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Research Article

Application of Fuzzy Set Theory and SPOT Satellite Images in Site Selection of Public Libraries (Case Study: Saqqez City, Iran)

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Abstract: Easy availability to public libraries is one of the main keys in successful presentation of public library services with high quality will be valueless for those have not access to them. Availability to services should be configured in such a way that maximizes easiness and facility for potential and de facto users. In present research the required number of public libraries and establishment situation of public libraries in Saqqez city in Kurdistan province in North West of Iran were investigated and evaluated by using fuzzy set theory and SPOT 5 satellite images in 2009. In addition, optimum regions for generation of new public libraries were distinguished in city area in form of recommended map. Results showed that weighting variables classes were determined between 0-1 (profusion proportion). Fuzzification each one of effective factors using IDRISI software terminated and after was assigned type and shape membership function. Final map of suitable regions for construction of new public libraries in saqqez city area indicates that none of the libraries were situated in suitable regions.

Keywords: Adjustment, centralization, fuzzy set theory, GIS, public libraries localization, Saqqez

INTRODUCTION

Libraries manifest a community's intellectual and cultural identity. They are a place for learning and a repository for a community's past. A Public library is an institution working with the public and it is responsible to serve all people of society with books. In order to fulfill this responsibility towards the public, all people in charge of book and bibliography must provide conditions by which public libraries could serve maximum people (Shia, 2003).

Finding the proper site for a library is contingent upon understanding whom the library might be serving. Considering to establishment place of libraries in vicinity of overcrowded places, museums, cultural places and mosques may play an effective role for increase of returnees. On the other hand, position of libraries in vicinity of incompatible labor intensities such as highways, railroads, airports and etc., may decrease efficiency and reference to them (Abazari *et al*., 2012).

From city planning view, public libraries are considered the most important cultural establishment in the cities and need more and special attention. In big cities, that infrastructure establishments were created in different generations, city establishment's development makes new difficulties in the city. These cases are not much problematic in not very big cities, but more the population rate and cities and establishments extensity increase, needing a planning is sensed more than before, considering such these problems, not only decrease city difficulties, but also causes reduction of costs totally and as a result, decrease the pressure on citizens and causes decrease of municipals and governmental systems financial load (Shia, 2003).

Nowadays, according to increase of demand for informational services, it is necessary to use modern techniques which are effective for facilitating fulfill of demands. One of the criterions which can play the main role in educational- cultural servicing is the correct place of each library and the manner of alighting it according to other city elements (Rostamy, 2001). So, public libraries, like other city labor intensities, require special attention to principles and Rules of correct localization. Services with high quality will be useless for those who have not access to them. Availability to services should be configured in such a way that maximize easiness and facility for potential and

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defector users. Gill (2000) correct localization is one of the factors that facilitates access level and provides possibility for each person in the society. In recent years, we have observed numerous researches about localization of city services through GIS models in site selection of public libraries.

Hamplet University (1997) in Germany used a fuzzy model to analyze lands' suitability for construction. Priorities are determined by different levels of suitability, number 1 being the most suitable land and number 5 the least suitable. Outstanding of fuzzy analysis is that no result is achieved but optimistic and conservative assumptions are considered (Tehran Geographic Information Center, 1996). Mehrandish (2001) considered current position of educational spaces in the 17th district of Tehran according to current standards and criteria and finally presented some propositions and models for establishment of educational spaces. Important point in this research is the usage of GIS software for displaying dispersion of educational spaces on the map of this district. Zangi (1992) investigated the situation of public libraries and access to them in Kerman city. He localized the presents and future public libraries in Kerman city by using Geographical information station. Rangzan *et al*. (2009) localized public libraries of Ahvaz Township by using geographical information station models and hierarchical analysis and fuzzy logic. The present research will investigate and evaluate the present situation of public libraries establishment place in Ahvaz city with localization components super impossibly and represent consistent and incompatible regions in form of syncretistic maps. In addition, according to localization components, this research recommended some regions for construction new public libraries in city area. The main goals of current research are as below:

- Determination of conformity between location of public libraries and centralization consistency factors in current location or future.
- Determination of best sites for site selection of public libraries in Saqqez city.

STUDY AREA

Saqqez city is located between 46°13'-46°16' eastern longitude and 36°11'-36°15' northern latitude within north-west of Kurdistan province in northwest of Iran and covers of approximately 1474.8 ha. At the 2006 census, the city's population was 135037, whereas its current population is about 145000. Building area was 618.26 ha. The average elevation of the city is about 1496 m above mean sea level. Saqqez is characterized as a mountainous area which is located within Zagros Mountains rages from south-east to north-west. This area comprises about 15.5% of Kurdistan province. The difference of height between the highest elevation point (Chehel-Cheshme mountain, 3173 m and Simineh-Rood basin, 1150 m above mean sea level) is about 2023 m. Saqqez river (Chom Saqqez) emanates from western mountains (Gardaneh Khan) and continues its path across the city toward north-east. Fig. 1 shows location of study area in Kurdistan province, Iran (Shahabi *et al*., 2012a).

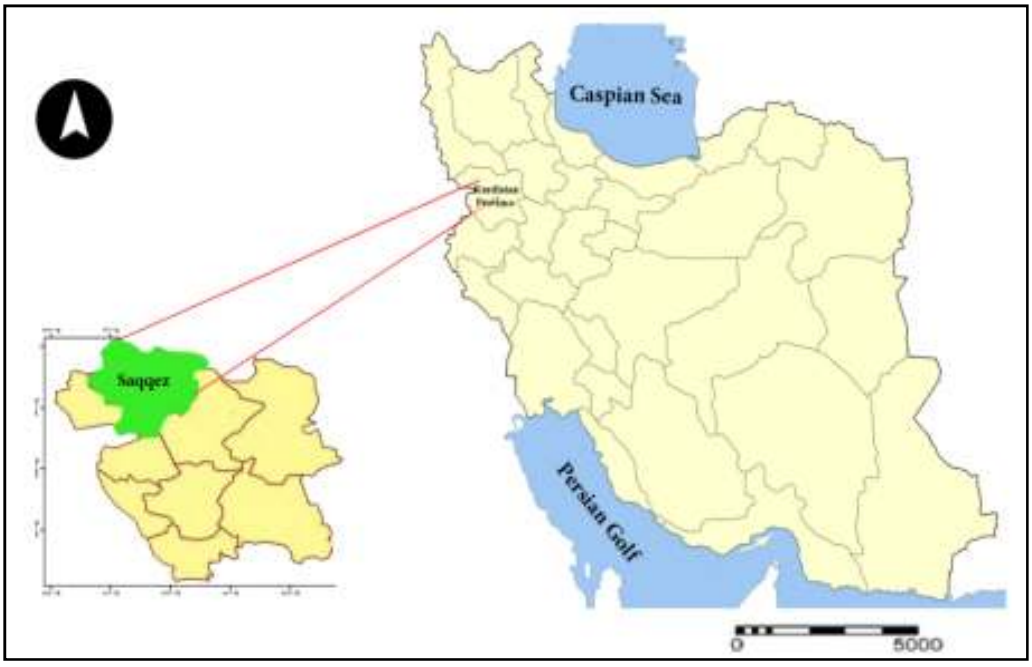

Fig. 1: Geographical location of study area

Table 1: Hierarchical structure of criteria and relevant weights

Consistency	Weigh of criteria	Consistency criterions	0.5	Security rate	0.36
	0.34			Distance to police stations	0.33
				Distance to fire stations	0.31
		Inconsistency criterions	0.5	Distance to playground	0.719
Centralization	Weigh of criteria	Accessibility	0.43	Distance to river	0.281
	0.66	Distance from urban utility	0.04		
		Population density	0.41		
		Distance to crowded centers	0.12		
				Distance to park	0.03
				Distance to schools	0.09
				Distance to culture	0.13
				Distance to religious cultural center	0.51
				Distance to mosques	0.26
				Distance to Govemmental office	0.15

MATERIALS AND METHODS

Statistical information was collected from the Iran Statistics Center and Saqqez Municipality and population diagrams were prepared. Dispersion for libraries distribution in the city and its reflection on maps were considered using observation and field study. All uses with positive and negative effects on library were determined using consistency matrix (Pourmohammdi, 2003). It was also determined that a subset of each main criteria is centrality or consistency. The GIS land use layer of Saqqez Municipality was updated using other maps and SPOT satellite images of 2009 were used. All required maps were designed for centralization and consistency criteria using updated GIS layer and the weight of every layer was calculated by hierarchical analytic method. Then results were accommodated with characteristics of saqqez city layers.

In stage of conflating informational layers and extracting final map, after weighting and valuation of each basic and secondary components which are effective in localization of public libraries, layers conflation process was done by weighted overlay method and final map was provided. Because the principle components have other subcomponents in conflation of layers according to the components hierarchy, first lower levels components were conflated in order to distinguish cooperator layer in conflation of higher levels components.

For example, centrality component includes 4 subcomponents of availability, vicinity to city establishments, population density and neighboring with overcrowded centers. Now, component of neighboring with overcrowded centers includes subcomponents of park, schools, cultural houses, mosques, governmental offices, for providing centrality map, first all the components necessary for providing map of neighboring with overcrowded centers were conflated together, then all the higher levels layers were prepared and their conflation, led to providing centrality map (Table 1).

In providing centrality map after weighting all the components in it, considered layers were conflated together and final map was provided with high flexibility. In providing consistency map, consistency components such as consistency and inconsistency land uses were considered. First map of consistence regions was provided by applying weighting each components in it. In next stage, map of inconsistence regions was provided without applying weighting. It means that all the effective components were providing separately and map of inconsistency land uses were important equally and it was necessary to prevent from neighboring library with these centers as much as possible.

For overlapping and analysis of GIS layers, the fuzzy method was used. Basic criteria intended in this research are centralization and consistency. These factors are mentioned in a handbook by Padilla (2002) is published by the Institute of American Architects (Masoumi, 2003). All layers regarding their weights were consolidated together in final map. All areas on the map were categorized according to conditions for the construction of libraries. Finally, it was determined that which library was in a better location than other libraries.

Fuzzy logic: Fuzzy logic is a superset of conventional logic that has been developed to handle the concept of partial truth- truth values situated between ‘‘completely true’’ and ‘‘completely false’’. The fuzzy sets theory was first proposed by Zadeh (1965) of University of California, Berkeley, in the 1960’s, as a means to model the uncertainty within natural language. The fuzzy logic method allows for more flexible combinations of weighted maps and could be readily implemented with a GIS modeling language (Shahabi *et al*., 2012b).

The fuzzy-logic method allows flexible combinations of weighted maps derived from any measurement scale. Given two or more maps with fuzzy-membership functions for the same set, five fuzzy operators, namely:

- Fuzzy-OR
- Fuzzy-AND
- Fuzzy algebraic sum
- Fuzzy algebraic product
- Fuzzy-gamma, can be employed to combine membership values. A script can be written in GIS

to employ this method. Fuzzification each one of effective factors using IDRISI software terminated and after was assigned type and shape membership function.

RESULTS AND DISCUSSION

Those libraries located in shielding limit of saqqez city and at present. There are 4 public libraries in saqqez city area. Public libraries number 1 and 2 are active in city area, but public library number 3 and municipal library (library number 4) are localized but didn't begin their activity yet.

Determination of localization criterions and their pre parathion: Localization indexes of libraries are divided to two group: centralization and consistency, that in localization process of public libraries in saqqez city, these two indexes were considered each of two mentioned components include subgroups which are separated as follow: Zareii (2011).

Centralization: Centralization is one of the main indexes for localization of public libraries, that it is formed from following criterions:

Accessibility: For determination of rate and accessibility to public libraries in saqqes city, data related to public transportation routes were collected by using map of land using in saqqez city, then these data were up to dated by using SPOT satellite images of saqqez city in 2009.

Distance from urban utility: Public libraries should be established in regions with highest population rate. On this basis, the number of population in each 6 districts of saqqez municipal provided by using census results of 2006. In which population in future 10 years was predicted. Then for identifying co-density points, at first stage, localization map city was provided, then population characteristics of city was added.

Population density: Required data in this section were provided by using land use information in saqqez city, then up to dated by using SPOT satellite images of 2009 and also audit design of saqqes city and their segregate map was provided.

Distance to crowded centers: Libraries should be established in neighboring of overcrowded centers as much as possible. Overcrowded centers means that, those centers include numerous people, in this research overcrowded center include parks, schools, culture house, mosques and governmental offices. First situation of each land uses was provided by using land use map in broad map of saqqez city. Then new information's were added by using enumeration design and satellite image. Finally, according to collected data, segregate maps of each overcrowded center provided in software environment of Arc GIS.

Consistency regions: In this research, consistency regions including police stations (for providing outside security) and fire stations (for providing security in the library when fire starts) are compatible for library construction in their vicinity is recommended. local situation of police stations and fire stations of city, was determined by using enumeration design and map of land use in saqqez city and their layering maps was provided in software environment Arc GIS.

In this consistency, the situation of public libraries are measured and evaluated in comparison with other neighboring centers. From planning view, some land uses are inconsistency and these land uses shouldn't be with other and the place of establishing public libraries should be in border of consistency land use. In this study, consistency component can be divided in two groups of consistency criterions and inconsistency criterions.

On the basis of last country census in 2011, population of saqqez is 133331 people (Iran Statistics Center, 2006) according to population increase, Now this city has 2 active libraries and two inactive libraries.

In some small cities that structurally and city morphology, extended along river, road, coast and valley or constructed in mountain foot two sides of river, presence of only one library doesn't provide availability for their all population. For this reason it is necessary to build two or three smaller libraries in proper situations in order to provide accessibility for all the population (Ashrafy, 2009). For this point of view because this city is located in mountain feet and two sides of river, besides these for libraries, some other libraries are require in other proper situations.

Inconsistency regions: In localization of public libraries, Inconsistency land uses including all land uses that cause sound pollution and also are up setter of other effective components activities in libraries localization. In present research, most inconsistency are because of effective sound pollution land uses such as playgrounds and River were considered as inconsistency land uses in providing segregate maps. Data related to each above land uses were collected from aforementioned sources. In this research, centrality map of four public libraries in saqqez city was obtained by inflation of four components "city transportation lines", "population distribution", "Distance to crowded centers" and "Distance from urban utility" (Fig. 2).

Establishment place of each public quadruple libraries in saqqez city, as indicated in Fig. 2, was illustrated with number and mark (+) in every six area of city. Bright area on the map indicate points with

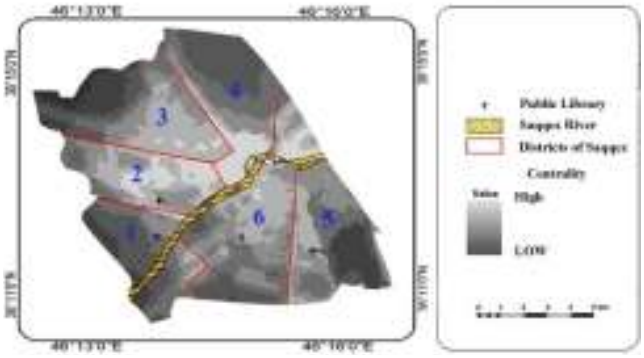

Fig. 2: Centralization of public libraries in Saqqez city

Table 2: Population information of Saqqez city in 1996 to 2016 (Consulting Engineers of Naghsh Pyravsh, 2006)

Divisions	Are	Population of 1996	Population of 2006	Residential Area	Number of households 2006	Gross density 2006	Net Density 2006	Population estimate 2016
District 1	179.56	13427	13427	43.73	3570	75	307	5150
District 2	183.92	24700	23599	59.6	5686	128	396	27500
District 1	363.48	40954	37026	103.37	9256	102	358	49150
District 3	372.53	38965	46127	116.99	10792	124	394	54500
District 4	211.07	9637	13262	34.91	3056	63	380	20000
District 2	583.61	48602	59389	151.90	13848	102	391	74500
District 5	311.36	18103	20224	40.01	4357	65	505	34000
District 6	274.92	7735	14710	41.81	3406	54	352	20500
Region 3	586.28	25838	34934	81.83	7763	60	427	54500
Total	1533.27	115394	131349	337.10	30867	85.66	389.64	178150

most and highest adaption rate and with four components of centrality. With little hesitation, in Fig. 2 we find that among four aforementioned libraries, none of them were placed in white regions (regions with high centrality). Libraries 2, 3, 4 are placed in areas with relative centrality. Library number 2 have a lack of library area for study, lack of sources lack of table and chair, having not software for searching sources. These difficulties affect on lack of users reference to library. Libraries number 3 and 4 with-relatively good centrality, did not start up yet on the other hand, library number 4, because it is located in the park during summer and peak of activity in the park and play round, is crowded. Library number 1 as a central public library, is active but is not desirable from centrality view. In spite of the fact that population distribution is considered one of the very important indexes in all the localization processes and also in spite of the fact that region 3 of saqqez city has the population density rate, comparison of population layers and centrality map of saqqez city indicates that none of these four public libraries in this city, regions 3, were not established and this subject represents inequality between public libraries distribution and city population distribution. Whatever, investigating layers related to overcrowded centers, such as parks and mosques, indicates that in localization of public libraries in saqqez city, two criterions “distance to park” and “distance to mosques” were considered, because most of the public libraries were located in regions with most number of parks and mosques (Table 2).

Consistency and Inconsistency of local situation of public libraries: In Fig. 3, situation of public libraries in saqqez city in relation with consistency and inconsistency regions was illustrated. The main point of aforementioned map is considering the present difference between consistency region and inconsistence situation. Sometimes a library may be located in consistency region in aspect of adaption with consistence components. But the same library, may not be located properly because of lack of attention to inconsistency land uses and may have improper situation because of neighboring with inconsistency land uses. So consistency regions in present research, is not equal with consistency situation. For example as indicated in Fig. 3, library number 4 in aspect of equality with consistency criterion, was located in completely consistence region (black region) but, the same library, on bases of Fig. 3, because of neighboring with playground, was discriminated inconsistence.

Fire stations and police stations are a class of land uses that provide internal and external security of libraries considerably, respectively library was always exposed to risk because of having ample fuel sources. In spite of the fact that, standard interval for on time servicing of fire stations is 5 min, investigating map inflating limited servicing layer of stations and public libraries limit showed that libraries numbers 1 and 2 are placed in 5 min front of fire stations, but libraries number 3 and 4 are not in this limit and libraries in vicinity of disciplinary police stations have desirable situation. In maps investigation, we result that libraries number 1 and 2 (Active libraries) are in vicinity of river

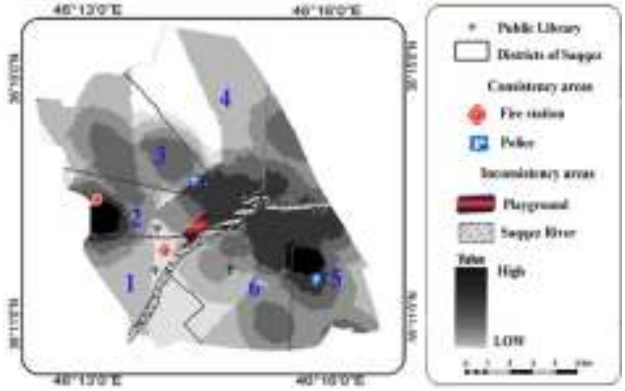

Fig. 3: Compatibility of public libraries in Saqqez city (Consistency and inconsistency land uses)

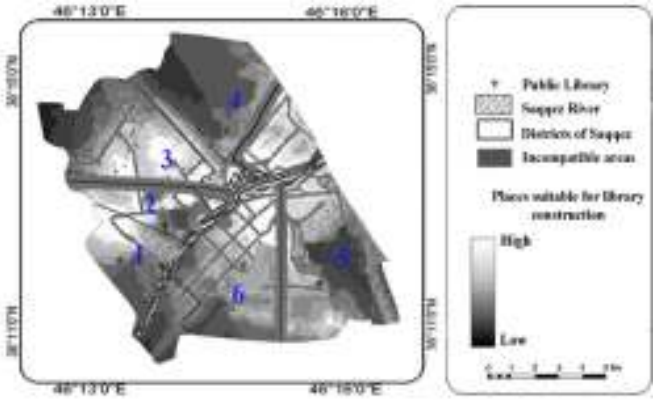

Fig. 4: Recommended suitable regions for construction modern public libraries in Saqqez city

that river is one of the inconsistence criterions in /localization of libraries.

Recommended regions for construction of modern public libraries: Recommended regions were discriminated on basis of centralization and consistency criterions and considering inconsistence criterions. Figure 4 indicates recommended suitable regions from inflation of centralization and consistency maps (with figuration of inconsistence limits). As shown in Fig. 4, white limits, indicated on map, in aspect of localization, were discriminated suitable for construction modern public libraries. It is considerable that, cloudiness of city limits on the map increase, credit and ranking regions for construction modern libraries decreases. Whit little hesitation we see that in final map of public libraries, none of the libraries are located in recommended regions. Libraries number 3 and 4 are placed relatively in white region but as mentioned before, these libraries are not active now.

CONCLUSION

The fuzzy logic approach used in this research provides a flexible method with which to include an expert's opinion in developing an inference network. The variety of fuzzy operators enables the expert to examine different combinations and produce an intermediate map, or add any new data layer to the model and to test its affect on the final possibility map. In present research, the number of required libraries and also situation of public libraries in saqqez city in from of two criterions, centralization and consistency and by using GIS models and SPOT satellite images were investigated and evaluated. Research results showed that according to mountainous position and having river n saqqez city, in addition to present libraries, some other numerous libraries should be established. Findings showed that lack of considering establishment place of consistence and inconsistence land uses caused that libraries of this city in aspect of establishment and not establishment region, not place in proper situations. In spite of the fact, region 3 of saqqez city, has the most population density, but no libraries were located in this region. Investigations showed that of all 4 libraries, only two cases are in 5 min front of fire station. Final map of suitable regions for construction of modern public libraries in saqqez city area shows that none of the libraries are located in suitable regions.

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