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Modify Existing Forest Road Network and Offer New Path with Least Variation

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Abstract

In this study we tried to modify the existent road network with minimal changes in its terms. Therefore Map of the existent road, hydrology, slope, direction, fault lines, pedology, geology, roads and waterways crossing and the drainage were prepared and digitized, then these maps analyzed by Arc GIS 9.3. We used Pegger accessory package of ArcView 3.2 software in order to employ step compass technique and road design using longitudinal slope direction and negative points. Therefore, 8 variants (proposed road) in the study area was designed using Pegger software. Five of eight variants were selected, and then combined with the existent road. We selected the common paths with existent road, and then reforms were undertaking by removing some parts of the existence road because of passing from negative points and replacing some paths of this variants. After preparing the improved road network map, outdoor observation were taken to verify the accuracy of the implemented reforms, For this, we surveyed the longitudinal slope, drainage conditions and passing positive and negative points of substitute paths (5 variants) by field controlling. The existent road network survey results showed that the network percent equal to %51, %42 of existent roads were on slopes over %60 and %16.5 were completely on unstable points, 5 lateral drainage with incorrectly situation and 750 meters of the road is located along the north-west's fault line. The results of modified path with minimal changes indicate that the road situation decreased from %42 to %22.6 by passing some hillside with slope over %60, from 47 to 44 points by road crossing with existent waterways network and from 750 meter to 0 (no passing) by road crossing the fault lines.

Keywords: Modify Existing Road, Offer New Variant , Positive and Negative Points ,culvert

INTRODUCTION

Forest road network is one of important factors of apportion forest into the district, parcels and is the introduction of forestry projects. Destruction of roads in mountainous areas is more than non-mountainous areas. In such areas, Because of uneven and sloped lands and also a lot of horizontal and vertical curves which are created in the road, the actual length of road would be more than its aerial length. The lowest destruction and damage in biological stand and habitat would occur, if the forest roads are well designed and distributed. To solve these problems using a computer for analysis in the design and evaluation of forest road network has been popular since the 1950s [2]. Akay [3], has used the digital maps of slope, direction, altitude and pedology for optimal designing of forest roads, to investigate the factors affecting routing of forest roads in turkey using GIS software and stated that application of this software in such surface of computer analysis can be used in supplying the map of designing optimal paths. Abdi et al. [1], developed a method using GIS and Multi-criteria Evaluation (MCE) to design a forest road network with the lowest construction cost. Six road alternatives including slope, soil, geology, aspect, altitude and standing volume were developed using PEGGER. Then MCE was used to evaluate the construction costs of the candidate networks. Heralt [8], noticed the importance of slope and direction in evaluating and designing of forest road network by technical assessment of forest road network in terms of availability and suggestion new variants. Babapour [4], by emphasizing on soil stability, combined the maps of soil texture and bedrock and provided the map of region's stability in different classes and used this map for evaluating the existing road network and designing new variants. She gave an important attention to slope, direction, elevation, vegetation type and stock per hectare in designing forest roads and indicated that the designed road with optimum density, in terms of technical and environmental parameters is better than existing road. Dean [6], used automatic routing method to find the optimum location for the extension of an existing or planned roads and used four factors, soil type, slope, hillside direction and condition of waterways to calculate costs. In order to plan the design and construction of forest roads, the major aspect is the path crossing more and less from positive points and negative points, respectively. Today the evaluation of improved access to forest areas based on technical classification and geomorphology of forest areas have been established [9]. In this study regarding to maintain positive characteristics of existing road and using techniques of software and ground control, we tried to execute changes in existing road network with observing maximum technical and environmental principles and minimum maintenance costs to suggest a proposed path

MATERIALS AND METHODS

Khalkheil district is placed at 53° 16' 10" to 53° 22' 55" east and 36° 16' 20" to 36° 21' 35". The forest roads lenght in Khalkheil district are 25.5 kilometers and the total area is 2430 hectares. In this study, first by using Arcinfo in Arc GIS 9.3 software, maps of slopes and directions, hydrology, soil, Ggeology and fault lines were prepared. Then by overlaying the existing road map and the mentioned maps, the situation of road passing for each of them was studied separately. The existing road was studied in terms of suitable slopes and directions, drainage condition and the correct place of introduction of stream crossing fault lines, the mass movement and slip and drift. Areas that are environmentally incompatible with nature were identified and in next step were intended as a guide to draw variants. Then by using pegger software in Arc veiw GIS 3.2 regarding to the longitudinal slope of the road, using the step compass eight new variants was proposed and 5 variants with a close location and a common path with the existing road was chosen and the roads which were not in accordance with the technical principles and environmental conditions had been returned to nature. Considering that the aim is modifying the existing road with minimal changes, the best combination was selected by overlaying six roads, so the modified road is a combination of five variants (some parts of variant) and parts of the existing road. In order to check the accuracy of the reforms, after providing the improved road network maps, forest survey was accomplished and proposed routes were controlled in terms of longitudinal slope and existence of positive and negative point. To study the appropriate location for construction of culverts, field observations were conducted and seasonal waterways which intersect with existing roads first were checked on the map, then by visiting the area, the main route of outgoing stream flow was detected and removed with a GPS device, as the main route of outgoing stream flow can be a combination of multi-branching channels or in some areas can be the branches by the ditches .

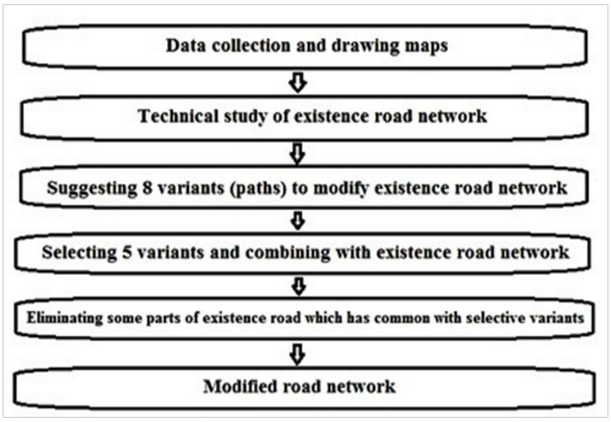

Fig.1. The process works in order to achieve modified road network

RESULTS

Comparison of Modified and Existence Road Condition in Terms of Various Slopes and the Directions

Software analysis and objective observations in the region show that a large distance (42%) of the study area is located on the slopes with over 60 percent (Figure 4). The results of the passage of existence road from different slope class are expressed in Table 1 separately. High percentage of road is located on western and southern slopes (Table 2) which the reason is the general tendency towards these directions (Figure 4).

Modified and Existence Roads Condition Regarding to Hydrology and Drainage

Improper use of culverts in some areas (Figure 5) shows that the stream flow is not considered during installing these pipes. There are 47 points of the contact between existence roads seasonal waterways and field surveys showed that 10 of them were covered properly. Many of the stream crossing due to lack of maintenance are blocked and are not able to conduct water. So the consequence of this incidence is mass movement between 27 and 31 parcels. Culverts for channel number (1) has not been constructed at appropriate locations and waste water flows on the road and the pipe and drainage channel number (2) due to lack of performance is out of efficiency (Figure 6). The usage condition of another drainage pipes (Figure 5) have shown by letters (P) as appropriate application and (I) as unappropriate application. Modified road is juncture with main streams at 44 points which we suggest 23 culvert according to surveys to organize hydrologic flow.

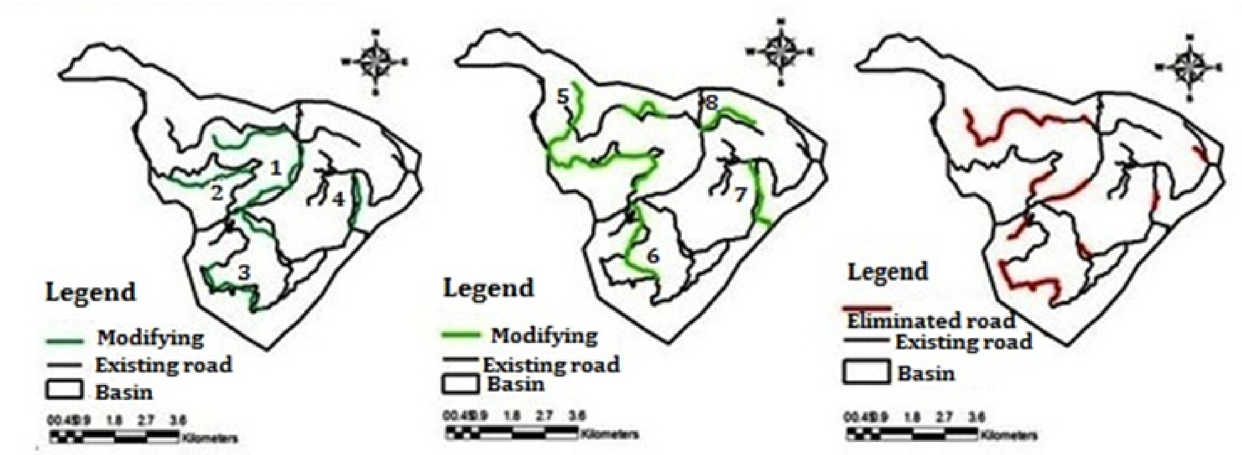

Fig.2. Selecting some parts of eight variants (with shared routes and close) and removing the negative points of the road network

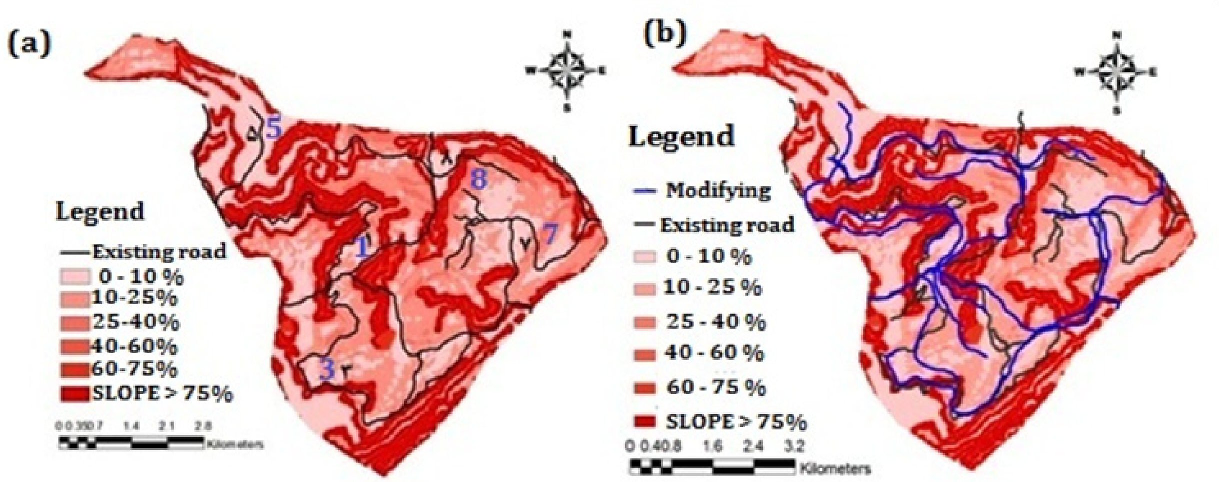

Fig.3. The existence road network and 8 designed variants by software (a) and Selecting five variants and integrating it with the existing road network (b)

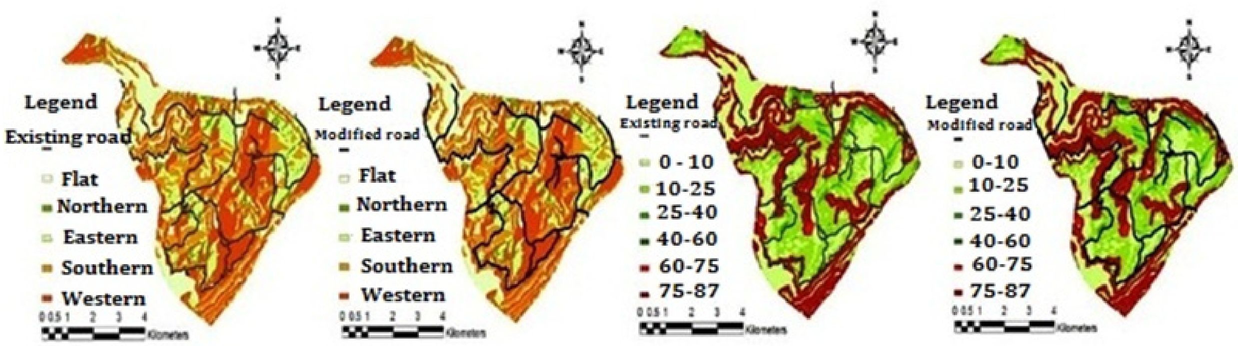

Fig.4. Comparison of passage of modified and existence road from right to left on slopes and directions respectively

Table.1. Comparison of the passage proportion of existence and modified from different slope class

Slope classes (percent)	Existence road length (km)	Total existence road (percent)	Modified road length (km)	Total modified road (percent)
10 – 0	7/6	29/8	8/1	31
25 – 10	4/9	19/2	4/9	18/8
40 – 25	1/4	5/5	2/4	9/2
60 – 40	0/9	3/5	4/8	18/4
More than 60	10/7	42	5/9	22/6

Table.2. Comparison of the passage proportion of existence and modified from different directions

Total modified road (percent)	Modified road length (km)	Total existence road (percent)	Existence road length (km)	Geographical direction
4/3	1/1	4/6	1/2	North
16/9	4/3	18/8	4/9	East
18/8	4/8	19/9	5/2	South
43/9	11/2	33/4	8/7	West
16/1	4/1	23/3	6/1	Flat

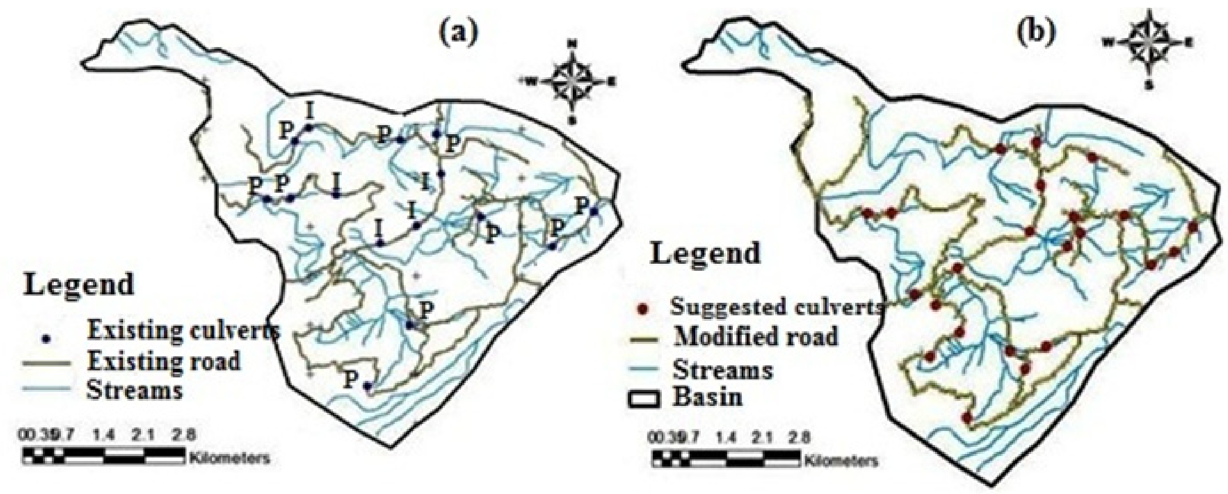

Fig.5. Transverse drainage condition of existence roads (a) and Suggested Transverse drainage for modified road (b); P : Proper installation; I : Improper installation

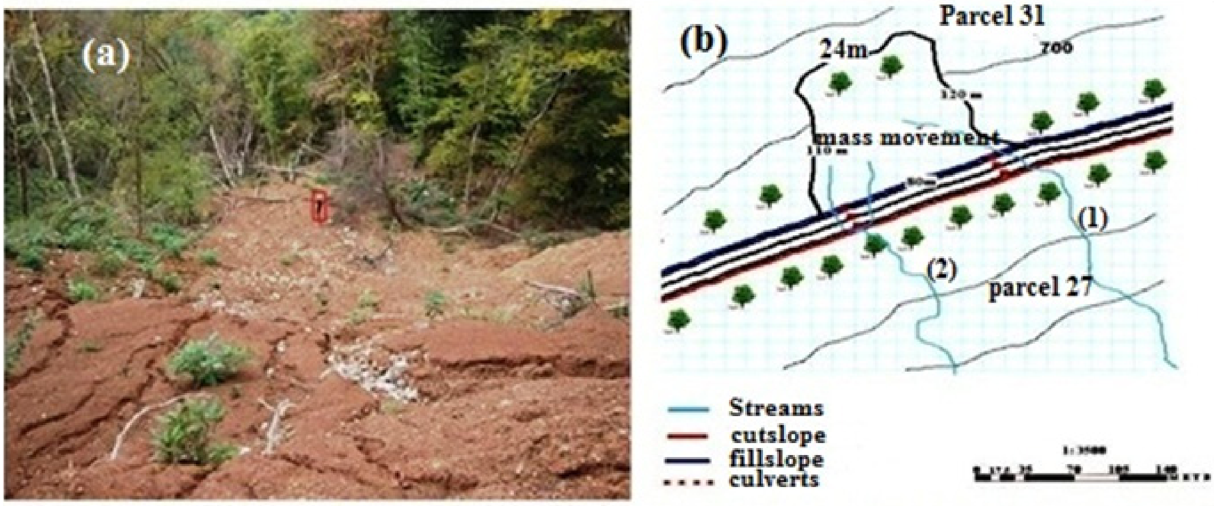

Fig.6. A view of mass movement on forest road, Khalkheil (a) and Simulation of a mass movement from the top view (b)

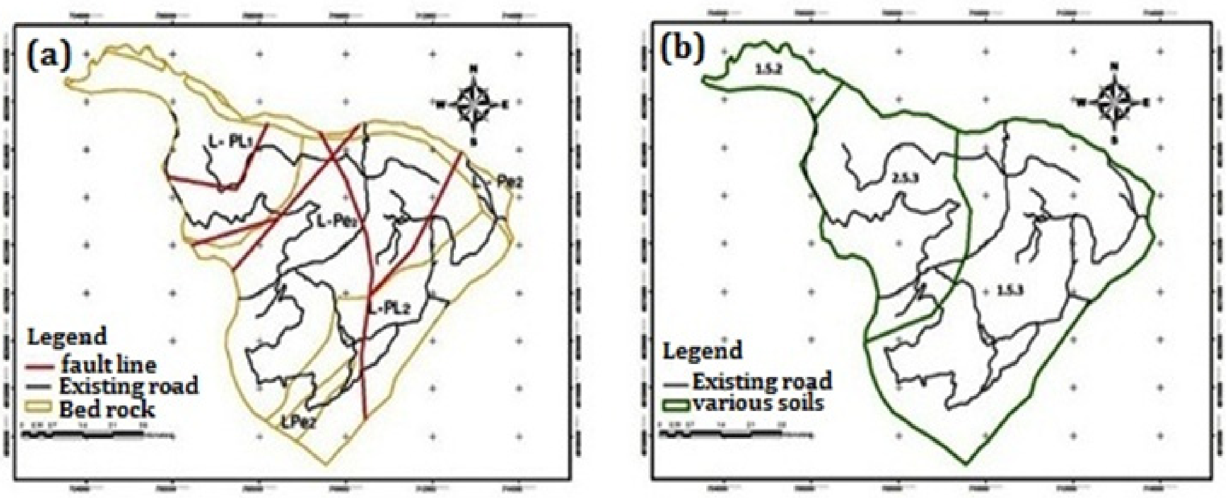

Figure 7. Road passing situation on geological and fault map (a); Road passing situation on the soil Map (b)

Table.3. Comparison of the passage proportion of existence and modified road on various soils

Total modified road (percent)	Modified road length (km)	Total existence road (percent)	Existence road length (km)	Various soils
16/3	4/25	16/1	4/2	1.5.3
24/7	6/45	23/4	6/1	2.5.3

Table.4. Comparison of the passage proportion of existence and modified road on various geological formations

Total modified road (percent)	Modified road length (km)	Total existence road (percent)	Existence road length (km)	Type of mother rock
16/3	4/25	16/1	4/2	L-PL_1
24/7	6/45	23/4	6/1	L-PL_2
59	15/4	59/5	15/2	L-Pe_2

Comparison of Modified and Existence Roads Condition Regarding to Passage of Stable Regions

The percentage of the passing road on soil with (1.5.3) sign which is evaluated for passing road as average road, increased from 58.6 to 59, and in soil with (2.5.3) sign which is evaluated for passing road as inappropriate, decreased from 41.4 to 41 (Table 3). Also, the percentage of road passes on the mother rock L-PL1, which is evaluated as average road, increased from 16 1 to 16.3, the percentage of roads crossing the Bedrock L-PL2 which is evaluated as average, increased from 23.4 to 24.7 (Table 4). The road passes on the Bedrock L-Pe2 which has low permeability and is was unstable at valleys and fault lines, is not recommended for road crossing, the crossing condition declined from 59.5 to 59. The red lines in Figure 7 shows the 10 points between fault lines and existence roads and about 750 meters passing of road length on the north-west fault (area of the mass movement). Important benefit of modified road is outgoing of road on north-west fault lines and preventing degradation.

DISCUSSION

Many roads in forestry projects had been constructed due to forestry projects obligations and also can be applicable in the future. Many studies about using the technical and environmental principles in designing of forest roads in mountainous forest road of Iran have been done, which in most studies little attention gave to existing road network. Therefore, modification of existing roads in many cases would reduce the cost of building and maintaining roads and also can reduce environmental degradation. Pegger software has a good ability in designing suitable forest roads and designs roads with high percentage better than long roads with low slope [12]. Pegger software is a guide one for designing forest roads based on longitudinal slope and variants derived from this software does not consider environmental issues [13]. In this study, in order to correct the mentioned problems, the only part of the road has been considered and alternatives controlled by field observations and pegger software was considered only as a guide. Installing transverse drainage at proper place and adequate number would prevent of water flow on forest roads and reduce maintenance costs. The distance between transverse waterways would reduce, if the road was at down of hillside, length of hillside and the area of providing flow increased [10]. 13 factors are effective in designing forest roads which water management and drainage of forest roads have the highest importance and reclamation has the lowest importance [7]. One of the reasons of incorrect installation of transverse waterways is lack of hydrological studies and economizing which usually transverse waterways are installed without deep study and greater distances from each other. This situation caused exacerbates erodibility of road area and mass movements. At boundary of parcel 27 and 31, the mother rock continuously is marl and water does not penetrate into it, thus water creates spongy soil between soil and bedrock in that area and will facilitate the movement of soil mass. The slope factor is very important and influential in forest road design [1]. 42% of the existing road of the study area passed from slopes greater than 60% While the proportion of modified path for this slope class is 22.6%. It is therefore important that during the excavation of soil and the wall, soil stability factor does not deteriorate. By increasing slope of hillside, the steam flow increases and in order to conduct correct hydrological flow which is crossed with existing road the installation of additional cross drainage increases. Therefore construction costs and road maintenance and environmental degradation would increase. Generally southern direction is receiving two to three times more light and heat and southwest directions due to more sun radiation in the afternoon and soil drying, have the highest temperature [11]. According to the receiving more sun light on these directions, the road surface dried sooner and in terms of maintaining humidity are weak and thus forest road maintenance costs will be lower. The role of geographical direction in road maintenance case is important when the design of road is correct and is not passing from areas which are prone to slippage and drift. In order to reduce costs of road construction and soil erosion, we should use areas which are stable for designing forest road. In addition, other researchers, including [5], considered the stability of soil in their studies.

CONCLUSION

The results of the integration road map, soil and geological maps showed subtle changes in crossing the condition that the reason is modification of the existing road with the least possible changes the various types of soils and geology. Returning some parts of roads to nature which are located on the northwest fault, can be a great help in preventing the escalation of the environmental consequences. Applying this study in works can reduce manufacturing costs and maintenance of forest roads and on the other hand by surface scratching and sowing the roads which are facing technical and environmental problems in order to return them to the nature, avoid aggravating environmental damage.

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REFERENCES

[1] Abdi E, Majnounian B, Darvishsefat A,. Mashayekhi Z. and Sessions J. 2009. A GIS-MCE based model for forest road planning. J. For. Sci, 55: 171-176.

[2] Akay A. E, Boston K, session J. 2005. The evolution of computer aided road design system. international journal of forest engineering. 20: 180-191.

[3] Akay A. E. 2006. Minimizing total costs of forest roads with computer-aided design model. Sādhanā, 31(5): 621–633.

[4] Babapour M. 2008. Designing forest road according to soil stability using GIS software in shafarood, Gillan . Master's thesis. Some Sara University, Gillan, Iran.

[5] Cretu O. and Rusnaee C. 1998. Forest Road in Romania,Planing and Design, National Conference of Wood Romania. 151-159.

[6] Dean F. 1997. Finding optimal routes for networks for harvest site access road using GIS-based techniques. Can.j. for. Res 27.

[7] Egan A, Jenkins A. and Rowe J. 1998. Forest Road in West Virginia, USA:Identifying Issues and Challenges. West Virginia University Morgan, Town.WV. USA, 8p.

[8] Heralt L. 2002. Using the ROADENG system to design an optimum forest road variant aimed at the minimization of negative impacts on the natural environment. J. For. Sci., 48: 361-365.

[9] Kaskova M. 2004. Design of forest road network in relation to all-society functions of forests Journal of forest science, 50, 2004 (5): 243-247.

[10] Majnounian B. Nikooy M. Mahdavi M. 2005. Cross drainage design of forest road in shafarood basin, Iranian J.Natural Res., 58 (2): 339-350.

[11] Mohajer M R. 2007. Silviculture, University of Tehran, Tehran university publication No : 2709.

[12] Rafetnia N, Abdi O, Shataei S. 2006. Determining proper method of preliminary forecasting of mountain and forest roads using GIS, Iranian J. For. Popular Res, 14(3): 245-257.

[13] Rogers W L. And P. Schiess. 2001. Pegger and Roadview – a New Gis Tools to Assist Engineers to operation planning, Proceeding International Mountain Logging and Elevenths Pacific Northwest Skyline Simposium , Dec. 2001 . University of Washington , Seattle ,WA.P.177-183