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Full Length Research Paper

Comparison between the accuracy of RoadEng and Arcinfo softwares in designing forest roads

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This research looked at the differences in forest road planning techniques and the existing software products (RoadEng and Arcinfo softwares) that have been developed to assist in forest road location. Forest road designing is conducted based on route survey using NIVO C™ mapping camera (for RoadEng software) and Garmin tools (for Arcinfo software) in Birenjestanak forest of Iran. In order to evaluate the accuracy, the outputs of RoadEng were compared to outputs of Arcinfo software. Results showed that the designed road in RoadEng software was geometrically more accurate than that of digital elevation models (DEM) 20 and 50 m intervals. The difference between real length of road and designed routes on DEM 20 and 50 m was 260 and 360 m, respectively. Also, the slope map achieved from DEM 50 m is not a good indicator for slope status in research area. The total earth working volume computed by Arcinfo software was more than that of RoadEng software. These differences for computed volume of cutting and filling were 1653 and 638 m^3, respectively. The results showed DEM 50 m and DEM 20 m is not a good indicator for designing road. We can solve this problem by using the RoadEng software. With use of survey data (using mapping camera) we can transfer (Survey_Map) the route of a forest road into the plan, longitudinal, horizontal and vertical profiles, and economic calculations.

Key words: RoadEng, Arcinfo, Garmin tools, digital elevation models (DEM), forest road, accuracy.

INTRODUCTION

The road design and construction process is the most expensive and time consuming portion of a harvest operations plan (Epstein and Sessions, 2001). It is not surprising then, that so many road design tools and optimization models have been built to assist with the development of transportation plans. It has been demonstrated that “judicious and appropriate use of forest engineering tools can enable the designer to develop a far superior harvest plan (Schiess and O'Brien, 1995). The forest road designing has been conducted in accordance with traditional method as well as more path finding. Nowadays, it needs to be changed and converted into routine method on the basis of forest planning development and its requirements to design forest road establishment that also covers annually related inflation rate cost, (the material costs, worker wage, technician and expert) which is required to change the forest road designing (Rogers and Schiess, 2001).

Since 1974, many others have introduced road design software packages for the desktop computer. Of these road design packages (RoadEng, Autocad, Roadpac, F.L.R.D.S., Tracer, Routers…), only one has given the user the ability to quickly look at alternative road locations at varying scales, routers (Reutebuch, 1988). Using RoadEng, forest planners can quickly show the topographic modifications of a planned forest road and evaluate visual impacts associated with alternative road locations. Also, the RoadEng software, although not

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constructed for finishing the optimization studies, is highly applicable for the activity. In addition, the data outputs serve the purpose of decision making. The forest manager can certainly claim the variant of forest road to be optimized and therefore needed. Besides some benefits, any road and any route will also have some negative impacts on the environment. However, these can be minimized with the help of a powerful tool (Heralt, 2002).

Some researchers applied the geographic information system (GIS) techniques to design the optimal forest road density in northern forest of Iran (Najafi et al., 2008; Rafetnia et al., 2006). They concluded that using GIS and computerized analyzing cause to economize in time, costs and to minimize environmentally damages. In this method, the best area is selected to plan forest roads with overlaying effective factors such as maps of soil, slope, direction of slope, and bedrock and trees volume per hectare maps (Hosseini and Solaymani, 2006). Reutebuch (1988) acted on fulfilling of the computer software (GTR) for specialized location of the certain path in USA and they concluded that certain software could be used to execute new system. Leaded into ways location and this method had more effect on cost reductions that was related to path designing. Abdi et al. (2009) 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. This research looked at the differences in forest road planning techniques and the existing software (RoadEng and Arcinfo software) products that have been developed to assist in forest road location.

MATERIALS AND METHODS

Description of the study area

The study was conducted in Birenjestanak forest. Birenjestanak forest is located in southeast of the city of Ghaemshahr in Mazandaran province, Iran (Figure 1). The latitude, longitude and elevation ranges of this forest are 36° 19′ 08″ to 36° 23′ 30″ N, 52° 51′ 22″ to 52° 56′ 55″ E and 480 to 1090 m at sea level, respectively.

Designing forest road using RoadEng and Arcinfo software

There are two methods for designing road. In first method (field survey), road designing is conducted based on route survey using NIVOC^{TM} mapping camera and taking geometric specifications of longitudinal and cross-sections of road. Second method (routing softwares) is carried out on digital elevation models (DEM) of research area. In this study, the RoadEng software, which has been produced for road construction project, was used to design existent road (for first method) in our study area. At first, the geometric specifications of longitudinal and cross-sections of existent road were taken and then the collected data from field survey were inserted into TRAVERSE DOC of Survey_Map package. In the next step, the map of existent road was extracted from TRRAIN package (Figure 2). In second method, the existent road was surveyed using Garmin tools (GPS and Garmin software) (Figure 3). For this purpose, 55 points were recorded along 2.7 km of road. Then, according to latitude and longitude, the route was established on DEM in Arcinfo software. In order to evaluate the accuracy of RoadEng software, the outputs of RoadEng was compared to outputs of Arcinfo software. DEM with resolution of 50 and 20 m was used in Arcinfo software. For this purpose, for each of DEM map the slope, plan and skidding buffer map (a 600 m buffer at both sides of road for Timberjack 450c) was produced and then compared to outputs of RoadEng software. Moreover, in order to compare the earth working volume, the maps of mass haul, cut and fill areas and cross-section was produced in RoadEng software and the map of cut and fill volume was provided in Arcinfo software. The mentioned maps were automatically calculated in RoadEng software. These maps were computed in Arcinfo software through the menu of 3D analysis and section of cut and fill.

RESULTS AND DISCUSSION

A mistake in planning a road, such as ignoring the effects of environmental and other parameters, leads not only to the waste of public investment, but also to adverse environmental impacts and increase maintenance costs (Heralt, 2002). In previous studies, different formulas were proposed by scientists for evaluating the alternatives of forest road network (Segebaden, 1964; Sundberg, 1976). Advances in personal computers (PCs) have increased interest in computer-based road-design systems to provide rapid evaluation of alternative alignments (Akay, 2006). RoadEng software is a state-of-the-art designing tool which was used for detailed planning of road (Enache, 2009). Results of this study show that the designed road in RoadEng software was geometrically more accurate than that of DEM 50 and 20 m intervals (Figure 4). The difference between real length of road and designed routes on Dem 20 and 50 m was 260 and 380 m, respectively (Table 1). Moreover, the relative openness of forest through skid trails of Timberjack 450c (Common skidding machine in Iran) for designed routes on DEM 20 and 50 m have decreased 11 and 16 ha, respectively (Table 1). The importance of this data is that if the transportation routes are designed untruly without field survey for control, the construction and maintenance cost of roads as well as the overlapping area of roads would increase. The recent case cause to reduce relative openness of forest by roads. Therefore, the access to compartments for timber skidding will decrease. The results accuracy increased to reality (the existence road specifications) with increasing the DEM resolution. It is better that the tools with high accuracy are used for initial predicting of routes.

The forest road 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. Increasing the cut and fill slope length increases the amount of environmental damages and sediment yield

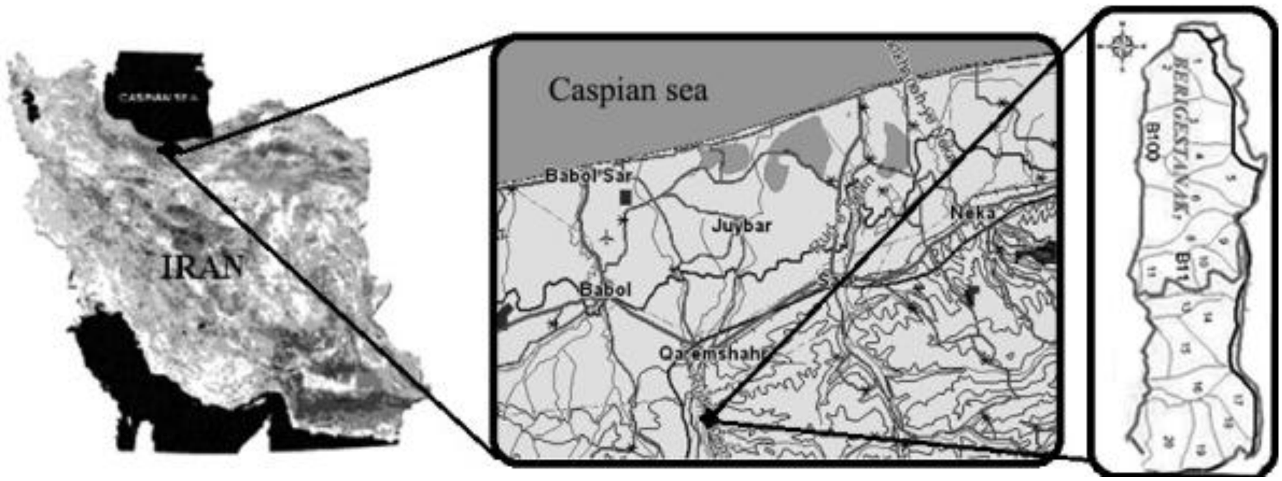

Figure 1. Map and geographical location of study area.

Table 1. Comparison of the road lengths and Coverage area in different designs.

Alternative	Length (km)	Coverage area (ha)
RoadEng	2.75	132
Dem 50 m	2.37	116
Dem 20 m	2.49	121

Table 2. Comparison among the lengths of roads designed in different slope.

Slope (%)	RoadEng (km)	Dem 50 m (km)	Dem 20 m (km)
0 - 30	0.95	1.15	0.89
30 - 60	0.78	1.06	0.68
X > 60	1.02	0.16	0.92

from cut and fill slopes area to ditch through soil creep, sheet wash and slumping (Akay and Karas, 2004). The road construction in slope gradient of more than 60% causes to increase construction, repair and maintenance cost (Hosseini and Solaymani, 2006; Najafi et al., 2008; Rafetnia et al., 2006). In addition, the landslide and mass wasting may be occurred because of establishing road on unstable bedrock and floppy lands. The results of this study indicate that the slope map achieved from DEM 50 m is not a good indicator for slope status in research area (Table 2 and Figure 5). Thus, in many cases the designed roads are not applicable.

The computer software and hardware is extensively and effectively used especially in the developed countries for the solutions of complex problems. The cross-sections and profiles output can be directed to a printer or export to RoadEng software to calculate earth working volume. Project cost is the leading factor in evaluating the alternatives of forest road alignments (Enache, 2009). The most important item affecting the cost is excavating works. Results show that the total earth working volume computed by Arcinfo software was more than that of RoadEng software. These differences for computed volume of cutting and filling were 1653 and 638 m^3, respectively (Table 3). The volume of cut and fill is calculated first by using cross-sections that are taken along the axis of the road in order to calculate the cost of earth works and expenses related to earth works (Figures 6, 7 and 8). Cut volumes are used in constructing fills. The alignment plan that constitutes the lowest cut and fill volume in evaluating the alternatives of forest roads should be planned as the optimum alignment since it constitutes the lowest cost at the same time (Rogers and Schiess, 2001). Traditionally, the planning of low-volume road networks highly depends on economical and social considerations. In recent years, forest road construction and maintenance activities have become controversial, because of increasing public concerns about short- and long-term effects of forest roads on environment and the value that society now places on road less wilderness. Cut and fill slopes length and earth work width highly depend on hillside gradient. Even though hillside gradient effects on cross-section components vary based on the cross-section types (just filling or cutting), the most

Table 3. Comparison of the earth working volume between the RoadEng an Arcinfo software.

Tool	Total cut volume (m^3)	Total fill volume (m^3)	Price unit (Rials) *	Total of amount of excavation (Rials)	Total of amount of soil filling (Rials)
RoadEng	12589.2	6986.5	8400	105747600	58682400
Dem 20 m	14242.8	7625	8400	119632800	64276800

*, The prince index of excavation and soil filling completely in 2011 year, the management and programming organization of Mazandaran province.

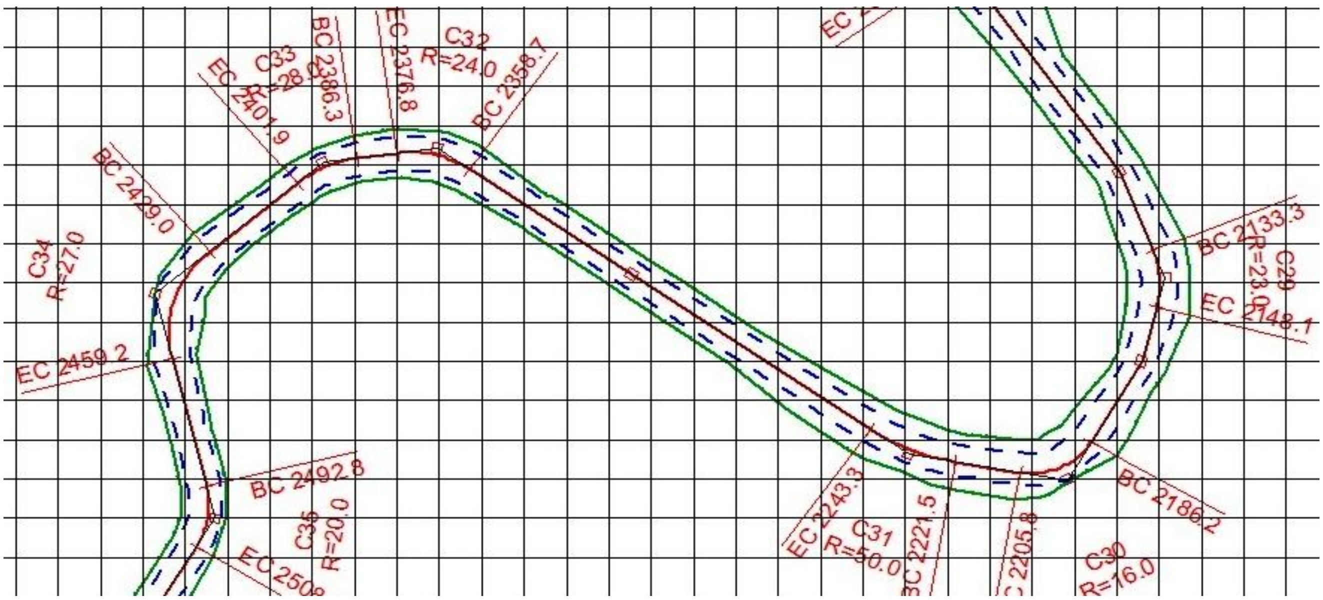

Figure 2. Designing forest road using RoadEng software.

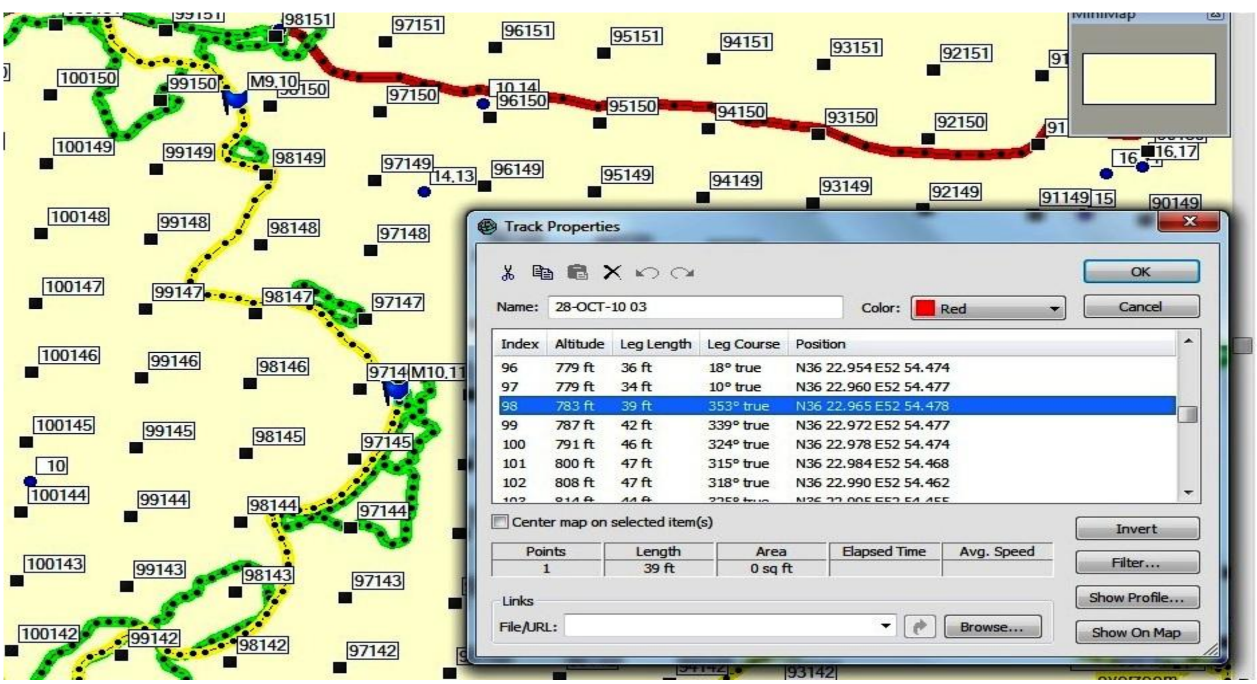

Figure 3. Designing forest road using Garmin tools and Arcinfo software.

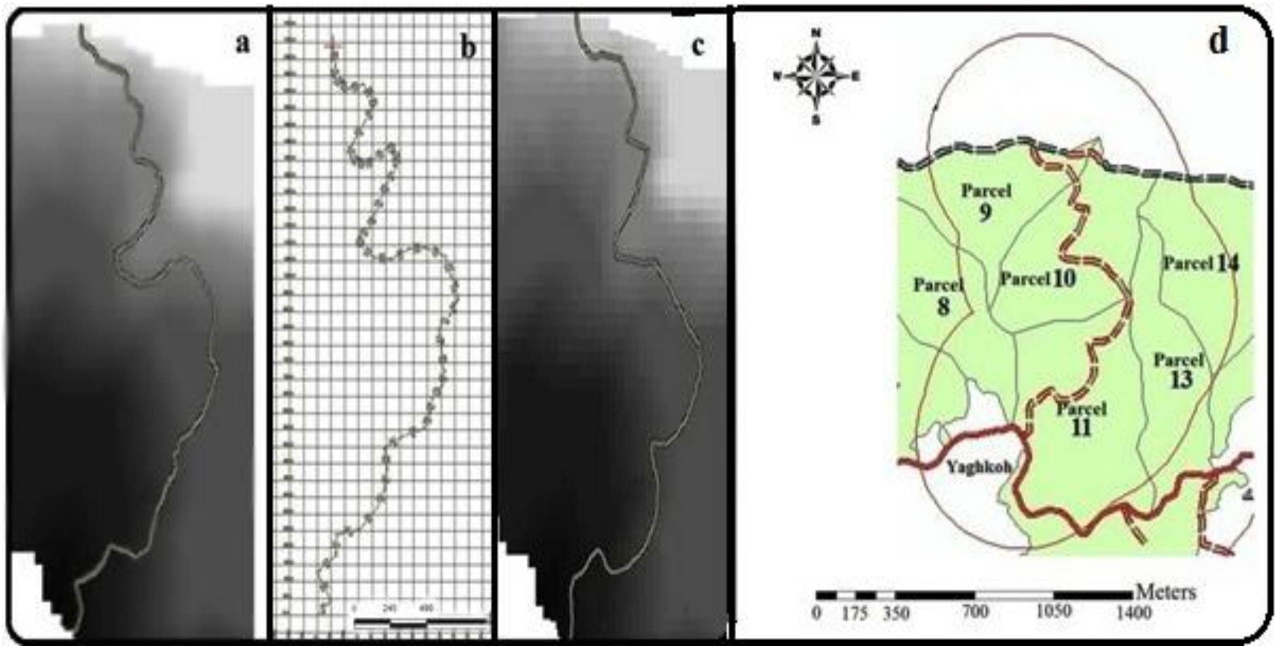

Figure 4. Illustration of the error rate of routes designing in (a) DEM 20 m and (c) DEM 50 m as compared to (b) real route and relative openness of forest through skid trails for rubber tires skidder (d).

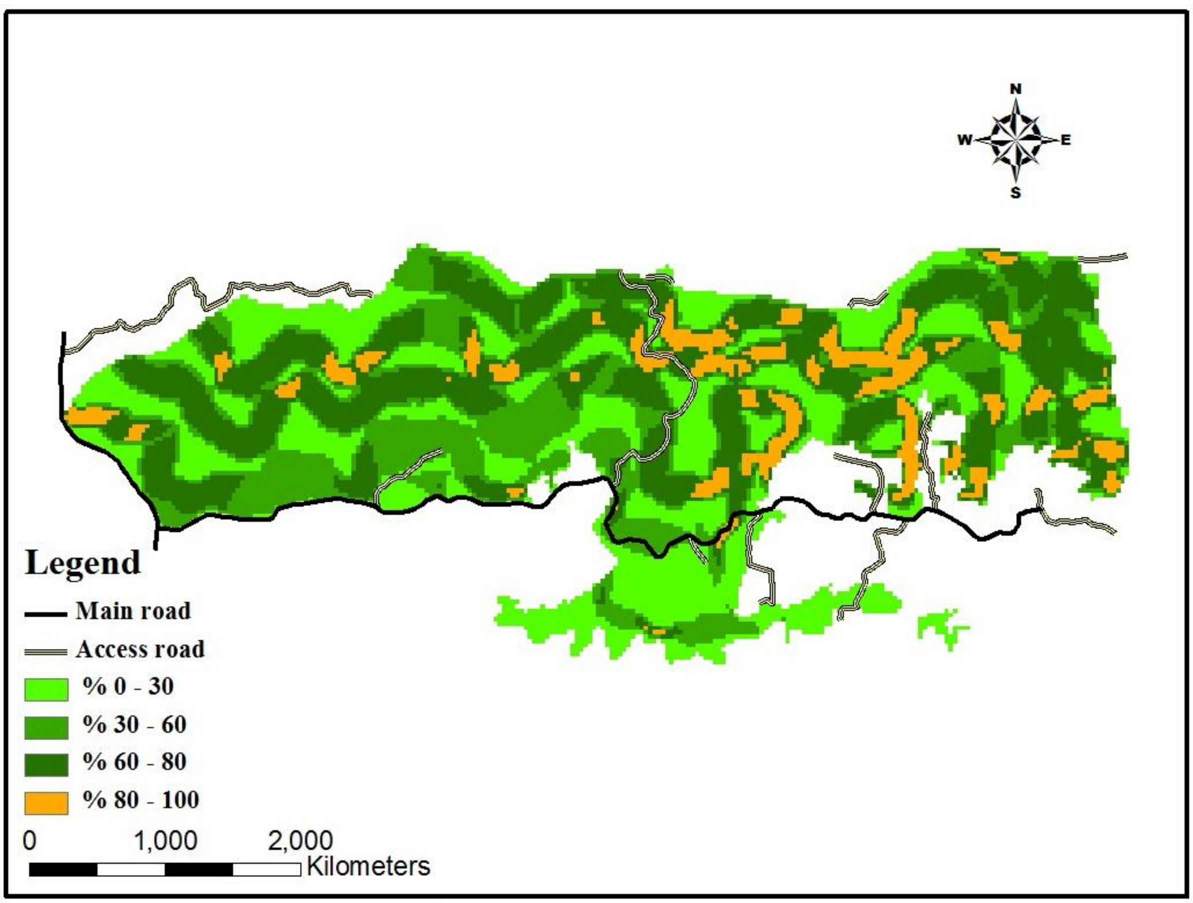

Figure 5. Comparison of the status of road passage on slope map achieved from DEM 20 m.

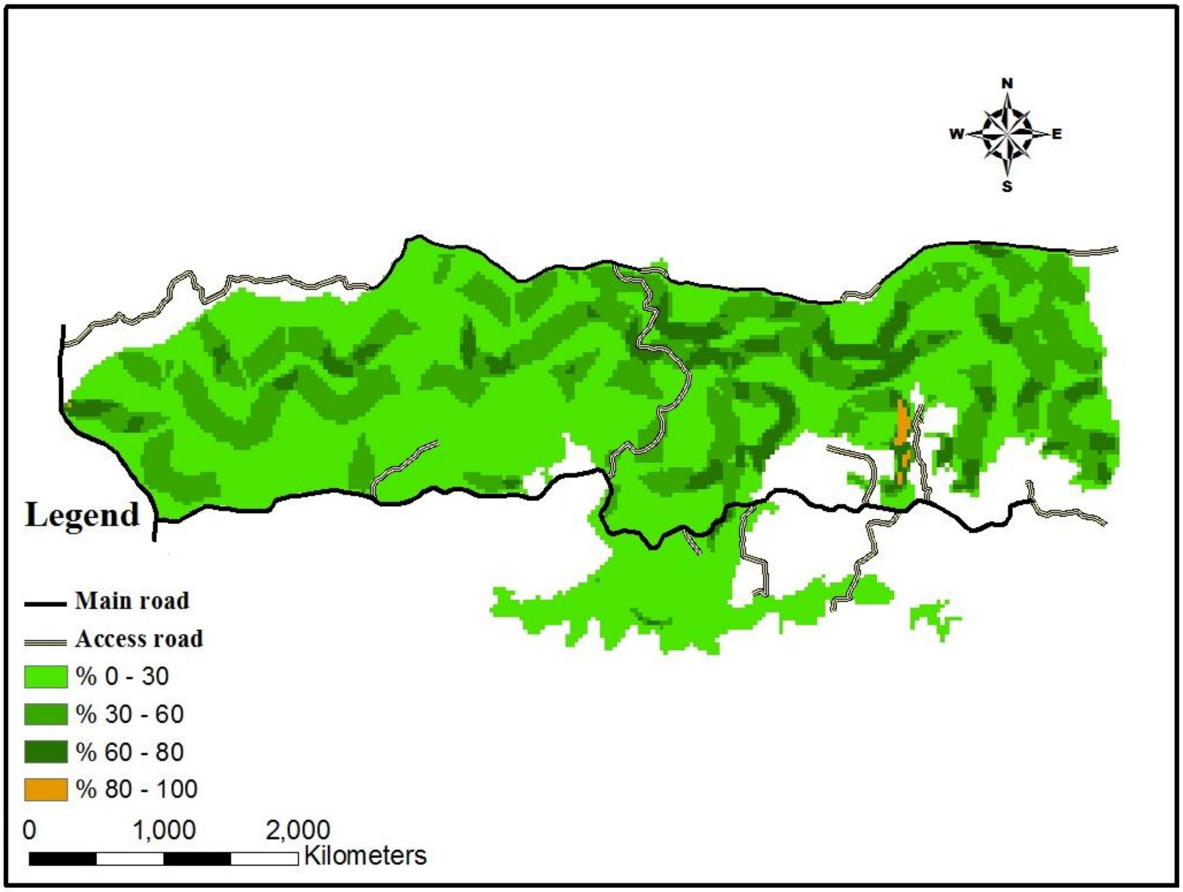

Figure 6. The status of road passage on slope map achieved from DEM 50 m.

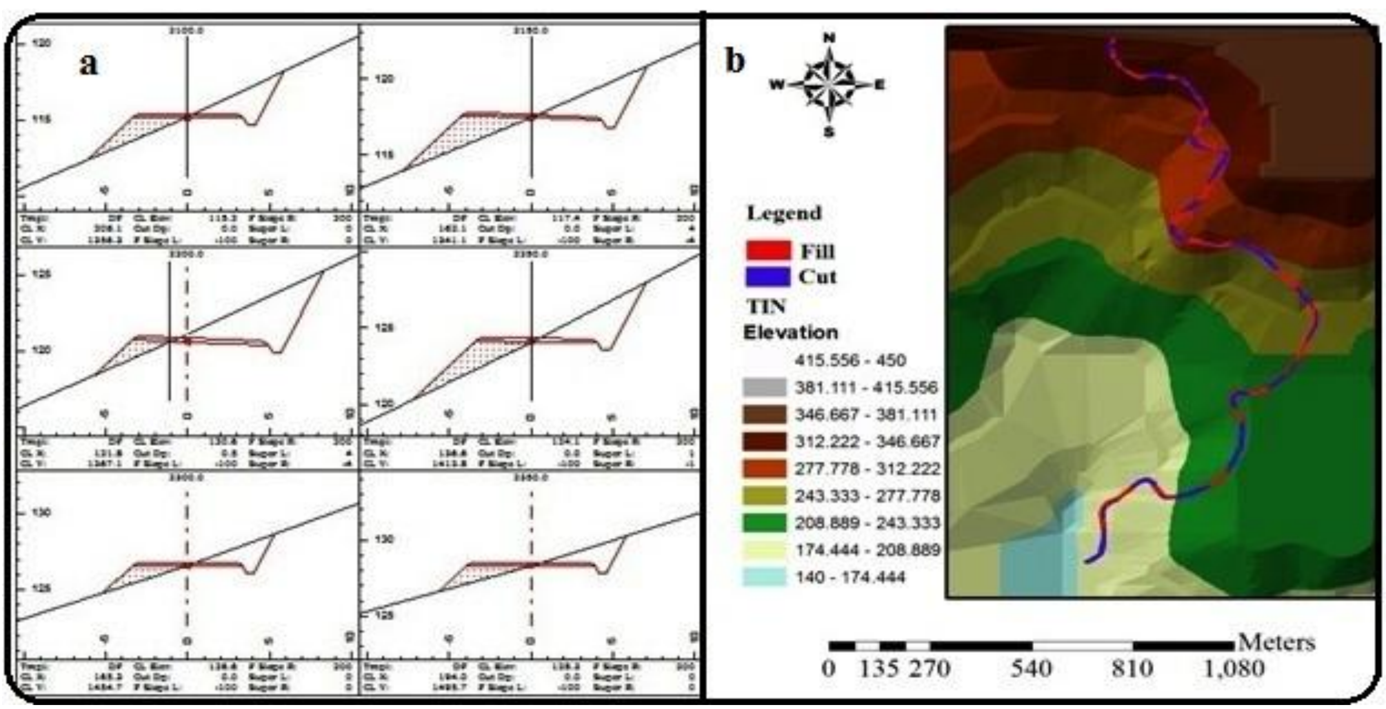

Figure 7. Calculation of the earth working volume using (a), RoadEng and (b), Arcinfo software.

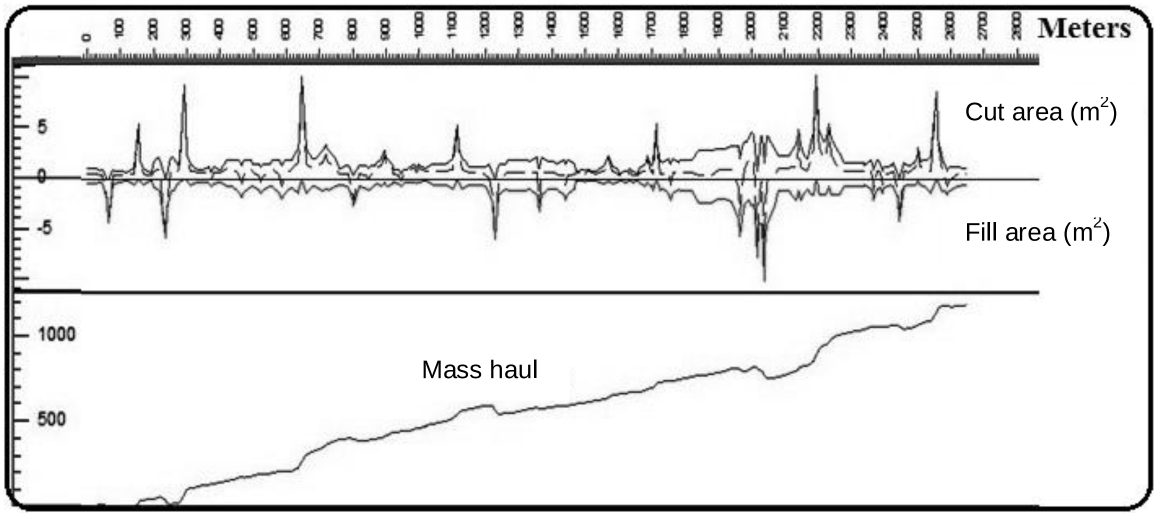

Figure 8. Calculation of the cut and fill areas and mass haul using RoadEng software.

important attributes to consider in predicting earthwork width, cut and fill slope length are hillside gradient and soil texture. To minimize the cost of construction, roads are routed directly to merchantable timber and then traverse as close as possible while considering local conditions and topographical features. When locating roads, special consideration is given to rivers, lakes, and known sensitive areas in adherence to environmental guidelines.

Conclusion

GISs are the most valid means of producing different projects with the evaluation of information related to location and analyses. All route location software relies on topographic models that are commonly referred to as DEM or digital terrain models (DTM). Methods for storing the data vary from contour lines, to cell-based raster datasets, to triangulated-irregular-networks or TINs. Most route location software relies on some form of the raster data model in which each cell in the data is assigned a particular elevation value. The appropriate cell size to use for forest route location is specific to the particular software application and geography of the area. The results showed DEM 50 and DEM 20 m is not a good indicator for designing road. Many have suggested that a cell size of between 1.0 and 3.0 m is sufficient for operational route location (Akay and Karas, 2004; Coulter and Chung, 2001; Krogstad and Schiess, 2004). With use of survey data (using mapping camera) we can transfer (Survey_Map) the route of a forest road into the plan, longitudinal horizontal and vertical profiles, and economic calculations. We can solve this problem by using the RoadEng software prepared by the Canadian Company Softree (Heralt, 1999).

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