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A physical-spatial analysis of the existing slaughterhouse of Sanandaj, Iran, and site selection for a new one by using fuzzy logic and index overlay model

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ABSTRACT

There are land-uses and services such as urban burial sites, slaughterhouses, cemeteries, airports, silos, vegetable and fruit markets and inter-city transportation terminals which are located outside the cities but thoroughly serve the central cities. The site selection of such uses in development plans is done regardless of the basic built and environmental parameters, and is affected by the governmental ownerships, organizational relationships, or just few environmental factors like topography. Currently situated in the south of Sanandaj city in west of Iran, the slaughterhouse of Sanandaj does not have a proper location due to the fact that it is on the way of the city's future development. In addition, the dominant wind of the city blows from south to north with a velocity of one knot. Proximity to a river named Gheshlagh, proximity to Iran's most important site of strawberry production, high level of underground water, heavy environmental pollution, etc. are some of the shortcomings of the location of the current slaughterhouse of Sanandaj. This article aims at applying the Geographic Information Systems (GIS) as a powerful analytical means of site selection of the urban slaughterhouse, and using Fuzzy Logic. By combining different natural and synthetic indicators, three sites are suggested in the vicinity of the city of Sanandaj.

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KEYWORDS

Geographic information systems;
Fuzzy logic;
Index overlay;
Slaughterhouse;
Site selection;
Sanandaj.

INTRODUCTION

Statement of the problem

Along with rapid urban growth in Iran during the last decades, many urban facilities, which used to be located outside the legal limits of the cities, were in-

cluded in the cities; and this reflects the necessity of new site selection and transferring such facilities. With regard to their high environmental pollution, slaughterhouses of livestock and poultry are some of the facilities that are in top priority of being transferred out of the cities. Due to fulfilling the daily needs of people, the

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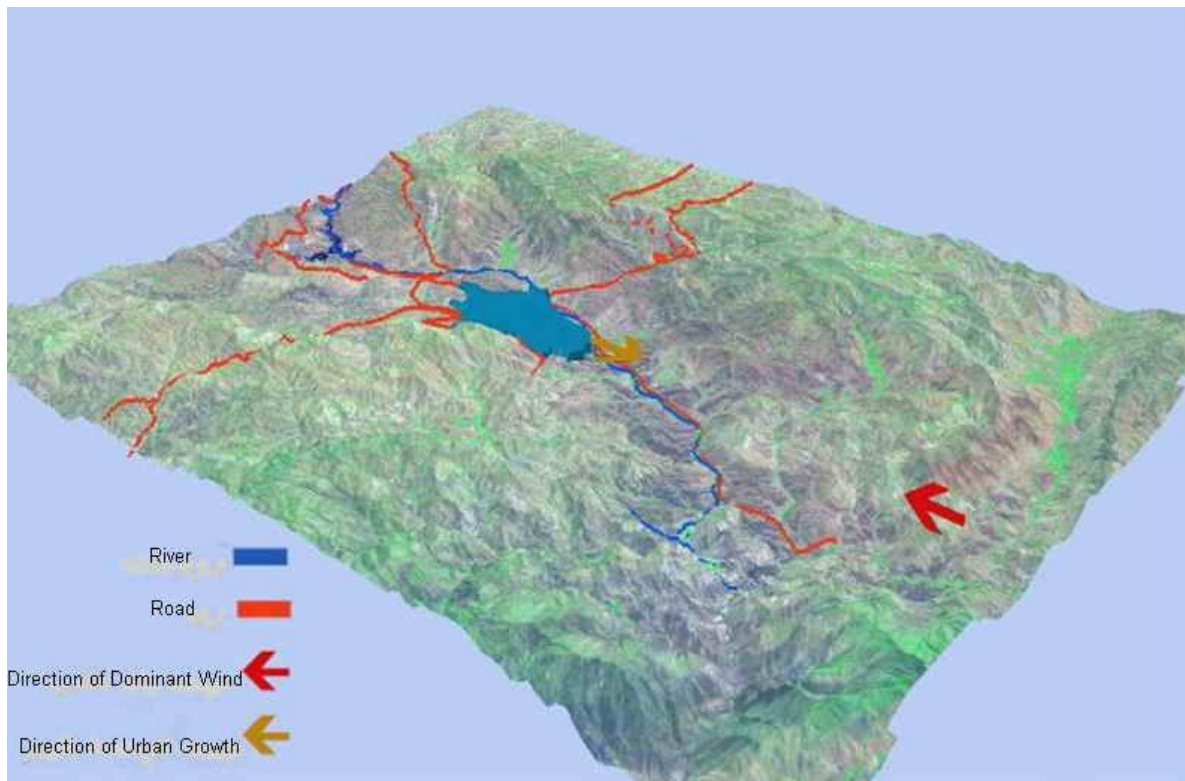


Figure 1a

slaughterhouses are of great importance; therefore depending on the level of needs of people, at least one slaughterhouse for each city is necessary. According to the rules and regulations of the Iranian Environmental Protection Agency, slaughterhouses must be located outside the legal borders of the city and 3 Kilometers away from it. Geographic Information Systems can be of great help to the planners and decision-makers in this field to locate a new slaughterhouse with maximum economic efficiency and minimum environmental impacts.

After implementing governmental land reforms in early 1970s in Iran, gradually the urban issues were challenged by migrants from rural areas to cities, increase in governmental meddling in urban management, economical growth, and increase in urban revenues. Like other mid-sized Iranian cities, the master plan and regional plan of the city of Sanandaj in west of Iran, were prepared in response to increasing needs of the people. On the other hand, capturing agricultural and garden uses, river borders, and numerous hills of the periphery of the city gradually occurred. The direction of growth in the master plans of before and after Iranian revolution in 1979 was focused on the places in the periphery

of the city which had the most agricultural uses. Also, in order to implement the preset strategies of the master plan, the detailed plan of Sanandaj has led the growth direction of the city to south and south-west of the city. These areas, which are among most valuable urban and natural spaces of Sanandaj, are continuously selected as ground for new uses. Locating urban service centers like petrochemical industry plant, urban waste burial site, slaughterhouse, Sanandaj airport, etc. which has been done regardless of environmental capacities and limitations, are forms of weak urban and rural management of the region. There are land-uses and services such as urban burial sites, slaughterhouses, cemeteries, airports, silos, vegetable and fruit markets, and inter-city transportation terminals, which are located outside the cities but thoroughly serve the main cities. Similarly, the present location of the slaughterhouse of Sanandaj in south of the city and near Gazaneh village is not suitable because it is on the way of the future development of the city. In addition, the dominant wind of the city blows from south to north with a velocity of one knot. The location of the slaughterhouse on the way of the dominant wind causes the produced pollutants to be transferred to the residential areas. The proximity of

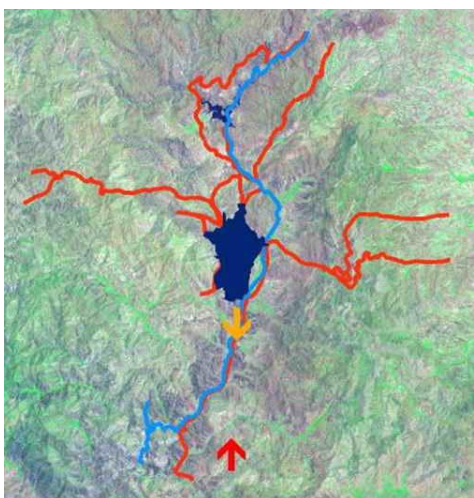


Figure 1b

the existing slaughterhouse to a river named Gheshlagh, its proximity to the most important site of strawberry production in Iran, high level of underground water, and heavy environmental pollution, are among the shortcomings of the location of the present slaughterhouse.

Literature review

The issue of slaughtering livestock, the resulted pollution and the way of dealing with it, has a long history; for example, Michael Kucher^[7] in his article *The Use of Water and its Regulation in Medieval Siena* have discussed the problem of waste water and the pollution caused by slaying livestock in Medieval Siena. He discusses that polluted water had caused conflict between the guild of butchers and the municipality. The reason behind these struggles was that the municipality believed that the waste water left after slaying, polluted the city's water and fountains throughout the city. The municipality believed that the sites where slaughter was carried out must be transferred to somewhere out of the city. Kucher also believes that the water system of ancient city of Yazd in Central Iran can be a good pattern for water use and reuse in developing or developed countries.

In fourteenth century, Ibn-e-Ekhvah has in the sixteenth article of his book entitled *City Management* emphasized on the necessity for butchers not to slay the livestock inside their shops so that less pollution was caused.

The Iranian Environmental protection Agency, in a research entitled *The Principles and Regulations for Site Selection in of Service Industries and Centers* sets the

slaughterhouses in the category of "highly-pollutant" industries. The above-mentioned organization simply presents strategies which are limited to a list of pros and cons^[6]. Ahmad Saeidnia, in the ninth volume of a series of Green Books published by the municipality of Tehran, entitled *Urban Infrastructure*, categorizes the issue of slaughterhouse in a general subject of urban infrastructure and suggests some guidelines for site selection^[10].

In Iran, the site selection of slaughterhouses is done in master plans. But this fact should be noted that the systematic and environmental view of such plans is not so strong. So we can not define the location based on several factors. In 1992, in their research, *Use of GIS for Selection of Sites for Land Application of Sewage Waste*, William Hendrix and David Buckley considered a 210-hectare area in Vermont, USA in terms of physical and economical factors like suitable soil, depth of bedrock, land-use, surface and underground water, altitudinal zone scheme, etc. and identified the suitable location in the vicinity of "Mad" region^[4]. Mohammad Reza Ali Nouri^[9], in his study, *Preparation of a Mathematical Model for Site Selection of Poultry Slaughterhouses*, presents discussions on selecting the optimum location, preparation and estimation of capacity for slaughterhouses. He uses transportation model which aims at making maximum profit with consideration of cost and income.

The presented process for modeling the location of slaughterhouse

This article resents an application of features and capabilities of Geographic Information Systems for modeling site selection. These systems have become a functional decision-making tool due to, on the one hand, having outstanding capacities such as conducting precise, fast, and reliable analysis of geographic data and descriptive information, and on the other hand, the increasing attention of the Iranian administration of the industries and also the decision making organizations. Geographic Information Systems consist of hardware, software, specialists, and geo-reference data, which have the capability to collect, store, maintain, retrieve, analysis, model, and display the spatial and descriptive information. Therefore the mentioned systems are very effective tools in order to promote decision-making, especially for macro level managers^[11].

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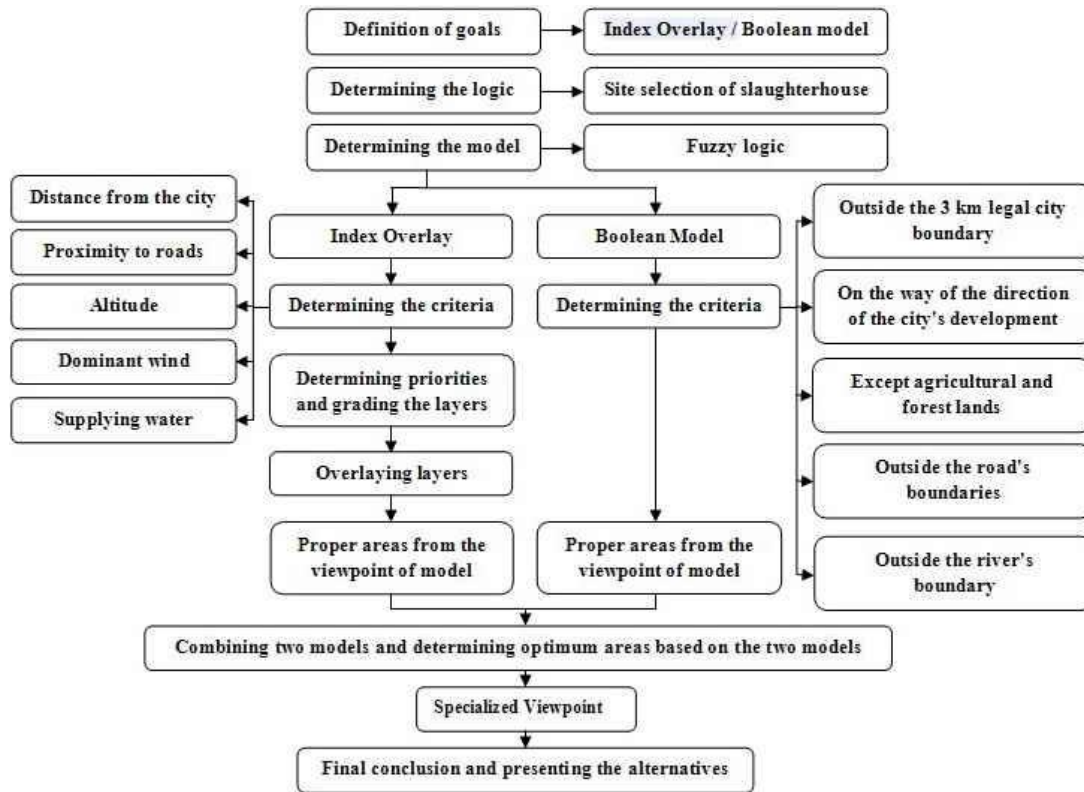


Figure 2 : The process of modeling

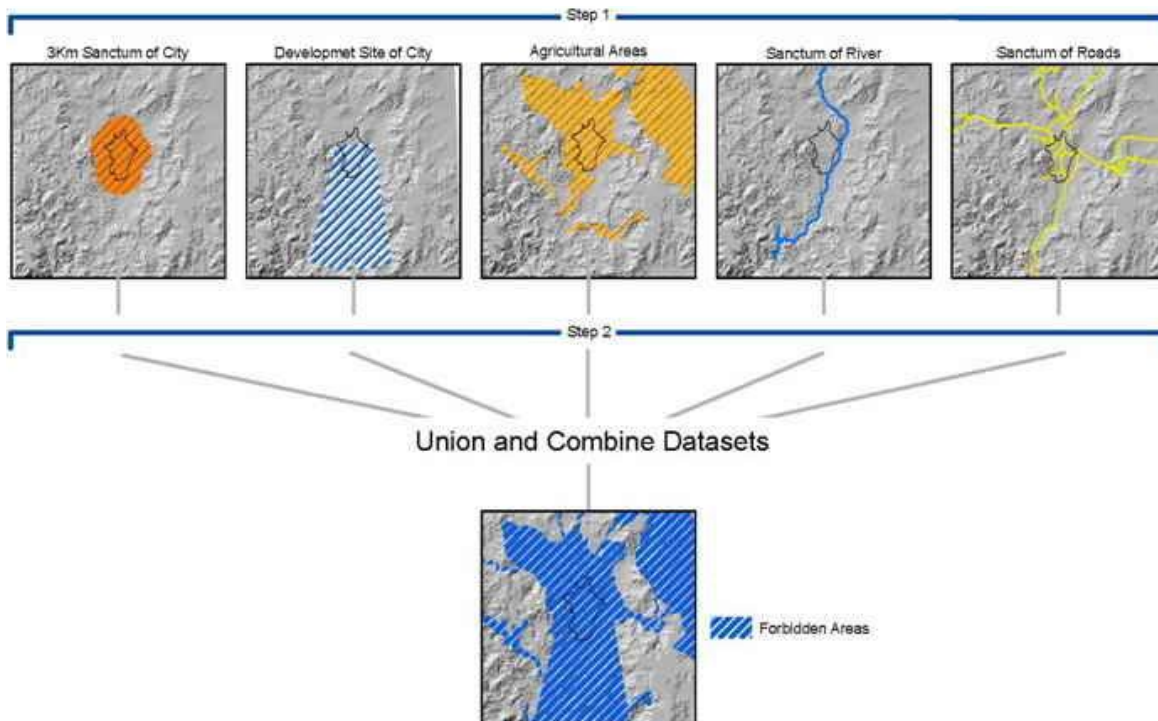


Figure 3

One of the most important features of the Geographic Information Systems is modeling. The prediction of results and simulation of reality can be conducted

through taking advantage of a wide range of geographic functions such as altitudinal functions, Buffering, overlapping layers, shortest path; and taking to account the

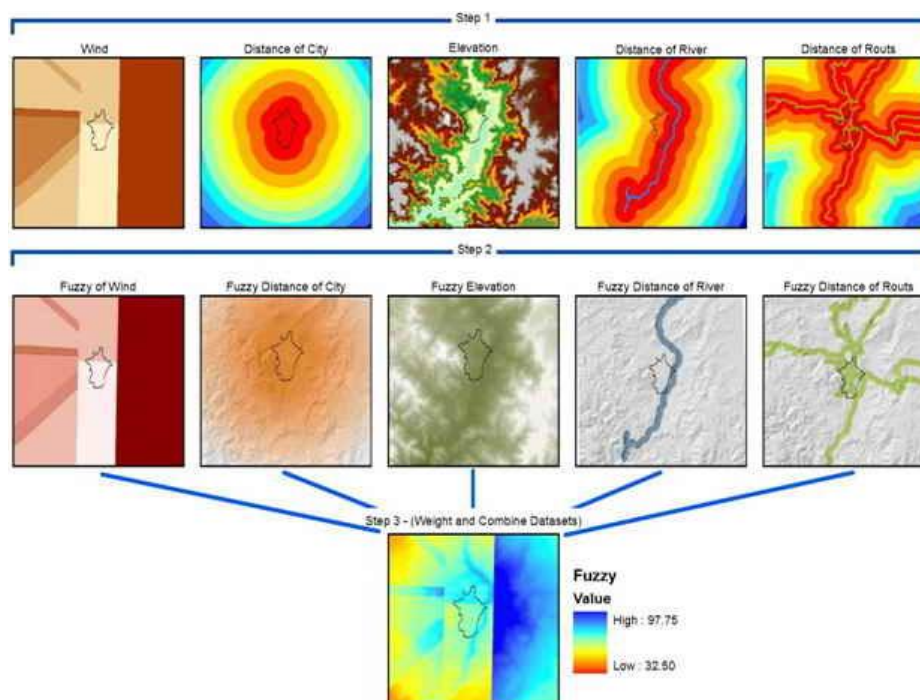


Figure 4

influential parameters.

One of the successful models, which have shown prominent capabilities, is Index Overlay. In this model, after defining weights for effective factors, the layers get overlaid and therefore proper locations are determined according to the model. On the other hand, most of the common ways that are used in modeling, reasoning, and calculation have definite nature and precise structure. In other words, it is assumed that the parameters of a model exactly represent our perception of a phenomenon or the characteristics of the real modeled system, and there is no ambiguity. But real situations are often equivocal or uncertain, and the future status of the system may not be fully known due to lack of knowledge and information. When confronting these uncertainties, regarding the nature of the problem, several models have been proposed to be used based on Probability Theory, Dempster-Shafer Theory, Non-Uniform Logic, Theory of Interval, and fuzzy Set Theory, each of which are appropriate for a certain type of uncertainty of phenomena. This study applies Fuzzy logic which is a highly-efficient tool in modeling ambiguity, and was first introduced by Professor Lotfizadeh. A brief discussion of the process of decision-making within the framework of the applied model follows.

The first executive measure for construction of a slaughterhouse is to select an appropriate location for it. In selecting a site for a slaughterhouse, the following points must be taken into consideration:

(1) Position with respect to the city

A slaughterhouse must be located outside the city's legal territory and not be on the way of the city's development^[10].

(2) Distance from the city

A slaughterhouse must be distant from the edge of the city's legal territory; at least 6 km if it is large, 3 km if it is mid-sized, and 2 km if it is small^[10]. With regard to the current population of Sanandaj, a mid-sized slaughterhouse will suffice.

(3) The position of land with regards to the communications networks

A slaughterhouse must be next to the edge of one of the main roads leading to the city; or be connected to the main road by an access short sidetrack. In the cities that are located on railroads, it is better that the slaughterhouse get located near the railway, and if possible, a side-railway is provided^[10]. In the meantime, the location for constructing a slaughterhouse should be outside the legal construction-forbidden zone of the

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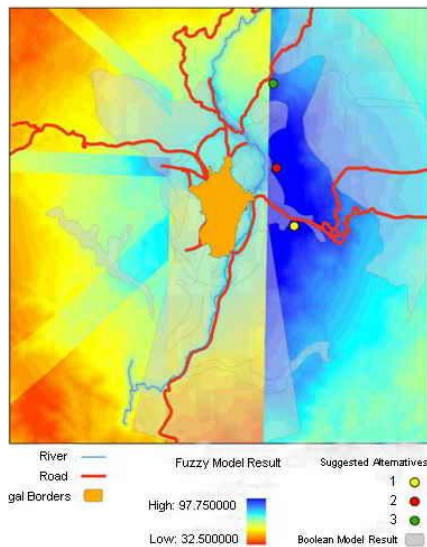


Figure 5

roads. In Iran, this distance is 150 meters away from the road axis^[1].

(4) Slope

A slaughterhouse must be constructed where the altitude is lower than altitude of other parts of the city, so that the resulted pollution does not spread to other parts^[10].

(5) Dominant wind

Slaughterhouse should not be on the dominant wind direction^[10].

(6) Water

A slaughterhouse should be located in a place where providing the necessary water is possible. Due to high water consumption in Slaughterhouses, using urban treated water is not recommended. It is better instead to dig a deep or semi-deep well for supplying the needed water^[10].

(7) Position with respect to the permanent rivers

Slaughterhouses fall into the category of "D" of Iranian industries (highly polluting industries). According to the Iranian Environmental Protection Agency, the mentioned industries should be located beyond a 200-meter boundary of permanent rivers^[1].

(8) Site

The location of a slaughterhouse should not be in forest^[8] or agricultural type^[1].

These suggested guidelines were categorized in two

models of Boolean and Index Overlay in a way that compulsory indicators (that are normally related to the Iranian Environmental Protection Agency) fall into the Boolean model category and relative indicators are put under Index Overlay type. Figure 2 illustrates the modeling structure in this study.

The indicators of the Boolean Model have only come within a union; and as a result the places, which legally do not have the possibility to construct a slaughterhouse around them, were identified. The result of this model is represented in figure 3. In addition, the indicators of Index Overlay were rated by using Fuzzy logic (TABLE 1) and finally, each layer was given a rating between 1 and 100 so that the total sum of all layers equaled 100. For overlaying and merging layers, first each layer's score was multiplied by its Fuzzy rating, and then all the results were added. The final result of this process is shown in figure 4.

CONCLUSION

Any scientific research is conducted to reach a specific goal. In other words, the researcher's aim of carrying out a research is either fundamental that leads to an improvement in a scientific field, or functional and practical, which aims at solving a problem or boosting the quality or quantity level. Therefore the researcher should present a theory by taking into consideration the mentioned objectives and results of the research. The important point in any scientific research is that the research process should always be accompanied by endeavor and remarks; and at the end of the research process, based on the observations, the researcher should decisively express his/her viewpoints about the subject in order to help expanding the range of knowledge^[3]. Due to the complexity and uncertainty of evolution and development of the contemporary cities, long-term and definite planning and predictions must be put aside and planning should be as close as possible to the present time. This is possible only by relying on intelligent systems for collecting and updating the information at every moment. In this study we tried to delineate and select the most proper location for construction of a slaughterhouse based on the presented criteria. For this purpose, different information layers were analyzed by means of the two models of Boolean and Fuzzy. By

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using the achieved results from these two models, the optimum location of the slaughterhouse can be selected. The suggested sites are located in the eastern lands of Sanandaj. Figure 5 shows the proposed alternatives for a new location of the slaughterhouse. As the results show, the system's ability of showing the suitability of each alternative^[11], paves the way for the decision-makers for better management and prioritization of the existing options. Modeling based on the Geographic Information Systems, enables the decision makers to develop, improve, and optimize the model according to different environmental conditions and also to consider various aspects of a subject.

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