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WOOD PRODUCTION AIMED FOREST ROAD NETWORK PLANNING BY GEOGRAPHICAL INFORMATION SYSTEMS

It was aimed that developing of wood production forest road network plan for achieving of forest multi-functions usage as in sustainability concept of forests have been managed by various objectives by this research.

A forest road network planning approach was realized for wood harvesting from forest by this aim. Geographical Information System (GIS) was used for evaluating of data and planning process.

The new forest road network plan of Catak Forest District was prepared by adding of 16 new roads segment, total length of 59+067 km, to existing road network plan for serving of wood harvesting operations. Forest road density value was determined as 22.79 m/ha for Catak Forest District. While opening up rate of area was increased to 77.82 %, opening up rate of existing stand value was increased to 94.30 % after planning studies. 90.24 % of roads were planned on the forest areas where occurring of minimum negative environmental impact.

Keywords: Forest Functions, Wood Harvesting, Forest Roads, Geographical Information System, Global Position System

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Планування мережі доріг для лісогосподарської діяльності за допомогою геоінформаційної системи

Мета дослідження спрямована на розроблення схеми мережі лісових доріг для здійснення багатфункціонального лісокористування з використанням геоінформаційної системи.

Лісотранспортна мережа в лісоексплуатаційному масиві Катак була утворена додаванням до наявних лісових доріг нових сегментів загальною довжиною 59+067 км. В результаті густина мережі лісових доріг зросла до 22,79 м/га, а коефіцієнт доступності площі лісового масиву підвищився з 77,82 % до 94, 30 %. 90,24 % нових лісових доріг були спроектовані з мінімальними негативними наслідками для довкілля.

Ключові слова: функції лісу, лісозаготівля, лісові дороги, GIS, GPS.

1. Introduction

Exploitation of forest land by determined goals can only be possible by forest roads network that designed for this goal.

In Turkey, forest road network planning applications are executed only evaluation of stand volume amount without taking into consideration of forestry goals that could be determined according to forest functions. It would be appear many unsuitable conditions.

Opening-up of forests would be made by good planed forest road network plans. Forest road network parameters change according to construction, location requirements, different terrain conditions, used technologies and management activities. These requirements and planning approaches would be related with economy, ecology and management.

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Public awareness of environmental questions has constantly increased in the last years. The construction of forest roads has been the main contentious issue in the discussion between foresters and environmentalists. The main criticism is that the construction of forest roads is destroying the environment causing soil erosion, habitat loss, scenic impacts, etc. Public acceptance of construction work has decreased significantly. In the context of sustainable development as stated by the UNCED the use of natural, renewable resources is a key element of environmentally sound development. Resource use depends on accessibility of the relevant areas. Therefore, it is impossible to give up the construction of forest road networks. However, the forest community has to look for ways on how to improve environmental soundness and public acceptance of road construction activities (Heinimann, 1996).

In this respect, a functional approach is needed in forest road designing. Forest functions are different for each nation. This is related culture and social life. Forest functions or planning aims can be reach up to fifteen different types. For this reason, it must be limited according for their effect on network design. Because, forest network planning units is whole river basin, some functions may not be enough area size.

In this study, forest road network layout aimed for main exploitation goal (forest function) is wood production forest.

2. Material and method

2.1. Study area

Catak Forest District was selected for investigation area that is research forest of Karadeniz Technical University, Faculty of Forestry. Total area of investigation area is 19553.76 ha. There are 26 number of forest stand type. Area of these stands is 10241.72 ha. The rest part of the study area is agriculture and range lands. These lands did not include for investigation.

2.2. Method

In this research, existing road network plan and redesigned road network plan are evaluated according to a set of criteria that include forest management goals, economical aspect and environmental impact assessment. New network plan was designed according to optimizing of these criteria set (Gumus, 2003).

It was started to research by design and building of database. In this context, the boundary of investigation area, available opening-up infrastructures and their conditions, road route analysis, positive and negative main points about road construction, topographical structure, water resources, forest structure, ownerships, social-economical structure and work opportunities of local people are used for database.

Inventory of existing roads was made by GPS. By the way, existing roads are investigated point of view qualitative and quantitative. Routes of roads were collected with track mode by GPS.

After determining of existing roads, new road segments designed according to management plan. In this phase, cutting areas, existing roads, and stand volumes took into consideration. Amount of road lengths was determined by Cost Benefit analysis (Turker, 1989).

Cost/benefit formula is bellow;

$$\frac{F}{M} = \frac{\sum_{k=m+1}^n \frac{G_k}{(1+i)^k} + \frac{H}{(1+i)^k}}{\sum_{j=1}^m \frac{I_j}{(1+i)^j}} \quad (1)$$

In Formula: G_k – Incomes trough whole amortization; I – Annual investment cost; H – Junk price; j – Years of cost; i – Real interest rate (% 3); m – Total investment time; k – Economical life (years) as symbolized

Benefit that used in economical analysis by cost and benefit rate is net present value of wood selling incomes getting from opening-up of forest by forest roads in the period of amortization time. Also, expenditures include road construction cost, maintenance and staff transportation (Erdas, 1997).

Cutting compartments which are determined in management plan were evaluated together according to getting service by roads that will be new designed roads for cost and benefit rate analysis. In determining of these areas, topographical structure and skidding direction were evaluated. Thus, total of 36 number of forest road cost compartment that will be used for economical analysis were constituted by combining of compartment. In determining of benefit amount, Macka Forest Enterprise Cashier's Office records were used.

An Environmental Impact Assessment (EIA) map was constituted to estimate affects of new planned roads on environment after determining of cutting areas and required road lengths for these areas. The routes of these roads are very important point of view impact assessment. Environmental Impact Assessment is a general term to estimate and evaluate environmental assessment both of management operations and development proposal (OECD, 1994).

Environmental impact assessment database was build to minimize of negative affect of road construction operations in developed planning approaches for wood harvesting function (Table 1).

As described bellow determined and digitized possible impacts are build in database. All different data coverages are combined by GIS software overlay option. Then, all points were multiplied and got a point for each polygon. These points are grouped and constituted an EIA points. These groups' points are described as positive values, negative values and zero points in total. In database, groups symbolized as +1 for positive areas, -1 for negative areas and 0 balanced areas. Thus, EIA coverage was prepared to analysis of road routes in designing phase.

3. Results and discussion

Potential cutting volume situation was determined by entering of volume and increment information to database of digital stand type map of whole planning unit.

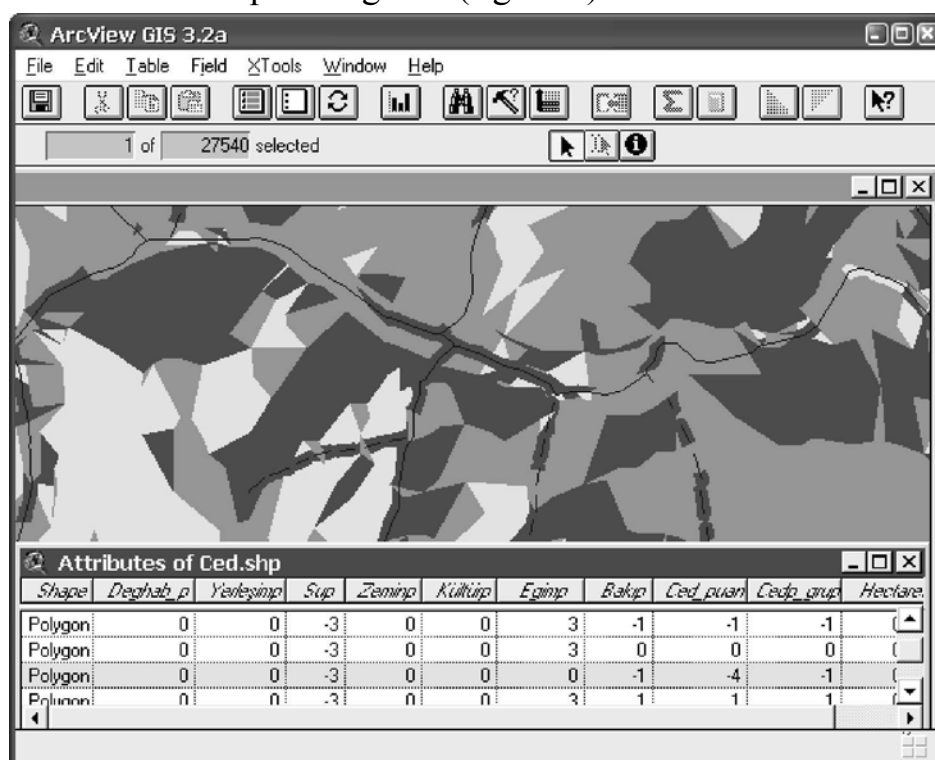
Total of 102 number compartments was planned for cutting in 10-year management period for investigation area. The total area is 5064.57 ha. 40930.6 m³ cutting volume were determined for this area. The total stand volume of planed compartment is 565962.91 m³. Annual increment of this stand volume is 13275.08 m³. 20-years, forest road amortization time period, amount of this increment was determined as 265501.6 m³.

Table 1. Environmental impact assessment indicator groups point system

Element of the environment	Risk	Indicator	Indicator groups	EIA points
Soil	loss of productive soil	Side slope groups	$S < \% 45$	+ 3
			$\% 45 < S < \% 75$	0
			$S > \% 75$	-3
		Rocky areas	Roads on rocky areas	-3
Water	Damaging water sources	Destruction of water source area	30 m zone around of stream bed	-3
Biosphere	Habitat loss	Destroyed area of valuable habitats	Seed stands	-3
			Picea sitcensis, origin test areas	- 3
			Aforestation areas	-3
Atmosphere	Road maintenance cost	Aspect groups	North aspects	-3
			East and West aspect	0
			South aspects	+ 3
Socio-economic conditions	Change of household characteristics	Nationalization costs	Private ownerships areas	-3
Cultural heritages	Destruction of archaeological and historic resources	Resources areas		-3

Economic value, reduced net present value for 2002, of 81861.2 m³ wood rawmaterial that calculated for 20-years management period is 3017926.33 USD. The economical value of wood rawmaterial, total increment occurred in this period, is 9788083.6 USD as net present value of 2002 year.

EIA was made as second phase in wood production aimed forest road network design. At figure 1, it can be seen constituted EIA coverage graphical and non-graphical database of planning unit (figure 1).


Figure 1. EIA graphical and non-graphical database

While, dark color polygons describe the areas that have maximum negative environmental impacts areas, white color polygons describe minimum negative environmental impacts areas. Polygons with gray tones describe second degree risk zones. EIA approach developed by this study is first in Turkish forestry. This subject did not used up to this study. GIS is very capable for these evaluations.

Catak forest district, study area, road network length is 248+815 km. Total forest road length is 232+209 km in planning unit. While, a part of, 43+412 km, existing roads longitudinally slope is over than 10 percent, 15+505 km roads slope is over 12 percent.

Total cutting area is 5064.57 ha according to management plan include 2000-2009 years. 3108.09 ha area (61.36 %) would be open-up of these areas by existing road network. There is 388812.48 m³ stand volume in this area. In this situation, the opening-up rate of total stand volume is 68.69 %. Opening-up annual increment rate was calculated as 9046.35 m³. 86.4 % rate of opened-up areas by existing roads was opened-up only one road segment. 7.2 % rate of area was opened-up twice time by different roads segments. Beside this, 1.4 % of total area was opened-up by 3 or more road segments.

It was determined that existing road network plan is not capable to activate all management plan facilities according to made calculations. If the works is make by existing road network, 68 % rate of work plan will be achieved.

Existing roads routes was accepted as 20 m wide corridor, and overlayed with EIA coverage. Thus, environmental impacts of roads were determined. It was determined that 32.32 % of existing roads was located on maximum negative environmental impact areas. 21.10 % of roads located on second degree risk zones. 46.58 % of existing roads were planed on minimum environmental impact area zone.

It was determined that more than half rate of existing road that constructed according to before network plan, are located on maximum negative environmental impact areas. Evaluating of results of existing forest network plan findings, new road segments were designed to achieve forestry management plan activities of 2000-2009 years.

According to new wood harvesting aimed forest road network designing approach constituted by this study, a part of functional forest road network designing, opening-up rates of area and stand volume's were used as planning criteria.

It did not an accept road density limit value before planning. By this approach result, local information got importance and road density value determined after design of capable road network plan that can be achieve all wood harvesting operations. New planned wood harvesting aimed forest roads total length is 59+067 km. Planning unit total road length reached to 307+882 km adding by new designed road segments. Total forest road length is 291+276 km. Total forest roads lengths for serving wood production area is 155+885 km. 114+706 km of these roads are exist on area. According to this amounts of roads, road density value is 22.79 m/ha. Forest roads on digital terrain model can be seen at figure 2.

Cost and Benefit rate calculation was used for economical investment evaluation of new roads that will be constructing. Incomes that will be getting 20 years period by selling of wood raw material is 3017926.33 USD as reduced net present value for 2002.

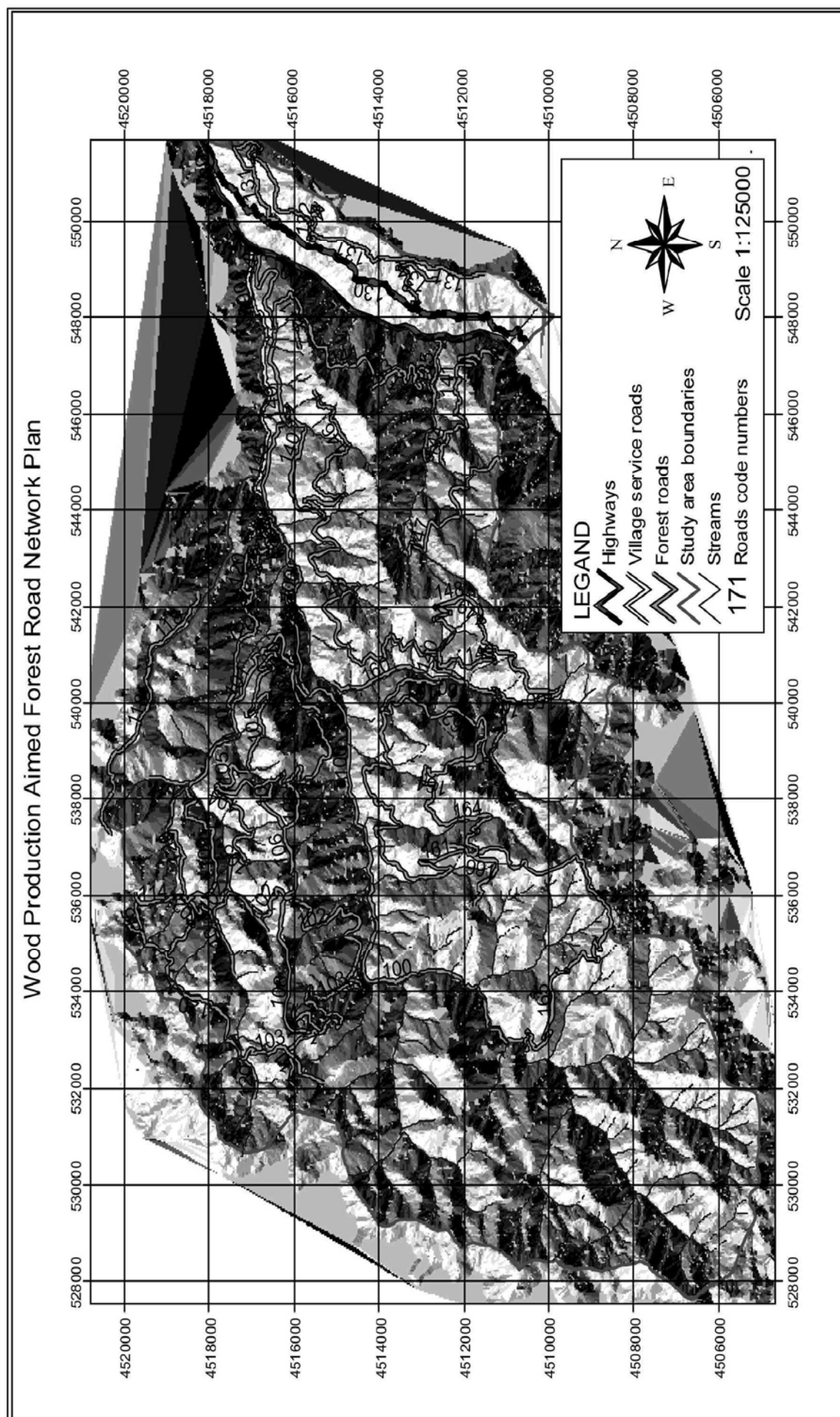


Figure 2.. Catak forest district new road network map

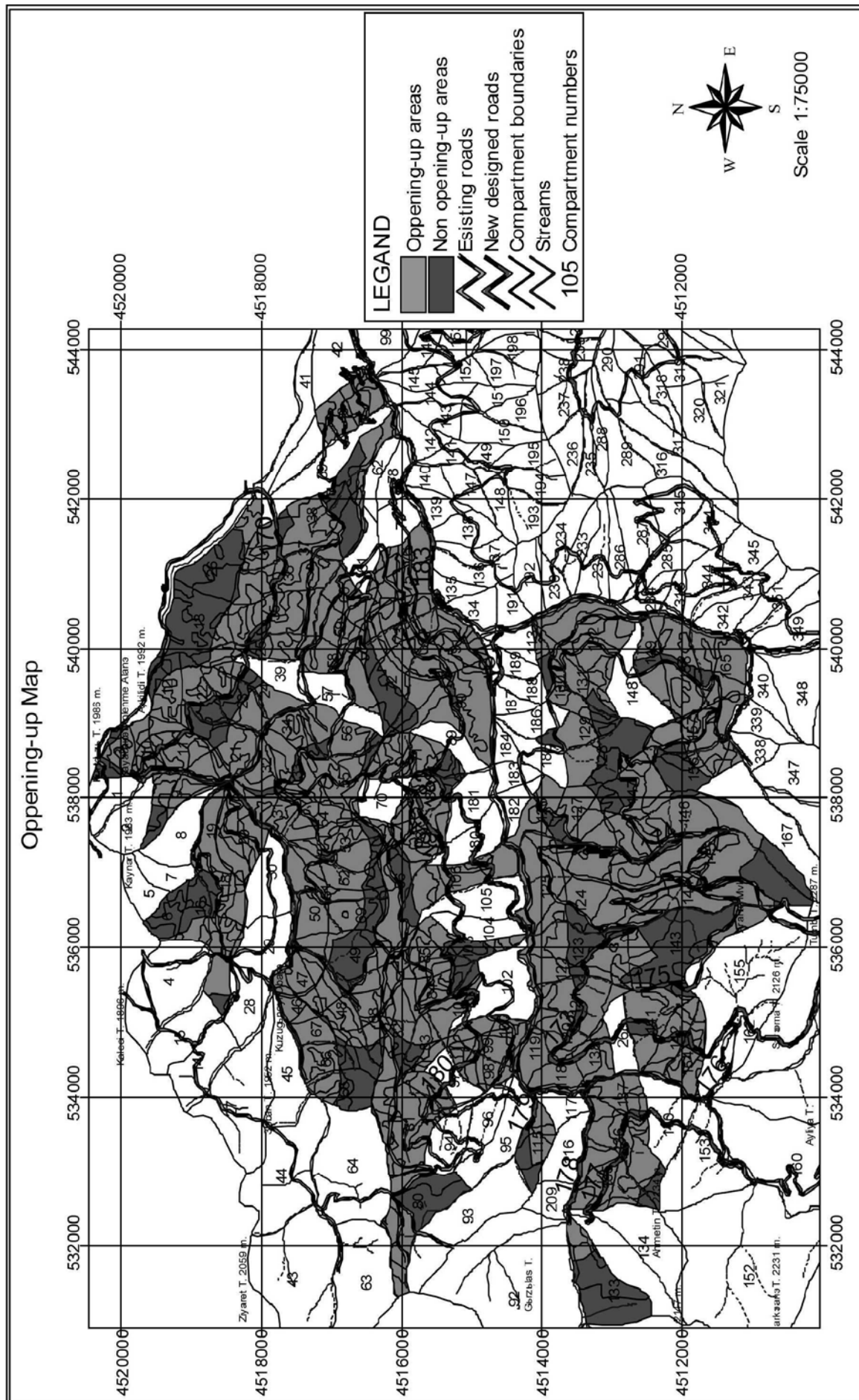


Figure 3. Opening-up areas map by wood productive aimed forest road network plan

New road construction and 20 year period maintenance cost (0.005 % of construction cost) are evaluated as cost of road network. According to this definition, reduced cost is calculated 692898.01 USD totally. Cost/Benefit rate is occurred as 4.35 according to these calculations. If cost/benefit rate is over 1 in evaluation of investment project, the project will be accepted as economic (Turker, 1989). Roads of decided to construct determined as economical by results of planning studies.

EIA coverage was took into consideration while new road routes planning. In this phase, it was paid attention to locate new roads on risk free zones. But, in some limited conditions, negative environmental impact areas were used also. While 63.54 % of new designed roads were located on minimum negative environmental impacts area zones, only 9.76 % of new roads were located on maximum negative environmental impact zones. 26 % of total designed roads were located on second degree risk zones.

Total opening-up areas that decided to cut were increased up to 3941.4 ha by new designed roads. So, opening-up rate also increased up to 77.82 % (figure 3).

4. Results and recommendations

New forest road network plan were constituted adding of total 59+067 km forest roads designed as 16 additional road segments for achievement of wood production aim. New planned forest roads network cost/benefit rate is 4.35. Roads of decided to construct determined as economical by results of planning studies.

Catak forest district wood production aimed forest road network road density value was determined 22.79 m/ha after planning studies. Opening-up rate is increased up to 94.30 %. While, existing road network could be open 68.69 % of total stand value.

Increasing 25.61 percent opening-up of wood volume by new designed forest roads, while increment of 16.46 % of opening-up areas, is contribution of developed forest road network designing approach for wood production forest for Turkish forestry. Especially, comprehensive GIS database and queries provided this success. 90.24 percent of designed roads were planned on minimum negative impact areas and second degree risk zones. Only 9.76 percent of designed roads were planned on maximum risk zones.

Forest road network plans must to redesign taking into consideration functions of forest in our country. Wood production aimed forest road network must be formed for achieving of management plan period targets level. 20 m/ha road density that is prudence for our country doesn't be a criterion for forest network plans. Opening-up area and stand volume rates should be main principle in planning operations.

Geographical information system owing to geographical data storage, update and many analysis must be used as a usefully tool for functional based forest road network plans.

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A RESEARCH ON FOREST ROAD PLANNING AND PROJECTING BY INROADS SOFTWARE IN BOLU REGION OF TURKEY

The computer software and hardware is extensively and effectively used especially in many countries of the world for the solution of complex problems. The facilities offered by the computer technology is used to great extent in forestry also as in numerous other areas. With this purpose, this research includes a study of forest road construction activities in Turkey, basic principles of planning forest roads, digital terrain models and forest road planning which were integrated in applied sample at the Mengen district of Bolu in Turkey. Analysis of slope and aspects have been made by digitization of maps and InROADS SelectCAD Version 8.0 software. The road network and the transportation planning of forest have been done by using above mentioned and general facts.

Keywords: Forest roads planning, Digital terrain models, Inroads software, Turkey.

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Планування та проектування лісових доріг за допомогою програмного забезпечення InROUDS в районі Болю, Туреччина

Можливості комп'ютерних технологій широко використовуються в багатьох країнах світу для вирішення комплексних проблем, пов'язаних з просторовим моделюванням. У статті наведено приклад планування лісових доріг з використанням інформаційних комп'ютерних технологій в районі Менген області Болю, Туреччина. Аналіз ландшафту було виконано в програмному середовищі InROUDS SelectCAD версії 8.0. Із використанням цифрових моделей місцевості стало можливим накреслити план мережі лісових доріг, призначених для виконання комплексу лісогосподарських робіт.

Ключові слова: планування лісових доріг, цифрова модель місцевості, програмне забезпечення InROUDS, Туреччина.

1. Introduction

It is known that exploitation of forests in rough terrain is highly impacted by transportation facilities. Consistent exploitation and protection of forests; and making the direct benefits of forests available to public, is primarily depended on a well arranged road network and transportation plan for such forests [1].

The computer software and hardware is extensively and effectively used especially in the developed world for the solutions of complex problems. The faci-

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