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Analysis of Settlements System through a Social Network Analysis

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Abstract

Different methods have been suggested and used in regional science for analysing human settlements patterns, relations, hierarchies and so on. This study reports on an introductory application of social network analysis in analysing human settlement systems. It illustrates how social network concepts and analytical tools can be applied to settlements and especially in case of finding key settlements in a region. The study was out in Khuzestan province, Iran.

Key words: Network Analysis, Human Settlements, Key Settlements.

Introduction

Analysis of the nature of settlement relations hold a prominent position in regional planning and practice. Equitable regional growth and development has been an outstanding ambition of many national governments since early 1970. So far economists, planners, policy makers and scholars in the field of regional development have proposed a number of appraoches and models in this regard which were a good basis for many theories and techniques

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that emerged afterwards in th 1970s and 1980s.

A good example of this is Christaller's (1933) approch to central place theory as one of the earliest theories in this area. He believed that establishing service centers in the middle of small settlements would be the most efficient way of delivering services to the surrounding small settlements. He also argues that the central place settlement and its surrounding small settlements would have mutual relationships with each other.

In the 1960s a set of descriptive methods-which were derived from various forms of scaling techniques based on settlement hierarchy theories such as Guttman scales were introduced. The scalogram was and still is a simple measurement technique of this kind. These types of techniques are based on the point that "human settlements tend to be organised into a hierarchy ranging from the smallest basic service centres tied to higher-level market towns. Which in turn are linked with urban centres. Each of these communities has sets of services available related to its role in the hierarchy. Thus the smallest, most isolated centres have a few basic functional activities catering to the immediate needs of the local population, such as grocery stores and gas stations, with the higher-order centres providing a more diverse set of retails as social and recreational services".

Dulkey and Rourke (1973), Perston (1975), Gould (1985), Dixon (1987), followed up with similar studies and introduced theories which represented their strong interest in bringing about a better quality of life for everybody through decreasing the huge socio-economic gap between rural and urban settlements which were known as poor and rich settlements in most parts of the developing world. Potter and Unwin (1989) believe that many developing countries, to cope with their settlements inequalities, adopted models and approaches or the synthesises of a number of models such as:

- Spatial Policy for Equitable Growth by Rondinelli and Ruddle (1978) and his Secondary Cities Approach (1983);
- Top-Down and Bottom-Up Development, by Stohr and Taylor (1981) and
- Generative Versus Parasitic Cities, by Lipton (1977, 1982)

It seems that one of the by-products of the synthesisation of the above theories and models plus a number of other related issues such as 'sustainable regional development' and the recent appearance of 'healthy cities' has tended to push regional planners and other scholars in the related fields towards the idea that finding and developing 'key settlements' may be an effective mechanism for providing fundamental services and facilities in the dispersed rural areas of many countries. This is especially so when a number of small settlements are located in a region and their threshold index for delivering basic services and facilities is low, selecting one or more of them as 'key settlements' of that region may be an appropriate way to solve the problem.

How to select or find the 'key settlements' for the above mentioned purposes is not always a simple task. Most of the time there may be many known and unknown complicated conditions and factors that have to be analysed to be able to assign a place as the appropriate key settlement. Therefore, utilising a reliable method or model will guarantee the validity of the measures that have to be taken through out the selection process. The social network analysis (SNA) approach that has been tested in similar cases such as Key Stone Sector

Identification[1] seemes to be suitable in this regard.

The main aims of this study are: 1) to conceptualise the application of social network analysis in regional planning and human settlements analysis. 2) to apply the social network analysis tools and techniques in a case. The rest of the paper is organized as follows: section two illustrates the fundumentals of social network analysis. Section three discusses the techniques of social network analysis. Section four reviews the study area and data collection process. Section five presents the application of social network analytical tools in the study area along with its findings. Finally, section six concludes the paper.

Social Network Analysis

As noted in the introduction, this study develops the key settlement concept coined by natural scientists and applied by social scientists in the analysis of socio-economic systems. We adopt the ecologists' definition of the key species as being unique and without which the system structure would be fundamentally altered. Robert Paine first introduced the concept keystone species in the late 1960s, in his identification of a predator as the critical species in an ecosystem. Over the decades, the keystone species concept has evolved beyond its focus on predators (Mills, Soule and Doak, 1993). Similarly, in the analysis of socio-economic systems. It was found that the exclusive focus on only one type of entity or one type of relation may also miss a great deal of what is important.

In what follows, a settlement system is defined to be the set of settlements (urban and rural) in a region. The keystone settlements are defined to be the type of settlements, town or village, which play a unique and critical role in achieving the objectives of a settlement system. By critical we mean necessary for the existing structure: without that type of settlement, the structure is destroyed. We use the social network analysis or SNA (Berge, 1962; Wasserman and Faust, 1994; Kilkenny and Nalbate, 2000) to describe the structure of the settlement system.

In studing social networks for almost 60 years researchers have also used statistical models based on this theory. The goal of these models is the quantitative examination of the stochastic properties of social relations between the entities of a particular network (Wasserman and Pattison, 1996). Applications range from studies of interactions between individuals: interpersonal relations, friendship, leadership, etc; to studies of interactions between groups: global studies of communities, studies of the elite and political behavior; project management, and studies of power sharing. However, there has been no application of this theory in case of the human settlement system.

Analytical Methods

This section introduces a method to identify keystone settlements from among many possible types of settlements, taking into account numerous possible types of interdependencies in a settlement system. The method must (1) describe interdependencies within and among settlements in the area, (2) determine the degree of importance of a settlement or groups of settlements, and (3) show the sensitivity of the structure of the settlement system to the absence of particular types of settlement. It seems that methods of social network analysis are appropriate for all three tasks. Methods of

1. Kilkenny M. and Nalbate L. (2000), "Key Stone Sector Identifica-tion – A graph Theory – Social Network Analysis Approach", Resea-rch Institute WVU, lowa, USA

network analysis have been widely used in transportation system research, infrastructure planning (Hanson and Huff. 1986; Koppelman and pas, 1985; Wright, 1979) and sociology research (e.g. Granovetter, 1973, Freeman, 1977). Applications of social network analysis to identifying key or critical settlements, however, are scarce.

The basic feature of network analysis, as distinct from the more usual data analytic framework common in the social sciences, is the use of relational information. Here a relation is the collection of ties of a specific kind among a set of entities or in this case settlements. The relational link between a pair of settlements is called a tie. A tie is a property of the pair and cannot be thought of pertaining simply to an individual settlement.

Ties exist only between pairs of settlements; therefore, the relevant unit of analysis is the dyad. In other words, a dyad consists of a pair of settlements and the possible ties between them (Wasserman, and Faust, 1994). For example, two cities connected by a commuter's travel pattern between them and a retail store and customer, are also dyads. Observing or interviewing individuals about the interactions between settlements in the network collects relational data. The unit of analysis is a settlement from which information about its ties with other settlements is collected.

For economic analysis, relational data may include data on the values of purchases or sales between settlements. Data on interactions between settlements can be presented in a matrix referred to as a sociomatrix and here after known as a settlement matrix. The rows of the settlement matrix represent the sending settlements while the columns represent the receiving settlements.

There can be two main types of ties or relations: i) dichotomous or valued, and/or ii) directional or non-directional. A dichotomous relation shows the presence or absence of a tie between two settlements in the system. A valued relation shows not only the existence of a relation but also the intensity or frequency of the relation (Wasserman and Faust, 1994). An example of a dichotomous relation is one settlement's provision of health services used by people of settlement B. An example of a valued directional relation is the monetary worth of purchases between settlements.

A directional relation has a clear origin and destination. A non-directional relation is imprecise about the origin or destination of the flow on the link (Wasserman and Faust, 1994). A non-directional relation is usually represented by an edge. A line between the interacting settlements that has no arrowhead illustrates it. An arc usually represents a directional relation. An arc is a line between settlements with an arrowhead at the destination. For example if village A sends students to village B, the direction of education is from A to B, reflecting A's educational dependency to A.

Directed graphs or digraphs can also present relational data. The entities in digraphs called nodes and arcs represent the relations. A digraph is a finite, non-empty set N, whose elements $n_i = \{n_1, n_2, n_g\}$ are called nodes, together with a set $A = \{a_{12}, a_{13}, a_{1g}, \ldots a_{g-1,g}\}$ of ordered pairs a_{ij}, called arcs, where n_i and n_j are distinct members of N (Robinson and Foulds, 1980). In a settlement system this graph shows how each settlement relates to all other settlements in the system. If he number of settlements (g) is not too large, a graph is an efficient way to show which settlements are connected to which others, and which are isolated: which are senders or receivers.

Adjacency is the graph theoretic expression of the fact that two settlements. Represented by nodes, are directly related, tied, or connected with one another. Formally, given settlements n_i and n_j in a set of settlements N, and the $A = \{a_{ij}\}$ arcs denoting the existence of relations from settlements i to settlements j; settlements i and j are adjacent if there exist either of the two arcs, a_{ij} or aji.

Given the digraph D=(N, A), its adjacency matrix A(D) is defined by A(D)= $\{a_{ij}\}$ where $a_{ij}=1$ if either a_{ij} or a_{ji} exists, and 0 otherwise. If all entities in the system have two-way ties a complete graph exists. In a complete graph all settlements have two-way ties to all other settlements. In other words, a complete graph has a density of 100%. Mathematically, the density of a digraph (D) is the actual number of arcs in proportion to the maximum possible number of arcs:

$$D = \sum_i \sum_j a_{ij} / N(N-1) \qquad (1)$$

In a settlement system, especially in large settlements it is far from reality to have a complete graph. However, if one for example studies the relations between European cities, especially, capitals in terms of economic or informational relations it is possible to observe such a graph. Some settlements have more connections with others. The strength of a node as a source or a sink in a system is most easily measured using the settlement matrix or adjacency matrix data.

The number of arcs beginning at a node is called the outdegree of the node. Given dichotomous settlement matrix data, outdegree is the row sum for the node. The number of arcs ending at a node is called the indegree of the node. The indegree is measured by the column sum for the node in a dichotomous settlement matrix.

When there is more links among some settlements and others, these are called the most prominent settlements. In social network analysis there are four measures of prominence: 1) local centrality, 2) local presige, global centrality in two forms: 3) closeness and 4) betweenness. Local centrality reflects the number of direct transmissions, and is thus measured basically by the outdegrees (or row sums) for each settlement. Local prestige reflects the number of direct receipts, and is thus measured by the indegrees (or column sums) for each settlement. Since these measures are based on the degrees of the nodes they are also known as degree centrality and degree prestige (Kilkenny and Nalbate, 2000).

With respect to a path, a settlement can be a transmitter (the arc is away from the node), a carrier (there are at least two arcs, one toward and one away), or a receiver (the arc is toward the node). A settlement is isolated when there is no arc that relates the settlement to any other in the network.

Basically, a settlement is a source or transmitter if its indegree is zero and its outdegree is non-zero; that is, if the column sum is zero while the row sum is greater than zero. A settlement or node in the network is a proper sink or receiver if its indegree is non-zero and its outdegree is zero, that is, if the column sum is greater than zero while the row sum is zero. A node is isolated if both indegree and outdegree are zero (Wasserman and Faust, 1994).

Now we can define the last two global centrality measures of prominence. If the settlement is in the shortest paths between others, the settlement is central. The shortness of the paths from that settlement to others is measured by closeness. The proportion of intermediary roles a settlement plays measures betweenness. Both measures rely on the geodesic measure of distance.

Closeness, $C(n_i)$, is the inverse of distance. The shorter the distances between settlement i and other settlements, the more central node i is. It can be mathematically shown as:

$$C(n_i) = \left[\sum j^N d(n_i, n_j)\right]^{-1} \qquad (2)$$

where $d(n_i, n_j)$ is the geodesic (shortest path) distance between i and j settlements in the network, and N is the network size.

Betweenness, $B(n_i)$ measures the probability that a path from settlement j to settlement k takes a particular route through settlement i. It can be mathematically shown as:

$$B(n_i) = \sum j^N g_{jk}(n_i) / g_{jk} \qquad (3)$$

where $g_{jk}(n_i)$ is the total number of geodesies through i, and $1/g_{jk}$ is the probability that a particular geodesic is chosen.

All these measures depend on the size of the network. Thus, the measures must be standardised before comparisons are made between networks of different numbers of settlements. In degree centrality and closeness measures, the measures are standardised dividing by N-1. For betweenness measures, the standardisation settlement is (N-1) (N-2), where N is the number of settlements or network size.

Settlements in a network that all relate to each other can be classified as a subset of the N settlements as a group, a sub-graph, or as we shall say here, as a component. A component is the largest subset of related settlements in a network. Components have two forms: strong and weak, depending on the directions of the ties, arcs, or relational links between the members of the component. A strong component is one in which the arcs that make up the paths are aligned in continuous chain without a change of direction. A weak component is made of settlements that are linked by non-directional edges (Scott, 1991).

Study Area and Data

To conduct a network analysis toward key settlement identification one needs dyadic data on a variety of relations among settlements in a system. We collected this type of data through a field survey done in Darkhovein County, Khuzestan, Iran. Darkhovein comprises 25 villages and a small town (Figure 1). Darkhovein Dehestan[1] is one of the six rural districts of Shadegan. The other ones are: Abshar, Boozi, Jefal, Hossaini and Khenafarah Dehestans.

As one of the southern shahrestans of Khuzestan Province, Shadegan has an area of about 3,600 square kilometers and a population of 121,000 . Darkhovein has a rural centre under the same name and 15 other villages. Darkhovein Central Village with an area of 383 sq. Km and a population of 10,536 is attached to the eastern side of the Karoon River at the west of Shadegan Shahrestan.

Being located at the cross sections of roads to the large cities such as the city of Shadegan, Abadan and Ahwaz has brought about an excellent locational position.

1. Dehestan is the lowest stratum of political boundary hierarchy that is assined by the Ministry of the Interior Affairs in Iran. Each Dehestan composed of a number of adjacent small and large villages. A set of Dehestan make a Bakhsh. A few Bakhshes plus their adjacent towns and cities in its turn make a Shahrestan (county). Ostan (province) is composed of a number of Sahrestan. Iran now has 28 provinces with total area of 1,648,000 Sq. Km. And total population of close to 70,000,000.
2. Iran Plan and Budget Organization, 1996 Statistical Report.

tion for it. Its distance from these places is 25.50 and 70 kilometers respectively. In fact, not only geographically, but also historically Darkhovein has been known as an important village from years ago (Kasravi, 1955). Climatically, Darkhovein is as dry as its other surrounding rural areas with an annual average rain fall of about 170 mm. This is much lower than the minimum amount that the farmers need to grow their crops, therefore, they take advantage of the Karoon river for the bulk of their needs in this regard. They usually do mixfarming; grow cereals legumes, cash crops and keep animals as small animal husbandry.

From basic service facilities, Darkhovein and its 25 other surrounding villages have access to rather good roads, electricity, potable water rural health houses, elementary and secondary schools, agricultural service centre telephone and facilities of these kinds. A number of these facilities can be found just in Darkhovein's small town such as a high school, health clinic, post office, police station, gass station, bank and so on (Table 1).

We interviewed the head of settlements councils of all 27 settlements. Each respondent was presented with a list of the other 26 settlements in the county, and was asked the following questions.

1. To which settlement on this list would your village be likely to give educational services?
2. To which settlement on this list does your village rely upon for educational services?
3. To which settlement on this list would your village be likely to give commercial services?
4. To which settlement on this list does your village rely upon for commercial services?
5. To which settlement on this list would your village be likely to give health care services?
6. To which settlement on this list does your village rely upon for health care services?
7. To which settlement on this list would your village be likely to give adminstrative services?
8. To which settlement on this list does your village rely upon for adminstrative services?
9. To which settlement on this list would your village be likely to give cultural services?
10. To which settlement on this list does your village rely upon for cultural services?
11. To which settlement on this list would your village be likely to give agricultural services?
12. To which settlement on this list does your village rely upon for agricultural services?

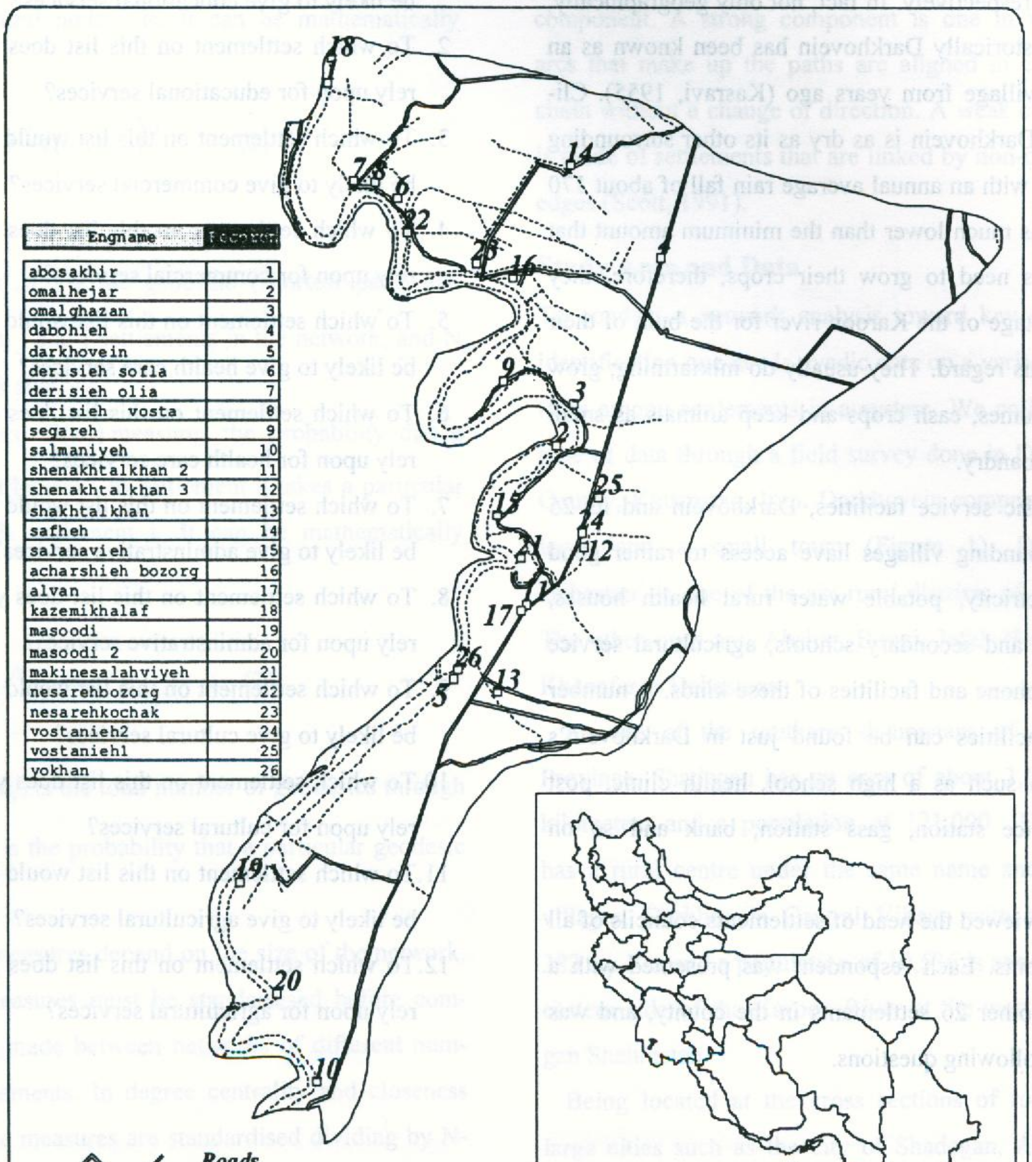

Figure 1: Map of study area

Table 1. Access of villages to the selected services in the study area

VILLAGES	Pipe water	Electricity	Telephone	Paved road	Mosque	Health house	Health Center	Perimery School	Secoundry school	High school	Bank
Abusakhir	1	1	0	0	1	0	0	1	0	0	0
Omalhejar	1	1	0	1	1	0	0	1	0	0	0
Omalghazan	1	1	1	1	1	1	0	1	0	0	0
Dabohieh	0	1	0	1	1	0	0	1	0	0	0
Darkhovein	1	1	1	1	1	1	1	1	1	1	1
Derisieh Sofla	1	1	0	1	0	1	0	0	0	0	0
Derisieh Olia	1	1	0	1	0	0	0	0	0	0	0
Derisieh Vosta	1	1	1	1	1	1	0	1	1	0	0
Segareh	1	1	0	1	1	0	0	1	0	0	0
Salmaniyeh	1	1	0	1	1	1	0	1	0	0	0
Shenakhtalkhan 2	1	1	0	1	0	0	0	0	0	0	0
Shenakhtalkhan 3	1	1	0	1	1	0	0	1	0	0	0
Shakhtalkhan	1	1	1	1	1	1	0	1	1	0	0
Safheh	1	1	0	1	1	0	0	1	0	0	0
Salahavieh	1	1	0	1	1	0	0	1	0	0	0
Acharshieh Bo-zorg	1	1	0	1	0	0	0	0	0	0	0
Alvan	1	1	0	1	0	0	0	0	0	0	0
Kazemikhalaf	1	1	0	0	1	0	0	1	0	0	0
Masoodi	1	1	0	1	0	0	0	0	0	0	0
Masoodi 2	1	1	0	1	0	0	0	0	0	0	0
Makinesalahviyeh	1	1	1	1	1	1	0	1	0	0	0
Nesarehbozorg	1	1	0	1	1	1	0	1	0	0	0
Nesarehkochak	1	1	0	1	0	0	0	0	0	0	0
Vostanieh 2	1	1	0	1	0	0	0	0	0	0	0
Vostanieh 1	1	1	0	1	1	0	0	1	0	0	0
Yokhan	1	1	1	1	1	1	0	1	0	0	0

0= without access. 1= without access

Analysis and Findings

In this section we apply social network analysis techniques to the Darkhowein data to establish: 1) settlement-wide patterns, 2) the patterns of interactions among the individual settlements in the system and compare their various roles, 3) the role each settlement in the network plays. From the responses to the questions, six dyadic relations were defined: Education (1,2). Commercial (3,4) and Health care (5,6), administrative (7,8) , cultural (9,10) and agricultural (11,12).

A settlement was determined to be "in relation to" another settlement if the former settlement representative answered yes to the first question in a pair, or the latter settlement representative answered yes to the second question in the pair. Note that if either settlement in the dyad reported the existence of a tie, a tie was recorded. In other works, for each relation R a 27x2' adjacency matrix (A^R) was constructed with entries $a^R{}_{ij}=1$ if the ith settlement has a relation R the with the jth settlement and $a^R{}_{ij}=0$ if not. (Also, $a^R{}_{ij}=0$.)

This section presents the main findings on: density of settlement network in all relations, local centrality and prestige, global centrality, peripherial settlements, and key settlements.

The first step was to study the density and connectivity of the whole network to find out the structure of settlements' system. The density measure describes the general level of linkage among the settlements in the system. This measure compares the number of actual to possible relations, to show how far from completion the settlement network is. Since all six settlement matrixes have the same symmetric number of settlements (N=27), the maximum possible number of arcs is 27x26=702. Table 2 presents the density results for all matrixes. The density measures are 10.5, 10.4, 7.3, 12.8, 10.8, and 16.7 percent. Agricultural and commercial linkages are denser, and thus more complete. Administrative relations are the least dense and thus the least complete in the county.

Table 2. Density of Settlement Network

	Density
Educational Relations	10.5
Health Care Relations	10.4
Administrative	7.3
Commerical	12.8
Cultural	10.8
Agricultural	16.7
Total	19.8

Prominent settlements are those that are extensively involved in relationships with other settlements. This involvement makes them more visible in the county. The prominence could be due to both receiving and transmitting. To determine which settlements are prominent, we consider all the directed ties (arcs) originating from the settlement (outdegree), all the received ties (indegree), and all the indirect ties (multiple-step paths) as well.

Tables 3-9 present the measures of local centrality and prestige for all variables. The first four rows in each table show the sample statistics for each degree measure for selected settlements. The mean of local centrality, for example, is the average outdegree among the 27 settlements. With respect to educational ties (table 5), on average, a settlement gives educational services to 2.66 other settlements in the area.

The mean of local prestige is the average indegree measure across all 27 settlements. In this case Shadegan has the maximum local prestige (26) and Alvan is one of the settlements that has the lowest local prestige (0).

It means that Shadegan gives educational services to all other settlements in the area.

Table 3. Local Centrality and Local Prestige in Adminstrative relation

ADMINSTRATIVE RELATIONS		
	LOCAL CENTRALITY	LOCAL STIGEPRE
Sample statistics:		
Mean	1.88	1.88
Minimum	0	0
Maximum	2	26
Top Two Settlements		
Shadegan	0	26
Darkhovein	1	25
Lower Two Settlement		
Masoudi	2	0
Alvan	2	0

Table 4. Local Centrality and Local Prestige in Economic Relations hierarchy

ECONOMIC RELATIONS		
Economic Relations	LOCAL CENTRALITY	LOCAL ESTIGEPR
Sample statistics:		
Mean	3.33	3.33
Minimum	0	0
Maximum	5	26
Top Two Settlements		
Shadegan	0	26
Darkhovein	1	25
Lower Two Settlement		
Abu Sakhir	3	0
Yokhan	2	2

Table 5. Local Centrality and Local Prestige in Educational Relations

EDUCATIONAL RELATION		
	LOCAL CENTRALITY	LOCAL PRESTIGE
Sample statistics:		
Mean	2.66	2.66
Minimum	0	0
Maximum	4	26
Top Two Settlements		
Shadegan	0	26
Darkhovein	1	25
Lower Two Settlement		
Salahaveyeh	2	0
Masoudi 2	2	0

Table 6. Local Centrality and Local Prestige in Health Care Relations

HEALTH CARE RELATIONS	LOCAL CENTRALITY	LOCAL PRESTIGE
Sample statistics:		
Mean	2.96	2.93
Minimum	0	0
Maximum	5	26
Top Two Settlements		
Shadegan	0	26
Darkhovein	1	25
Lower Two Settlement		
Makineh Salahaveyeh	2	0
Masoudi	2	0

Table 7. Local Centrality and Local Prestige in Cultural Relations

Cultural Relations	LOCAL CENTRALITY	LOCAL PRESTIGE
Sample statistics:		
Mean	2.8	2.8
Minimum	0	0
Maximum	4	26
Top Two Settlements		
Shadegan	0	26
Darkhovein	1	25
Lower Two Settlement		
Yokhan	2	0
Solymaneiyeh	2	0

Table 8. Local Centrality and Local Prestige in Accessibility and Communication

Accessibility and Communication	LOCAL CENTRALITY	LOCAL PRESTIGE
Sample statistics:		
Mean	2.84	2.84
Minimum	0	0
Maximum	5	26
Top Two Settlements		
Shadegan	0	26
Darkhovein	0	25
Lower Two Settlement		
Solymaneiyeh	2	0
Yokhan	2	0

Table 9. Local Centrality and Local Prestige in Agricultural Relations

Agriculture	LOCAL CENTRALITY	LOCAL PRESTIGE
Sample statistics:		
Mean	4.44	4.43
Minimum	0	0
Maximum	6	26
Top Two Settlements		
Shadegan	0	26
Darkhovein	1	25
Lower Two Settlement		
Abu Sakhir	2	0
Yokhan	2	1

Shadegan appears to be locally prestigious with respect to all variables, but not locally central (has high indegrees but the outdegree value is 0). This is the main difference between social network analysis and settlement network. In fact the key settlement here is the one that has outdegree value of 0, or the Lowest level of local centrality. Here the difference between indegree values for the first top settlement and the second top is very large. In sum: we have shown how to classify settlements with large indegrees as important service providers settlements with low indegrees are apparently less service provider and more receiver, or peripheral to a network.

The global centrality measures as discussed earlier are based on the length and the number of carrier and multiple-step path roles. When a settlement has a position of strategic significance in the overall network, that settlement is considered globally central. Interactions between non-adjacent settlements depend, by definition, on an intermediary. Thus, globally central settlements can have widespread effects on a settlement system because they are more closely tied with more of the other settlements, and act as intermediary for more settlements, than any others. Globally central settlements are detected using the closeness and betweenness measures.

The settlements with the lowest values of local and global centrality are the settlements that are peripheral to the network. According to our data, the settlements that do not have many interactions with other settlements and their interactions are significantly below the mean and only have relations with few settlements are peripheral settlements. As many of the villages have at least two relations with other settlements, there is no completely isolated settlement. Settlements that are vital for the connectivity of a network are those without which other settlements will become isolated.

Conclusion

This paper has presented a new method for identifying keystone settlements in regions, where settlements are broadly defined to include villages, and small towns. In this paper, we developed a new method for identifying a keystone settlement in any kind of settlement system, but explicitly for regional planning analysis. We proposed that a keystone settlement in a region plays a unique role, without which the region is fundamentally and detrimentally altered.

Comp are to other methods, it seems that social network analysis can be a useful tool for studying settlement patterns and relations. However, attentions should be paied to differences existing between social systems and settlement systems. Moreover, additional research is needed using the same method with different scales to elaborate the advantages and disadvantages of this method. It seems that there are many areas in regional planning that one can use this methodology.

The outcome of analyses of Darkhovein data is the robust finding that Darkhovein and Shadegan are key settlements. These towns are key according to all the various network analytic measures of centrality, prestige, and connectivity. Now that we have a way to identify the key settlements in a region, how might we use this information to enhance regional planning and development or to support innovative regional system change?

It seems that there is a need for further studies of similar types to many regions before concluding that any one settlement is the key settlement in regions in general. Unlike social relations, in a settlement system it is not expected that higher rank settlements have facility relations with lower level settlements. Therefore different types of analysis are needed in this context. We believe this method can be applied for analysing sustainable settlements and or a self-sufficient settlement,dependent settlements and so on. In closing, we hope that this work inspires other researchers to apply a key settlement method to analyze other regions.

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