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The Application of Fuzzy Logic in Social Science Research (A Fuzzy Analysis of Social Development in Tehran)

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Abstract: *The present research aimed to study the application of Fuzzy logic in social science research. In this regard, based on two variables, Social Capital and Quality of Life, the degree of Tehran's membership in the set of social development was studied using FSQCA software. This research was an applied and descriptive research methodologically; and extensive in quantitative parts and in-depth in qualitative parts. The statistical sample contained 920 residents and 10 experts in sociology who were respectively selected by using volume-related random sampling and purposive sampling methods. Questionnaire and semi-structured interview which had face validity were the instruments for data gathering. The reliability of the questionnaire was assessed by internal consistency. As an important finding of this research, the degree of Tehran's membership in social development set determined 0.4683. By inserting this degree of membership to the Fuzzy Logic Toolbox derived from experts' opinions, the degree of Tehran's membership in the set of social capital would be 0.50 in a range from 0 to 1.*

Keywords: *Fuzzy Logic, Social Science Research, Social Development, Tehran City.*

Introduction

In social science, using the theoretic knowledge of experts along with the data gathered from the survey in the analysis of social phenomena has long been utilized. But relating this knowledge which provides the researcher with qualitative data, to quantitative data requires researcher's personal abilities and this issue may affect the results of the analysis. Social scientists have brought up the use of qualitative data combined with quantitative data as a way to explain and predict social phenomena more accurately. The use of fuzzy methods enables the researcher to utilize both quantitative and qualitative data. Also related software allows the researcher to apply set analysis along with correlation analysis in order to clarify what could be missed or overlooked. Since social phenomena are complex, relative, and multifactorial to where instead of "direct and indirect relationships" it seems more appropriate to speak of "relationships network", considering this complexity is necessary. Posing realistic explanations and helpful solutions needs to utilize data from the survey and theoretical knowledge of experts (Ragin, 2008).

Fuzzy logic is known as a novelty in contrast with two-valued or binary logic. It argues that one element or component is the member of a set or not, but relying on fuzzy logic concepts, "the degree of membership" puts the two-valued logic away (Ragin, 2008; Zadeh, 1964). For instance a specific society is not addressed a developed society, but instead we speak about the extent of development or the degree of membership of that society in a set called "development". In addition, by putting the variables

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together which form a concept and making many sets out of these variables, the degree of membership of a component can be studied.
In this research, social development of Tehran city has been assessed and by using fuzzy-set concepts, its degree of membership in the set of social development was determined. Thus the main questions of present research are what is the degree of Tehran's membership city in the set of social development and how qualitative and quantitative data can be combined through fuzzy logic in order to reach an explanation of social phenomena, particularly social development.

Research Literature
In this part, first the basic theoretic framework of this research about fuzzy logic and social development is mentioned and then the conceptual model will be presented.

Fuzzy Logic
Lotfi A.Zadeh who has introduced fuzzy mathematics, fuzzy set theory and fuzzy logic in 1965, has defined a fuzzy set as follows:

> *A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is characterized by a membership (characteristic) function which assigns to each object a grade of membership ranging between zero and one. The notions of inclusion, union, intersection, complement, relation, convexity, etc., are extended to such sets, and various properties of these notions in the context of fuzzy sets are established. In particular, a separation theorem for convex fuzzy sets is proved without requiring that* the fuzzy sets be disjoint.

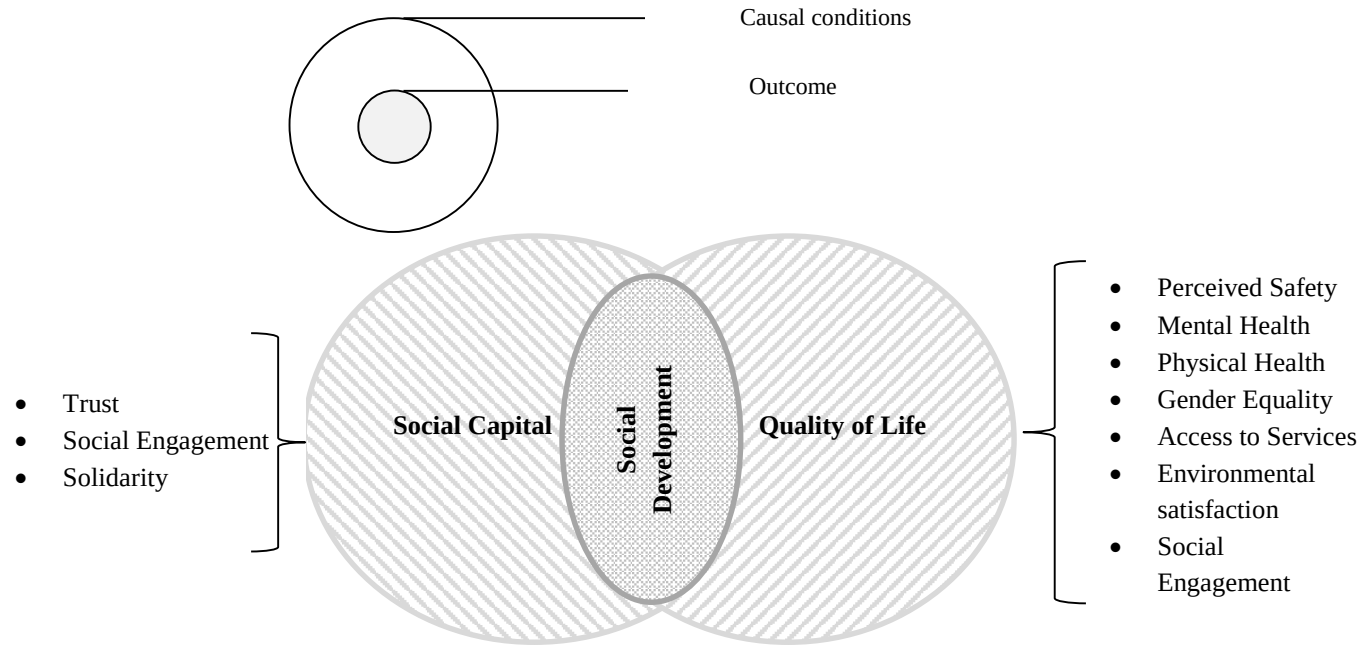
Fuzzy thinking seems to be an appropriate way of studying vague concepts which don't have one clear exact truth value. According to Zadeh (1972) "In general, complexity and precision bear an inverse relation to one another in the sense that, as the complexity of a problem increases; the possibility of analyzing it in precise terms diminishes."
Zadeh in Fuzzy Logic and Approximate Reasoning (1975) adds that fuzzy logic is A logic whose distinguishing features are (1) fuzzy truth-values expressed in linguistic terms, e.g., true, very true, more or less true, or somewhat true, false, nor very true and not very false, etc.; (2) imprecise truth tables; and (3) rules of inference whose validity is relative to a context rather than exact."

Social Development
Like many other concepts in humanities, the concept of development has various aspects and in social development area, this variation even multiplies. Some scientists and researchers believe that social development means infrastructural progress and evolution of institutions and organizations of the society in order to provide well-being for individuals. However nowadays simultaneously considering objective and subjective aspects has replaced paying attention to sole economic aspects and enhancement of quantitative measures. Among social development topics, measures like economic growth, Gross Domestic Production and per capita income aren't only criteria for a society's development and concepts like solidarity and social engagement (silver, 1994; li, pickles and savage, 2005), trust (li, pickles and savage, 2005), quality of life and social security (Costanza, 2008; Philips et al, 1994) are taken into account. Social progress index presented by social progress imperative is a comprehensive index which considers different aspects of development (economist, 2013).

Increase in people's capabilities and abilities in order to supply their welfare and development and evolution of society's institutions in order to meet people's needs in all levels especially lower levels are main concepts and goals of social development. There's a common opinion that following social development, relationships between people and social institution and resource use in society can be led to equilibration of qualitative and quantitative needs of society, and in this way there's a close relation between social development and social justice (Paiva, 1977). After documentary studies, "social capital" and "quality of life" were chosen as two variables which constitute social development.

Conceptual Model

Based on the research literature and fuzzy approach which considers not only relationships but also recognizes the membership degree of a component in a specific set relying on set theory, that is the membership degree of each municipal region in the set of socially developed regions, the conceptual model of this research is illustrated as follows:



(~Social Development) ⊂ [(~Social Capital), (~Quality of Life)]

Fig (1): Conceptual model

Research Hypotheses

Using fuzzy-set concepts hypotheses of present research are as follows:

1. Social capital is a necessary causal condition for social development.
2. Quality of life is a necessary causal condition for social development.
3. If social capital in Tehran is high and quality of life in Tehran is high, then social development in Tehran will be high.
4. If social capital in Tehran is high and quality of life in Tehran is medium, then social development in Tehran will be medium.
5. If social capital in Tehran is high and quality of life in Tehran is low, then social development in Tehran will be medium.
6. If social capital in Tehran is low and quality of life in Tehran is high, then social development in Tehran will be medium.
7. If social capital in Tehran is low and quality of life in Tehran is medium, then social development in Tehran will be low.
8. If social capital in Tehran is low and quality of life in Tehran is low, then social development in Tehran will be low.

Methodology

This research was a cross-sectional applied research and descriptive from the viewpoint of method and extensive in quantitative parts and in-depth in qualitative parts from the viewpoint of depth. The method of data collection was documentary research for studying and choosing variables of social development and their measures and fuzzy survey for gathering quantitative data. In qualitative part, based on interviews with 10 experts in social development area, the fuzzy logic toolbox was built.

First statistical population in this research was all residents of Tehran's 22 municipal regions who were above 15 which include 6248779 persons (Statistical Centre of Iran, August 2013). Another statistical population in this research was academic experts and specialists in social development area. Using calculation formula, sample size of the first statistical population was determined 920 persons by stratified random sampling method. By targeted sampling method for the second statistical population 10 experts in social development area were chosen and interviewed for building fuzzy conditions in Fuzzy Logic Toolbox.

The data collection tool in documentary research part was research notecards and in survey the tools were semi-structured interview a researcher-made questionnaire which its validity and reliability were tested respectively by face validity and internal consistency (Cronbach's alpha: 0.85). In this paper, all data are processed and represented in two forms: descriptive and inferential. In descriptive parts, sample and variables are described using frequency, percentage, valid percentage and mean calculated by SPSS and degrees of membership by MATLAB. In inferential part using fuzzy methods by MATLAB and fsQCA software research hypotheses are tested.

After determining the scores of all regions in terms of development, each region received a number between 0 and 1 which indicates its degree of membership in the set of socially developed regions. Fuzzy degrees of social development were determined by the values mentioned below:

Table (1): Different degrees of membership and their verbal labels

Degree of membership	Verbal label
0.99	Full membership
0.83	Mostly in
0.67	More in than out
0.50	Cross – over point
0.33	More out than in
0.17	Mostly out
0.01	Full non membership

After determining the degrees of membership of each region in the set of social development, correlation between membership in two sets of social capital and quality of life and the set of social development was studied by consistency and coverage evaluation. Research hypotheses were based on that the set of social development is a subset of social capital and quality of life sets. In addition to consistency and coverage evaluation conducted by fsQCA software, for testing the hypotheses of this research, the degrees of membership of each region in the sets of social capital, quality of life and social development were studied by MATLAB software. Moreover using results of interviews which formed the fuzzy logic toolbox, a fuzzy inference system was designed and extracted as "if-then" propositions, then inserted into MATLAB software.

Research Findings

4.88 percent of residents of Tehran were fully in the set of social capital and 10.04 percent of them were fully in the set of quality of life. Overall, residents of Tehran earned higher scores in quality of life indexes. Also 35.90 percent of the sample population of non-members in the set of social development is non-members in the set of social capital too. Frequency distribution and membership degree percentages of sample population are presented in the table below:

Table (2): Frequency distribution and membership degree percentages of sample in the set of social development

Social Development Variables	Full non membership	Mostly out	More out than in	Cross – Over point	More in than out	Mostly in	Full membership	Total (Percent)
Social Capital	35.90	8.07	11.60	10.73	17.08	10.30	4.88	100
Quality of Life	16.01	16.14	18.93	13.66	15.87	9.22	10.04	100
Social Development (Total)	25.95	12.10	15.26	12.19	16.47	9.76	7.46	100
	53.31				33.69			

The membership degree of Tehran's 22 municipal regions in the set of social development

Based on the means of social capital and quality of life variables, the membership degree of each region in the sets of social capital and quality of life, and finally in the set of social development were calculated using "min" and "prod" functions by MATLAB software and all of these quantities are presented in the table below:

Table (3): Membership degrees of Tehran's municipal regions in the sets of social capital, quality of life and social development

Region	Quality of Life		Social Capital		Social Development		Membership grade in the set of Social Development
	Mean 1 to 7	Membership Degree	Mean 1 to 7	Membership degree	Membership Degree calculated by Prod function	Membership Degree calculated by Min function	
1	3.99	0.4983	3.94	0.49	0.2442	0.49	3
2	4.1	0.5167	3.9	0.4833	0.2497	0.4833	5
3	4.26	0.5433	3.99	0.4983	0.2708	0.4983	1
4	3.37	0.395	3.75	0.4583	0.181	0.395	22
5	4.12	0.52	3.91	0.485	0.2522	0.485	4
6	4.14	0.5233	3.88	0.48	0.2512	0.48	8
7	3.52	0.42	3.84	0.4733	0.1988	0.42	17
8	3.93	0.4883	3.89	0.4817	0.2352	0.4817	7
9	3.62	0.4367	3.7	0.45	0.1965	0.4367	15
10	3.48	0.4133	3.8	0.4667	0.1929	0.4133	20
11	3.39	0.3983	3.69	0.4483	0.1786	0.3983	21
12	3.71	0.4517	3.79	0.465	0.21	0.4517	13
13	3.66	0.4433	3.96	0.4933	0.2187	0.4433	14
14	3.51	0.4183	3.59	0.4317	0.1806	0.4183	18
15	3.49	0.415	3.72	0.4533	0.1881	0.415	19
16	4.35	0.5583	3.98	0.4967	0.2773	0.4967	2
17	3.62	0.4367	3.97	0.495	0.2162	0.4367	16
18	3.81	0.4683	4.03	0.505	0.2365	0.4683	9
19	3.79	0.465	4	0.5	0.2325	0.465	11
20	3.93	0.4883	3.81	0.4683	0.2257	0.4683	10
21	3.89	0.4817	3.79	0.465	0.224	0.465	12
22	4.14	0.5233	3.9	0.4833	0.2529	0.4833	6
Mean	3.81	0.4683	3.85	0.475	0.2225	0.4683	

Region 3 with membership degree of 0.4983, region 16 with membership degree of 0.4967 and region 1 with membership degree of 0.4900 earned first 3 grades of membership in the set of social development and region 10 with membership degree of 0.4133, region 11 with membership degree of 0.3983 and region 4 with membership degree of 0.3950 earned last 3 grades of membership in the set of social development.

Necessary condition hypotheses test

In this section, two proposed hypotheses in the form of causal/sufficient condition were tested using fsQCA software.

The first hypothesis test

The first hypothesis of this study was "Social capital is a causal condition for social development in such a way that the fuzzy membership degree in the set of social development is a function of the fuzzy membership degree in the set of social capital". This hypothesis was tested relying on the standard curve and on the basis of consistency and coverage. Based on fuzzy theory, if data points are clustered below the line of best fit, the cause is accepted as the necessary condition (Ragin, 2000).

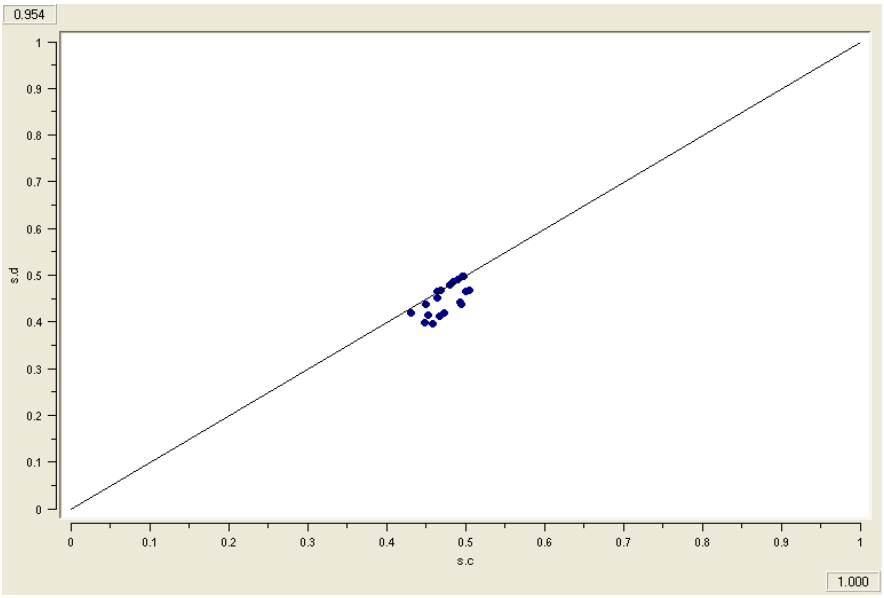


Fig (2): The scatter-plot of social capital and social development fuzzy scores dispersion

Refereeing to the specific characteristics of social phenomena such as being multidimensional, complex, etc., Ragin (2000) introduced a concept as Probabilistic Criteria. In this sense Ragin believes that in the study of human phenomena, all cases must not necessarily comply with algebra of sets and one or more cases of the violation cannot be the reason to revoke a necessary condition. Proposing the cut-off value, he believes terms such as "Almost Always", "Usually" and "More Often Than Not" can be used in the humanities. He has proposed three cut-off values - 50% (More Often Than Not), 65% (Usually) and 80% (Almost Always). For instance he states that in 22 cases similar to the present study that tested the necessary condition in 22 municipal regions with the cut-off value of 80% (Almost Always) and in the significance level of 0.05, 21 regions should follow subset relation of social development as a subset of the set of Social capital. In the table below, other cut-off values are shown at different significance levels.

Table (4): the number of consistent cases, required for accepting the probability test of necessary conditions

Criteria Values									
N	0.50			0.65			0.80		
	=0.10 α	=0.05 α	=0.01 α	=0.10 α	=0.05 α	=0.01α	=0.10 α	=0.05 α	=0.01 α
4	4	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...
22	15	16	17	18	19	21	21	21	22
...	...	...	...	...	...	...	...	...	...
30	19	20	22	24	25	28	28	28	30

(Ragin, 2000: pp. 114)

According to the table number 5 and the significance level of 0.01 with 99% confidence and the cut-off value of 0.80, the hypothesis that membership in the set of social capital is a necessary condition for membership in the set of social development has been maintained. In addition to hypothesis test, using the scatter plot and probabilistic criteria table, consistency and coverage assessment by fsQCA software provided some information.

Table (5): the causal analysis of the relation between the two sets of social capital and social development based on the necessary conditions

Analysis of Necessary Conditions		
Outcome variable: Social Development		
Social Capital Conditions tested:	Consistency	Coverage
	0.977214	0.984820

Experimental data indicating fuzzy set relation in the sets of social capital and social development suggests that the consistency index between these two sets is 0.984820. This value shows that 98% of the studied cases confirm the claim that social capital is a necessary condition for the social development. The coverage index between these two sets of social capital and social development is also 0.977214. This value shows the empirical importance of social capital for social development. Available evidence indicates that %97 of social development is covered by the social capital. So it could be concluded that in all Tehran's 22 municipal regions, the degree of membership in the set of social development is less than the degree of membership in the set of social capital.

The second hypothesis test

The second hypothesis of this study was "Quality of life is a causal condition for social development in such a way that the fuzzy set membership degree in the set of social development is a function of the fuzzy set membership degree in the set of quality of life." To test this hypothesis, consistency and coverage measurement and the standard curve were used.

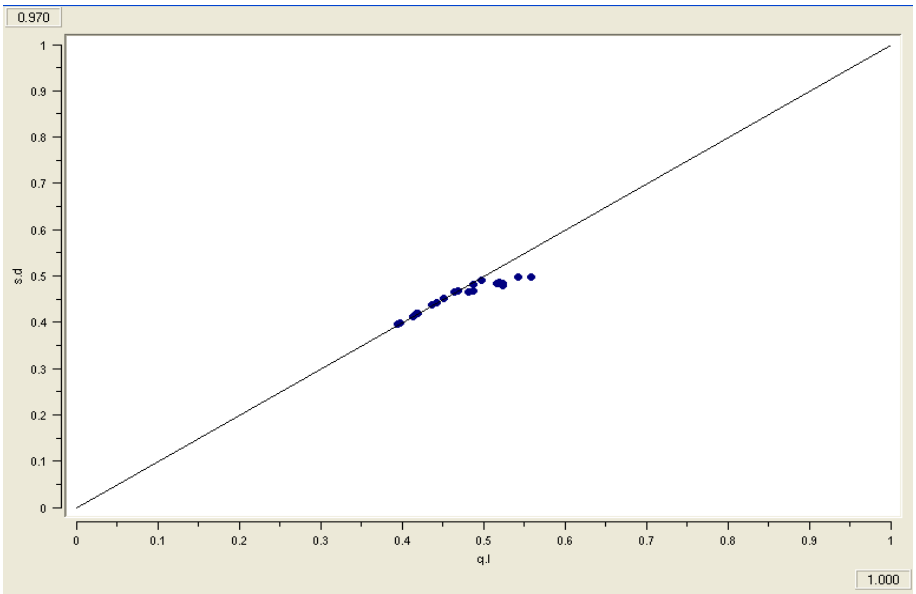


Fig (3): The scatter-plot of quality of life and social development fuzzy scores dispersion

The above scatter plot indicates that the density of the social development fuzzy values and the quality of life values is below the main diagonal of the scatter plot. According to available evidence, necessary condition hypothesis can be accepted and it can be stated that fuzzy membership degree in the set of social development is a subset of fuzzy set membership degree in the set of quality of life.

Table (6): the causal analysis of the relation between the two sets of quality of life and social development based on necessary condition

Analysis of Necessary Conditions		
Outcome variable: Social Development		
Quality of Life Conditions tested:	Consistency	Coverage
	0.976688	0.984985

Empirical cases exhibiting fuzzy set relation in the sets of quality of life and social development suggest that the consistency index between the two sets is 0.976688. This value shows that 97% of the studied cases confirm the claim that quality of life is a necessary condition for the set of social development.
The coverage index between the two sets of quality of life and social development is also 0.984985. This value shows the empirical importance of quality of life set for the set of social development. Available evidence indicates that 98% of the social development set is covered by the quality of life set. Thus the set of quality of life as a causal condition covered 98% of the membership of total result.

If-Then Hypotheses Test

In order to test the third to eighth hypotheses which were proposed in the form of if-then proposition, 33 conditions were established at first using material resulted by interviews with experts. The conditions are presented in the following table:

Table (7): Summarization of fuzzy conditions for defining the Fuzzy Logic Toolbox

Condition	If			Then
	Social Capital	Operator	Quality of Life	Social Development
1	high	and	high	high
2	high	and	medium	high
…	...	…	...	...
33	low	and	high	low

The above propositions can be considered as input to Fuzzy Inference System. For each of the concepts -social capital, quality of life and social development, there's a code, for each code there are three sets and for each set there's one code defined. The mentioned cases are presented in the table below:

Table (8): fuzzy sets for the input concepts and defined codes

Codes	Fuzzy sets
S.C. (Social Capital)	Low
	Middle
	High
Q.L. (Quality of Life)	Low
	Middle
	High
S.D. (Social Development)	Low
	Middle
	High

After selecting the code and the fuzzy sets for each concept used in this research, the proposed conditions were inserted into the fuzzy logic toolbox. Set intersection which is an associative operation, was used as the functional operator and triangular-shaped membership function was used to define the fuzzy sets for input and output variables of fuzzy inference system. The degree of membership in a fuzzy set based on triangular-shaped membership function was calculated using the following formulas:

$$trimf(x,a,b,c) = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ \dfrac{c-x}{c-b}, & b \le x \le c \\ 0, & c \le x \end{cases}$$

The cut-off values of the parameters a, b and c which were also the calculation criteria for social capital, quality of life and social development variables in MATLAB software, are given below:

Table (9): Default values for triangular-shaped function parameters of 3 fuzzy sets, low, middle and high

Social Capital, Quality of Life and Social Development Fuzzy sets	Parameters		
	a	b	c
Low	-0.4	0	0.4
Middle	0.1	0.5	0.9
High	0.6	1	1.4

The stated hypotheses in the form of if-then propositions and the results are presented in the table below:

Table (10): If-then hypotheses and the results with regard to the fuzzy logic toolbox

Hypothesis	Functions	Degree of Tehran's membership in the sets of social development			Result
		Low	Middle	High	
If social capital is **high** and quality of life is **high**, then social development is **high**	$b \le x \le c \Rightarrow \frac{c-x}{c-b}$ $\mu_{Middle}(0.613) = \frac{0.9-0.613}{0.9-0.5} = \frac{0.287}{0.4} = 0.7175$ $a \le x \le b \Rightarrow \frac{x-a}{b-a}$ $\mu_{High}(0.613) = \frac{0.613-0.6}{1-0.6} = \frac{0.013}{0.4} = 0.0325$	Zero	0.7175	0.0325	Rejected
If social capital is **high** and quality of life is **middle**, then social development is **middle**	$b \le x \le c \Rightarrow \frac{c-x}{c-b}$ $\mu_{Middle}(0.613) = \frac{0.9-0.613}{0.9-0.5} = \frac{0.287}{0.4} = 0.7175$ $a \le x \le b \Rightarrow \frac{x-a}{b-a}$ $\mu_{High}(0.613) = \frac{0.613-0.6}{1-0.6} = \frac{0.013}{0.4} = 0.0325$	Zero	0.7175	0.0325	Accepted

Hypothesis	Functions	Degree of Tehran's membership in the sets of social development			Result
		Low	Middle	High	
If social capital is **high** and quality of life is **low**, then social development is **middle**	$b \le x \le c \Rightarrow \frac{c-x}{c-b}$ $\mu_{Middle}(0.5) = \frac{0.9-0.5}{0.9-0.5} = \frac{0.4}{0.4} = 1$ Or $a \le x \le b \Rightarrow \frac{x-a}{b-a}$ $\mu_{Middle}(0.5) = \frac{05-0.1}{0.5-0.1} = \frac{0.4}{0.4} = 1$	Zero	1	Zero	Accepted

If social capital is **low** and quality of life is **high**, then social development is **middle**	$a \le x \le b \Rightarrow \frac{\mathrm{x}-\mathrm{a}}{\mathrm{b}-a}$ $\mu_{Middle}(0.387) = \frac{0.387-0.1}{0.5-0.1} = \frac{0.287}{0.4} = 0.7175$ Or $b \le x \le c \Rightarrow \frac{\mathrm{c}-\mathrm{x}}{\mathrm{c}-\mathrm{b}}$ $\mu_{LOW}(0.5) = \frac{0.4-0.387}{0.4-0} = \frac{0.13}{0.4} = 0.0325$	Zero	0.7175	Zero	Accepted
If social capital is **low** and quality of life is **middle**, then social development is **low**	$b \le x \le c \Rightarrow \frac{\mathrm{c}-\mathrm{x}}{\mathrm{c}-\mathrm{b}}$ $\mu_{Low}(0.13) = \frac{0.4-0.13}{0.4-0} = \frac{0.27}{0.4} = 0.675$ $a \le x \le b \Rightarrow \frac{\mathrm{x}-\mathrm{a}}{\mathrm{b}-\mathrm{a}}$ $\mu_{Middle}(0.13) = \frac{0.13-0.1}{0.5-0.1} = \frac{0.03}{0.4} = 0.075$	0.675	0.075	Zero	Accepted

Hypothesis	Functions	Degree of Tehran's membership in the sets of social development			Result
		Low	Middle	High	
If social capital is **low** and quality of life is **low**, then social development is **low**	$b \le x \le c \Rightarrow \frac{\mathrm{c}-\mathrm{x}}{\mathrm{c}-\mathrm{b}}$ $\mu_{Low}(0.13) = \frac{0.4-0.13}{0.4-0} = \frac{0.27}{0.4} = 0.675$ $a \le x \le b \Rightarrow \frac{\mathrm{x}-\mathrm{a}}{\mathrm{b}-\mathrm{a}}$ $\mu_{Middle}(0.13) = \frac{0.13-0.1}{0.5-0.1} = \frac{0.03}{0.4} = 0.075$	0.675	0.075	Zero	Accepted

Combining experimental data and fuzzy logic toolbox

In this phase of the research, the membership degrees of Tehran's residents in two sets of social capital with a membership degree of 0.4750 and quality of life with a membership degree of 0.4683 were obtained by using questionnaires and a sample containing 920 residents of Tehran. Then the two degrees of membership were inserted to the fuzzy logic toolbox, which was made based on interviews with experts in social development area, to determine the membership degree of Tehran's residents in the set of social development considering their present status of membership in two sets of social capital and quality of life.

The findings of this study suggested that in the current situation of Tehran, with Tehran residents' membership degree of 0.4750 in the set of social capital and membership degree of 0.4683 in the set of quality of life, according to experts will lead to a membership degree of 0.5 namely "middle" in the set of social development.

Discussion and Conclusions

The results of this study showed that variables such as social participation, solidarity and trust are of great importance as concepts which have direct relationship with the residents and their interactions and with the society structure. Also quality of life which was measured by variables such as perceived safety, physical health, mental health, environmental satisfaction, gender equality, access to services and social engagement -in both the formal and informal forms, was not desirable. It indicates low quality of life of the people who should be effective on social progression. Numerous theories have been proposed in the importance of social capital and quality of life as effective variables in development. Although some of them have not directly referred to the concept of social development, but indexes proposed by them can be considered as social development indexes. Among them, emphasizing on the elimination of inequality in society by Dudelly (Kalantari, 2009), mentioning poverty reduction, citizens' access to facilities by Mirdal and emphasizing on the coordination of institutions and organizations in society in line with meeting the citizens' demands by Todaro (Azkiya & Ghafari, 2008) can be mentioned.

In the present research which fuzzy approach was used to study social development concept, focusing on relations among variables is replaced by determining the membership of the regions in related sets. In other words, unlike usual methods in the field of social science that seek to explore the correlation of x and y in order to explain the amount of variance in y by x, fuzzy approach seeks to explain differences among groups in the amount of the dependent variable, etc. This study was after determining the degree of membership of each studied case in the target set. Therefore, the hypotheses were designed in accord with set theory principals to discover if social capital and quality of life are causal conditions for social development or not.

Relying on the presented information, it can be mentioned that the degree of Tehran citizens' membership in the set of social development was not satisfactory with a membership degree of 0.4683. This indicates that Tehran citizens' membership in the set of social development was below the cross-over point. Among the indexes of social capital, social engagement with a membership degree of 0.20 had a more inappropriate status compared to solidarity and trust, so citizens of Tehran were largely out of the desired set. It should also be noted that Tehran citizens' degree of membership in the set of subjective engagement was much higher than their degree of membership in different aspects of objective engagement set. It shows that citizens are more endowed with the context of mentality in comparison with practical collaborative activities in the city, neighborhood, etc. The importance of social engagement in realization of development has been underlined. For instance William Reuben (2003) in a document published by World Bank declares that "the dynamic relationship between civil society and the state sets the basic conditions of governance. This relationship, which is in essence contradictory, can become symbiotic and crucial to achieving good governance and sustained development."

The results of the study on indexes related to quality of life measuring Tehran citizens' degree of membership in the set of quality of life were lower than middle level (0.5) and this indicates poor situation in all 22 municipal regions of Tehran in terms of quality of life. Furthermore by analyzing the results of two mentioned tests of necessary condition, in which social capital and quality of life were assumed as causal conditions for realization of social development in 22 municipal regions of Tehran, coverage of the set of social development by two sets of social capital and quality of life was determined. The coverage assessment showed that the two sets of social capital and quality of life had covered respectively 97.72 percent and 98.84 percent of the set of social development. Although these numbers indicate these two sets of social capital and quality of life covered the set of social development similarly, the coverage of the set of quality of life is more than the coverage of the set of social capital and it shows the importance of it.

According to Paiva's theory, in which social development is people's capacity and ability to act constantly for their and society's welfare, and regarding to the indexes of quality of life in this research, it can be concluded that realization of social development in all municipal regions of Tehran will not happen unless the citizens are mentally and physically healthy, have access to urban facilities, are satisfied with the environment, have perceived safety to an extent that provides achievements and provide social engagement and participation.

The indexes of quality of life as indicators for realization of social development can be also noted in many documents. For example the United Nations Commission for Social Development refers to quality of life in the form of indexes such as education, employment, health, housing, etc. (UNSD, 2013), the United Nations Educational, Scientific and Cultural Organization emphasizes on empowerment and upgrading of living conditions (UNESCO, 2013), the Social Progress Imperative divided the social progress index to basic human needs, foundations of wellbeing and opportunity (SPI, 2013), Azkia and Ghaffari underscore achieving higher standard of living in order to eradicate poverty, increase health, housing, employment, etc. (Azkia & Ghaffari, 2008).

In another part of the study, the knowledge of ten social development experts was used to build a fuzzy logic toolbox by MATLAB software. Then hypotheses in the form of if-then propositions were presented. According to the formulated conditions in fuzzy logic toolbox based on experts' opinions, if the citizens' degree of membership in two sets of social capital and quality of life is high, then the Tehran is a member of the middle set of social development, which is the highest degree of membership. It means that even if these two variables are high in Tehran, there are other factors that affect social development of Tehran. Other hypotheses in this part of research were maintained. Therefore it can be concluded that the Fuzzy Logic Toolbox which was made of interviews with experts was consistent with the proposed hypotheses and confirmed them.

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