



GIS - based evaluation of Public Libraries locations for more sustainable building site selection (An Iranian experience)

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Abstract:

The main objective of this study is to examine the location of public libraries located in Four Region of Tehran, in terms of centrality, compatibility criteria, and sustainability so as to offer more suitable locations for the new libraries to be constructed.

The data in the Research base were collected by means of GIS (geographical information system). According to predetermined criteria, maps were prepared separately. And on the basis of their overlap, the existing libraries were evaluated. Also, on the final map, some appropriate locations for the new libraries to be established were proposed.

After the review and calculations, it was determined that existing libraries have a high rate of relative fit with the centrality criterion and factors related to compatibility, although they are not in desirable conditions in terms of sustainability. From the GIS data it can be observed that most libraries are not built in green areas. So the existing libraries do not have appropriate geographical distributions from this point of view. According to the considered criteria, there are better opportunities for library constructions in these areas, marked white in the final map. With the construction of libraries in these locations, deficiencies can be compensated.

Keywords: *Public libraries, Site selection, Hierarchical analysis, GIS, Sustainability*

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With the Fourth Five-Year Plan under consideration, Tehran Four Region suffers from a shortage of libraries. So with an eye on the need for building libraries in these areas, it is important to determine appropriate locations in advance of starting construction, locations that possess the required merits, with respect to the criteria of centrality, compatibility and sustainability. It is also necessary that libraries which are among the most important public buildings be kept as sustainable buildings. This important consideration is necessary for building more libraries in more regions, and this can be done thanks to the help of GIS data. Building libraries in green areas is more sustainable since they will increase the efficiency of both library and users, as this provides a suitable location for using renewable energy sources. Moreover, in this case public libraries could be a role model for other public buildings.

Introduction

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). One of the main conditions for optimal service of libraries, is the location of the library in terms of distance and timesaving as well as environmental condition; these are often ignored factors, usually causing many problems for citizens. In megacities where usually there are problems of inter-city traveling, such as heavy traffic and pay of high cost of such traveling, the optimal location and layout of libraries in different points of the city, together with preventing the concentration of libraries in certain areas of the city may help people in reaching a good library.

Local features of the library are very important and research shows that place is an important factor for users and optimal location increases usage of library by users (Dehdari Rad and Didgah, 2008). The library could create motivation and interest in people to read, (besides social reasons). Some internal and external elements are reasons why a library is interesting or not interesting for people. A study by means of specialized texts indicates that problems of public libraries are focusing on internal aspects of libraries such as library's shortcomings, lack of space etc. External aspects as influential factors on effectiveness of public libraries have not captured as much interest. One of the main effective external aspects for increasing the level of approximation to, and usage of public libraries is geographical location and distribution of such libraries inside cities, especially megacities. The environmental aspects in such cities are important, too because of traffic and mechanized life. One of these aspects is the usage of natural space around the libraries. If these principles are not respected according to standards and terms, this might generate lack of interest and motivation in people approaching the library wanting to use it. Clearly, lack of interest about location of public library at the moment of building would cause ineffectiveness of all subsequent efforts for equipping such library and upgrading services (shia, 2003)

Goals of research: the main goals of current research are as below:

1. Determination of conformity between location of public libraries and centralization - consistency factors.
2. Determination of sites where public libraries could be built in the 4th district of Tehran.

Research's questions:

1. Whether libraries under research are conformed to centralization and consistency criteria?
2. What are optimal and suggested sites for building of public libraries in the 4th district of Tehran?

Conceptual and operational definitions:

1. Geographic Information System: it is the computer-based integrated system for collecting, saving and exploiting local data in the form of maps (Queen and Blinn, 1993).
2. Public libraries of the 4th district of Tehran: Those libraries giving services to people in the range of the 4th Tehran district. Currently, 13 public libraries are operating in this district.
3. Consistency: Location of public libraries in terms of proximity to other kinds of centers is evaluated by this factor. This factor includes consistence usages (such as firefighting and police stations) and inconsistence usages (such as industrial regions, highways and etc.) (Mokhtarpour, 2008)
4. Centralization: one of the important factors for location of public libraries is centralization or tendency to centralization, with the subcategories below:
 - 4.1 Accessibility: in order to determine accessibility, data related to the routes of public transportation were collected from lands map of the 4th district of Tehran, updated using the latest satellite images (Mokhtarpour, 2008).
 - 4.2 Population distribution: Data were collected from the last census performed in 2006. In order to determine points with the same density, a zoning map of Tehran was prepared as a first stage and then demographic features of the district were added to this map. At the next step, the map indicating population density of the district was prepared (Mokhtarpour, 2008).
 - 4.3 Proximity to urban facilities: Data for this stage were collected through information of land use in the 4th district of Tehran, updated using satellite images and the district's audit plan, then the disaggregated map was determined (Mokhtarpour, 2008).
 - 4.4 Proximity to crowded centers: Crowded centers such as parks, schools, cultural centers, mosques and governmental offices. In order to collect data for these centers, resources such as the district integrated plan, land use map and the city's audit plan were used. Based on collected data, a disaggregated map for each center was prepared (Mokhtarpour, 2008).

Background of Research

Zangiabadi (2002) analyzed and evaluated the place for establishment of public libraries using GIS and effective indexes and suggested new sites for the establishment of different public libraries. The goal for such research was to evaluate the distribution of different public libraries in Kerman city, determining areas lacking such libraries based on their priorities as well as suggesting that authorities use GIS facilities and specialists to determine suitable sites for building public libraries. Results of this research indicate that the positioning of public libraries in Kerman city is not based on specific criteria and requires reorganization and re-planning. It is possible to analyze in a short time the current condition of libraries using GIS and determine sites lacking cultural spaces according to the criteria required for public library and then choose the suitable site for building a public library.

Mokhtarpour (2008) considered and evaluated conditions for establishing public libraries in Ahvaz city based on two criteria of consistency and centralization using GIS. He determined optimal sites in the map for building new public libraries in this city.

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.

Hamlet 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 (Geographical Information Center, 1996).

The Organization of Cultural Spaces of Egypt (1994) first prepared a precise database of its educational centers and then determined optimal points for development of schools as a goal for this organization. After completing the stages of this project for overlapping GIS standard layers, the resulted layer indicates optimal regions for construction of new schools (Haukshold, 1998).

Positioning is one of the basic topics for each field of human activity and its importance is increasing. Therefore, organizations pay more attention to it, because if the site of a center is not chosen consistent with current scientific criteria and predetermined without any attractive features like using green nature standards, then other efforts are ineffective. For example, a library in a high traffic area is not welcomed despite optimal facilities and sources.

Research Methodology

Positioning with GIS includes the following stages:

1. Determination of positioning criteria;
2. Valuation of informational layers;
3. Modulation of informational layers and extract of final map for region layering.

Statistical information was collected from the Iran Statistics Center and Tehran 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 centralization or consistency. Afterward, a database was created using 1:25000 scale maps of Gitashenasi Institute (geographical and cartographical institute of Gitashenasi, 2009) and GIS land use layer of the 4th district of Tehran (Urban Processing and Planning Company, 2009) was made.

The GIS land use layer of Tehran Municipality was updated using other maps and Google Earth images so that all current libraries were recorded on the map and other details such as high voltage lines were added. 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. Digital maps in distanced manner were converted to machine analyzable images called "raster images".

Because our considerations in this research are based on terrains' distances from each other, distances indicated on images were converted to ten intervals, in order to give one to ten points for each interval. In this case, the appropriate numbers of points are given to different uses based on closeness so that more points are given to library according to closeness. For other factors, inconsistent to library, more point are given to libraries according to separateness. This stage is a reclassification as necessary stage for the modulation of layers.

Table 1: hierarchical structure of criteria and relevant weights

Consistency	Weigh of criteria	Factors of consistency	Elements of consistency	0.5	Subdivides	Wastelands	0/14		
	0.34					Police stations	0/6		
						Firefighting stations	0/26		
			Elements of inconsistency	0.5	Subdivides	Highways	0/04		
						Industrial centers	0/39		
						Health centers	0/16		
						High voltage lines	0/16		
						Sport centers	0/16		
	Agricultural centers		0/03						
	Kindergartens		0/06						
Centralization	Weigh of criteria	Factors of centralization	accessibility	0.43	Subdivides				
	0.66					Distance from urban utility	0.04		
						Population density	0.41		
			Proximity to population centers	0.12	Subdivides	Green space	0/03		
						Educational centers	0/09		
						Religious-cultural centers	0/13		
	Commercial centers					0/51			
	Governmental offices		0/26						

As mentioned earlier, the weight of each factor was calculated by a hierarchical method after determination of effective factors. Results are indicated in table No.1.

According to table no1, the lowest number belonged to green space (0.030), Unfortunately this shows the poor attention given to this important factor.

Stage of data analysis:

In this main stage of research, layers from the same group were overlapped with relevant weights and results were recorded in different maps and tables (Derakhshan, 2005). For overlapping and analysis of GIS layers, the fuzzy method was used. Basic criteria intended in this research are centralization

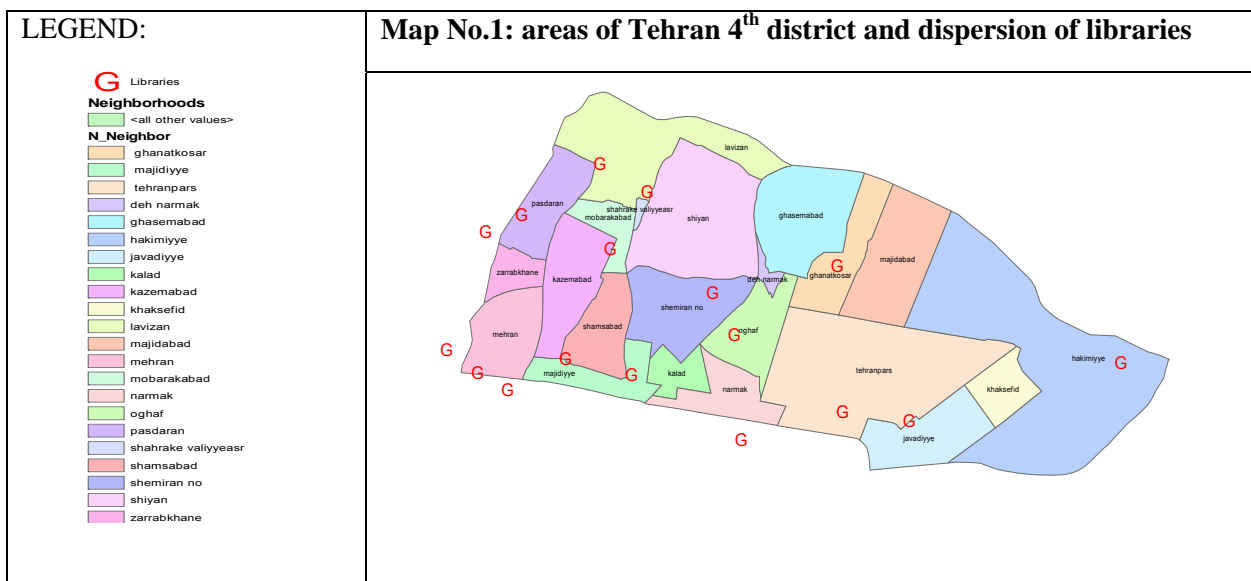
and consistency. These factors are mentioned in a handbook by Lisa Padilla (2002) is published by the Institute of American Architects in 2002 (Masoumi 2003).

A map of centralization was prepared using maps for administrative and commercial centers, public transport route, residential areas, religious-cultural centers, green space, educational and centers of higher education. The position of current libraries in this map was considered, and appropriate score was given based on proximity to terrains. Consistency map was prepared using maps for police stations, firefighting centers and wastelands; then appropriate score was given based on proximity to terrains. Inconsistency map was prepared using maps for sport complexes, agricultural areas, kindergartens, military areas, industrial areas, health centers and high voltage electrical lines; then appropriate score was given to libraries.

All layers regarding their weights were consolidated together in final map. General scores for current libraries were extracted from this map. All areas on the map were categorized with special colors according to conditions for the construction of libraries. Finally, it was determined that which library was in a better location than other libraries. If we consolidated the final map with a map of current libraries, then the zoning map would be drawn for the construction of libraries. The zone for the 4th district of Tehran in this map according to the score achieved was categorized using different colors based on suitability for construction of libraries.

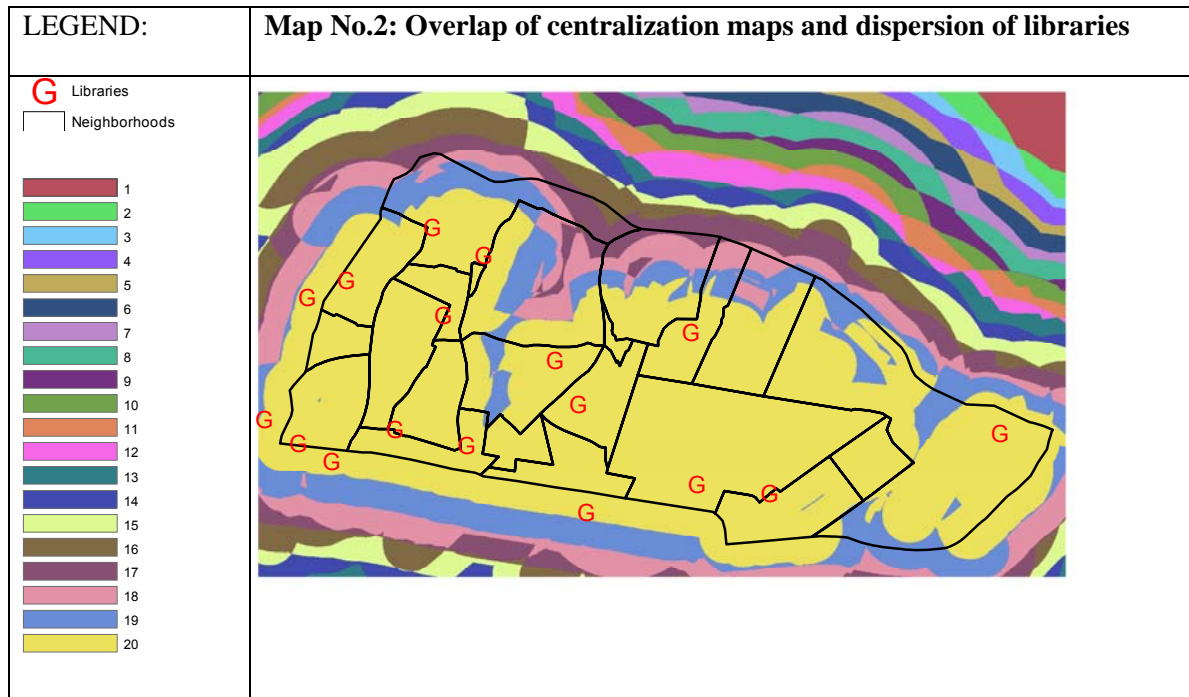
Findings:

Map No.1: areas of Tehran 4th district and dispersion of libraries



Based on IFLA recommendations, a local library must be organized based on a minimum 10 thousand populations (Saidnia, 2003). Based on statistics for the region's population, apart from Qasem Abad, Shahrak Valiasr and Deh Narmak districts, other districts include more than ten thousand populations and each of these districts has at least one library according to standard. On the other hand if we look at map N° 1, eleven areas in this region have no library. In Pasdaran, Qanat Qusar, Tehran Pars and Lavizan districts, with more than one library, the number of libraries is not proportional to population. The remaining 7 areas have one library, the number of libraries is not proportional to population. 13 libraries are not enough for the 4th district of Tehran, for a population of 760.000 (Iran Statistics Center, 2006).

Map No.2: Overlap of centralization maps and dispersion of libraries



Colors of this map indicating points given to different parts of the 4th district of Tehran according to centralization criteria.

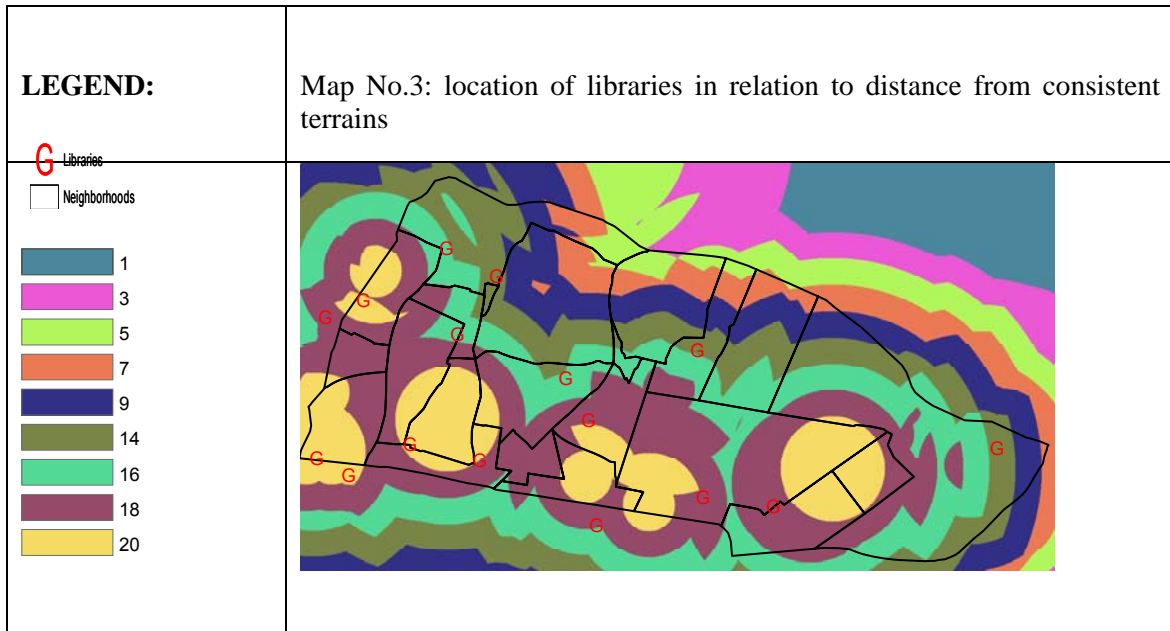
In order to draw map No.2, first of all a separate map was drawn for centralization criteria such as administrative, commercial, religious, cultural and educational centers as well as green spaces, transport routes, population density and urban facilities. Afterwards, layers were overlapped through fuzzy method and different areas of Tehran's 4th district were categorized using colors. Areas with the same condition are shown with the same color. Current libraries are given relative points in the table below according to their current condition:

Table No.2: points designated to libraries according to centralization criteria

Score	LIBRARY NAME	RO W	Score	LIBRARY NAME	RO W
20	Allame tabtabayi	8	20	hakimiyye	1
20	valiyyear	9	20	Sheikh-e-eshragh	2
20	shaghayeg	10	20	Mashfg-eOgolshan	3
20	riyasatjomhuri	11	20	salamat	4
20	resalat	12	20	omid	5
20	dekhoda	13	20	Lavizan-e-shahrdari	6
			20	Lavizan-e-nahad	7

As table No.2 shows, libraries with 20 points are the best libraries in relation to centralization criteria. According to information provided by this table, all libraries are located in best area according to centralization criteria.

Map No.3: location of libraries in relation to distance from consistent terrains



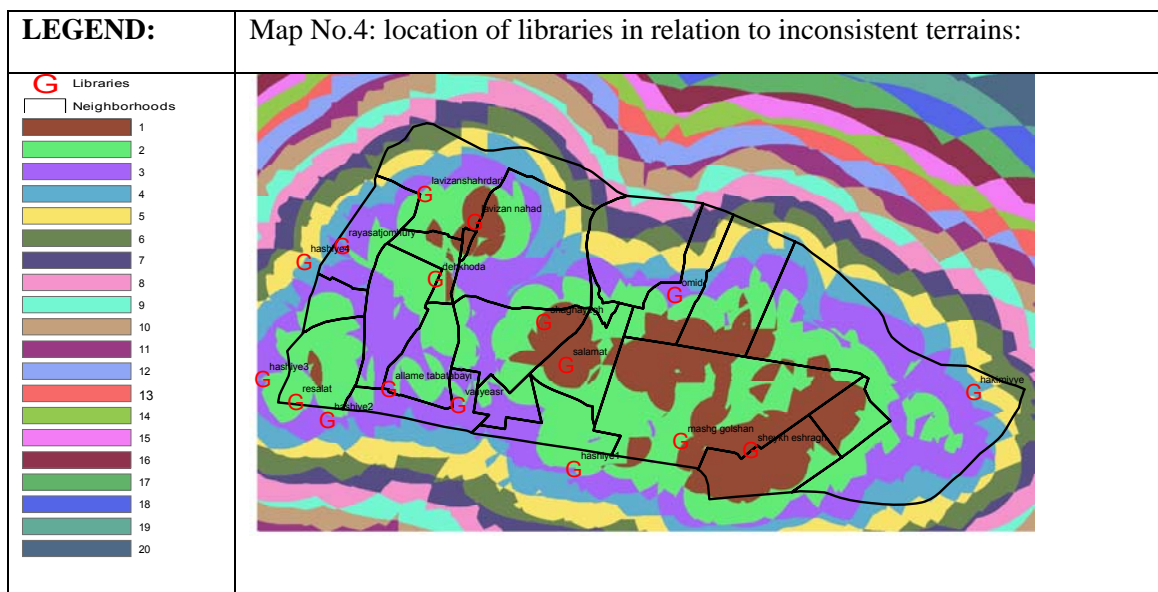
Colors used for this map suggesting different points of Tehran's 4th district in relation to consistency criteria.

Table No.3: points given to current libraries in relation to consistent uses of libraries:

Score	LIBRARY NAME	ROW	Score	LIBRARY NAME	ROW
20	Allame tabtabayi	8	14	hakimiyye	1
20	valiyyeasr	9	18	Sheikh-e-eshragh	2
16	shaghayeg	10	18	Mashfg-eOgolshan	3
20	riyasatjomhuri	11	18	salamat	4
20	resalat	12	14	omid	5
16	dekhoda	13	16	Lavizan-e-shahrdari	6
			14	Lavizan-e-nahad	7

Points given to table No.3 were also considered same like previous table. In order to draw map No.3, separate maps were drawn for every use, consistent to library such as police stations, firefighting stations and wastelands. Then these maps were converted to analyzable images using space analytic instrument in the form of zoning. At the next stage, these images were consolidated together by fuzzy method. After overlapping location of libraries on the map, the condition of current libraries in relation to distance from consistent terrains was clearly determined. Map No.3 suggests best areas with 20 points in relation to consistent uses. Points are reduced according to distance from consistent terrains. In regard to table No.3, four libraries are located in the best rank with 20 point. Three libraries are at the third rank with 18 points. Three libraries are at the fifth rank with 16 points. Three libraries are at seventh rank with 14 points. Calculation of average points: $80+54+48+42=234 = < 234 \div 13=18$. Therefore, seven libraries have a higher score than average.

Map No.4: location of libraries in relation to inconsistent terrains:



Colors of this map suggesting points of different parts for 4th district of Tehran in relation to inconsistent terrains.

Table No.4: points given to libraries based on inconsistent terrains

Score	LIBRARY NAME	ROW	Score	LIBRARY NAME	ROW
3	Allame tabtabayi	8	4	hakimiyye	1
3	valiyyeasr	9	1	Sheikh-e-eshragh	2
1	shaghayeg	10	2	Mashfg-e0golshan	3
3	riyasatjomhuri	11	1	salamat	4
2	resalat	12	3	omid	5
2	dekhoda	13	2	Lavizan-e-shahrdari	6
			1	Lavizan-e-nahad	7

In this part, drawing the map, overlapping and analyzing the map are done the same way as before. In this map, a higher score is given to different libraries distant from inconsistent terrains.

According to information provided by table No.4, it is clear that density of terrains that are inconsistent to libraries in the region is so high that it is impossible to find an area with a high score.

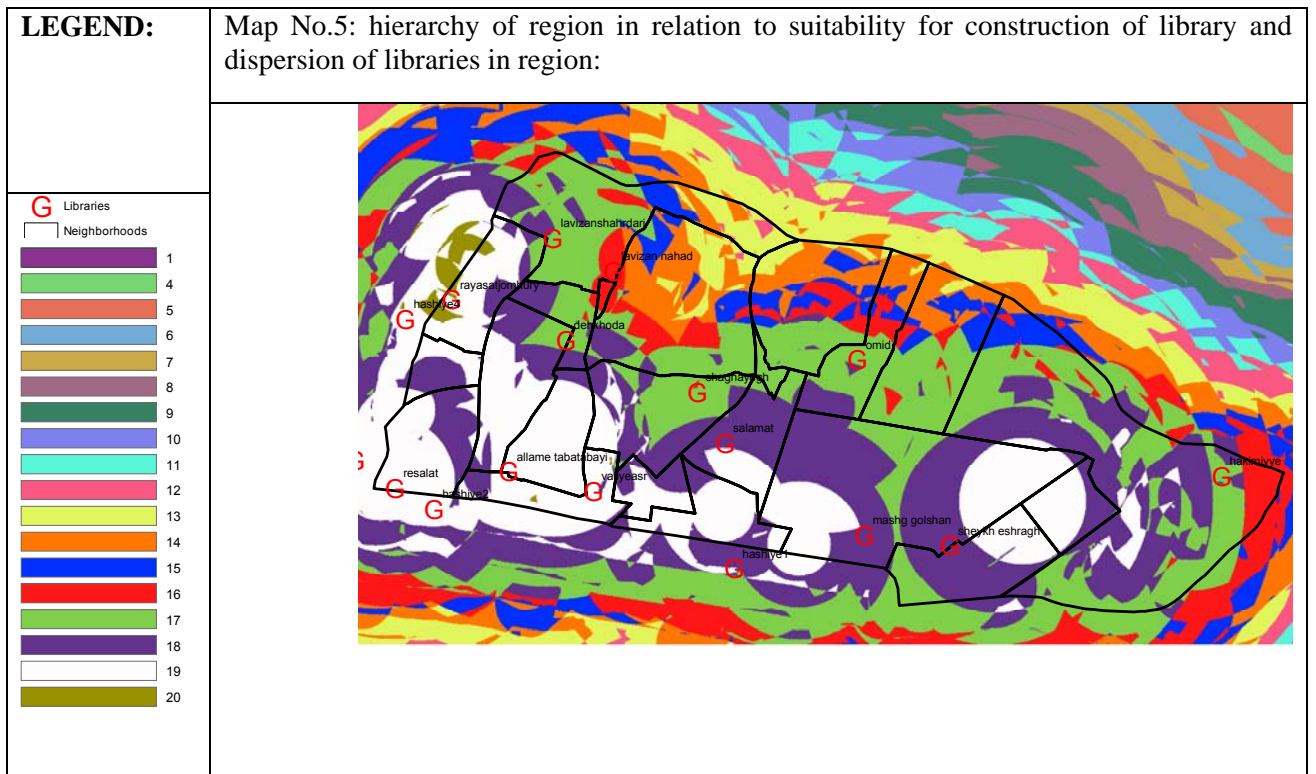
In such cases, those in charge of the municipality would try to move such terrains to the countryside. However, no such action is performed in the 4th district of Tehran. The table No.3 indicates: one library with 4 points is in the best rank. Four libraries with 3 points are in the eighth rank. Four libraries with 2 points are in the ninth rank.

Four libraries with 1 point are in the tenth rank.

Calculation of average points: $4+12+8+4=28 \rightarrow 28 \div 13=2/1$

Therefore, calculation suggest that 9 libraries have points higher than average but overall, current libraries have no enough distance from inconsistent terrains.

Map No.5: hierarchy of region in relation to suitability for construction of library and dispersion of libraries in region:



Colors on this map reflect the scores given to different parts of the 4th district of Tehran in relation to suitability for construction of new libraries.

Table No.5: total points of current libraries based on centralization and consistency criteria

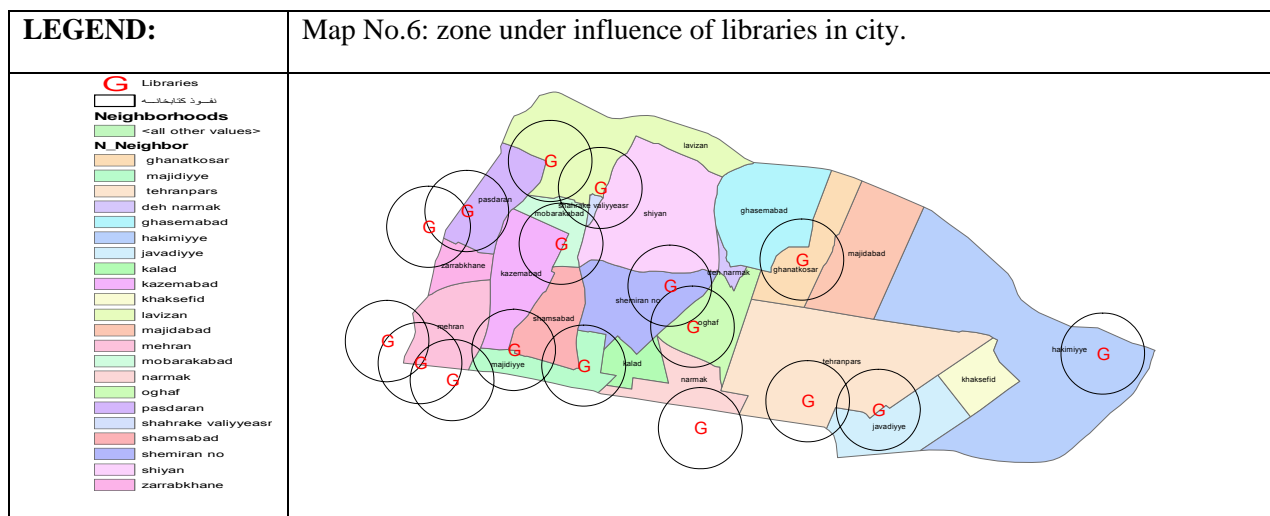
Score	LIBRARY NAME	ROW	Score	LIBRARY NAME	ROW
19	Allame tabtabayi	8	17	hakimiyye	1
19	valiyyeasr	9	18	Sheikh-e-eshragh	2
17	shaghayeg	10	18	Mashfg-e0golshan	3
19	riyaosatjomhuri	11	18	salamat	4
19	resalat	12	17	omid	5
17	dekhoda	13	17	Lavizan-e-shahrdari	6
			16	Lavizan-e-nahad	7

Table 5 suggests that current libraries are built in regions with high consistency. According to table 5: four libraries, i.e. Alame Tabatabai, Valiasr, Riasat Jomhuri and Resalat equivalent to 31/2% of libraries are at the best rank with 19 points. Three libraries, i.e. Sheykh Eshragh, Mashgh Golshan and Salamat, equivalent to 23.4% of libraries are at the third rank with 18 points. Five libraries, i.e. Hakimieh, Omid, Lavizan Shahr-dari, Shaghayegh and Dekhoda equivalent to 39% are at the fourth rank with 17 points. One library, i.e. Lavizan Nahad equivalent to 7.8% is in fifth rank with 16 points.

The main problem is this fact that these libraries are mostly located in zones influenced by each other. Accordingly, services provided by public libraries are offered to citizens equally. It is reminded that minimum distance between two libraries wouldn't be less than 1600 meter according to abovementioned standards.

This fact is shown on map No.6 using circles as radius of influence by libraries.

Map No.6: zone under influence of libraries in city.

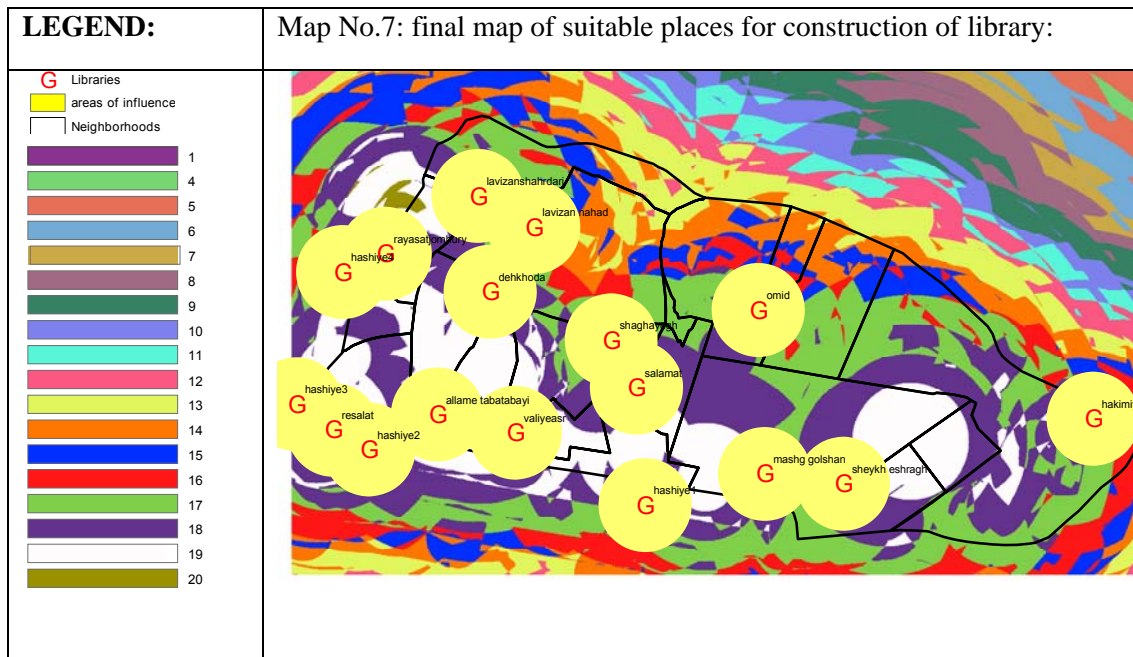


Drawing the final map

At the final stage, in order to determine suitable places for construction of library, so that all citizens have the same opportunity to use a library, different layers are overlapped on each other. Accordingly, the intended region is distinguished from other regions. Map No.7 is a final map of real work according to all criteria and usage of Arc GIS software. As we can see, the whole 4th district of Tehran is divided into many parts using different colors.

Areas marked in white color are the best areas in the region for building new libraries. These areas are located in the central parts of the region and if a new library is built, these are the most suitable. In case of constructing more new libraries, it is possible to use areas determined with violet color. One of the privileges of fuzzy analyzes is that different areas are categorized in such way that if there is no possibility to prepare land in the best area, then it is possible to use areas with the next levels of consistency. It is reminded that the chosen area must be distant at least 1600 meter from other libraries. If we apply this index to the final map, then we can conclude that areas with 800 meter distance from current libraries are not suitable for construction of library. This zone is shown on map No.7 by yellow color circles.

Map No.7: final map of suitable places for construction of library:



In map No.7: zones determined with white color (total score of 19) are the best areas for the construction of a library. If there is no land available in this zone, then it is possible to use a violet colored zone with a total score of 18. It is reminded that zones marked in yellow are unsuitable for the construction of library, because it is located in a zone under the influence of current libraries.

Discussion and conclusion:

As mentioned before, this research includes two questions that they are answered separately regarding to the analyzes performed.

Answer to research questions:

1. Whether current libraries are consistent to centralization and consistency criteria?

Table No.6: points given to libraries in relation to distance from factors of centralization and consistency criteria as well as relative total score.

The total score relative	Incompatibility	Compatibility	Centralization	LIBRARY NAME	ROW
17	4	14	20	hakimiyye	1
18	1	18	20	Sheikh-e-shragh	2
18	2	18	20	Mashfg-e0golshan	3
18	1	18	20	salamat	4
17	3	14	20	omid	5
17	2	16	20	Lavizan-e-shahrdari	6
16	1	14	20	Lavizan-e-nahad	7
19	3	20	20	Allame tabtabayi	8
19	3	20	20	valiyyeasr	9
17	1	16	20	shaghayeg	10
19	3	20	20	riyasatjomhuri	11
19	2	20	20	resalat	12
17	2	16	20	dekhoda	13

According to calculations made by the software, maximum achievable score by libraries was 20. Accordingly, current libraries are relatively suitable in relation to centralization and consistency criteria but according to inconsistency criteria they are not suitable. Overall, table No.9 shows that current libraries are built in areas with relatively high suitability. Among current libraries, 4 libraries, i.e. 31.2% of libraries are in second rank with 19 points. Three libraries, i.e. 23.4% of libraries are in third rank with 18 points. Five libraries, i.e. 39% of libraries are in fourth rank with 17 points. One library, i.e. 7.8% of libraries is in the fifth rank with 16 points.

2. What are optimal proposed areas in 4th district of Tehran to build public library?

As it was mentioned early, optimal areas for building public library were chosen in the 4th district of Tehran and these areas have higher scores a compared to current libraries. On the final map, zones marked in white color (with total 19 points) are the best current zones for construction of a library. If there is lack of land in such area, then it is possible to use the violet zone (with total point of 18). It is emphasized that zones with yellow color are least suitable zones for construction of libraries, because they are in the area of influence of current libraries.

Conclusion:

According to table No.6, although current libraries are not in the best location, they have relative good location, because according to diagram, while the maximum score is 20 and all libraries have point higher than 16. The first problem clarified after calculation is that libraries are few in the region as required for population size. The main problem is geographical distribution of libraries in the 4th district of Tehran, because these libraries mostly influence each other, which causes improper distribution of public library services between citizens. It is reminded that minimum distance between

two libraries shouldn't be less than 1600 meters based on above mentioned standards. This problem is indicated in map No.6 by buffer in Arc GIS using circles around libraries as influenced radius.

After the review and calculations, it was determined that existing libraries have a high rate of relative fit with the centrality criterion and factors related to compatibility, although they are not in desirable conditions in terms of sustainability. From the GIS data it can be observed that most of libraries are not built in green areas. So the existing libraries do not have appropriate geographical distributions from this point of view.

As mentioned before, the optimal areas for construction of library in the 4th district of are marked in the final map using white color with a relative score of 19 points and also violet color with a relative score of 18 points.

Suggestions:

1. According to analyzes, the construction of a library with enough resources and facilities and minimum 2000 m² floor area in Northwest of Tehranpars district as central library is proposed, in order to cover shortages of this district and also as a regional library to cover current deficits of other neighboring districts.
2. It is suggested to construct four local libraries in Hakimieh (west part), Khak Sefid, Shams Abad and Kazem Abad districts with floor area of 500 meter in order to cover current deficits in these districts.
3. It is suggested to determine location for public libraries in all cities of the country in order to prevent wasting national capitals, because as mentioned before, if the positioning of a library is not performed based on predetermined scientific criteria, then subsequent efforts would be ineffective.
4. According to the uses of GIS in research and high abilities of Arc GIS software in the field of information management, the use of this software and related methods is recommended for shelving and categorizing books, and overall they are necessary for informatics.
5. Green spaces should be considered in all libraries. It is recommended to build the libraries inside parks or to consider tree planting around the buildings.

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