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Using GIS for Priority Assessment of Road Construction in Kermanshah Province

S.H. Sanaei-Nejad (PhD)
Ferdowsi University of Mashhad, Iran
Sanaei_h@yahoo.co.uk

B.Badkoo
MSc Students Khajeh Nasiroddine Toosi University
bbadkoo@yahoo.com

S. Monajjem (PhD)
Khajeh Nasiroddine Toosi University

Abstract

Construction and improvement of road network is one of the most essential tasks to reduce transport cost and increase management efficiency in a country. However, considering of three factors that traditionally are used for such studies including travel time, travel distance and population may not end to realistic results. Therefore we need to consider a multiple criteria model to take all of the effective factors into account using Geographic Information Systems (GIS).

Kermanshah province in West of Iran was considered for this study. A dynamic database was established to store and retrieve the data for the effective factors in road construction, such as human, social, road, driving, and vehicle factors and also the related secondary factors to each of the main ones. The data were processed and linked to the thematic maps.

A Multiple Hierarchy Decision Making (MADM) model called Analytical Hierarchy Process (AHP) was used in a GIS platform to combine and compare the factors for the assessment. Finally, the layers were overlaid and combined together to produce a composition map that can help decision makers for constructing new roads and improving current road network in the province.

A pilot study was also planned to assess the results, which shows a fair agreement with the other methods that are used by professional staffs in the related section.

There were still some differences in the results, which can be modified by changing the factor values based on a new investigation.

Introduction

Road transport is the most common way in transportation industry in the world and especially in Iran, where roads are used for nearly 85% of total transportation. There are different reasons that make the road transport very important in Iran such as:
- International demands for good transit between the adjacent countries.
- Governmental development plan, which is based on agriculture, mineral and industrial activities.
- Tourist and pilgrim demands (the latter is very important in Kermanshah province which is an important terminal for the huge number of pilgrims who travel to Karbala from different parts of Iran).

Kashefipoor (2001) used Markof method for randomly network analyzing to present a model for road maintenance in Iran. Niaraki (2003) used GIS to evaluate road network in Iran. He considered road traffic, tourist, security and climate factors for his model. The main factors has 5, 12, 6, 3 and 4 sub factors respectively. He used a hierarchical analysis for comparing his main and sub factors. Peded et al. (1993) used GIS for road security analysis. He considered road factors, human factors and vehicle factors for his analysis. Prasad et al. (2003) also used GIS for their case study for rural road planning program. Chavarria (2002) used Analytical Hierarchy Process (AHP) for a road management system in Champaign. More researches also show that this method can be used for different conditions in different places.

This study is directed to investigate into road construction priority in Kermanshah province in west of Iran. There is a very complicated situation in this province for developing roads network. The province is very big and mountainous with different social, economic, road traffic (imbalance between demands and current roads network), security and environmental matters. These special conditions of the province increase the cost of road construction projects.

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The following subjects are considered in the general aspect of this study.

- Determining of main factors and sub factors for road construction in the area
- Choosing a suitable model for comparing the attributes and combing them based on their values using GIS
- Comparing the results with the old manual calculated methods
- Producing a spatial data base of road maps and the related descriptive data
- Assessing of priority factor for road construction in Kermanshah province

Methods and materials

It is obvious that there are many factors affecting decision-making process for a road construction project. Therefore a Multiple Criteria Decision Making (MCDM) model should be used for such a problem. These models are divided into two main categories, Multiple Objective-Decision Making (MODM) and Multiple Attribute-Decision-Making (MADM). MODM models are used for planning while MADM models are used for choosing the best option from many different available alternatives.

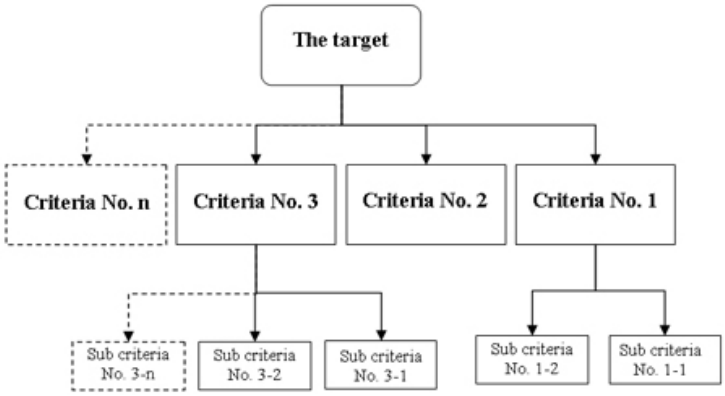

Figure 1. Analytical Hierarchy Process (AHP)

We used Analytical Hierarchy Process (AHP), which is a MADM model for this study. This technique was proposed by Tomas-L Saaty (1979). This model considers personal assessment and experiences as well as a logical comparing of factors, which are essential for our final decisions. We can use a systematic vision and detail factors together in our analysis. The general systematic visions are considered in top levels and detail factors are compared and assessed in lower levels and finally values are assigned for different factors from top to the bottom levels. Figure 1 shows a chart demonstrating general aspect of the model.

Based on the above chart the model uses the following function to combine the criteria:

$$F=k_1X_1 + k_2X_2 + k_3X_3$$

In which K1, K2 and K3 are the coefficients for X1, X2 and X3 criteria respectively and should be determined by professional personnel who are involved in road construction planning in the area.

After the tree structure is completed for the related criteria, all of the criteria in each level are compared together two by two. The results of this comparing process are assessed as figures that are weighting factors for the criteria. These figures are classified between 1-9 according to the table 1. Values 2, 4, 6 and 8 are also used for the interval values according the decision maker.

Relative comparing of criterion i with criterion j	The Value
Equally Preferred	1
Less Preferred	3
Moderately Preferred	5
Very Strong Preferred	7
Extremely Preferred	9

Table 1. Criteria values

In this study we used the following parameters to provide the hierarchical tree structures of the criteria in road construction in Kermanshah province:

Economic parameters:	8. Road security
1. Border market	9. Road traffic
2. Customhouse	- Cars
3. Industry	- Mini buses
o Industrial towns	- Buses
o Industrial units	- Vans
o Storage points	- Lorries
4. Agriculture	- Lorries with two axes
o Irrigation network	- Lorries with three axes
o Stakeholder centers	- Lorries with four axes
o Dams	- Agricultural vehicles
o Green house activities	- Motorcycles
o Fisheries	- Other vehicles
5. Mines	10. Topography
Road parameters	- Slope
2. Departure and destination	- Aspect
3. Trip length	- Slope length
4. Road facilities	- Shadow area
- Services	**Political and security**
- Terminal	1. Border check points
5. Land use	2. Military roads
- Agriculture	3. Military places
- Jungle	4. Administration border
- Pasture	**Human factors**
6. Type of road	1. Population area
- Old unused roads	- County
- Rural roads	- City
▪ Roads grade 1	- District
▪ Roads grade 2	- Village
▪ Roads grade 3	2. Population change
- Main roads	3. Spatial distribution of population
▪ Wide main road	4. Population structure
▪ Ordinary main road	5. Administration centers
- Secondary roads	6. Education centers
- High way	**Vehicle parameters**
- Dual carriage way	1. Height
7. Tourist	2. Type of wheel
- Lakes and moorlands	3. Weight of Vehicle
- Dams	4. Type and amount of fuel
- Religious buildings	5. Speed
- Historic buildings	6. Light
- Rivers	7. Type of Vehicle
- Mountainous landscape	- Private car
- Jungle landscape	- Lorry
- Other tourist attractive areas	- Others

Results

The criteria were evaluated by consulting of professional staffs in road administration office of Kerman shah province and they were compared two by two. Table 2 shows a typical comparison results.

The selected criteria converted into thematic maps and the related data was saved in a database. Some technical works has been done to organize and adjust the maps to make them ready for a GIS analysis based on the model.

Some of the most important maps are shown in the figures 2 and 3. Figure 4 also shows the final composition map, which demonstrate the results of model and the priority of road construction in the province.

	industry	Mine	Terminal	Custom	BorderMarl	Agriculture	Fishery	Rancherinc	IndustryCity
industry		2.0	3.0	3.0	3.0	1.0	3.0	2.0	2.0
Mine			1.0	2.0	2.0	3.0	1.0	2.0	3.0
Terminal				2.0	2.0	3.0	2.0	2.0	1.0
Custom					1.0	3.0	1.0	2.0	3.0
BorderMarketPlace						3.0	2.0	2.0	4.0
Agriculture							5.0	2.0	1.0
Fishery								2.0	5.0
Ranchering									3.0
IndustryCity	Incon: 0.05								

Table 2. A typical comparison results of the criteria values.

Figure 2.: current road network in Kermanshah province

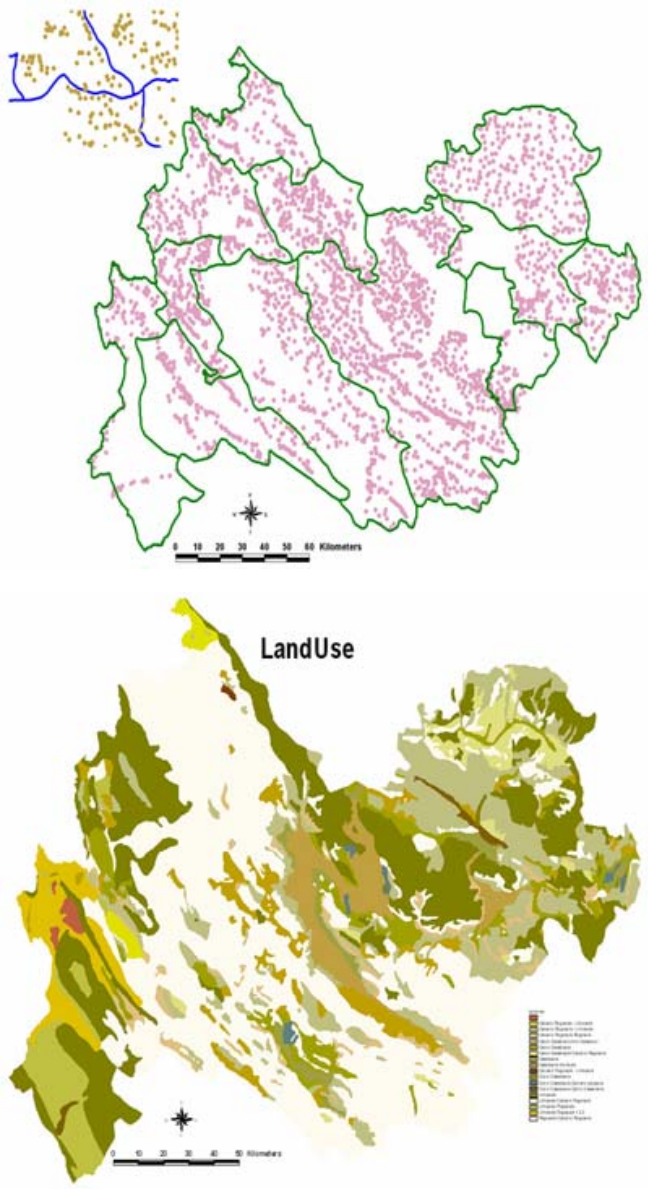

Figure 3. Top: Population points, bottom: Land use map

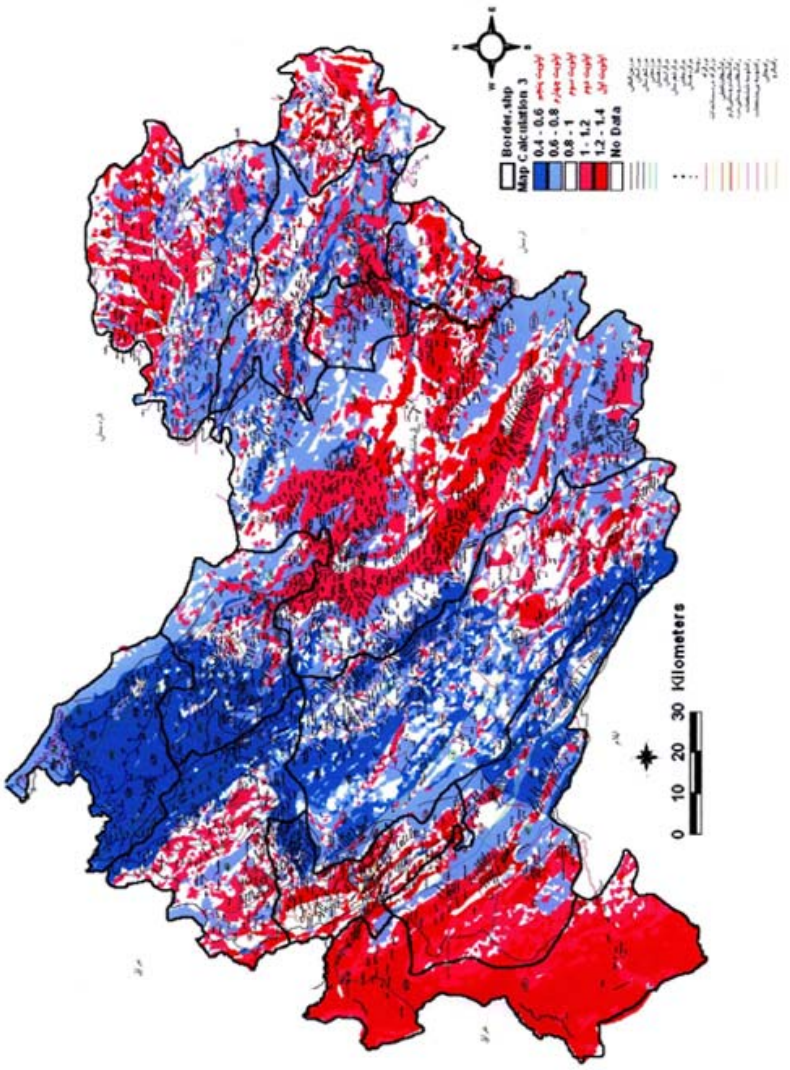

Figure 4. Final map of road construction priority in Kerman shah province

Conclusion

Even though using AHP model is not so difficult for such a decision making process, but collecting the necessary data and maps are very time consuming and also costly procedure, which has been done in this study and can be used for the future modification or running a new model. The current results should be calibrated by using some experiments methods and evaluate before they are used by the road administration in the province.

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