FORMEC 2010
Forest Engineering: Meeting the Needs of the Society and the Environment
July 11 – 14, 2010, Padova – Italy

FOREST ROAD NETWORK PLANNING ACCORDING TO ENVIRONMENTAL CRITERIA IN SERIES 4 RELATING TO TYRUMRUD FORESTRY PROJECT

Amir Hossein Firouzan[1], Ahmad Samadi Largan[2], Hamid Reza Maskani[3], Armine Hashemi[4]

[1] Department of Forestry, Faculty of Natural Resources, Lahijan Branch, Islamic Azad University
PO Box1616, Lahijan, Iran
firouzan@iau-lahijan.ac.ir

[2] MSc. Student, Faculty of Natural Resources, Lahijan Branch, Islamic Azad University
PO Box1616, Lahijan, Iran
ahmadsamadi50@yahoo.com

[3] Member of scientific board of Iranian Academic Center for Education, Culture and Research (A.C.E.C.R), Institute for Environmental Research, Rasht, Guilan, Iran, Box 41635-3114
hrmaskani@yahoo.com

[4] Department of Forestry, Faculty of Natural Resources, Lahijan Branch, Islamic Azad University
PO Box1616, Lahijan, Iran
ahashemi2004@yahoo.com

Keywords: Road network, Forestry, GIS geographic, database, suitability map, sustainable development

Abstract: *With respect to the importance of forest road network in approaching to the goals of sustainable development and its role in the economic of forestry plans, need for accuracy in designing of road directions in forestry pans and getting help from other sciences, specially use of GIS geographic database with regard to the high capacity of saving data and analysis of this data in the form of presentation of different layers with high speed and accuracy, actions can be taken for improvement of forest road network design in forestry pans. This matter gains more importance of observance of environmental issues are indispensable matter for achieving goals of sustainable development to this end, for designing and creating suitable road network with economic and environmental considerations, in addition to the complete evaluation of studied region and comprehensive study of required maps preparation and determination of negative and positive points for road direction establishment in the form of data stability, growth place type, stock in hectare, productivity, geology, plane points and… and valuing of these layers through two by two comparison and use of Expert Choice Software importance coefficient of the layer is obtained, then through giving weigh to the factors and attributes and limitations and putting layers on each other with respect to the importance coefficient of each by using Arc GIS software, resulted suitability map was valued and 6 alternatives road network was designed. Attention was paid in designing of direction so that directions pass the points with high value levels. Finally environmental and economic evaluation toward choosing appropriate option which is option number one was done.*

Introduction

In general forest road network as the basic installations has a major role in organization the region, harvesting and transportation goods and services and keeping it. The roads network from planning single route to completing it has technical and principle points that needs to make an exact decision. Up to now most of the designs have made based on economic and harvest goals and paid less attention to environmental issues and the losses that the routs can help the environment. All of these objectives are

based on the framework of the sustainable development.. Following the establishment of changes in the style of forestry and convert them from clear-cutting to single selection, the necessity of increasing mechanization to reducing the percentage of loss and waste production are factors for proper road network with enough coverage; it is worth mentioning that all of these objectives are based on the framework of the sustainable development. Accordingly designing a suitable road network in forestry projects should be considered to achieving to fourfold objectives of forests organization including protection, restoration, development and principal exploitation, using the new rout designing system such as facilities concerned with GIS geographic database as an important and principal element in scientific management of northern forests which are the most important ecological reserves in the world.
In the recent years researches, thesis and plenty of have been done about designing routes using GIS that can be helpful for principal designing of a complete network in the watershed that these researches are mainly done in the universities especially using new sciences and tools for designing routs, and also despite alienating of country's administrative section from the forests organization about preparing forestry projects, including use of old methods such as dividing the road to several parts in the plan booklets in order to ten years old projects and also lack of the assessment of road network plans .
Gumus, S (1994) in his study got through the design of forest roads in Turkey forests using GIS. In this research, designing an optimized rout for the forestry roads using digital maps and achieving to the low cost cells and also connecting them together was done with the minimum cost by GIS. Survinen and colleagues (2003) started a research about finding optimized routes by using GIS. He based the cost of project on machines, earth, tree cover and climate. In the next step to showing the options, evaluating started to the routes and it was concluded that many factors can be extracted and identified in the maps and be used in the assessment to design the best route based on enough factors considering the capabilities of GIS.
Hosseini (2003) examined the efficiency of GIS in enhancing accuracy and quality of forest road network and using a slope map, latitude, present type and the stock per hectares in the Arcview software environment, ans with overlap maps like slope plan, direction, habitat, was provided stable and unstable region map, and also using land information and GIS data in the study region, a good road network was designed.
Eventually was revealed that GIS application has appropriate efficiency in speed, accuracy, quality, and cost than traditional methods. Svrvnyn (2003) examined an issue naming optimal road routing using GIS. He set the cost level based on machine, earth, tree cover and climate factors in his study. And concluded that many factors can be extracted in the maps and applied for evaluation and also concluded that the best route considering the capabilities of GIS can be designed by using a sufficient number of factors.

2. Materials and methods

This region is located in 4 series of TirumRud's forestry plan, 32 watershed in Tonekabon city. This part is known as Tosakti which is a local name and the road to this region has been split from Tonekabon asphalt road to Dohezar, at Pordsar village, and after 23 kilometers and passing through series 1, 2 and 3 reaches to the beginning of series 4. The forests of this series are located between 36.40.25 and 36.44.30 latitude, and 50.40.10 to 50.43.48 longitude. Minimum height from sea level is 400 meters and the maximum is 2370 meters, also the total area of this series based on new area by using GIS geographic database is 2144 Hectares.
During first decade of project a single road, length of 8 km, was built through the site in order to ease the access, and for the second decade a road of 7.5 kilometers was predicted which was built until the second year of performing operation. So the length of all roads in this series is 15.5 kilometers, due to the site area that the density is 7.5 meter/hectare and the average annual harvest is 3000 m^3 for 10 years.
For better assessment of the series and considering different information, we proceeded to prepare maps of topography, altitude, geology, soil texture, appropriate depot zones, stock per hectare, habitat and regeneration types. Also positive compulsory points and locations including flat areas, open space, natural terraces, sand and gravel mines and suitable zones for connection to the adjacent districts and negative compulsory points (rocky and stone areas, sliding and buoyancy areas, steep areas, springs and villages' water supply areas, extent faults and regenerations), were transferred on the maps using GIS and Arc GIS software.

With respect to the classified informational layers, all levels were valuated so that the used value range for all maps was the same between1 to 9. For example, in slope region, value of 9 indicates the best slope to build a road and value of 1 indicates the worst slope for a road. After determining the priority classes within each map (informational layer) the importance of different information layers and valuation of them were defined. In this step we used Multi Criteria Evaluation methods for preparing a suitability map so that after classifying and valuating the inner layers of the maps we used pair- wise comparison methods in the context of a decision- making process known as the Analytical Hierarchy Process(AHP) to develop weights of map layers and were entered the opinions of some experts were collcted by using of some questionnaires in the process . This process was done by using Expert Choice(EC)software.

layers were overlaperd due to important coefficient of layers based on MCE using of Arc GIS software and at last final suitability map obtained. This map divided areas into five classes and was entered codes in order to class. 1 has the least value and class 5 has the most value to plan and build a road.
In the next stage six variants of the road network was designed using PEGGER software so that in the all of the variants, we tried the routs cross high levels of values. Finally,road was compare base on environmental and technical **criteria** For assessment of environmental aspects, the value of each class considered as a coefficient which is multiplied by the percentage of the pass in each area and the total is the value of that option.
Finally designed routes compared by technical technical. (by Backmund index) and the best options (variant)was selected.

3. Results

A) The results of the environmental assessment

Regarding the environmental considerations we tried to design the routes in order to pass high value areas so that the selected area is more suitable and sustainable to constructing a road.

Table 1. Length, rate and percentage of the pass through areas with different values

Class 5		Class 4		Class 3		Class 2		Class1		road length in meter	variant number
value	percent	value	percent	value	percent	value	percent	value	percent		
462/23	3/87	10331/3	86/52	1147/47	9/61	0	0	0	0	11941	1
145/96	1/02	11689/31	81/51	2347/59	16/37	158/13	1/10	0	0	14341	2
121/26	/76	11689/31	83/98	2344/44	72/14	84/88	0/53	0	0	15922	3
254/71	1/95	11344/87	8695	1447/42	11/09	0	0	0	0	13047	4
505/96	3/77	11436/30	85/19	1481/74	11/04	0	0	0	0	13424	5
343/05	2/52	11227/83	82/50	2038/12	14/98	0	0	0	0	13609	6
141/50	0/92	12447/62	8075	2528/88	18/33	0	0	0	0	15415	constructed

Table 2. Results of the environmental assessment of the variants

Sum of multiplying different percentage of the pass through areas in valuable classes	Variant number
394/26	1
382/45	2
384/94	3
390/72	4
392/73	5
387/54	6
382/59	constructed

As was seen in the table above, option (variant) 1with the score 394.26 placed in the first grade, fifth option with the score 392.73 in the second grade and forth option with the score 390.72 in the third grade. In this assessment the option with the score 382.59 and with a very short distance placed at the last option which was sixth grade.

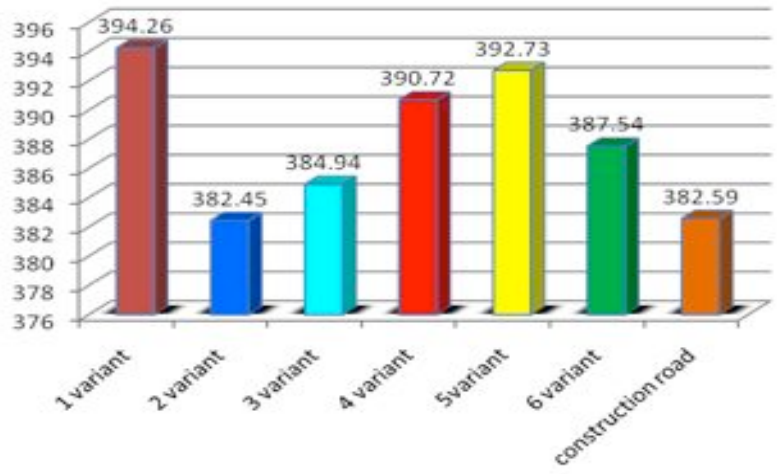

Figure 1. Priority options (variant) based on environmental criteria

B) The results of technical evaluation

In addition to compute the length and density digitally, we can draw bands precisely by using GIS. Especially in the GIS environment, creating bands in the slope regions with regard to the distance of on the slope rather than on the horizontal distance (given that it is closer to the reality) is done with high accuracy.

Table 3. The results of road efficiency assessment about length and cover in 4 series of Tirum Rood.

Backmund index	Networking percent	Covered level ha	Maximum drawing-stick distance M	Distance density m	Density road m/ha	Length road m	Variant number
0/090	%62/12	1331/8	892/85	1785/71	5/6	11941	1
0/110	%60/37	1294/4	746/27	1492/94	6/7	14324	2
0/118	%62/4	1343/2	675/67	1351/35	7/4	15922	3
0/103	%59/25	1270/4	819/67	1639/34	6/1	13047	4
0/102	%61/85	1324/6	793/65	1587/30	6/3	13424	5
0/104	%61/02	1308/3	781/25	1562/50	6/4	13609	6
0/123	%58/25	1257/6	694/44	1388/88	7/2	15415	constructed

Using Backmund method, we calculated Longitudinal density, distance Density, maximum drawin. Stick distance, cover surface and networking percentage. From Backmund view, whatever RD is smaller the efficiency of that network will be highe

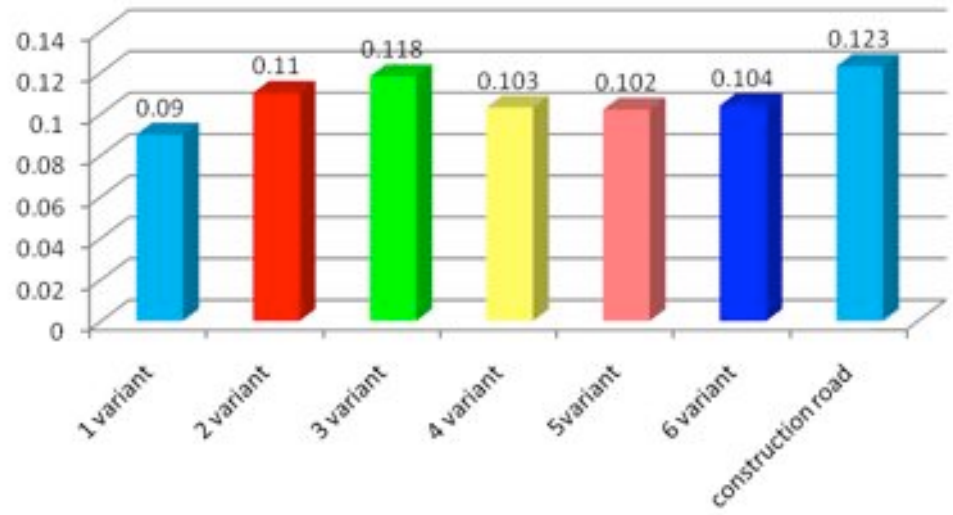

Figure 2. Rout technical priority based on Backmond index

In this section, despite the less length of option 1, it has the best coverage and less amount of Backmund index in the first grade, option 5 is second, option 4 is third and constructing option despite the maximum length has the most amount of Backmund index and is the last grade.

Conclusion

Forest road networks have a special role in the management, conservation, restoration. Thus, as the most important element of management in long-term planning of forestry projects which last 10 years, designing a suitable road network with environmental priorities, sustainable development, should be considered particularly. In addition, the use of new sciences, especially geography GIS system is possible in fast designing, predicting and evaluating of routs. It is worth mentioning that generally forestry projects are made from connected multi-series and cannot be considered separately. With regard to placing this series of researches above the last three series, the road entrance is clear just from a particular point and all possible designs must be start from that point. Social sensitivity due to public view

to the operations of clear-cutting of the trees has forced us to use various layers of information to achieving better result that can intervene in forest complex ecosystems as the time forest damage is minimal.

Variant 1 despite the less length has the best coverage and lowest rate of Backmund in the first grade, and option 5 does in the second grade. On the other hand, option1 with a 26/394 score is in the first grade, and the option 5 with a 392/73 score is in the second grade environmentally. Therefore the first road is in the first priority from environmental and technical quality point view and the fifth road allocates the next grade to itself. Moreover, the fourth road allocates the third grade to itself environmentally and technically.

On the other hand, with respect to the emphasis on Article 44 of constitution, the most important elements of privatizing agencies and economic companies are the positive balance and economic projects.

These studies are important due to the routes of the road since 70% of total project costs relates to forestry operations, which more than 30% of this cost relates to the road construction and has a direct relationship with increasing clear-cutting of the trees mechanization. Detailed regional information is needed for principal design which includes complete identifying of the region and slope mapping, soil - Geology - Regeneration – capacity, geographic direction ... that are used for study, analysis and optimal design of the road routes.

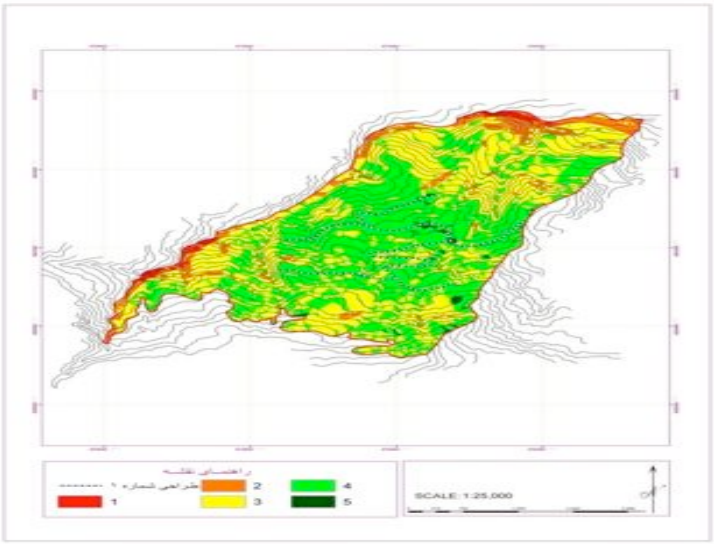

Figure 3. The number 1 designed route of series 4

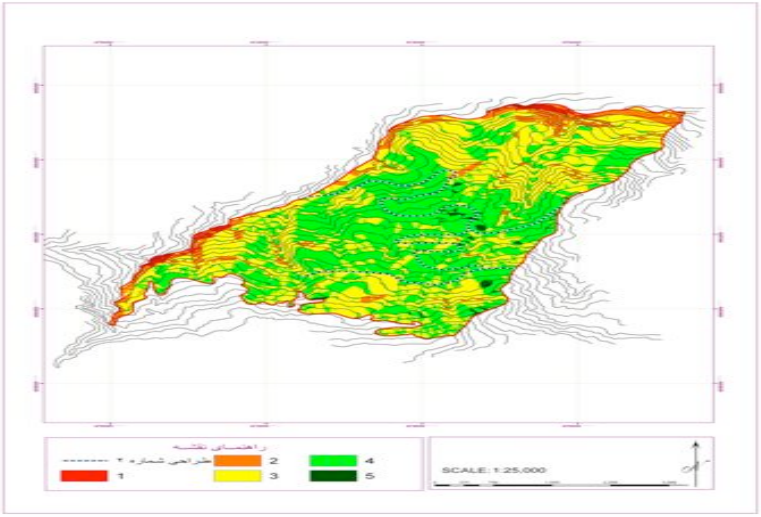

Figure 4. The number 2 designed route of series 4

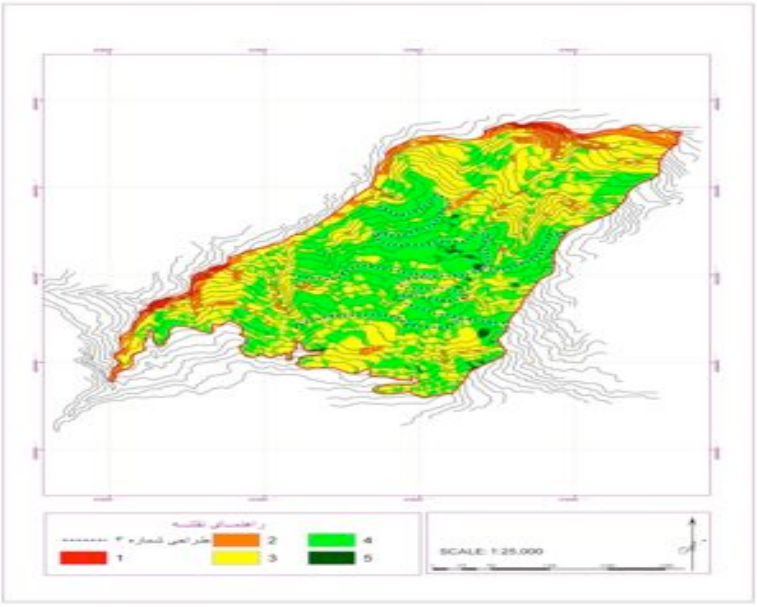

Figure 5. The number 3 designed route of series 4

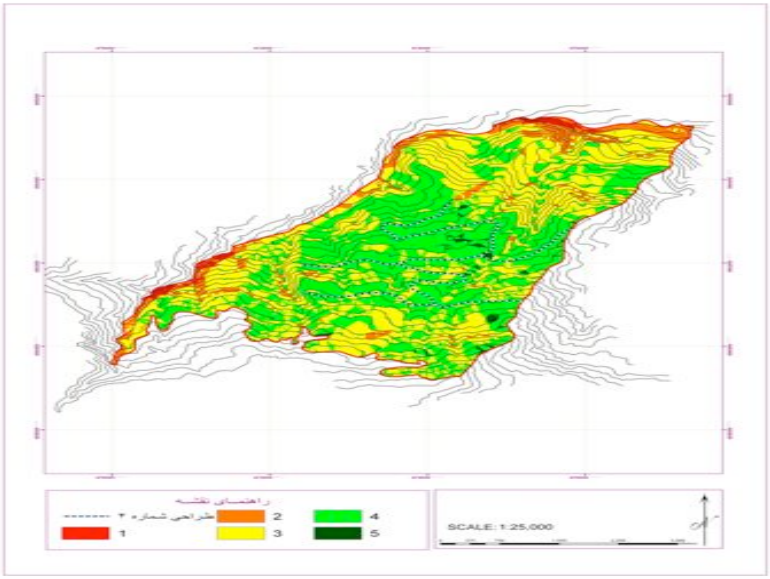

Figure 6. The number 4 designed route of series 4

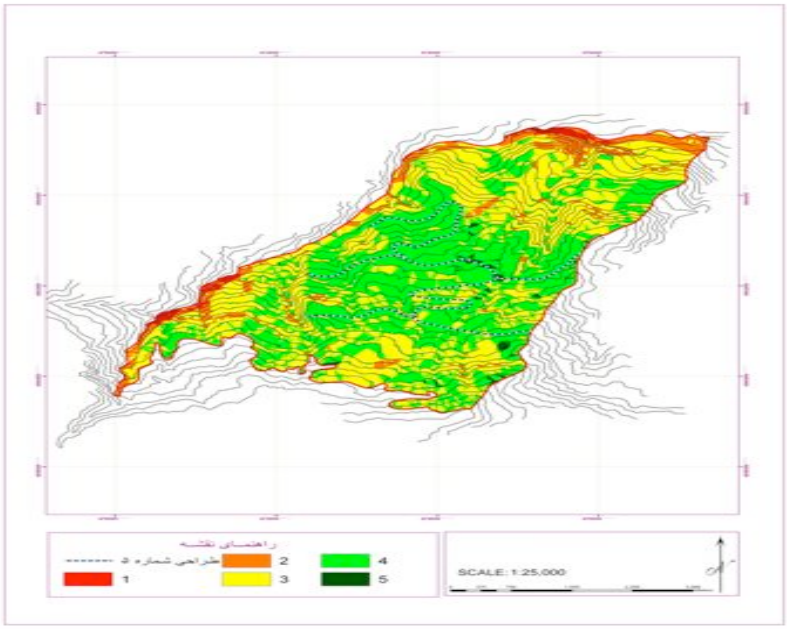

Figure 7. The number 5 designed route of series

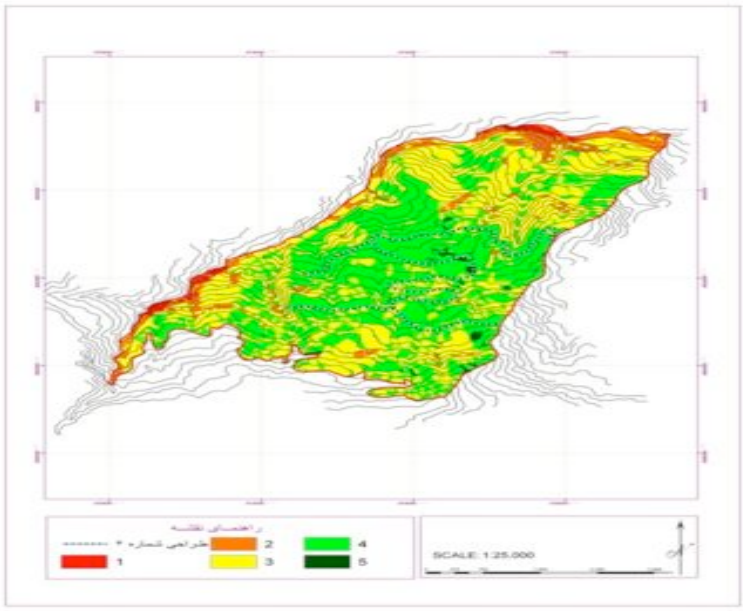

Figure 8. The number 6 designed route of series 4

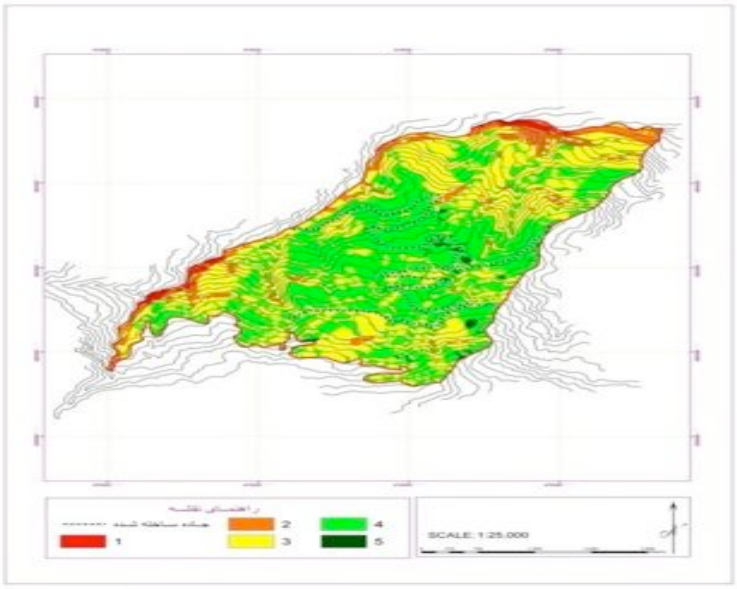

Figure 9. Constructed route of series 4 related

Suggestion

Considering the results of research and topics that were discussed, the complete and comprehensive revision of forest road network in a forestry project is imperative therefore, suggest that:

1. Having the relation with the university of forests logically to provide new strategies of route designing and achieve to sustainable development objectives should be done.
2. Identifying the operation region should be done completely and positive and negative points regarding to new science progress should be determined and considered after transferring to the plan.

3. All connectional factors should be used with designing and route area as the informational layers.
4. Complete designing of the road routs relating to watershed should be specified and its time of distance should be divided to ten-year period. Thereby, in addition to the logical relation among the series of a watershed, it also prevents from problems caused by side in the series converges in mechanized operations.
5. Sub routes should be identified and combined possibly in designed routes permanently.

References

Akay, A. (2003) minimizing total cost of construction, and transportation cost with computer- aided forest and design

Firouzan, A H. (2005). Forest road network planning Singel Selection Silviculture by using GIS. Ph.D thesi

Firouzan. A H. (2006). the handbook of networking forest Graduate tuition

Gumus, S. (1994). The use of geographical information system in selecting forest road routes.

Hosseini. (2003). Determining the appropriate method to predict primarily forestry and mountain routes using GIS 2003

Murry, A.T. (1998) . Route planning for harvest site access. Can. J. For. Res. 28: 1084-1087

Maleki- Khodayar. M.S thesis. 2004. The route design in single selection method.

Rogers, L . and P. Schiess. (2001) . PEGGER & ROADVIEW. A new GIS tool to assist engineers in operation planning. The international mountain logging and 11th pacific Northwest skyline symposium 2001

Suvinen, A., M. Saarilahti and T. Tokola. (2003). Terrain mobility model and determination of optimal off – Road route. University of Helsinki, Finland

Sarikhani - Nusrat Ullah - Book clear-cutting of the trees book, Tehran University Publications

Tan, J. (1999). Locating forest roads by a spatial and heuristic procedure using Microcomputers. Journal of Forest Engineering Pages: 90 – 100