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Forest road network assessment using lookout points orienting in Hyrcanian forest using GIS – Short Communication

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Abstract

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Road is a necessity for attaining ideas, principles and management plan in a forestry unit (district). The forest road network design must be aimed at a multi-purpose use of roads such as landscaping and tourism activities. This study was performed in the Namkhaneh section of Kheyrud forest 10 km east of Noshahr (Hyrcanian forest). First, the map of factors affecting the road routing was provided including trees type, soil, aspect, slope, altitude, etc. using GIS and determined parts of lookout on a topographic map of the study area. Then a new variant was designed as the secondary road and turnoff from the existing road trying to pass from more parts of lookout in its designing. Finally, existing and completive road networks were compared in terms of opening up and parts of lookout using the Backmund method. The results showed that the completive road network has more forest openness and more parts of lookout compared to the existing road network.

Keywords: completive roads; view points; physiographic; Backmund method; Kheyrud forest – Iran

Forests provide many ecosystem services such as preparation of nutrients, soil conservation, wood production, etc. Thus, multiple use management of forests has been growing recently for all services in the forest potentially instead of wood production dominantly. This method of management includes ecotourism, socio-economic issues of forest dwellers and several goals considered in addition to wood production (Amani 2000). Road is an essential part in silviculture, afforestation and other required operations in forests (Hay 1998). On the other hand, road construction has harmful environmental consequences, like forest area diminution, natural canalization destruction and sedimentary soil and water destruction (Egan et al. 1985; Gardner 1997). Above all, forest roads play an important role in forest management, conservation and reforestation and provide access to research, recreation or thinking in the natural ecosystems (Demir, Hasdemir 2005; Soleymanpour 2010). Nowadays, it is important to consider other services of non-wood production such as tourism, lookout and landscape because of the importance of other forest values; moreover, it is necessary to consider them in designing a road network (Sarikhani 2000; Sepahvand et al. 2005). 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). Ecotourism management is necessary for community growth and development due to population growth and depletion of natural resources. Ghomi et al. (2013) suggested that in order to implement road construction projects

in forests, the safety rate of some methods must be evaluated and an appropriate method, having higher safety percent should be chosen and used in road construction projects, which take high costs in forestry plans. Over the recent decades, planners, managers and executives of jobs have been making investments around the world considering poverty and low income (Emadi 2005). The purpose of scenic spots is to explore the spots that view landscapes from different directions in the field, where we can see the landscape with beautiful views (Jahani et al. 2011). In 1966, Hargrien provided a forest road design based on environmental principles and landscaping in Kainua Park and calculated their landscape value and tourist attractions (Häyrinen 1998). Heralt (2002) performed a study to select the optimal route of the forest road according to the least negative impact on the environment. He found that, in the forest road network, the effect of the design includes not only the cost but also other factors such as appropriate spatial distribution of roads in the entire area, landscape, forest hydrology and soil protection. Sepahvand et al. (2005) evaluated the forest road network in the Patom section of Kheyrud forest based on landscaping. They found that, based on landscape, the completive road network has a priority in addition to having more forest openness compared to the existing road network. Jahani et al. (2011) studied landscape quality and lookout spots in order to examine ecotourism in the Patom section of Kheyrud forest. They found that lookout spots can provide other options for construction routes, design and engineering of forest promenade, walking route and other ecotourism facilities based on some principles relating to the number and size of outings, installations and facilities. Moghadasi et al. (2013) performed a study on locating the best areas of road pass according to environmental aspects using GIS and multi-criteria evaluation. They considered a distance from landscape as one of the effective factors in road designing. It was necessary to pay attention to landscape in the forest road network design; moreover, optimal management of forest uses all dimensions and available options in the field optimally.

MATERIAL AND METHODS

Study area. This study was conducted in Hyrcanian forest (north of Iran), Namkhaneh district of the education and research forest of Kheyrud-Noshahr (Fig. 1). Study area was 1,079 ha including a logging

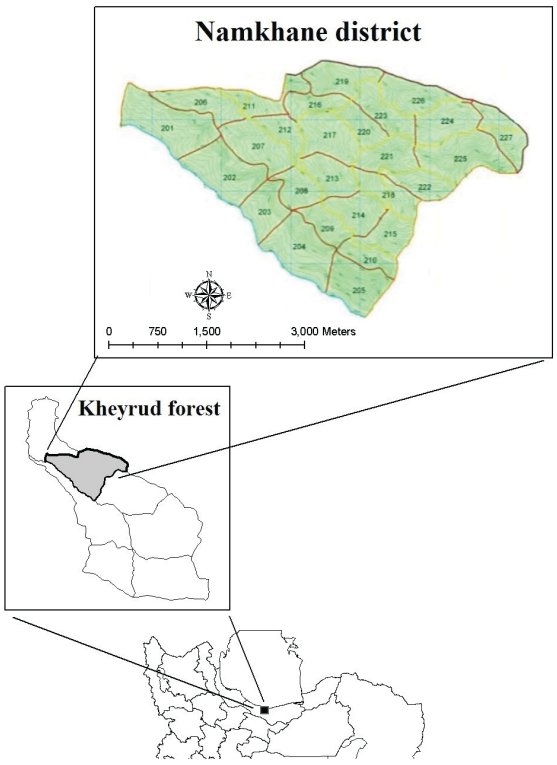


Fig. 1. Location of the study area

section (787 ha) and conservation area (290 ha). The existing forest road network was 21,472 m, elevation 450 to 1,300 m a.s.l., amount of precipitation 1,200 to 1,600 mm, having calcic bedrock, and much of the soil of the area consisted of calcareous skeleton and brown forest soil (Abdi 2005).

Methods. First, a topographic map of the study area was prepared. The scale of the used topographic map is 1:25,000. Then road routing factors including slope, aspect, elevation, tree types, soils and geology were prepared using Arc GIS (Version 9.3, 2008). The map of slopes was classified into 0–10, 10–30, 30–60 and more than 60% groups. The aspect map was prepared in nine directions including flat, north, northeast, east, southeast, south, southwest, west and northwest. Aspect direction is the main and effective factor for soil moisture, establishment of vegetation, degradation and erosion in terms of sunlight absorption (Ahmadi 2012). After the map preparation of each effective factor in routing roads, the landscapes were identified including *Parrotia* C.A. von Meyer and beech type, fountains and waterfalls, broadleaf and coniferous plantations, flat region and ridge overlooking the valley with beautiful landscapes were pointed on the topographic map of the study area. In regions where it was necessary to design an access road to the above points, a new variant was designed as a secondary road to follow the existing road. It was tried to pass from more lookout

points. Finally, distances of the points from the existing and added access road were calculated. After making the designed road, the proposed variant was investigated and analysed based on Backmund method. Therefore, such issues as designed road density, skidding distance and opening up of the road were calculated (Moghadasi 2012). Road density (m·ha^{-1}) of the completive and existing road network was calculated by dividing the length of the completive and existing road by the area of logging section. Next, the road space – RS (m) was calculated as follows (Eq. 1):

$$RS \times RD = 10,000 \quad (1)$$

where:
RD – road density (m·ha^{-1}).

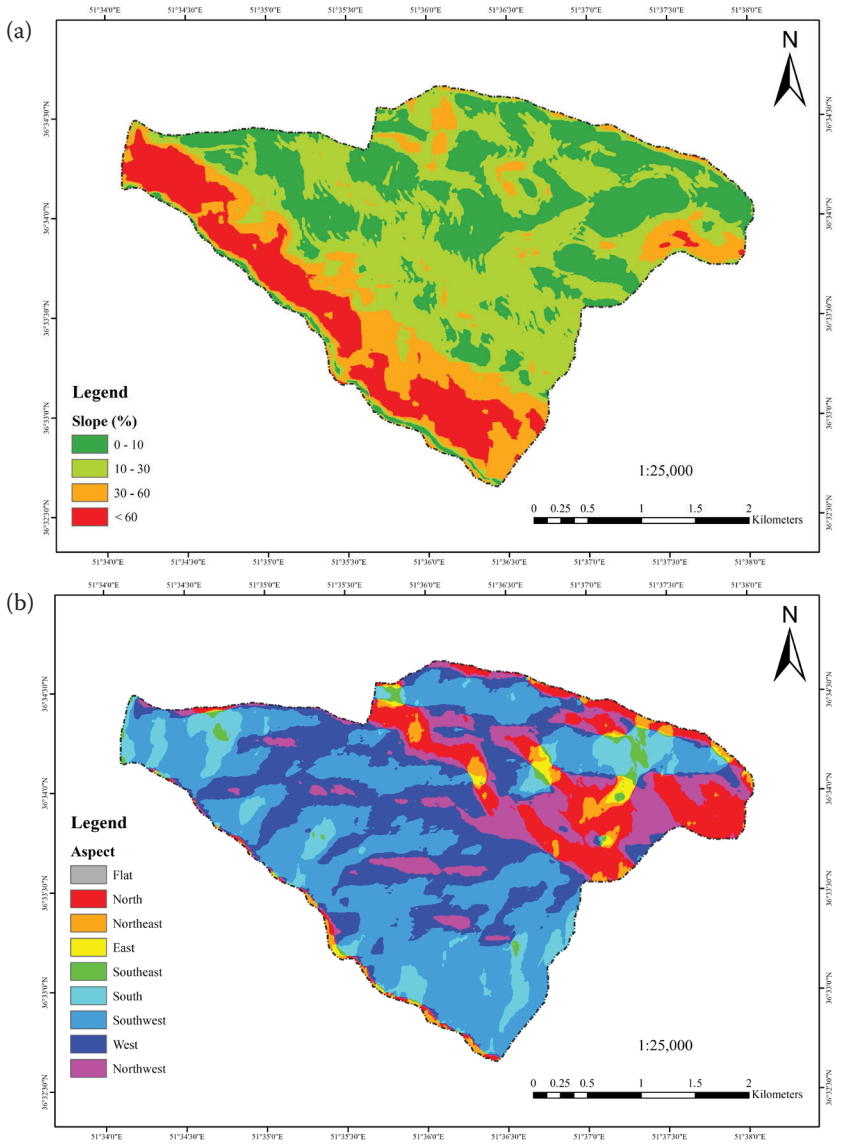
A buffer zone was created along the existing and completive forest roads by the width of maximum skidding distance (SD), as Eq. 2:

$$SD = \frac{RS}{2} \quad (2)$$

Total area of the buffer was calculated (Puya et al. 2009). Afterward, the skidding area was determined by Backmund method.

RESULTS

According to the final slope map in GIS (Fig. 2a), most of the area is covered by 10–30% slope class and least of the area is covered by 0–10%. According to the resulting aspect map in GIS (Fig. 2b), most of the area includes west directions and the least include flat direction. According to the resulting elevation map in GIS (Fig. 2c), most of the area is in 900–1,100 m a.s.l. class and the least in 400–700 m a.s.l. class. According to the map of tree types in the study area (Fig. 3a), the study area is covered with 5 different tree types including *Par-*



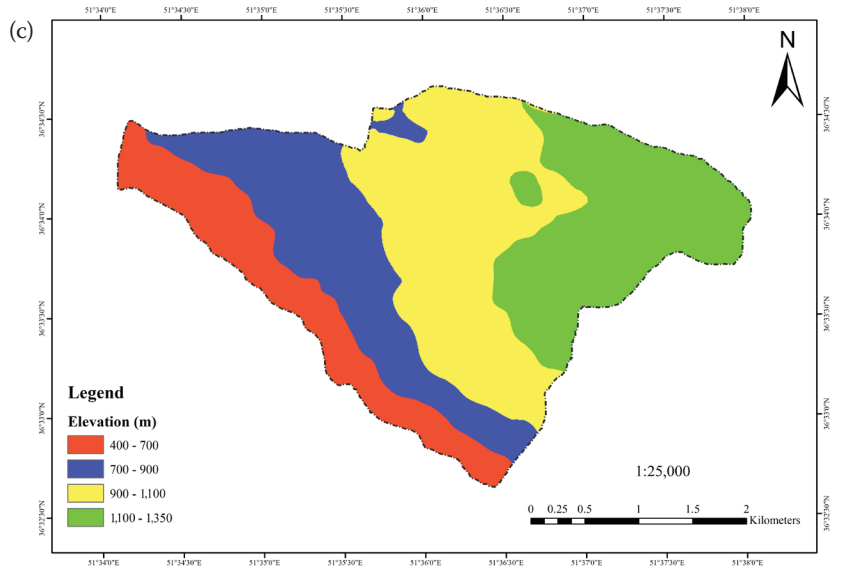


Fig. 2. Slope (a), aspect (b), elevation (c) map

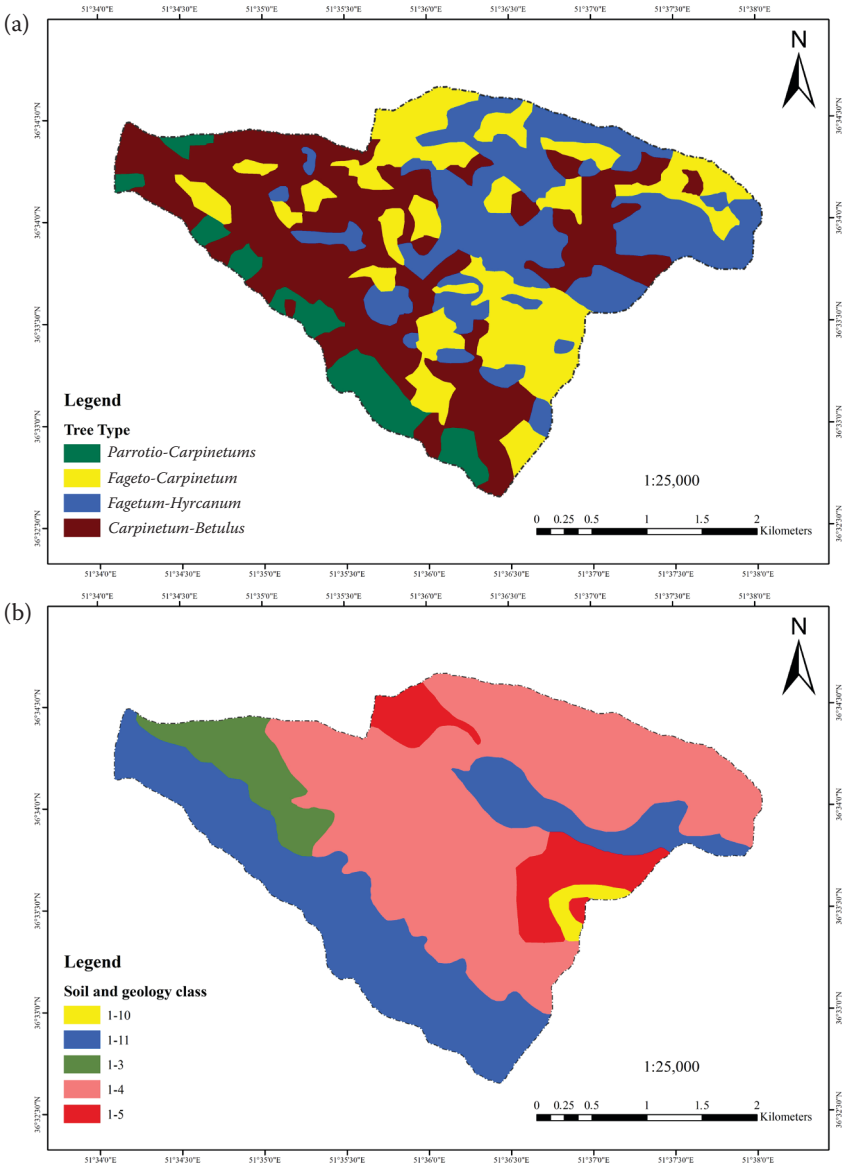


Fig. 3. Tree type (a), soil and geology class (see Table 1 for details) (b) map

Table 1. Characteristics of soil and geology classes of the study area

Class	Type of soil and bedrock
1-3	very deep dark brown soil, poor drainage, chert limestone bedrock
1-4	deep dark brown soil, relatively good drainage, marl bedrock
1-5	deep dark brown soil, relatively good drainage, fissured limestone bedrock
1-10	deep greyish dark brown soil, good drainage, limestone bedrock
1-11	deep dark brown soil, relatively good drainage, limestone bedrock

rotio-Carpinetum, *Fageto-Carpinetum*, *Fagetum-Hyrcanum* and *Carpinetum–Betulus*. According to Fig. 3a, most of the area is covered by *Carpinetum-Betulus* and the least by *Parrotio-Carpinetum*. The soil and geology map (Fig. 3b) documents five different soil classes whose descriptive information is shown in Table 1.

In this study, locating of 8 landscape points such as *Parrotia* type, afforestation, byres, hill overlooking the valley with beautiful landscapes, etc. was determined on the topographic map (Fig. 4). The name of each landscape and their descriptive information is given in Table 2.

Since there are 21,472 m roads in Namkhaneh district, the range of changes made in the completive forest road network option compared to the existing road network is not extensive. Hereby, the purpose is to increase the efficacy and tolerability of opening the existing road network in Namkhaneh in addition to tourist attraction and capability of landscaping with completion of the existing road network. The evaluation results of the existing and completive forest road network are given in Table 3 separately.

DISCUSSION AND CONCLUSIONS

For projecting development planning, it is essential to organize a perspective to preserve the existing landscape and find beautiful landscapes, and then locate the development in scenic areas (Jahani et al. 2011). The forest road network design must estimate plan executive goals and, if it is possible, report the other forest functions such as landscaping and tourism. Regarding the effect of roads on landscape, landscaping seems essential as a management tool in the design of forest road network (Sepahvand et al. 2005). Häyrinen (1998) and Rogers and Schiess (2001) also attended to this point in their study of road design.

Table 2. Descriptive information of the lookout points

Type of soil and bedrock*	Tree type	Elevation (m a.s.l.)	Direction	Slope class (%)	Distance (m)		Lookout name	No.
					from completive road	from existing road		
1-3	*Parrotio-Carpinetum*	710	northwest	10–30	0	0	*Parrotia* C.A. von Meyer type	1
1-4	*Carpinetum-Betulus*	777	south	30–60	75	75	broad-leaved afforestation	2
1-11	*Fageto-Carpinetum*	900	west	30–60	175	275	Alashoor byre	3
1-4	*Fagetum-Hyrcanum*	1,040	northwest	0–10	50	375	flat area and ridge overlooking the valley	4
1-4	*Carpinetum-Betulus*	1,110	north	0–10	50	50	Jalebon byre	5
1-11	*Carpinetum-Betulus*	1,120	north	30–60	100	100	mixed afforestation	6
1-4	*Fagetum-Hyrcanum*	1,120	north	0–10	100	525	flat area and ridge overlooking the valley	7
1-4	*Fagetum-Hyrcanum*	1,176	southwest	0–10	0	0	*Fagetum*	8

*see Table 1 for details

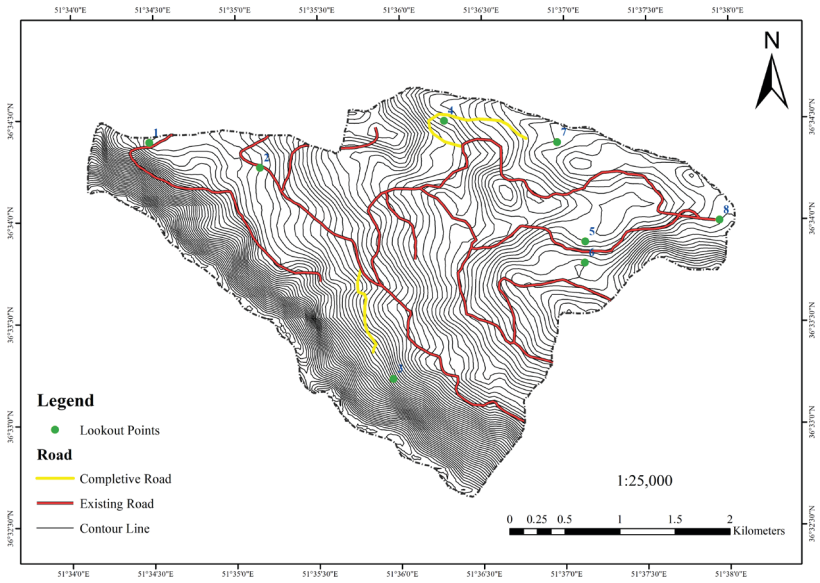


Fig. 4. Lookout points in the study area

Table 3. Comparison of different options of existing and completive road network based on Backmund method

Option	RL (m)	RD (m·ha^{-1})	RS (m)	SD (m)	Opening up (%)
Existing road network	21,472	27.2	637.64	183.82	63
Completive road network	24,272	30.84	324.25	162.125	74

RL – road length, RD – road density, RS – road space, SD – maximum skidding distance

Because the study area has many beautiful landscapes, the perfect design of the road network makes it possible for people to get a larger view of beautiful landscapes. Sepahvand et al. (2005) and Moghadasi et al. (2013) considered environmental and landscaping principles in the design of forest roads. In this study, it was observed that with completion of the existing road network, first opening up of the area significantly increased (Table 3) and maximum skidding distance was reduced from 183 m to 162 m. So if landscaping principles are applied in the design of forest road network, road serviceability can be used for tourist attraction correctly as the ecosystem potential.

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