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ENVIRONMENTAL OPENING UP PLAN DUE TO MODERN TECHNIQUES

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Abstract: *The public awareness of environmental issues has constantly increased in the last years. The construction of forest access structures was presented as one of the main forest activities responsible for destroying the environment. Forest professionals therefore have to look for improved procedures for planning, designing and constructing forest transportation networks to improve public acceptance.*
The development of an integrated forest opening-up method with forest works such as primary haul roads, haul passages and staking grade line harvesting methods (tractor roads, hauling road path) of wood, constitutes an interference to nature.
This has to be studied with a very critical mind from the ecological aspect because of the consequences to the natural environment.
Aim of this paper is the presentation of an integral opening up plan considering environmental impact assessment with the help of modern techniques such as digital photogrammetry and GIS.
The combination between the technology of the digital photogrammetry and the GIS technology was used in order to evaluate the compatibility between the general forest opening up works and the natural environment. In order to evaluate the compatibility, practical criteria of the intensity of the human influence as well as criteria of the environment absorption to the opening up works were used.
The paper introduces analysis methods to evaluate the different indicators, and discusses multicriteria decision-making procedures.
The digital maps and the spatial analysis allowed the efficient and reliable evaluation of these criteria. The results proves that the usage of this method provides the ability to evaluate the compatibility of the existing opening up works with the natural environment and the possibility to choose the most compatible for the environment solution.

1. Introduction

The opening up with roads of low cost for the Greek forests began from 1956. In sustainable managed forests, roads, their network and technical specifications have to be in accordance with natural conditions and land uses (Abegg and Hünerwadel, 1983), expected logging operations (FAO, 1998) and landscape aesthetics. In mountainous terrain suitable road networks in combination with other logging means are recommended because of their favourable economical-ecological balance.

The development of an integrated forest opening-up method with forest works such as primary haul roads, haul passages and staking grade line harvesting methods (tractor roads, hauling road path) of wood, constitutes an interference to nature. This has to be studied with a very critical mind from the ecological aspect because of the consequences to the natural environment (Sedlak, 1993; Becker, 1995). Since the forest opening-up is inevitable, (Heinimann, 1994) in order to achieve their commercialization and at the

same time their protection that corresponds to the viable development and the efficient forest fire confrontation, a golden section has to be found.

The development of mountainous areas constitutes principal objective of the forest policy that is put into practice, applied today in our country.

This development presupposes however human interventions into the natural environment, that often leads to its falsification, deterioration and soon to its degradation.

One of the most important interventions of the human into a forest ecosystem is its opening up with the planning and construction of one network of means of transport (or transport installations) (forest roads, tractor roads, trail, skidding etc.) that for shifting and transport of forest products, tourist development and to its protection effectively contributes (Sedlak, 1993; Becker, 1995).

Nevertheless except these positive effects mentioned above, the opening up overloads the environment and causes damages to the landscape. Some of them are partly reversible, but most times it is impossible for the environment to be restored in the previous situation.

It is very difficult to be evaluating these effects with economic sizes in the context of the well-known methods of decision-making, like the cost-profit analysis and other mathematical methods. With the term compatibility with the environment we mean the determination, description and evaluation of effects of a forest technical work in the environment and the taking of measures for its protection. Accordingly is major task of a forest engineer to carry out the compatibility control of the development works with the environment. These kinds of works are the opening up works. For this aim evaluation criteria of the forest technical works were used in order to give the assessment capability of the impacts of the existing works in the natural environment, like to provide the possibility to choose the best (compatible) environmental solutions between quite a few alternative ones before their construction.

The positive effects that determine the size of the contribution of the opening in forest exploitation and forest protection are: a) the prevention of fires, b) to develop first the local and then the national economy (approximate the incomparable beauty of forest landscapes, development of recreational areas, approach to agricultural land, transport of agricultural products, wood supply market, improving transportation by extending the country road network, improving labor market and job creation, etc.) c) the management of water resources (easy access of springs, construction of works for torrent control), d) contribute to the defense of the country e) contributing to the Range Science, etc.

The rapid development of the P/C technology and the software of GIS give nowadays the possibility to investigate and analyze the above mentioned criteria with objective and economic way.

Aim of this paper is the presentation of an integral opening up plan considering environmental impact assessment with the help of modern techniques such as digital photogrammetry and GIS.

2. Materials and Methods

2.1 Research area

The public forest of Krousion included primary forests of Commences: 1) Kerkini 2) Lithotopou 3) Rodopolis 4) Anatolis, 5) Kastanousas. Located in western part of the prefecture of Serres and dominating N, NW and E slopes of the mountain of Krousion, which is northwest direction at an average distance of about 55 km from the city of Sidirokastro. The altitude ranges from 40 to 1,200 meters and the slope from strong to steep (20-70%).

The geographical coordinates are between:

North latitude 41° 7' and 41° 17' east longitude 22° 52' and 23° 14'.

The mountain of Krousion has a general direction from NW to SE of Serres. The studied forests are in the northeast slope of the mountain and have a general aspect that ranges from North up to East. In table 1 we can see the land uses for the area. In figure 1 we can see the study area from Google earth.

Table 1. Land uses of the research area.

A/A	Land use	Extent in Ha	Percentage in %
1	Forest	10.189	66,7
2	Wooded land and sparse forest	1.647	10,7
3	Agricultural areas	1.156	7,6
4	Bared land and Grassland	1.698	11,1
5	Barren land	592,5	3,9
	Total	15.282,5	100

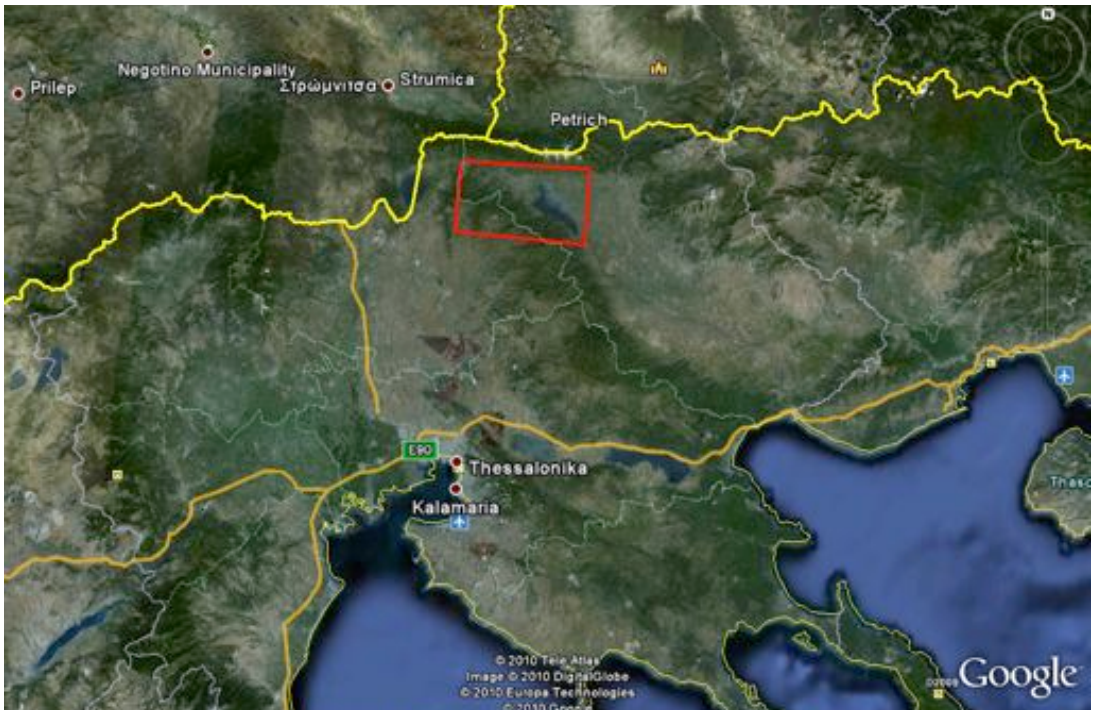

Figure 1. **Research area**

2.2 Methodology

Digital orthophotomap (Figure 2) of the research area resulting from a photogrammetric processing of two aerial photos in a digital photogrammetric station and the further processing of the orthophoto in GIS software are the tools used to achieve the research goals set in this paper. Then, follow the digitalization of the land uses and the forest road network. Also terrestrial measurements by stepping out the area were conducted to determine the size of criteria.

The absorbency and intensity criteria and their weight came from a questionnaire sent to specialist scientists (Giannoulas 2001). The grading of these criteria depends on the following principle:

We accepted a situation as ideal (=100%) for the forest protection. The percentage of deviation from this ideal situation will be subtracted from 100%. The result will be the grading of the criteria.

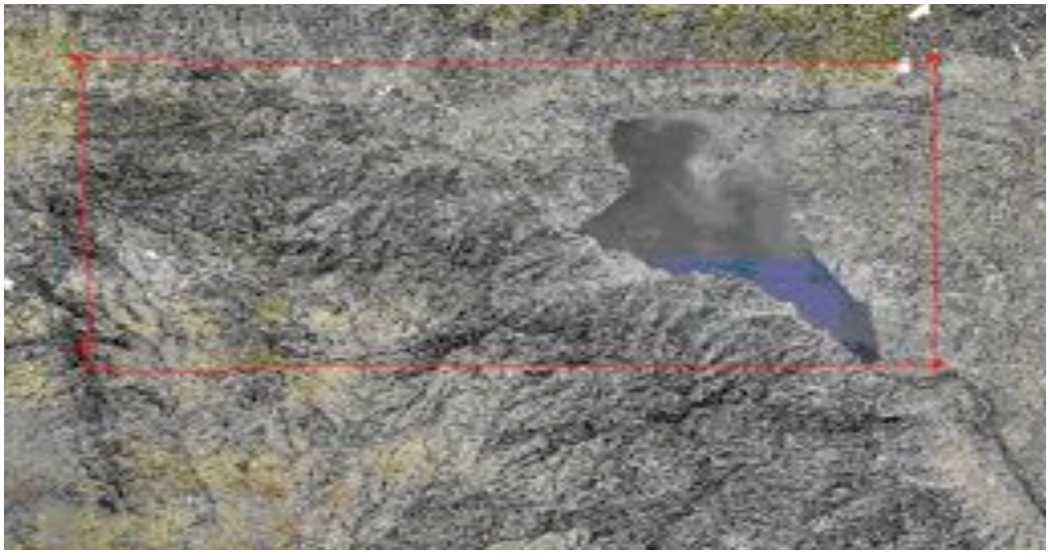

Figure 2. Digital orthophoto of the study area

For the definition of the intensity of the human impact to the natural environment from the existing forest opening-up works and the exploit of the forest, we used respective criteria (Buwal, 1990; Mader, 1990; Heinimann, 1994; Doukas, 2004). At the same time were specified the coefficient weight that represent the intensity value of each criterion from expert scientists' opinions.

In detail, the intensity criteria that were used are:

1. Road density. The excess percentage of D_{ec} and D_{max} is rated as the reduction of the optimum 100. The comparison of the existing road density D_{ex} with the optimum theoretical D_{th} and the optimum economical road density D_{ec} is based on their calculation applying the Kroth method (Kroth, 1973; Doukas, 1984; United Nations, 1988; Zundel, 1990; Trzesniowski, 1993). Coefficient weight: 3.

2. Logging means. Logging means: Tractors and animals.

2.1. Skidding with draught or load animals. Coefficient weight: 3.

2.2. Skidding with mechanical means or combination from animals and mechanical means. The percentage of the use of tractors for skidding is rated as the reduction of the optimum 100. Coefficient weight: 3.

3. Percentage of opening up. The reduction percentage of the forest opening-up from forest roads and tractor roads which is <70%, is rated as the reduction of the optimum 100. Coefficient weight: 3.

4. Skidding direction (horses, tractors, cable winches). The skidding direction percentage which is <45° comparing to the vertical to the road skidding, is rated as the reduction of the optimum 100. Coefficient weight: 1.

5. Traffic frequency and vehicle type.

5.1. Exceeding of traffic frequency. The excess percentage of the traffic load, in comparison to the one that is justified from harvesting, is rated as the reduction of the optimum 100. Coefficient weight: 2.

5.2. Overloading of transport vehicles. The excess percentage due to truck overloading of the uniform truck loading according to the rules is rated as the reduction of the optimum 100. Coefficient weight: 2.

6. Forest roads' categories. A ratio of 40% of main roads (category A΄, B΄ and C΄ of forest roads) and 60% of tractor roads in addition of infrastructure is considered as ideal (100). A deviation from this ratio

in favour of the main roads will be evaluated with reduction of the grading on a scale of 100. Coefficient weight: 2.

7. Position of roads.

7.1. Distance of water flows. Coefficient weight: 3.

7.2. Distance of forest boundaries. Coefficient weight: 3.

7.3. Problematic (unstable) soils. Coefficient weight: 3.

The value (%) that estimates the impact intensity (I), which is not negative, is multiplied by the respective weight coefficient (W_I) and is divided by the sum of the weight coefficient values so as to extract the barycentric average:

$$C_I(\%)=\frac{\sum(\mathrm{I}\times W_I)(\%)}{\sum W_I(\%)} \quad (1)$$

where $\sum(I \times W_I)$ and $\sum W_I$ are the sum of the estimate impact intensity multiplied with the respective weight coefficient (W_I) and the sum of the weight coefficient values, respectively, for matrix as size %.

Afterwards, the ability of absorption of the forest ecosystem of the forest opening-up work impacts was studied. Specifically, the term absorption is defined by whether the impact effect will be absorbed from the forest ecosystem as time passes, as well as the number of impact receivers.

The absorbency criteria are divided into 3 categories: 1st forestry criteria, 2nd topographical criteria and 3rd social criteria. The weights of the criteria are: three (3) for the forestry criteria, two (2) for the topographical criteria and one (1) for the social criteria.

The criteria were: 1) the kind of covering; 2) the forestry species; 3) the management form; 4) the forestry form (age); 5) the height of trees; 6) the site quality; 7) the productivity; 8) the cross ground slope; 9) the aspect; 10) the relief; 11) Distance from: 11.1) Tourist resort; l1.2) National road network; 11.3) Railway; 11.4) Archaeological site; 11.5) Adjacent big city; 11.6) Adjacent village; 11.7) European path; and 11.8) Natural or artificial lake or river.

- As far as absorbency is concerned:

Criteria 1, 2, 8, 9 and 10 can be estimated digitally; criteria 3, 4, 5, 6 and 7 are set based on the management plan or terrestrial measurements by stepping out the area were conducted to determine the size of criteria, while criteria from 11.1 to 11.8 are assessed with special software, displaying on the P/C screen what is observed from a different DTM point.

The absorption (A) of the forest ecosystem is multiplied by respective weight coefficient (W_A) and is divided by the sum of the weight coefficient values with a view to extract the barycentric mean:

$$C_A(\%)=\frac{\sum(\mathrm{A}\times W_A)(\%)}{\sum W_A(\%)} \quad (2)$$

where $\sum(I \times W_A)(\%)$ and $\sum W_A(\%)$ are the sum of the absorption's estimate multiplied with the respective weight coefficient (W_A) and the sum of the weight coefficient values, respectively, for matrix as size %.

3. Results

The following table 2 presents the percentages of intensity and absorbency criteria for the research area.

Table 2. Criteria of intensity and absorbency

INTENSITY				
	Criteria	**Grad %**	**Weights**	**Sum**
1	**Road density**	95.93	3	287.79
2	**Logging means**			
2.1.	Skidding with draught or load animals	-* It does not exist in the area.		
2.2.	Skidding with mechanical means or combination from animals and mechanical means	50	3	150
3	**Percentage of opening up**	100	3	100
4	**Skidding direction**	100	1	100
5	**Traffic frequency and motor vehicle types**			
5.1	Exceeding percentage of traffic frequency	92	2	184
5.2	Exceeding percentage due overloading	91.43	2	182.86
6	Forest roads' categories	50	2	100
7	**Position of roads**			
7.1	Distance of water flows	60	3	180
7.2	Distance of forest boundaries	80	3	240
7.3	Problematic (unstable) soils	80	3	240
	Total		25	1964,65
	Average value $C_I = \sum(I \times W_I) / \sum W_I$	**1964.65 / 25 = 78.586%**		
ABSORBENCY				
	Terrain conditions			
1	Kind of covering	75	3	225
2	Forestry species	75	3	225
3	Management form	55	3	165
4	Age	65	3	195
5	Tree height	75	3	225
6	Site quality	45	3	135
7	Productivity	50	3	150
8	Slope of ground	31	2	62
9	Aspect	85	2	170
10	Relief	15	2	30
11	**Distance from:**			
11.1	Tourist resort	30	1	30
11.2	National road network	50	1	50
11.3	Railway net	60	1	60
11.4	Archaeological site	100	1	100
11.5	Adjacent big city	100	1	100
11.6	Adjacent village	30	1	30
11.7	European path	100	1	100
11.8	Natural or artificial lake or river	80	1	80
	Total		35	2132
	Average value $C_A = \sum(A \times W_A) / \sum W_A$	**2132 / 35 = 60.914%**		

4. Discussion

1. Road density: For the definition of the existing road density we applied the software AutoCAD Civil 3D 2009 (definition of topology, road length measurement) from the digitized map of the study area that derived from the respective orthophotomap. For the determination of the mean vertical skidding distance,

the mean inclined skidding distance and the curvature coefficient we applied the software GIS taking under consideration the logging means (animals and tractors, two-sided skidding). The values that were rated are: D_{ex} = 211,320 / 15,228.2 = 13.88 m/Ha (D_{ex}: existing road density), D_{thex} = 9.81m/Ha and D_{ec} = 13.06 m/ha (D_{ec}: optimum economical road density, D_{thex}: theoretical existing road density).

The excess percentage of D_{thex} = 9.81 m/ha, and of D_{ex} = 13.88 m/ha is 4.07%, therefore the value of the criteria is 95.93%.

2. Logging means. Percentage of tractors' use in skidding: At the study area, are used animals and tractors in skidding, therefore the criterion value is 50%.

3. Opening-up percentage: The opening-up percentage was calculated by creating on the digitized map, a zone of width twice as the mean horizontal skidding distance in both sides of the forest roads in the study area. The opening up percentage is 75.30% in the region of our investigation and as developed by the Backmund (1968) the situation of opening up is favourable. The criterion value is 100%.

4. Skidding direction: The skidding direction is always > 45º if tractors are used as skidding mean. Therefore, the criterion value is 100%.

5. Traffic frequency and motor vehicle types:

5.1. Exceeding percentage of traffic frequency: At the study area we observed excess of the traffic load (25 tractors) comparing to the admissible from harvesting, number of tractors (23). Therefore, the excess percentage is 8% and the criterion value is 92%.

5.2. The excess percentage due to truck overloading: We observed excess of the truck loading, 35tn rather than 32tn. Therefore, the excess percentage is 8.57% and the criterion value is 91.43%.

6. Forest roads' categories. The criterion value is 50% because the rate between main roads and tractor roads is almost 46% to 54%.

7. Position of roads:

7.1. Distance of water flows. The criterion value is 60%.

7.2. Distance of forest boundaries. The criterion value is 80%.

7.3. Problematic (unstable) soils. The criterion value is 80% because of the percentage of the road passing by a sandy clay ground and unstable soils (landslides or erosion problems).

Grading the absorption ability of the skidding consequences from the forest ecosystem:

1. Forestry criteria.

1. From the digitized map of land uses is clear that the 66.7% of the study area is covered by forest, the 10.07% from wooded area, the 11.1% is covered by grasslands, the 3.9% has no vegetation, 7.6% from agricultural area. The value of the criterion is 75.44%.

2. Likewise, the study area is covered by broad-leaved forests so the value of the criterion is 75%.

3. The forest management form is coppice with the oak coppice stands under conversion with criterion value 55%.

4. The forest age is even-aged with selection stands and the criterion value is 65%.

5. The mean tree height arises for the 40% from 10-20m and 60% <10m, therefore the value for this criterion is 65%.

6. The site quality is basically medium and poor; therefore the value of the criterion is 45%.

7. The forest productivity (Harvesting) is 2.14 m^3/year×ha, according to the last forest management plan, which is between 1-3 m^3/year×ha, so, the criterion value is 50%.

2. Topographical criteria.

For the extraction of the absorption values we created slope and aspect maps, applying the software AutoCAD Civil 3D 2009 and the digital terrain models D.T.M. of the area.

1. The cross slope of the ground ranging from medium to steep. The criterion value is 31%.

2. The aspect to the horizon varies. The criterion value is 85%.

3. The terrain relief is described as intense with value 15%.

3. Social criteria.

1. The study area is nearby the tourist resort of the lake of Kerkini. The absorption is 30%.

2. There are two provincial roads with total length of 50 km, thus the criterion value is 50%.

3. There is railway net passing through the study area, thus the criterion value is 60%.

4. There is no any archaeological area in the study area, thus the criterion is valued with 100%.

5. There is no any adjacent big city. The criterion value is 100%.

6. There are at least five villages in and nearby the study area. The criterion value is 30%.

7. There is no any European pathway in the study area thus the criterion value is 100%.

8. In the study area there is the lake of Kerkini, therefore, the absorption is 80%.

5. Conclusions

From the processing of the data and the presentation of the results we concluded the following:

The average of the positive intensity of the impact that arises from the study area (C_I = 78.59%), represents that the existing forest opening-up works were constructed in a compatible way for the environment. It is confirmed from the absorption average which was calculated (C_A = 60.91%), that the specific forest ecosystem has absorbed the negative consequences that came from the forest opening-up works.

It is an undisputed fact that forests everywhere and always are a source of joy and health as the harmony of nature with its unique insurmountable beauty excites the visitor and so the forest of Krousion is not an exception, but all the above.

Here you can add the importance of forests as habitat Krousion. The forest spread the edge of Kerkini, declared habitat of particular significance under the Treaty RAMSAR, the best breeding site, but an excellent hiding place for any game species animals and birds living or wintering in the area.

In forest cluster of Krousion there is no infrastructure for forest tourism. Apart from an old amusement park that was created in the 70s there has been no further response to forest tourism infrastructure. Taking into account the fact that Krousia bordering Lake Kerkini which brings together a large number of visitors, it is essential to creating views that will foster the emergence of the beauty of the landscape and serve the needs of visitors.

The positions where up view reveals a panoramic landscape. There, visitors can stop to rest and enjoy the scenery. These positions are part of the sight of a wide range of facilities alike. The choice of suitable sites is difficult because they often relied on their own and is almost always higher positions observer. The distinctive feature of places of sight is that large numbers of visitors. For this reason, these places should be set so as to ensure convenient and safe movement and residence.

The trails in a forest is the key in the hands of the browser, to make acquaintance with the beauties of the woods, but also and safeguards to protect that forest from damage that may result from heavy use of recreational (violation of sites purely economic function).

The correct link path to the network of forest roads is the best guide to the web browser places that have aesthetic interest. As in the case of roads, the design and construction of forest trails should ensure the traveler comfort, security and complete aesthetic satisfaction.

Lastly a network of trails in the forests should be marked with informative panels marking system. Because the use of even perfect in design and construction of pathways is not possible without proper marking of information boards, which are the silent guided browser-Walker forest.

The roads in the forests should be while serving the transport needs of forest products and the various operations to satisfy the requirements of the browser-visitor. It is multi-use paths, as is the function of forests.

With the construction of new forest roads, seeking the creation of appropriate and favorable conditions for opening up in the forest cluster of Krousion so that with the completion of the proposed integral opening up plan we can achieve:

- Create favorable conditions for shifting and transport of wood from the technical and economic terms, which affect the intensity of forestry operations.

- Increase the economic value of timber due to multiple facilities within the movement, both as to time, as well as to increase the dimensions of length and volume of mobile wood truck.

- The fast and convenient movement of vehicles to improve the transport of forest products for forest workers, personnel management, supervision, protection and exploitation of forest, timber merchant and machinery and materials for the unimpeded implementation of forest work.

- The best definition of segments and clusters by dividing the forest, and a satisfactory adjustment in time and space layout wood stock.

- The tourist development of the area, which varied very beautiful landscapes for recreation and creating the infrastructure to attract visitors who are already largely because of Lake Kerkini, resulting in increased jobs for residents of surrounding areas and increase their income.

An integral sustainable opening up plan of the mountainous areas of Greece ought to consider as a means for spatial transformations aiming at regional and social cohesion in the framework of the following strategic targets:

• Integrated development of mountains and mountainous areas and concentration of private and public investments to them, aiming at the environmental protection and economic revitalization of forests,

agricultural land, tourism activities, cultural heritage and network of villages, as well as total environmental upgrading.

• Adjustment of the economy of mountainous areas to the European and international evolution multiplying the distribution of public economic recourses and taking the proper restructuring measures for the improvement of the competitiveness of enterprises and the implementation of new technologies, management measures and economic incentives.

• Improvement of the general conditions (natural environment and infrastructure) of mountainous areas in order to be attractive for new competitive investments, taking into account the European economic environment and promoting the local specialties as an advantage of upgrading and development.

• Strengthening of the transportation system in mountainous areas and improving the access to the basic infrastructure system, as well as new means that could be developed in relation with information society, in order to solve isolation problems.

• Protection and upgrading of the natural ecosystems, the aesthetic forests, the natural and cultural resources of the mountainous areas.

• Establishment of new management bodies focusing on the integrated management of mountainous areas and the promotion of the opening up plan implementation, in cooperation with existing bodies responsible for mountain development, local authorities, institutions dealing with protected areas, non-governmental environmental organizations, forestry and agricultural cooperatives and other agencies.

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