Defining Urban Complex Problems with Fuzzy Analysis: The Case of Söke Settlement in Turkey

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Summary

Purpose: The purpose of this paper is to develop the concept and definition of multidimensional urban areas, thereby providing insights into our understanding of the sub urban structures of household spatial patterns. The output is to classify urban problems and patterns including measures of physical neighbourhood form related with the social or economic characteristics of household.

Design /methodology/approach: This paper explores associations between local socio - economic context and perceptions of neighbourhood quality of life, using a fuzzy logic modelling approach related with GIS for comparative purposes, objective and subjective indices' based, in the Söke case. The multi criteria fuzzy logic approach was applied for defining urban complex problems. The economic (income, food expenditure, house sell price and rent price), social (household person, education of house hold, qualified employment ratio) and physical (gross floor area rate and base floor area) indicators were taken account to find the Quality of Life Index. The survey including 333 household was realized for Söke settlement in 2010 to define the sub zones according to life quality indicators with 15 planning students.

Practical implication: Better understanding the complexity of individuals and house hold social economic conditions and their life style and satisfaction could result in more adequate initiatives and decisions being taken by city planning authorities.

Originality/value: The new sight to evaluate quality of life indicators.

Key words: quality of life, fuzzy logic analysis, urban analysis methodology

1. Introduction

Evidently, the city is too important to be explained by the historian, sociologist, economist, communication theorist, game theorist or social theorist alone because the images of the city are rendered with multiple values (Banai, Rapino, 1981). City form is the result of a multitude of “cumulative” and linked decisions by various actors. The “flow of decisions” in conjunction with the impact on city form constitutes the elements of a “complex system.”

Local governments, priorities for action include improving access by all citizens to social services and opportunities, overcoming the gap in the implementation of

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environmental policies, achieving sustainable consumption and production patterns, and better integrating the three dimensions of sustainable development – economic, social, and environmental– into policy-making. As communities and local governments have become increasingly concerned about quality of life issues, community indicators have become a widely used the tool to measure the status of the quality of life and progress being made toward improving it (Swain, Hollar, 2002).

Indicators are signs or signals of complex phenomenon and systems. They are bits of information pointing to characteristics of systems or highlighting what is happening. They are useful, within the context of an overall community improvement process, both as a planning tool, based on a community's vision, and as an evaluation tool to measure progress on steps taken toward improvement (Noll, 2004). Indicators can, in fact, influence action and positive change in a community. The range of public-policy areas that may be positively impacted is limited only by the choice of indicators (Swain, Hollar, 2002). The systematic focus of many indicators initiatives also reflects an appreciation for the interconnectedness of the many factors that together contribute to a high quality of life. One of the basic functions of indicators is to provide a comparison. This comparison can be based either on targets, benchmarks or performance in the past. The indicator index enables comparisons to be made across urban neighbourhoods and provides a starting point from which to identify relationships between social economic, physical structures in the local environment and well-being such as in this paper case. Moreover, the quality of life index contributes to identify differentiated part of the cities.

As a field of social science social indicators research which are measures of social well-being which provide a contemporary view of social conditions and monitor trends in a range of areas of social concern over time, was born in the United States in the mid-1960s (Noll, 2004) and then the concept has been widened by adding an economy, sustainability, healthy-community and benchmarking indicators (Swain, Hollar, 2002). Some notable sustainability projects are sponsored by governmental entities, especially in nations such as Canada, New Zealand, and some European countries. More than hundred indicators have been obtained from these kinds of studies. Some recent works suggest conceptual and operational approaches to the problem of the quality of life in urban spaces, that can be synthesize in the following points (Daniel et all, 2005)

(i) Quality of urban life can be described by dimensions;
(ii) Dimensions rely on liveability aspects of the urban space;
(iii) Quality of life dimensions may be described by objective or subjective indicators;
(iv) Dimensions and indicators can be combined in a weighted manner, through the application of different importance levels (weights), on a subjective basis

Expressions like "good city", "good place to live" and "good quality of life" involve conceptual perspectives that, frequently, vary from person to person, from place to place and along the time. From that point of view, the some writers accepted that the concept of life quality is essentially subjective, since it depends on the set of needs and aspirations that, if and when satisfied, make an individual happy or satisfied (Bossard, 1999, Liu 1975). In this frame, for any individual, the quality of life expresses the wills, translated as needs that, after fulfilled and all acquired, allow the individual to achieve

his happiness or satisfaction. On the contrary, many times, the proposed definitions are no more than exhaustive sequence of variables, or indicators defined as objectives (extracted from statistical files previously elaborated without the specific end of its use in the evaluation of the quality of life). Campbell and his colleagues suggested that domain satisfactions were a reflection of people's assessments and perceptions of domain attributes which in turn, were influenced by the objective attributes themselves. As a result, if subjective considerations (results of individual psychological inquiries), and objective data are measured together, it will be possible to make more realistic decisions.

In the literature, the quality of life framework contains mostly four main categories with numerous subcategories. Hundreds of indicators are listed in many studies as physical, economic, social satisfaction dimensions. Besides, it is noted that finding the best way of expressing an indicator depends mainly on the policy context it is used in and the associations the public makes with respect to the particular issue. The list of indicators was narrowed in this study taking only main indicator representing the nature of household to experience the fuzzy technique. The concept of quality of life as used in this project has three dimensions as social, economic and physical. In these limitations, income, food expenditure, house sell price and rent price represent the economic dimension, as the household size, education of house hold, qualified employment ratio, represent the social dimension. Gross floor area rate (FAR), and base floor area rate (BAR) are used as representative of physical dimension.

2. Data Base Description

The analysis focuses on the city of Söke, is located West of Turkey. The city population is approximately 62400, the rural hinterland population is 39400. Kuşadası and Didim which is the resort places on the Aegean side is 30 km far away to Söke. Many ancient places -Ephesus, Miletos, and Priene- are surrounded around the settlement. City services flourish agricultural rural area and tourism settlements located Aegean coast. % 15 of active employment is in agriculture, respectively % 56 in service and % 29 in industry sector.

The sample for the survey is designed to provide representative samples of private households derived from the Söke municipality GIS data base. A stratified random sample is selected such that every sampling unit in the population has an equal probability of being selected for the sample. From the 14582 housing units in Söke's GIS database, a sample size of 366 was chosen. However, 333 households were interviewed, 293 household has been combined with GIS data.

The indicators that have been used for the fuzzy model consist of three main blocks. The first one in the indicators that describe development of socio-economic system is the economic indicators such as income and food expenditures per person, property sell prices and rent prices. The second one is physical indicators that consist of availability of housing density, BAR and FAR. The third one is the social indicators which can be described as household size, education average of household, qualified employment ratio. Selected indicators can be usefully reflected important social

economic conditions and that facilitate the process of assessing those conditions and their evolution.

The goal is achieved by applying a new and straightforward method of GIS and fuzzy logic. This methodology was applied in the study area and the results presented in the form of tables and maps.

3. Methodology

This paper describes the development of an area-based index of physical, social and economic condition of household. Improved classification of urban pattern is useful for advancing the debate on urban assets for at least three reasons. 1) Classification facilitates easy understanding 2) classification is necessary for the effective development and implementation of public policy 3) classification is helpful in policy evaluation. Furthermore, community behavioural patterns and location decisions of households and lifestyle choices play important roles in achieving sustainability (Gloss, Vale 2009).

In this framework, we followed several steps in order to attain the final objective by using multidimensional analyses to define urban patterns. This paper is organised into sections based on these steps, which are as follows:

1) Selection and definition of the life quality criteria upon which the urban patterns will be designed.
2) Household surveying in Söke city for this aim.
3) FAR and RAR calculation using municipality GIS database.
4) Designing SPSS data set.
5) Calculating the fuzzy logic index for each indicator.
6) Providing the combination between Fuzzy index data set with GIS database.
7) The final results for each single indicator are presented in the maps and compared subsystems.
8) Zoning the final urban pattern on the map, using the each fuzzy result of the social, economic and physical indicators.
9) Interpretation of the result map.

Although the quality of life concepts has wide range, only a few indicators above mentioned are taking account. Physical indicators are calculated from school districts as a gross FAR and BAR. It is thought that gross density values include the district's facility lot size such as school areas and parks. The city is officially divided into 8 neighbourhoods. But, the neighbourhood border does not reflect the school's domain. That is why 17 domain of school was drawn by writers and some physical indicators such as gross floor area coefficient (FAR) and base area coefficient (BAR) are calculated for these school districts.

Gross FAR=Total construction area of buildings / school district area [1]

Gross BAR= Total basement area of buildings / school district area [2]

As economic indicator, income and food expenditure are calculated per person dividing the household income and food expenditure to household size.

Fuzzy Logic was conceived as a better method for sorting and handling data but has proven to be an excellent choice for many control system applications since it mimics human control logic. The term "fuzzy logic" emerged in the development of the theory of fuzzy sets by Lotfi Zadeh (1965). A fuzzy subset A of a (crisp) set X is characterized by assigning to each element x of X the degree of membership of x in A (e.g., X is a group of people, A the fuzzy set of old people in X). Now if X is a set of propositions then its elements may be assigned their degree of truth, which may be "absolutely true," "absolutely false" or some intermediate truth degree: a proposition may be more accurate than another proposition. Basic fuzzy propositional logic is the logic of continuous *t*-norms (developed in Hajek 1998). FL is a problem-solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large (Kaehler, 2011, Zalta, et all 2010). Simplest linear formula has been used in this study.

If the maximum value is good $(X- \mu_{\min})/ (\mu_{\max}- \mu_{\min})$ [3]

or

If the minimum value is bad $(X- \mu_{\max})/ (\mu_{\min}- \mu_{\max})$ [4]

in where, X is indicator value of household,

$$\mu_{\max} = mean_{\text{indicator group}} - standart\ deviation_{\text{indicator group}} \quad [5]$$

$$\mu_{\min} = mean_{\text{indicator group}} + standart\ deviation_{\text{indicator group}} \quad [6]$$

Education average of household is calculated in following formula. In the graduation levels, if the person didn't finish any school, the weight is accepted 0.20, respectively 0.4 for primary school, 0.6 for elementary school, 0.8 for high school and 1 for university graduation.

Education average of household $=\sum_1^n$ graduated level ratio $*$ weight [7]

Table 1: Indicators average, minimum and maximum value

		N	Min	Max	Mean	Std. Deviation	$\mu_{\min}$	$\mu_{\max}$
Social	House hold size	293	1,00	11,00	3,37	1,43	2,43	9,57
	Education average of household	293	0,00	1,00	0,54	0,22	0,22	0,78
	Qualified employment ratio	293	0,00	1,00	0,29	0,43	0,43	0,57
	Social assurance ratio	293	0,00	1,00	0,69	0,38	0,38	0,62
Economic	Property rent price	293	50,00	800	289,27	88,18	138,18	711,82
	Property sell price	293	5000,00	300000	71380	36843	41843	263156
	Income per person	293	14,29	6000	458,58	494,58	508,87	5505,42
	Food expenditures per person	293	8,33	800	91,36	76,07	84,41	723,93
	Credit payment affordability	293	1,000	1,000	1,50	0,86	1,86	0,14
Physical	Dwelling area per person	293	10,00	150,00	38,17	21,20	31,20	128,80
	Person per room	293	0,20	4,00	0,96	0,46	0,66	3,54
	BAR	293	0,25	0,74	0,57	0,12	0,37	0,62
	FAR	293	0,70	2,12	1,58	0,38	1,08	1,74

4. Findings

In the past few years, the concept of life quality, sustainability, smart growth, urban renaissance, neighbourhood typologies have been developed for the improvement of urban policy. According to these subjects some of discussions that inquiry about issues of urban sysytem can occur only as progress are made toward defining, measuring and understanding urban elements/units (Talen 2003). In this paper, quality of life indicators were used to understand the social, economic and physical urban patterns in Söke case study area to define the life quality typology of the city. Fuzzy logic index and GIS are used to identify urban patterns.

The study began by identifying and computing seven life quality indicators based on parcel-level data using GIS. The methodology was then applied to identify the urban pattern based on 293 household data in the year 2010. Fuzzy logic analysis was employed to derive generalized dimensions of social, economic, physical characters of the settlement. Using the indicators social, economic and physical dimensions of the life quality analysis has been implemented. Finally, making connection with space using GIS tool, fuzzy index for each unit (survey cell) was adopted to understand the variation in urban pattern with different dimensions. The urban pattern typology based on their similarity and dissimilarity within the predetermined set of dimensions derived from the fuzzy unit clustering.

With the use of social indicators, it is observed that there have been emerged urban areas diffrenciating from each other. The structure of the social differenciation is similar to economic pattern. In the south of the settlement, new developed housing areas and the north of the settlement which can be defined as the living space of upper income group are socially qualified from the others. It has been found some problem areas in terms of social indicators. These are the residential areas with low average fuzzy values near the city center, slope of a hill and the ruined sides of historic core. In addition, higher fuzzy indexes of economic indicators agglomerate in the north side of the settlement which is mentioned as socially qualified areas before.

In general, according to the overlaped zoning results, the old historical neighborhood with the immigrant population is socially, economically and physically deprived areas with the lowest fuzzy index values. Whereas, in the zone with native population concentration, extended through the north from the center to the new developed area, economic and social conditions are adequate. Yet in terms of inadequate facilities and high density, poor physical conditions are observed in the area. Furthermore, according to the results residential areas in the center received lower values as the historical core. In the southern side of the city, in new mass housing areas social and, physical conditions, are above the average, although economic conditions are below the expectations.

As a result, in this context different indicators are compared in the same place. Social and economic factors are overlapped with one another; however the physical parameters revealed a different character. In neighborhoods inhabited by high income population are expected to be physically more adequate conditions. But norms of the physical quality of life seem to deteriorate even for the high income group.

Table 2: Fuzzy index for Söke's sub district.

Economic Zones	Average of fuzzy		Physical zones	Average of fuzzy		Social zones	Average of fuzzy
1	-0,070048		1	0,455995		1	0,380174
2	0,273341		2	0,376285		2	0,884211
3	0,134362		3	0,240818		3	0,286752
4	0,083579		4	0,608226		4	-0,029468
5	-0,025625		5	0,163265		5	0,323611
6	0,015504		6	0,364729		6	0.039121
7	-0,126785		7	0,243522		7	0.745751
8	-0,042110		8	0,460130		8	0,087381
			9	0,606777		9	0,308149
			10	0,364729			
			11	0,151245			
			12	0,805170			

Note: Zone number does not represent the same place (see maps)

5. Conclusion

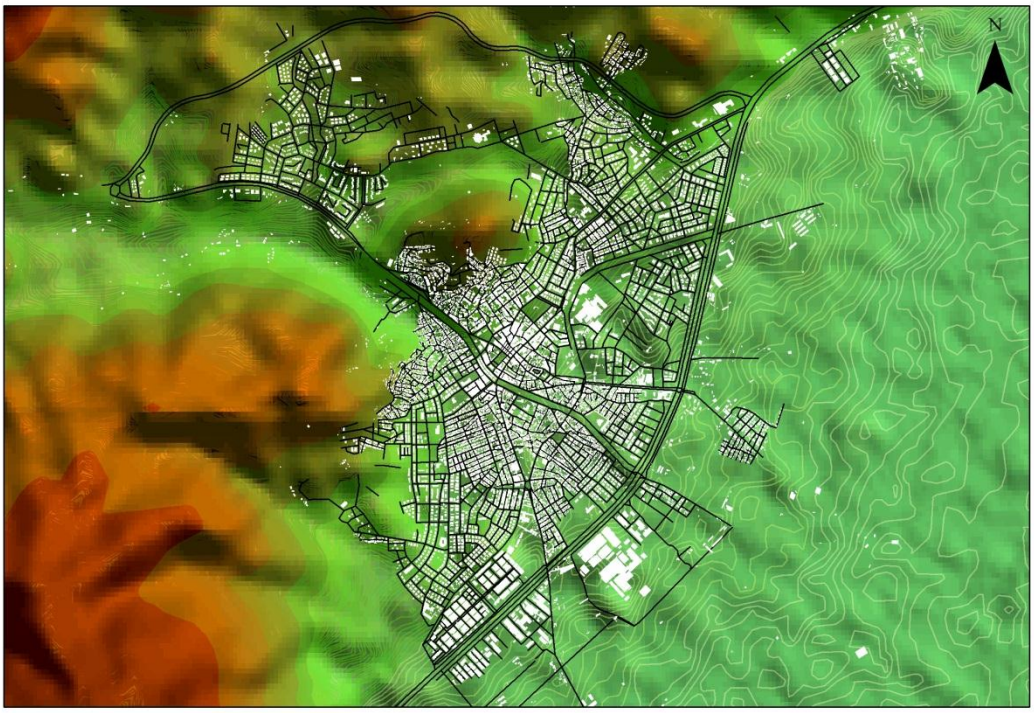
Brief household profiles of Söke city are provided by this limited study. A number of locality based studies, both quantitative and qualitative, have contributed to an understanding of the relationship between social, economic and physical condition of city.

Improving the quality of life of people is perhaps the most important role of local and central government. As seen in the paper experiences, the combination of QOL with fuzzy and GIS tools provide a comprehensive evaluation and also contribute in clarifying many issues. A set of issues can be grouped as the sector of the economy, environment or the geographic location that they mainly influence.

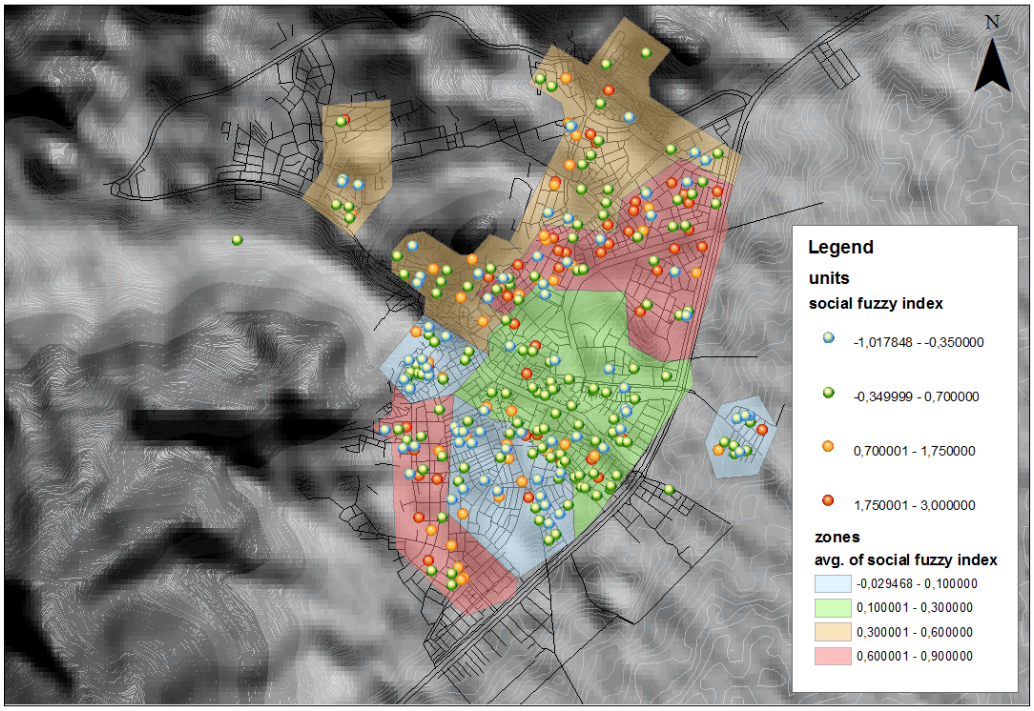
The results revealed that there are spatial, social and economic disparities in some parts of the Söke. The findings indicate that the fuzzy techniques are powerful analytic tools for helping planners define urban complex problems and to see relations between social, economic and physical factors.

As the ‘smart growth’, ‘new urbanism’, ‘sustainable development’ and creative city have now become common terms in the literature, land-use policy makers, and the public at large, must consider that there are significant gaps and weaknesses in how urban and suburban phenomena are currently measured (Talen,E.2003, Song, Knaap, G. 2007). The measurement, evaluation and representation of the urban realm have not kept pace with the sophistication of new ideas about how to change it. Without the tools to effectively measure and represent these ideas or complex systems– essential for implementation – the concepts or decisions prove intangible (Talen, 2003). QOL index methods with Fuzzy logic combined with GIS could contribute these kinds of needs.

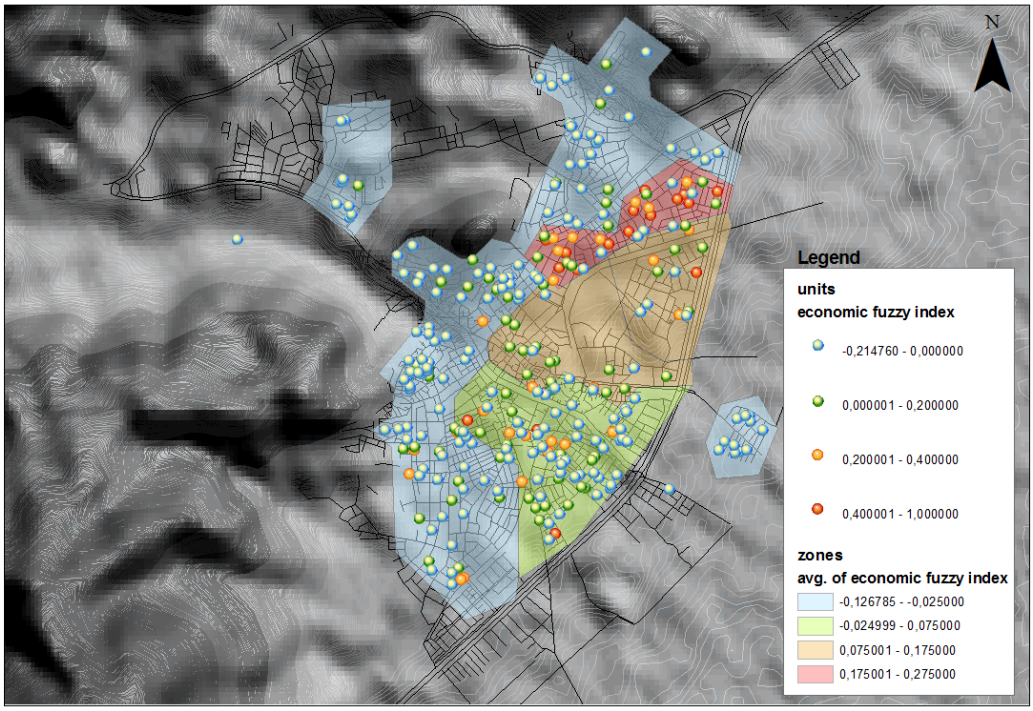
In the future researches, various pathways and variables can be added to determine the relationship including enhanced opportunities for physical activity associated with access and satisfaction in public services and the direct effects of close proximity to these amenities.



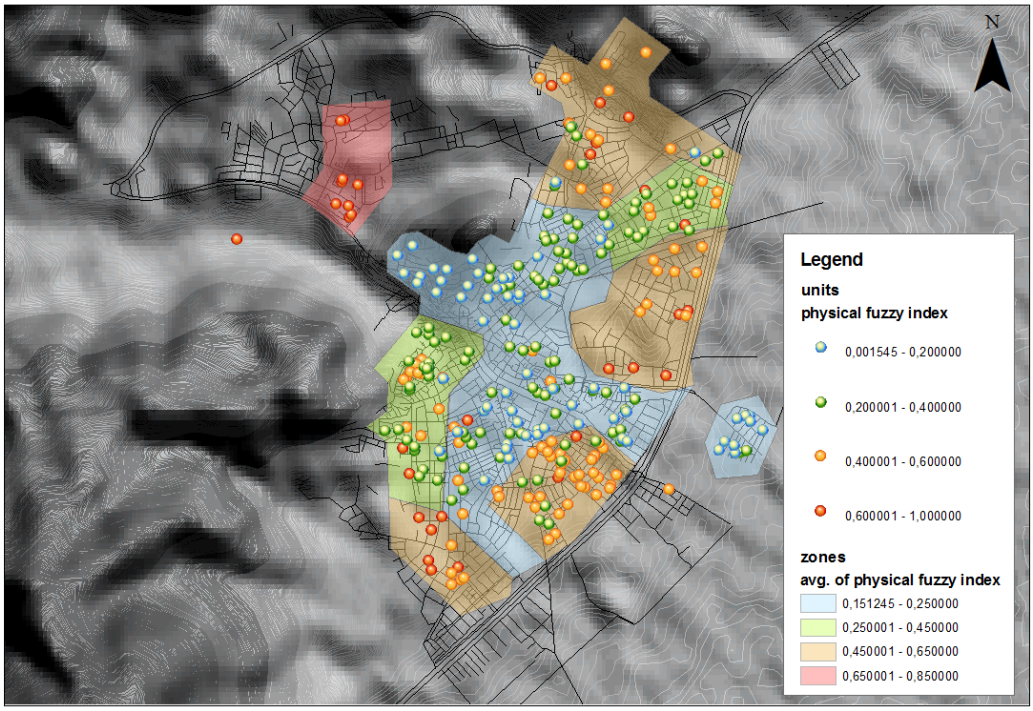
Map 1: Söke city macroform



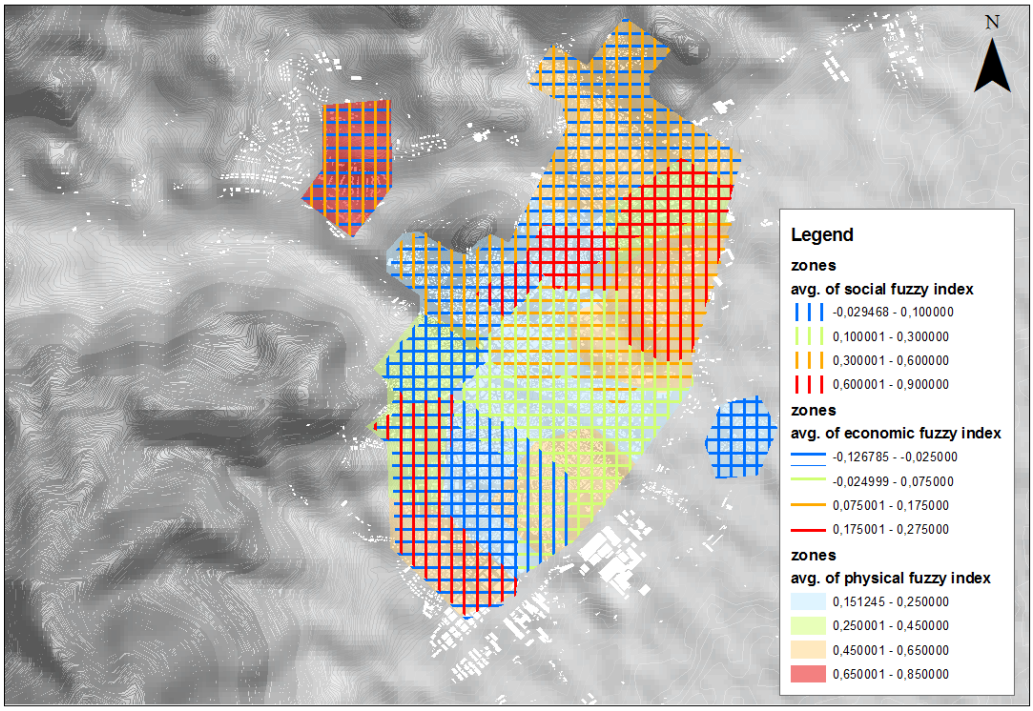
Map 2: The distribution of social indicators fuzzy index



Map 3: The distribution of economic indicators fuzzy index



Map 4: The distribution of physical indicators fuzzy index



Map 5: Comparison of all index values

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