
23	8.218	33	0
42	4.699	32	0
40	4.699	31	0
44	3.527	30	0
38	3.527	5	0

Fig. 6 is a hierarchical view of the cooperation network based on the status index. Individuals with more status are located at the top of the hierarchy. An individual who is perceived as trying to resolve the water shortage will have higher status in the network. As in other indices, #25 is located in the highest position. The findings of this index confirm results of the other indices. Table 5 shows the values of this index for index individuals.
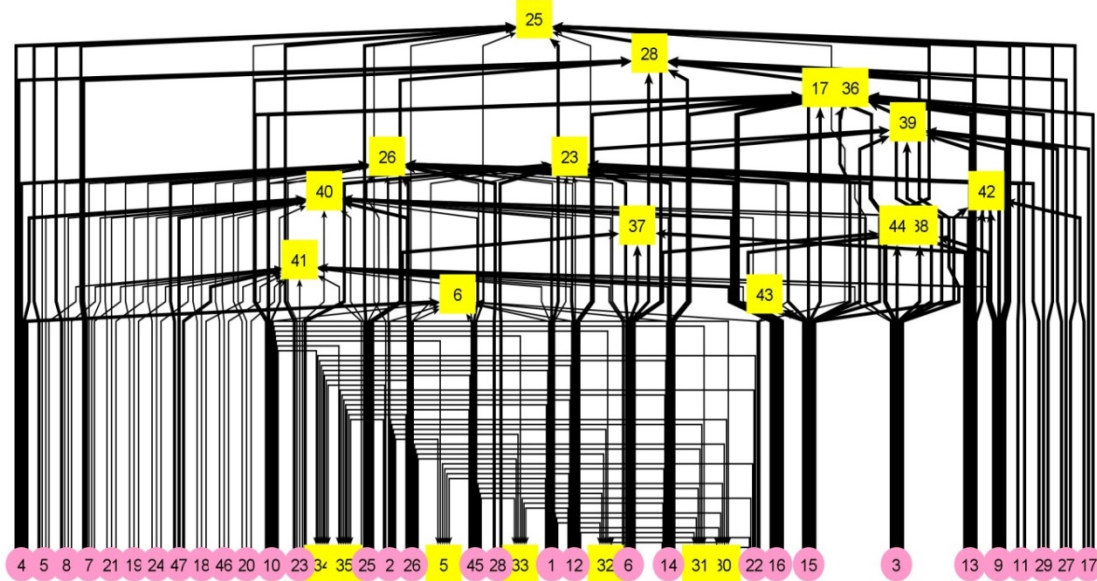

Fig. 7. Hierarchical view of the social cooperation network based on status index Circles denote respondents and rectangles denote members of recall list. Bold line denotes +1 value and narrow line denotes -1 value

Table 5. Status values for index individuals in social cooperation network

Index individual	Status	Index individual	Status
25	16.471	44	3.529
28	11.765	41	2.353
17	10.588	6	1.176
36	10.588	43	1.176
39	9.412	5	0
23	8.235	30	0
26	8.235	31	0
40	4.706	32	0
42	4.706	33	0
37	3.529	34	0
38	3.529	35	0

The centrality indices for social relations in Tutang show that individuals who are perceived as cooperative have more authority, power and status than individuals who are perceived as uncooperative. Individuals #26, #40 and #41 are members of the village council. Although they have more institutionalized power, respondents did not perceive them as using that power to resolve the water shortage and were not satisfied with their performances. This decreased their social authority, power, and status.

Individuals #5, #30, #31, #32, #33, #34, and #35 disagreed with construction of the levies and were rated as having the least social authority, power, and status.

4. Conclusion and Recommendations

From the results of this study, it can be concluded that the natural and physical parameters of a watershed are the ecological sectors of the SES. These influence social relations among residents of watersheds in social sector of the SES and can alter kinship relations and create new groupings.

In Tutang, a water shortage and drought created conflicts among residents and altered traditional groupings. These findings are in agreement with the research of Hiwasaki & Arico (2007) and Carmen et al. (2007), who emphasized

the multifaceted relationships of residents and the environment.

Dawson et al. (2008) found that economic development on an environmental platform divided residents into advocacy and opposition groups. Some residents favored environmental over economic development and others preferred economic over environmental development. This is reflected in the groupings for residents; however, all residents were representing their own interests. All required water, but some preferred to save their land instead of constructing levies for water, which caused the division between them.

The livelihoods of residents of a watershed depends on the natural resources. A decrease in these resources or inequitable distribution can lead to conflicts among residents. This issue must be considered in planning for a watershed.

Conflicts influence the results of water management projects and create social crises. This hinders the fulfillment of the goals because it decreases social acceptance of a project. Its implementation, regardless of grouping, may intensify the conflicts.

The new attitude in favor of participatory management and sustainability of natural resources places special emphasis on the central role of humans in development plans of ecosystems and natural resources. The results of research, such as the present study, are designed to determine which individuals have the highest authority, power and status. These individuals can act as representatives of stakeholders in participatory management of watersheds. The network analysis approach can be a useful method of identifying groupings and conflict and determine individuals with higher power in a network.

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