LOCATION OF FUEL STATIONS USING FUZZY MODEL IN GEOSPATIAL INFORMATION SYSTEM (CASE STUDY: 7TH DISTRICT, TEHRAN CITY)

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ABSTRACT:

In this study, by using the fuzzy method and geospatial information system (GIS), was attempted to locate the fuel station in the 7th district of Tehran. For this purpose, the information was digitized as a shape file by referring to the field and using the existing maps. The distance map was prepared using the Euclidean Distance function. Finally, using ArcGIS 10.8 software, this information was normalized by the fuzzy method and overlapped using the fuzzy gamma operator. It is presented as a map of prone areas for optimal positioning of fuel stations in the 7th district of Tehran. The most important criteria are the distance from the communication network, population density, incompatible users (commercial, industrial, administrative, residential, cultural and religious, health and medical), compatible users (park and green space, sports, fire department), and distance from fuel stations.

1. INTRODUCTION

With the growth in population in Iranian cities, especially big cities, the volume of demand for public services has increased. Also, the need to apply the creation of multiple fuel stations, is felt more than in the past. Although Iran is the second holder of natural gas reserves in the world, gasoline and diesel have been used for a long time as the two most common car fuels, like most countries in the world. Due to the difference in production capacity and gasoline consumption in the country, a major part of this fuel is supplied from abroad, which brings a large financial burden to the country's economy for the purchase, transportation and distribution at fuel terminals. Several ways have been proposed to solve this problem (Khayampoor, 2012). But considering the existence of abundant gas reserves in Iran and the ease of use of this fuel and other advantages compared to petroleum products, the most basic way is to replace natural gas instead of other fuels used by devices and systems.
Achieving a balance in the spatial distribution of resources and services at the city level is one of the main goals of urban planning (Arafat et al., 2010). Population growth and improper development of cities have created many difficult for cities, and correct and principled spatial bookkeeping of urban duties can be effective to a large extent in regulating the performance of cities (Abdi et al., 2012).
The subject of land and how to benefit it is considered the main platform of urban planning (Arafat et al., 2011; Soroor and Naderifar, 2006). Justly availability to land and its optimal use and organization of the place is also considered one of the basic components of permanent expansion. Today, the notion of urban spaces and places has changed qualitatively, both from the natural and physical point of view, and from the socio-economic point of view, and has made the dimensions of land use schematization and place organization very diverse and rich (Olusola, 2017). In fact, the somatogenic system of the city and the urban space is accounted a general source and public life and wealth and a public good, and its use can be carefully and thoughtfully managed in order to provide public benefits in the present and future. (Shirani, 2011).
Proper development and uniform and balanced distribution of fueling stations in the vicinity of residences and increasing the well-being of citizens, proper access to fueling stations, not forming traffic nodes and not forming queues at stations, increasing safety and reducing the economic costs of land supply are among these achievements (Behbahani et al., 2007). With the expansion and development of urbanization and the ever-increasing population, the need to apply cars and consequently to create fuel stations is felt more than in the past. The most important problem in the field of providing services in this sector is the lack of proper distribution of the stations in terms of quantity and the limited functional radius of the stations. As a result, it is necessary that the quantitative and qualitative distribution of fuel stations should be investigated. Therefore, determining the right place for fuel stations depends to a large extent on knowing the factors influencing their distribution. Due to the importance of the issue, the most important problem in the field of service delivery of this sector is the lack of distribution of stations in terms of quantity and the limited functional radius of said stations (Khahro and Memon, 2017). Therefore, it seems necessary to investigate the quantitative and qualitative distribution of fuel stations scientifically and professionally. In this paper, the spatial organization of fuel stations in the 7th district of Tehran has been discussed by using the capabilities of the geographic information system and using the fuzzy model.

2. THEORETICAL FOUNDATIONS

The location theory was invented by von Tanon in 1826 in the field of agricultural activities. Then, in 1882 and 1885, Leann Hard proposed the theory of positioning in the industry. But the systematic and scientific framework of this theory was formed in industrial positioning by Alfred Weber in 1909. According to the evolution of theories of location, they have been divided into three periods in terms of evolution and development over

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time: (i) Formulating the problem (from the beginning of the 20th century to 1960). (ii) Application of models in the industry sector (1950-1960). (iii) Development of models in the public and service sector (since 1970).

The location theories aim to explain the location of industrial, commercial, service, etc. activities by extracting general rules based on the factors and variables affecting the location of the existing structure and introduce the best place for establishment (Oloko-oba, 2016). Considering that since the 1970s, location theories have moved towards the location of service centers; Therefore, one of the basic and important tasks of urban planners is the allocation of land for various urban uses. Nowadays, the optimal location of urban service centers such as schools, health and treatment centers, fire stations, fueling centers, etc. is very important in urban planning. Urban planners provide effective help in ensuring the well-being and comfort of city dwellers with their proper location. As a result, while helping to realize social justice, they take a big step towards having a sustainable city (Taylor et al., 2016).

2.1 Fuzzy model

The theory of fuzzy sets and fuzzy logic as a mathematical theory for mathematical modeling and formulation of ambiguity and inaccuracy in human cognitive processes are very efficient and useful tools for this purpose (Lootsma, 1990). This theory, which was first proposed by Prof. Lotfizadeh, an Iranian-origin scientist at the University of California in 1965, has covered many fields of different sciences, especially urban planning and urban planning (Phillis and Andriantiatsaholiniaina, 2001). The main goal of this study is to determine the optimal locations for fuel stations using the fuzzy model. In this context, these steps are followed. (i) Definition of the problem/goal (choosing the place for fuel stations). (ii) Considering potential criteria to find optimal places. (iii) Collecting, preparing and transferring data to the GIS environment. (iv) Convert vector data to raster data in GIS environment. (v) Classification of raster data and their normalization with fuzzy function. (vi) Obtaining the final fit map for fuel location using fuzzy gamma operator for all data sets.

3. STUDY AREA

District 7 of Tehran Municipality is one of the urban areas of Tehran, which is located in the center of Tehran. The northern border of this area is Resalat highway, the eastern border is Majidiyeh (Ostad Hassan Bana) and Sabalan streets, the southern border is Elginal and Damavand streets, and the western border is Modares highway and Shahid Mufatteh street. The 7th district has good access to Tehran's highway network, the relatively surrounding of the region in the highway network is one of the advantages of this region. Three north-south highways of Imam Ali, Shahid Sayad Shirazi highway and Shahid Modares highway pass through 7th district.

4. RESULTS

By examining the effective criteria in locating, by using ArcGIS geographic information system and Spatial Analyst facilities, their distance and fuzzy maps were prepared and by using the fuzzy gamma operator method for overlapping, the normalized criteria were combined and the suggested sites for establishing the fuel station were determined.

The compatible indicators of that group are uses that are not damaged by the existing or proposed fuel station in terms of their neighborhood, but are complementary to each other or are prone to the construction and placement of the fuel station in this area; Therefore, in this part, the uses of green space, sports, fire department, and public parking lots have been selected and their layers have been prepared. Incompatible indicators include applications where the use of the fuel station should be located in a safe place from these groups as much as possible; Therefore, in this part, educational, medical and cultural-religious, sports centers, etc., have been selected and their layers have been prepared.

4.1 Preparation of layers

At this stage, a distance map was prepared for each of the sub-criteria using distance functions (Figures 1 to 4) and a population density map was produced for the population layer according to its nature using the density function (Figure 5).

Distance function path in GIS: Toolboxes\System Toolboxes\Spatial Analyst Tools.tbx\Distance\Euclidean Distance

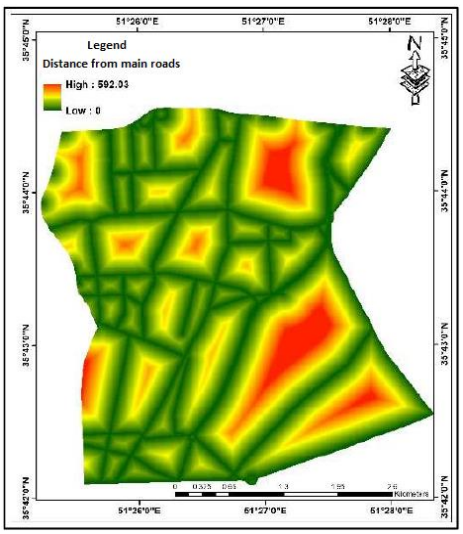

Figure 1. Distance from the main roads.

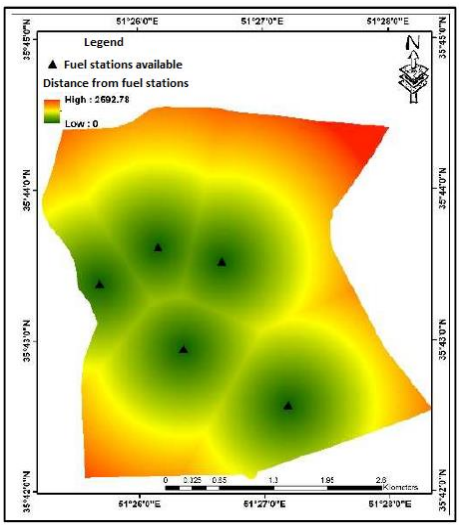

Figure 2. Distance from existing fuel stations.

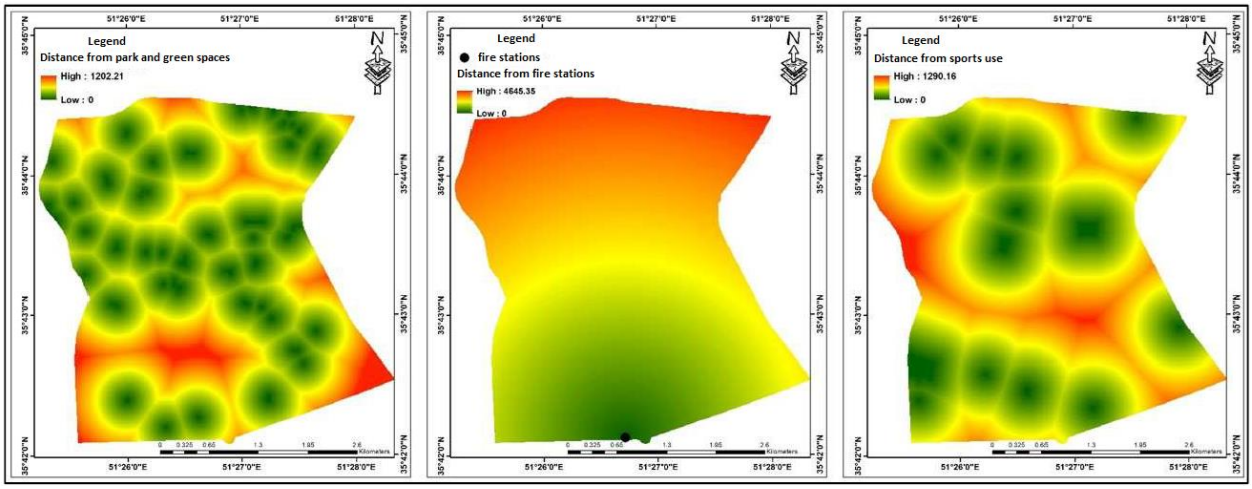

Figure 3. Distance from compatible uses.

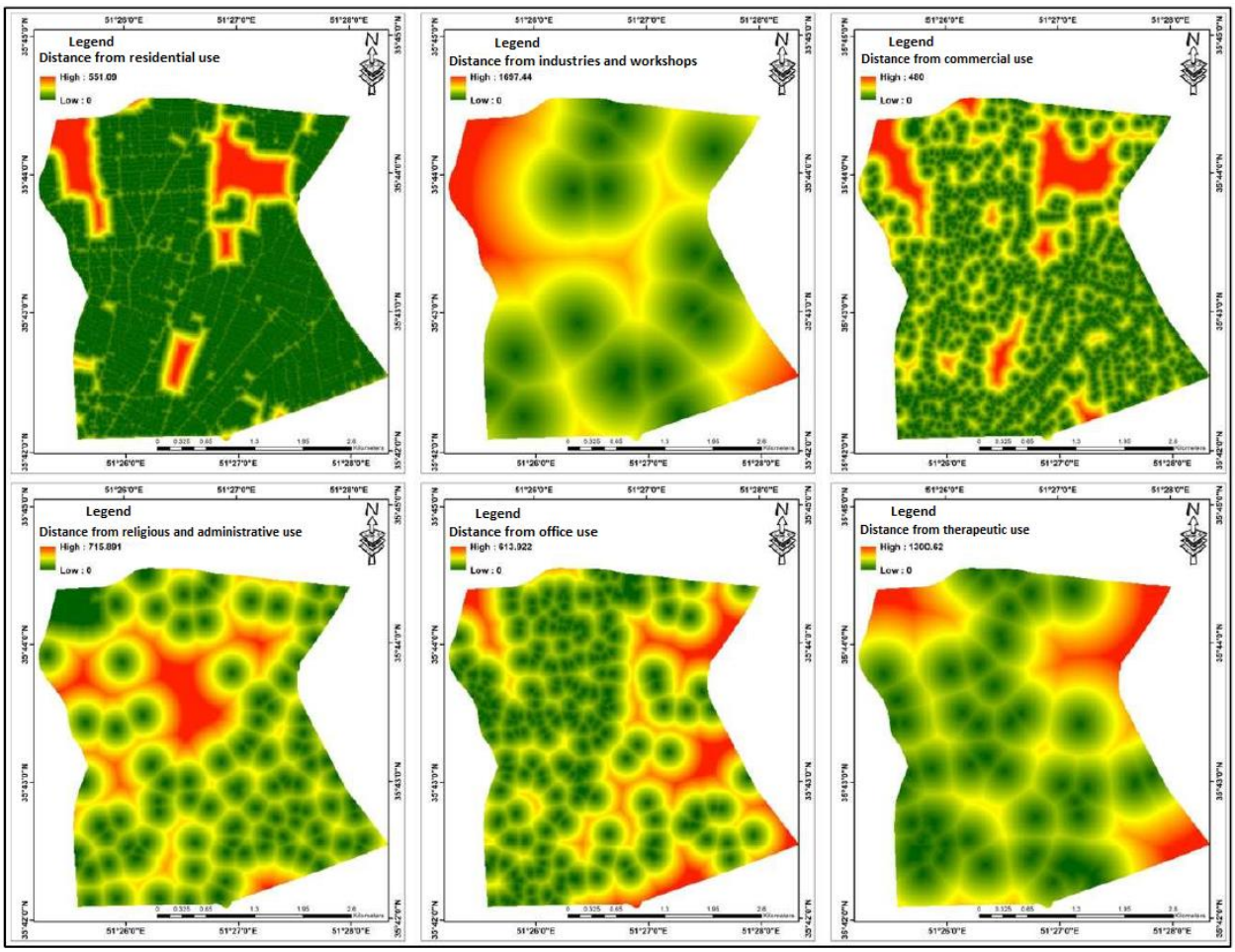

Figure 4. Distance from incompatible uses.

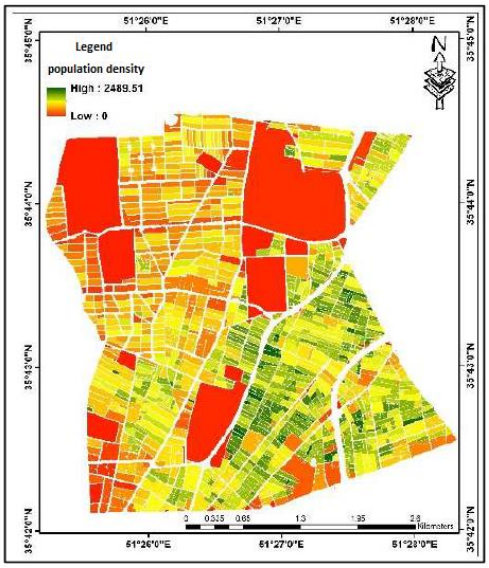

Figure 5. Population density.

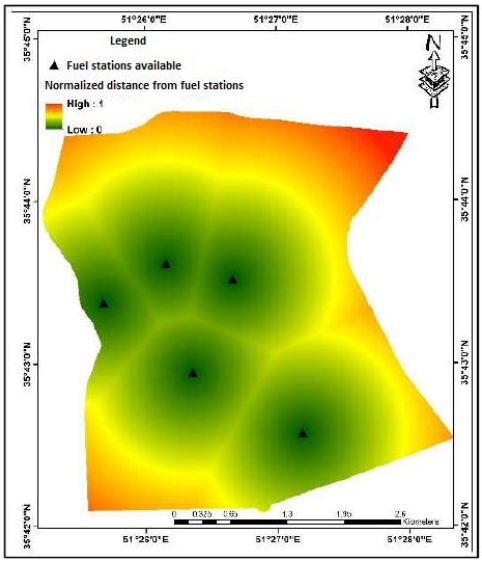

Figure 7. Fuzzy distance from fuel stations.

4.2 Normalization of layers (fuzzy maps)

The layers prepared in the previous stage using fuzzy functions, in the software using an increasing linear function for the incompatibility criteria and the distance from the existing fuel stations and a decreasing linear function for standardized compatible applications, and the population density in the form of a raster was entered as a value from zero to one (Figures 6 to 10). This number being closer to one indicates the appropriateness of the respective place for the establishment of fuel stations from the point of view of the relevant standard.
Fuzzy functions Path in GIS: Toolboxes\System Toolboxes\Spatial Analyst Tools.tbx\Overlay\Fuzzy Membership

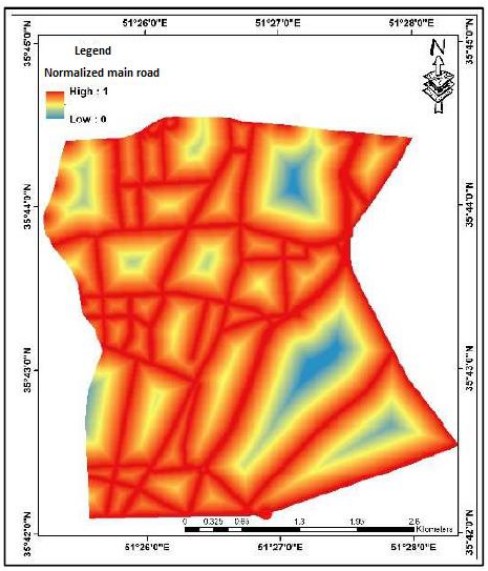

Figure 6. Fuzzy distance from the main roads.

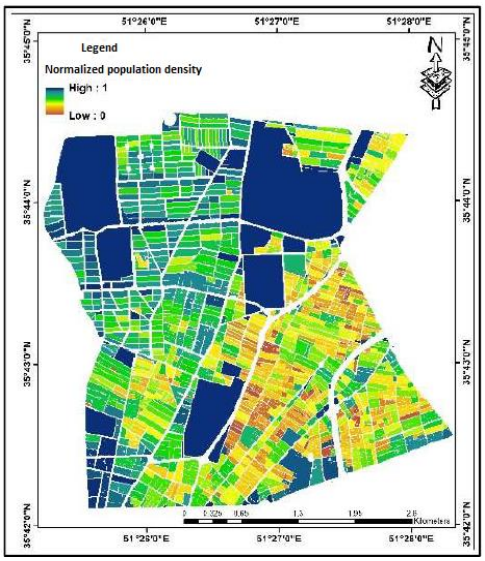

Figure 8. Fuzzified population density.

The path of the fuzzy addition operator in GIS: Toolboxes\System Toolboxes\Spatial Analyst Tools.tbx\Overlay\Fuzzy Overlay\Sum
After preparing all the standardized (fuzzified) layers in the previous step, they were combined with each other using the fuzzy sum operator FUZZY OVERLAY-SUM. Finally, after merging and superimposing the above layers, suitable areas for the establishment of fuel stations in the 7th district of Tehran were obtained according to Figure 11 and 4 places were identified as suggested places, which are indicated on the map.

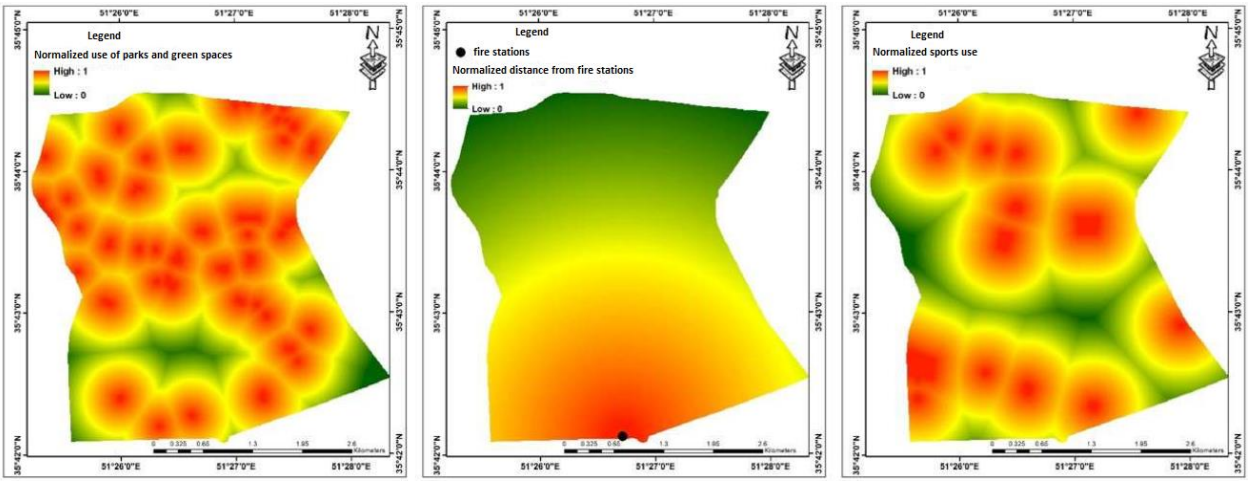

Figure 9. Fuzzy distance from compatible applications.

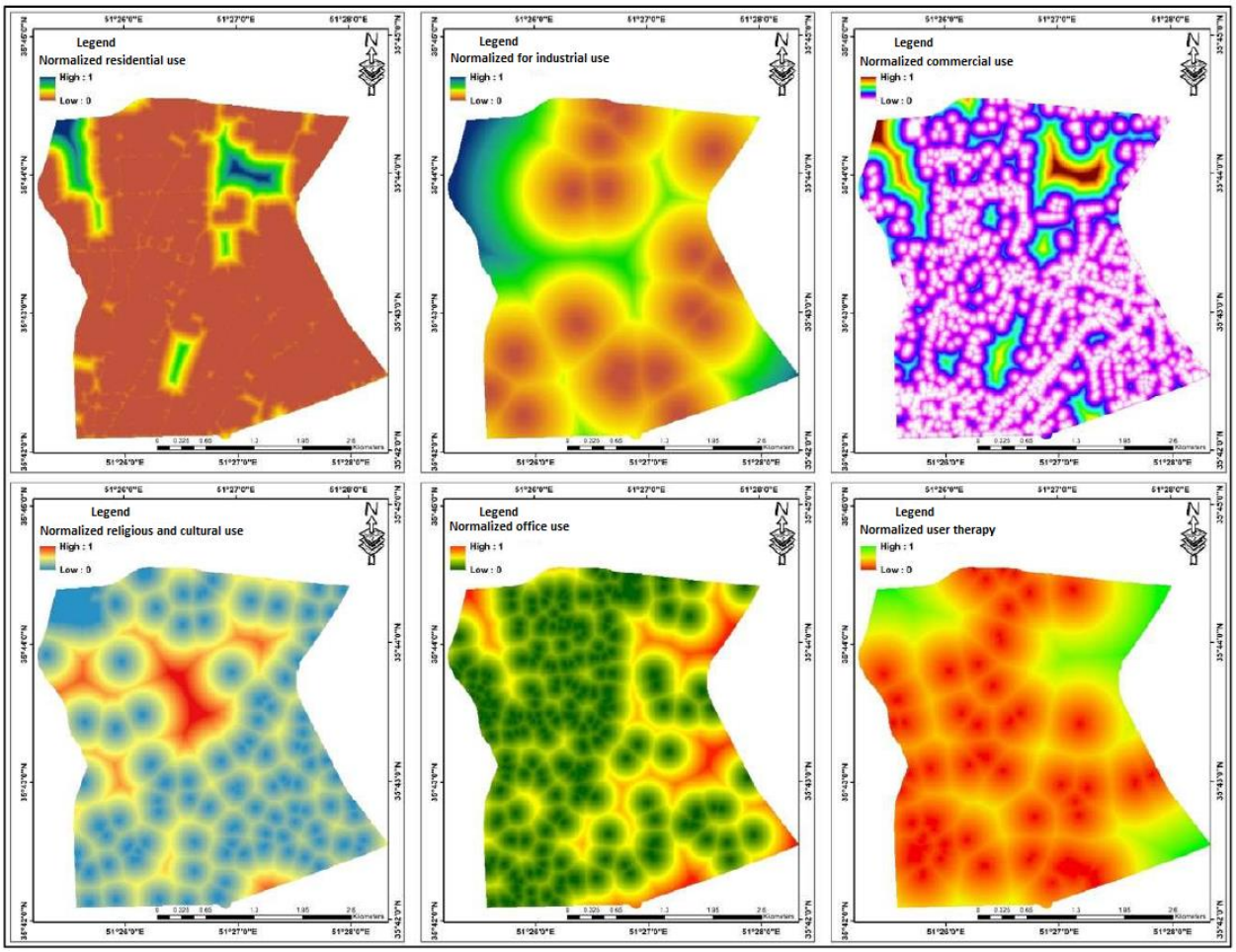

Figure 10. Fuzzy distance from incompatible uses.

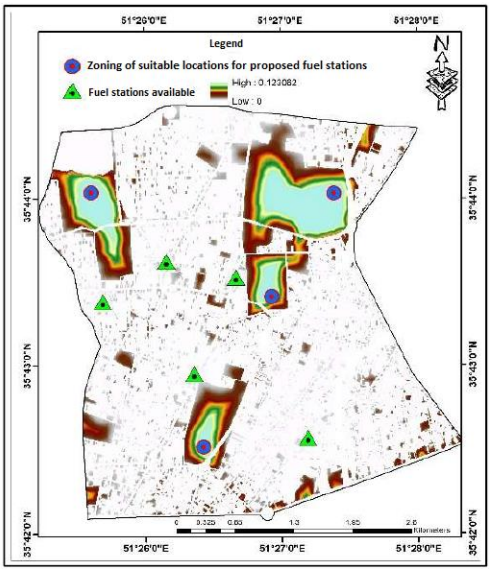

Figure 11. Zoning map of suitable places for fuel stations.

In the above map, white color indicates very unsuitable areas and light blue color indicates very suitable areas for establishing a fuel station according to the research criteria. In this study, taking into account the existing fuel stations, four stations have been proposed, which are marked as blue with a red circle on Figure 11, which are located in the pale blue area and near low density centres and roads.

5. CONCLUSION

This study presents a model for decision makers to determine the location(s) of the optimal fuel station with a combination of fuzzy and GIS. The role of fuzzy and GIS in determining the optimal locations was explained and the location selection criteria were specified, and the results for finding the optimal locations. The location of the fuel was determined in 7th district of Tehran. In this research, 12 criteria have been used (population density, road, distance from residential, cultural and religious, commercial, administrative, industries and workshops, and healthcare as inconsistent indicators and distance from sports, firefighting, and green spaces as indicators of compatibility and distance from existing fuel stations). First, according to the intended purpose, the related maps were prepared and were fuzzified and normalized by using linear decreasing and increasing function, and then overlapping was done with the fuzzy gamma operator and the final location map was prepared. Therefore, in the case of establishing new locations, it is better to pay attention to the places with high potential and ability, which are specified in the map of Figure 11, so that through this new locations, they can play a greater role in solving urban problems.

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