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EVALUATION OF AHP APPLICATION FOR HYRCANIAN FORESTS THROUGH ROAD CONSTRUCTION POTENTIAL MAP

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Abstract

Forest road network planning in ameliorated forest is an important factor for constant forest development that not only leads to decrease in cost but also prevents forest destruction. Final decision in forest road planning is not possible just by optimization of one variable. Therefore, multi criteria decision methods have been developed. Analytic Hierarchical Process (AHP) is one of the most well-known multi criteria decision techniques that has been introduced for resolving planning needs. The purpose of this study was to evaluate AHP application in preparing road potential map for Hyrcanian forests in northern Iran. Study area is a part of No 7 watershed domain in northern Iran and corresponds to the general peculiarities of Hyrcanian forests. Regarding natural condition of Hyrcanian forests, in this study, 8 factors were taken in to account, such as slope, exposition, altitude, vegetation type, volume of growing stock, hydrographic peculiarities, geology and pedology. In order to validate indicators, a questionnaire was developed and distributed among road construction experts in Natural Resource Organization. Indicators' relative weights were calculated by Expert Choice software. After getting every layer validity ratio, these layers were synthesized in ArcGIS9.2 software to make potential map for road construction. Resultant potential map was compared with one proposed by university professors. Forty points were designated electively in both potential maps and were evaluated with regards to mentioned factors. Studies showed that results proposed by professors were more accurate than these proposed by experts. However, with regards to percentages and results obtained this method cannot be used safely in potential map preparation for road construction in Hyrcanian forests.

Key words: AHP method, forest road network, Hyrcanian forests, potential road construction map.

Introduction

Forests have always been considered as renewable and productive resources. Human need for wood and its productions is permanent and inevitable. Therefore humans have found out that for permanent and economic exploitation of forests,

it is necessary to develop particular rules and orders. Forestry plans resulted from this attitude. Roads are the forest vital arteries in forestry plans and their main function is to open the forest and to make it accessible to apply methods of forestry, and finally forest management techniques (Najafi 2006). Road is an essential part in silviculture, afforestation and other required operations in forest (Hay 1996). On the other hand, road construction has harmful environmental consequences, like forest area diminution, natural canalization destruction and sedimentary soil and water destruction (Gardner 1997, Egan et al. 1985). The roadway grade should be carefully selected, not only to minimize the total road cost but also to reduce the environmental impact and to improve driver safety (Akay 2004).

Despite necessity of forest operation and importance of road in northern Iran forests, it's necessary to know that road construction is problematic too. Also, only some parts of northern forests in Iran have operation and road construction potential. Because of slope lands, unstable areas, ruined lands and environmental limitations in Iran's northern forests, activity opportunities are restricted. Therefore, it is necessary to select appropriate areas for road construction. In this way forest utilization will be constant (Najafi 2006). Type of forest road network designed, its optimal planning is a permanent forests development important factor that increases costs and destruction of nature and vegetation. It is necessary to identify the important points on eventual road and all probable points that road may cross, by topographic, vegetation, geology, pedology and other existing maps for a forestry plan and by using systems like GIS. Geographical Information Systems is a frequently used tool in the decision making process. It uses database queries to find the best solution requiring the least time and money (Erdas and Gumus 2000). The most important advantages of GIS application in road planning are: to fill a large number of layers in use, capacity of large volume data process, possibility of using digital maps in high correctness, easier editing capacity, high speed and low cost operating. These advantages caused growing use of GIS. The geomorphological mapping issues and the GIS role in doing it were consistently reviewed and applied on a small mountain area in Sweden by Gustavsson et al. (2006, 2008) and Gustavsson and Kolstrup (2009).

A comprehensive digital geomorphological mapping may be a useful tool for land reclamation planning, sustainable development of the area, risk and hazard assessment (Condorachi 2011).

In road planning for forest, different factors must be checked and their priority evaluated. In other word, final decision is not possible just by optimizing one factor. Obviously to resolve such problems is complicated and not easy task, especially when most of the mentioned factors are in contrast with each other and optimizing one may cause blight the other. Therefore some multi criteria decision methods divide the problems separately into smaller reasonable parts, and then synthesize the out coming results to make a global solution for main problem solving (Malczewski 1999). Hierarchical analyzing process is one of the most known multi criteria decision techniques, which was introduced by Saaty in 1980 to allocate rare resources and planning requirement for military purposes (Saaty 1997). Hierarchical analyzing process techniques make possible to formulate

problem hierarchically and to consider quantity factors in problem too.

Moreover, applying this method show a composition to cooperation and incoherence rate of decision too, this is one of the significant advantages of this technique in multi criteria decision (Ghodsipoor 2009).

Malczewski (1999) in his research in Ohio state of US, advanced a step and manifested that as each effective factor has not the same effect on routing , in other word, their potency rate in routing are not similar, so these factors are to be validated. In his research he used mutual comparison method between validation methods, because of its strong theory base, high accuracy and easy application.

A comparison matrix is formed in this method. In this case to minimize personal ideas in validation, expert viewpoints about effective factors relative validity are used, and factors mutual comparison is done by expert choice software.

Heralt (2002) in a research in Romania, express that forest road network planning is a hard and engaging work and depend on numerous factors. Except costs, which have no essential role in forest road completion and development, factors such as road appropriate locational distribution in total rejoin, perspective pattern, forest hydrology role, and soil protection, have significant effects on forest road network planning.

Naghdi and Babapour (2009) during their study on Guilan's Shafarood forest, planned the road by GIS and AHP, used 6 maps of direction, height, volume per hectare, trees species, slope, and stability, and realized this method may be useful on Iran's mountainous forest and is preferred to road planning by traditional method. They used university professor view point to complete AHP questionnaires.

Mohammadi Sammani et al. (2010) performed a study on Guilan forest enterprise to road planning and evaluating technically and environmentally. They considered different factors which may affect the forest roads planning and used analytic hierarchical process (AHP) to compare them to each other. They used university road construction professor's ideas to complete AHP questionnaires too.

The objective of the present study was to evaluate potential map for road constructions resulted from road construction professor's ideas in universities and road construction experts in natural resources organization, and to compare them in nature, in order to evaluate the function of AHP method in Iran's northern forest.

Materials and Methods

The study area (3559 hectares) is located within the watershed number of 7 in north of Iran (Fig. 1). This forest is located on 48°44'36" to 48°49'58" latitude and 37°37'23" to 37°42'31" longitude and at altitude ranging from 280 to 2120 m above sea level.

Study area is mainly in rainy regions and in term of climate classification is ranged as humid climate. Most of the year is rainy and maximum rainfall is in September and October.

The study forest is classified as mountainous forests and belongs to hyrcanian forests, and it is easily accessible to outdoor operations and data and information are available, so this forest was chosen as study area.

In order to have constant access to countless forest gifts, expected activities during plan accomplishment must be

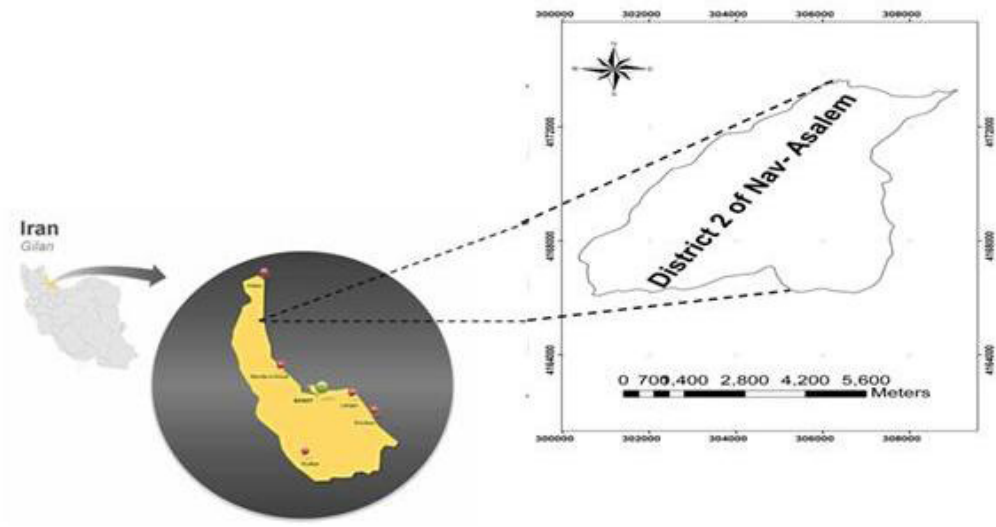

Fig. 1. The location of the study area.

in natural potential limits. Road network planning is the first activity in forestry plans preparation in which different ecological and economical factors must be considered, compared with each other and validated.

In this study, regarding hyrcanian natural condition, 8 factors were considered as effective ones and used for road construction potential map preparation. They were slope, aspect, altitude, vegetation type, volume of growing stock, hydrography, geology and pedology. Then to employ different experts' viewpoints in order to give value to each factor, a questionnaire was planned and the objectives, principles and general techniques were explained to road construction experts in natural resource organizations. Then the questionnaire was distributed among them and they were asked to present their view points about 8 mentioned factors by mutual comparison method (giving points are limited between 1 and 9). Next, questionnaires were collected, introduced factors relative values were calculated, and most effective factors on sylvan road path locating were determined by mutual comparison method in Expert Choice software, and each questionnaires variance was calculated. Saaty (1997) suggested if decisions variances were more than 0.1, it is preferred to modify decision. Also Mohammadi Sammani et al. (2010) in order to validate effective factors on road planning in Nav forest, district 1, which is located adjacent to district 2, and was very similar to district 1 topographically and climatically, applied analytic hierarchical process, except that they distributed questionnaire among university road construction professors and benefited their ideas. They gained different result from the result of this study, which is the base comparison.

After obtaining each layer validity ratio, in order to prepare potency map for road construction, in Arc GIS 9.2 software, each layer's validity ratio was multiplied by itself, and then these layers were add-

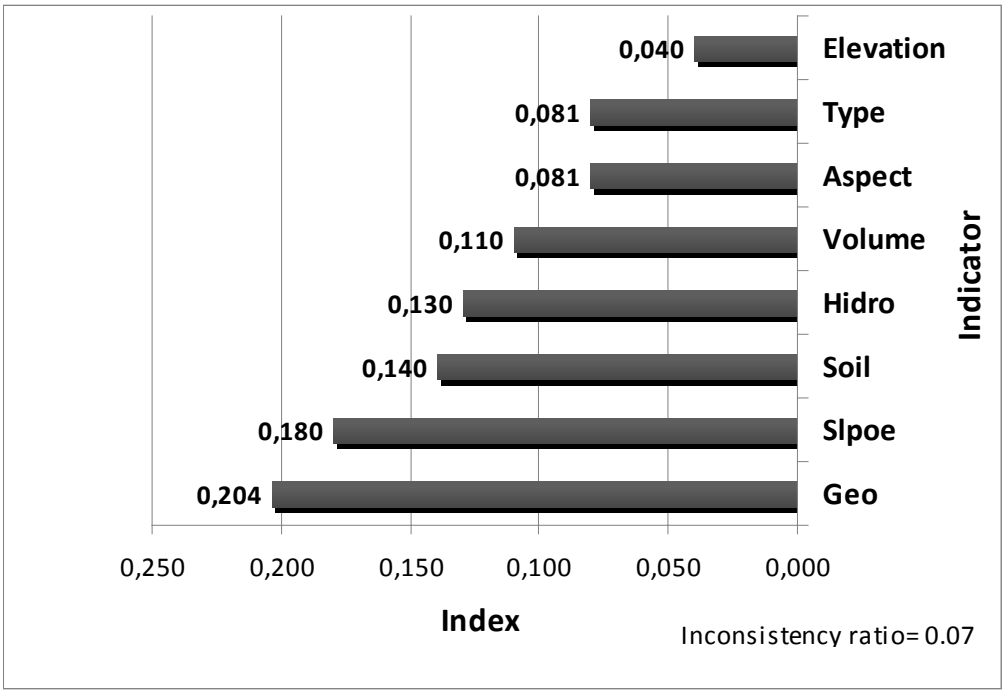

Fig. 2. Layers validation regarding to Natural Resource Organization expert's view points.

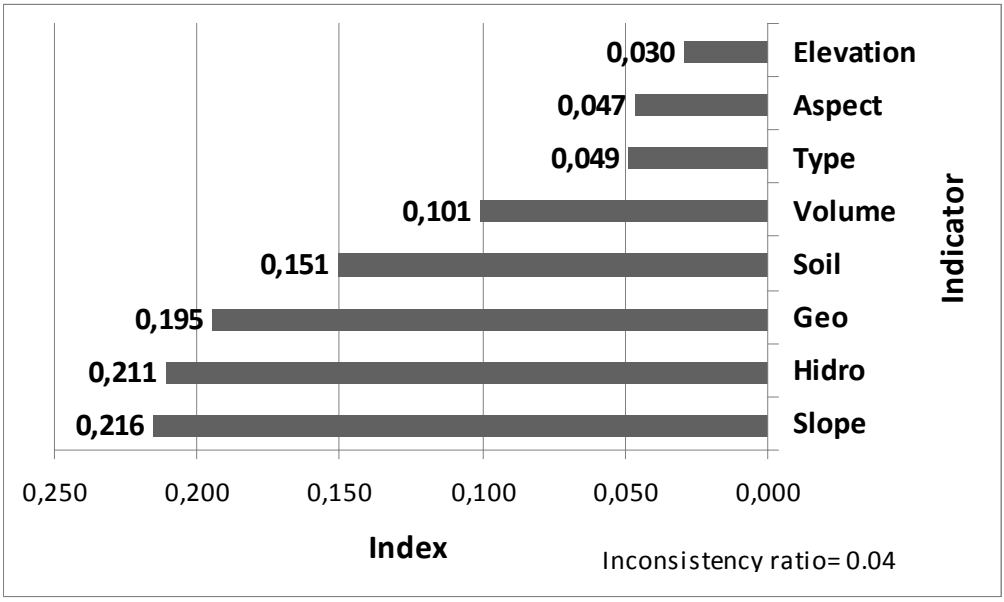

Fig. 3. Layers validation to university professors.

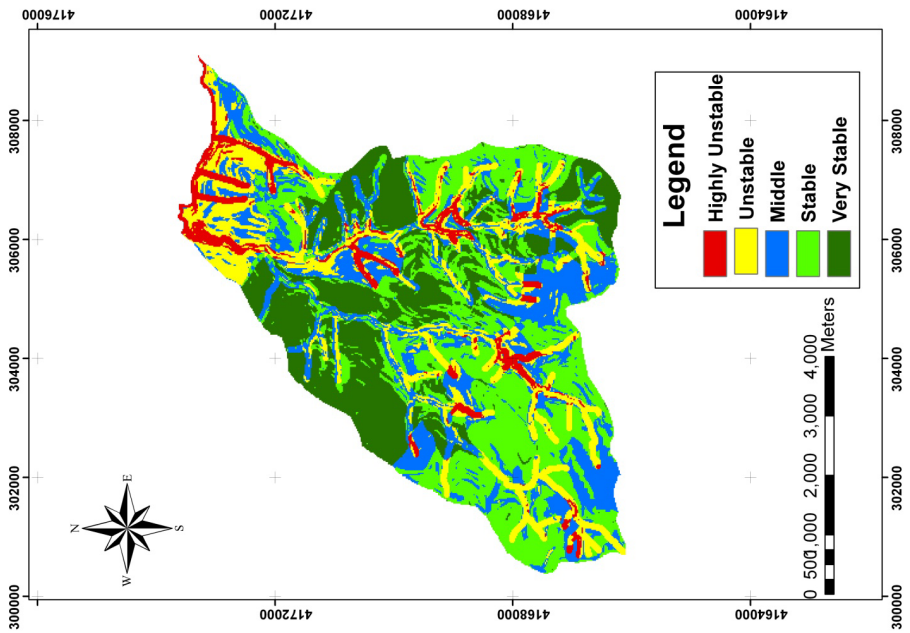

Fig. 5. Potency map to road construction by viewpoints of university professors.

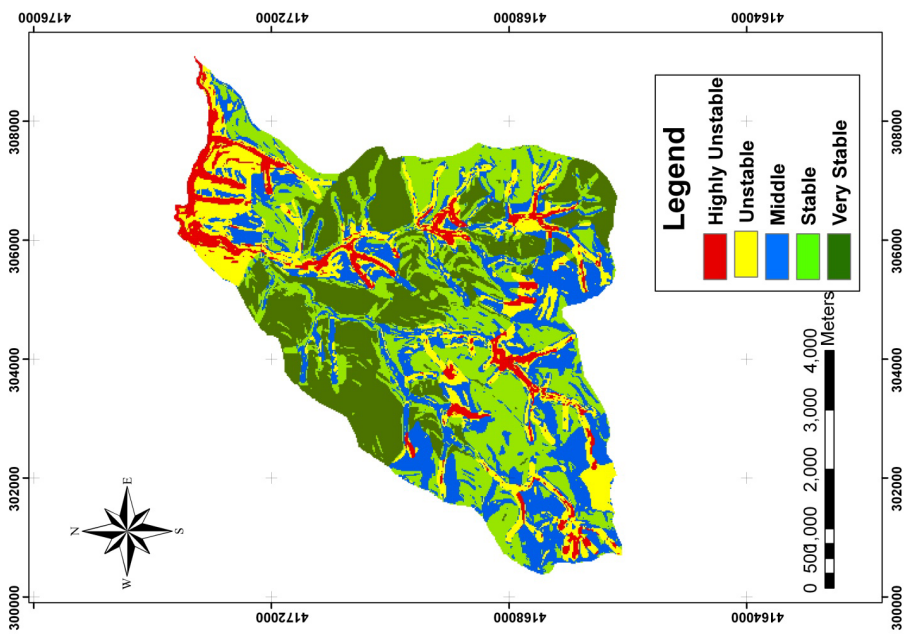

Fig. 4. Potency map to road construction by viewpoints of natural resources organization experts.

ed together. With compilation of these layers with regard to value of them potency map was prepared in 5 levels: very stable areas, stable areas, middle areas, unstable areas and very unstable areas. Very unstable areas are the areas which are unsuitable for road construction by all factors. Unstable areas are districts, which are suitable by 2 or 3 factors and other factors regarded are unsuitable. Middle areas in this division are districts which are suitable in 4 factors and unsuitable in 4 factors. Suitable areas which are suitable in most of factors are unsuitable in 2 or 3 factors. And finally, very stable areas are districts, which are suitable to road construction by all factors. In this classification the areas with more than 70 % slope were classified as very unstable areas without regarding other factors, because road construction in areas with such a slope is too hard and expensive. In next step, the resultant potency map regarding the ratios gained from expert's viewpoints were compared with potency map produced from resultant ratios by Mohammadi Sammani et al. (2010) regarding the 8 mentioned factors. Then 40 points were randomly selected and their coordinates were entered in to GPS. With regard to 10 areas were exist (5 area in potency map of experts view, and 5 areas resulted from defined ratios by Mohammadi Sammani et al., 2010), 4 control points were taken in each area. Next, prepared potency maps correctness was evaluated with outdoor observation.

Results

Derived results from analysis of distributed questionnaire among Natural Resource Organization experts by Expert Choice software, showed that geology layer by 0.204 validity ratio must be most important for forest road planning and respectively: slope, pedology, hydrography, volume of growing stock per ha, aspect, tree species and altitude were in next validity (Fig. 2).

However, result of the research derived from Mohammadi Sammani et al. (2010), which was achieved by university professors viewpoints showed that slope layer with 0.216 validity must have the highest effect on forest road planning. Hydrology, geology, pedology, volume of growing stock per ha, tree species aspect and height from sea level were in next validity levels, respectively (Fig. 3).

After analyzing the results of validations through analytic hierarchical process, studying layers by validity level of each one were combined and potential map to road construction was constructed on ArcGIS9.2 software (Fig. 4). Then using results of Mohammadi Sammani et al. (2010) a potential map for the same area was prepared, too.

Results from field visits showed that in 19 of 40 selected points (47.5 %) of university road construction professors' viewpoints case were compatible to nature. In 14 of 40 points (35 %) of natural resources organization experts viewpoints were compatible to field survey, and in 7 points (17.5 %) field survey observations contradicted to both professors and experts viewpoints.

Discussion

Today forest managers and foresters must be aware of forest road planning and construction, and care should be taken in road network planning, because road construction has the most share of forest manage-

ment cost and environmental effects on forest ecosystem are likely irreparable, so road planning and forest road locating must be achieved as carefully as possible (Dutton et al. 2005). If forest road is planned and distributed well, it will make less damage to forest and vegetation and forest will be in the best state from optimum management perspective. Therefore, forest road planner must pay attention to these basic principles in the planning (Baskent and Keles 2005). Effective factors determination and validation in road construction and planning is essential.

In order to plan a forest road, effective factors for road construction must be considered from technical, cost, and environmental perspective. With this, in addition to time saving it may profit from various persons ideas (Qajar 2006).

Many works have been done using GIS about forest roads planning in hyrcanian forests, majority of them used universities road construction professor's ideas. Babapour (2008) applied in his work topography, slope, aspect, growing, volume of growing stock per ha, forest type, pedology and geology layers as effective factors. Badraghi (2009) used height aspect, slope, pedology, geology and volume of growing stock in road planning. Naghdi and Babapour (2009) in Guilan province forests evaluated forest road network using analytic hierarchical process and stability map. Also Mohammadi Sammani et al. (2010) attempted forest road planning in Nav Asalem forests. He applied new layers like hydrology that was not applied before. All these people benefited universities road construction professors ideas in their effective factors validation. But no one paid attention to expert's ideas that work on natural resource organizations, which are more in touch to these factors that might be useful in validation matter. In this research, this case was noticed for the first time, and organizations expert's ideas were used in factors validation. As mentioned, field researches showed that 47.5 percent of professor's ideas were similar to nature and 52.5 percent were in contrast to nature. Also in 35 percent of cases, expert's ideas were similar to nature and in 65 percent of cases their ideas were in contrast to what was seen in nature. There are plenty of reasons, which could explain this contrast, but it seems that the most significant reason for this discrepancy would be the factors like slope in hyrcanian forests. In this case, it is suggested that the ideas of people who perfectly know the study area should be used to validate the factors. These people might be professors or experts who know the area well. However, professor's ideas were slightly predominant according to nature than expert's ideas, regarding the high error rate (52.5 % in professor's idea and 65 % in expert's idea), cautious use of this method in practice for these forests is recommended and more researches in this matter seem necessary.

General Conclusion

In this research correctness of universities professor's ideas was relatively more dominant than results of experts' ideas; however, regarding the resultant percentages and consequences, this method cannot be used safely in potential map for road construction in practice.

Finally, further evaluation of this research results in other areas of hyrcanian forests is recommended. And in order to

achieve road construction projects in forest, safety rate of other methods must be evaluated and appropriate method, having higher safety percent should be chosen and used in road construction projects, which take high costs in forestry plans.

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