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SPATIAL PLANNING INDICATORS FOR THE SUSTAINABLE DEVELOPMENT OF MOUNTAINOUS AREAS

Vasileios C. DROSOS[1] * **Georgios TASIONAS[1]**
Ioannis KOUKOULOS[1] **Iordanis KASAPIDIS[1]**
Vasileios STAVRIDIS[1] **Ioannis SISMANIDIS[2]**

Abstract: *The development of mountainous areas is linked with human interventions on them since any kind of economic development is usually characterized by unfavorable environmental impacts. However, there is an inherent paradox, namely the human intervention degrades the natural and built-up environment, which at the same time constitutes the raw material for its development.*

The objective of this paper is the specification of measurable criteria-indicators for an integrated strategy of sustainable development of mountainous regions. A basic and necessary condition for achieving this objective is the rational development in all three sectors of the mountain economy, which are forest - agriculture, livestock and tourism, that can evolve dynamically and plan various activities and functions. This requires a regional approach to nature conservation, spatial planning and water management leading to certified objective decisions in order to draw out proposals regarding specialized production activities, according to a proper typology that characterizes the differentiation of regional problems, needs and perspectives.

The concentration of private and public investments in these areas target to environmental protections and the economic revitalization of forestry, agriculture, tourism, cultural heritage and the existing network of villages, as well as to a total environmental upgrading.

All these can be achieved by improving the transportation system and the access conditions in the mountainous areas, as well as with the introduction of new technology and information systems can be addressed the problems of isolation of these areas. Total environmental upgrading of mountainous areas can be achieved by the protection and upgrading of the natural ecosystems, the forest landscapes, and their natural and cultural resources.

[1] Forestry & Management of the Environment and Natural Resources, Democritus University of Thrace, Ath. Pantazidou 193 Str., Orestiada, GR 68200, Greece;
[2] Secondary Education, Directorate of Secondary Education, GR 66100 Drama, Greece;
Correspondence: Vasileios C. Drosos; email: vdrosos@fmenr.duth.gr.

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1. Introduction

The concept of sustainability comes from forest terminology and in the literature the Saxon forester H. von Karlovic is considered to be the inventor of the concept, who in 1713 first used the expression "sustainable" in the following phrase: "*Art, science and their status for the country is based on the ability to maintain and develop wood capital in such a way as to achieve a stable, permanent and sustainable exploitation, because this is a necessary condition without which the country cannot exist*". The concept appears as an adjective and emphasizes the duration of an effect or an influence, while the word "sustainable" did not pre-exist in the dialect of German-speaking countries.

The development of mountainous areas is linked with human interventions since any kind of economic development is usually characterized by unfavorable environmental impacts.

Local development studies particularly of mountainous forest regions are limited and rarely integrated in the frames of a zoning that safeguards the space of vital importance with the help of an organic and flexible plan of land use [3].

During the past years due to the reckless and catastrophic for the environment linear economical "developmental" activity, dramatic significance facts for humanity were occurred. The perception that development will be either integrated, namely economic, social, technical/technological, political, and cultural, or otherwise there can be no development, is becoming more and more popular. Always in harmonious interaction and respect with the natural and cultural environment, whose part is also man [9].

There are cases where the term of the Integrated Development is used on schemes or programs (e.g. Integrated Development of the rural regions). It is of vital importance and requires the harmonious collaboration amongst the newest scientific and technological potentialities from one side and the virtual potentialities and restrictions from the other, although, the physical and socioeconomic reality on local, peripheral, national and global level has not yet been fully understood. The strategies for "development" that are being applied, as we can also see from the strategy applied on the fields of agriculture, stockbreeding and forestry, having as "standard" (or pretext) the sustainable development, characterize a development with ambiguous as well as documented dubious context [7, 8, 10]. In fact, encouraging classical sectoral development, with the aim of further developing competitiveness and economic growth, mainly serving the interests and needs of the modern human.

According to dictionaries, indicators are used to show the level or state of something. Therefore, they are very important tools to measure the success of a process.

The main difficulties to overcome in the identification process of indicators useful to evaluate the effectiveness of the sustainable development strategies in mountainous areas are the lack of monitoring systems and of the availability of data on local level.

On the mountain, each micro-region can choose their own indicators that will reflect the specific local conditions and their priorities and objectives. Before developing a set of effectiveness indicators, it is necessary to define the measures for achieving the objectives. Particularly important is to define the "measure units" which indicate the state of objectives or other monitored phenomena development, and to fix the target value of the indicators. On the other hand, in some regions, it may be difficult to raise the necessary information, due to a lack of available data. An additional difficulty is that some very important activities could even show their positive results not in a short-term view, but in longer perspective [6].

Effectiveness indicators should be relevant, easy to understand, reliable and based on accessible data.

The aim of this paper is the specification of measurable criteria-indicators as concern the opening up of a mountainous forest area for an integrated strategic of sustainable development of mountainous regions.

2. Material and Methods

2.1. Research Areas

The quality of the opening up efficiency was investigated in two characteristic mountain complexes.

The Oligyrtos (1935 m) mountain is laid in the west Argolida Prefecture which belongs to Peloponnesus region in Greece. Major peaks are Skiathis (1180 meters), Farmakas (1616 m) and Megalovouni (1273 m).

The mountain of Farmakas (Longitude: 22^{o} 30′ 10′′, Latitude: 37^{o} 46′ 20′′) - 1616 meters in altitude - dominates the north-western edge of Argolida Prefecture. Farmakas is a majestic mountain, overgrown with trees (especially fir trees), which owes its name to the many therapeutic herbs (medicines) that grow on the slopes and diligently collecting the old years, to use for each disease (Figure 1).

In the eastern ends of Farmakas, the neck forming with the Megalovouni, placed the great city of antiquity Orneai, whom Homer mentions as participating in the campaign against Troy, led by Menesthea. The city bore the name of the housing, Ornea, son of Erechthea and Praxitheas, descendants of Athena. In Table 1 we can see the land uses for the area.

Table 1

Land uses in 2009

Land use	Extent [ha]	Percentage [%]
Forestlands	1878.9	62.45
Partly forestlands	780.4	25.94
Grasslands	302.3	10.04
Agricultural lands	47.3	1.57
Grand total	3008.9	100

The second research area is the Pinakates - Milies - Vyzitsa of Pelion of Magnesia Prefecture (Figure 1). Showing almost all aspects on the horizon, with the predominant S - SW, N - NW and E and the altitude ranges from 0-1466 meters (top Tsakos). The slopes are on average between 10-70%. The predominant species are sweet chestnut, common walnut tree, forest beech and downy oak.

2.2. Methodology

The urgent goal of spatial planning of forest areas should be to ensure, within an organic and flexible land use plan of the living space for [2]:

a. The productive land;
b. The hydrological network;
c. Forests and forest areas;
d. The traditional-cultural heritage;
e. The development of the area in the context of maintaining compatibility with the environment.

Fig. 1. *Research areas*

Therefore, the spatial development plan of forest areas must contain the phases from Figure 2.

The rational and sustainable development of the mountainous areas goes through the spatial planning and mainly concerns in the mountainous forest areas the forest roads' network (Forest Opening Up).

As a concern of the opening up [4], the overall strategic planning of an integrated opening up of a forest area is affected and changed spatio-temporally by forest-ecological factors and the needs that the opening up of the forest is required to serve, such as shown in Table 2.

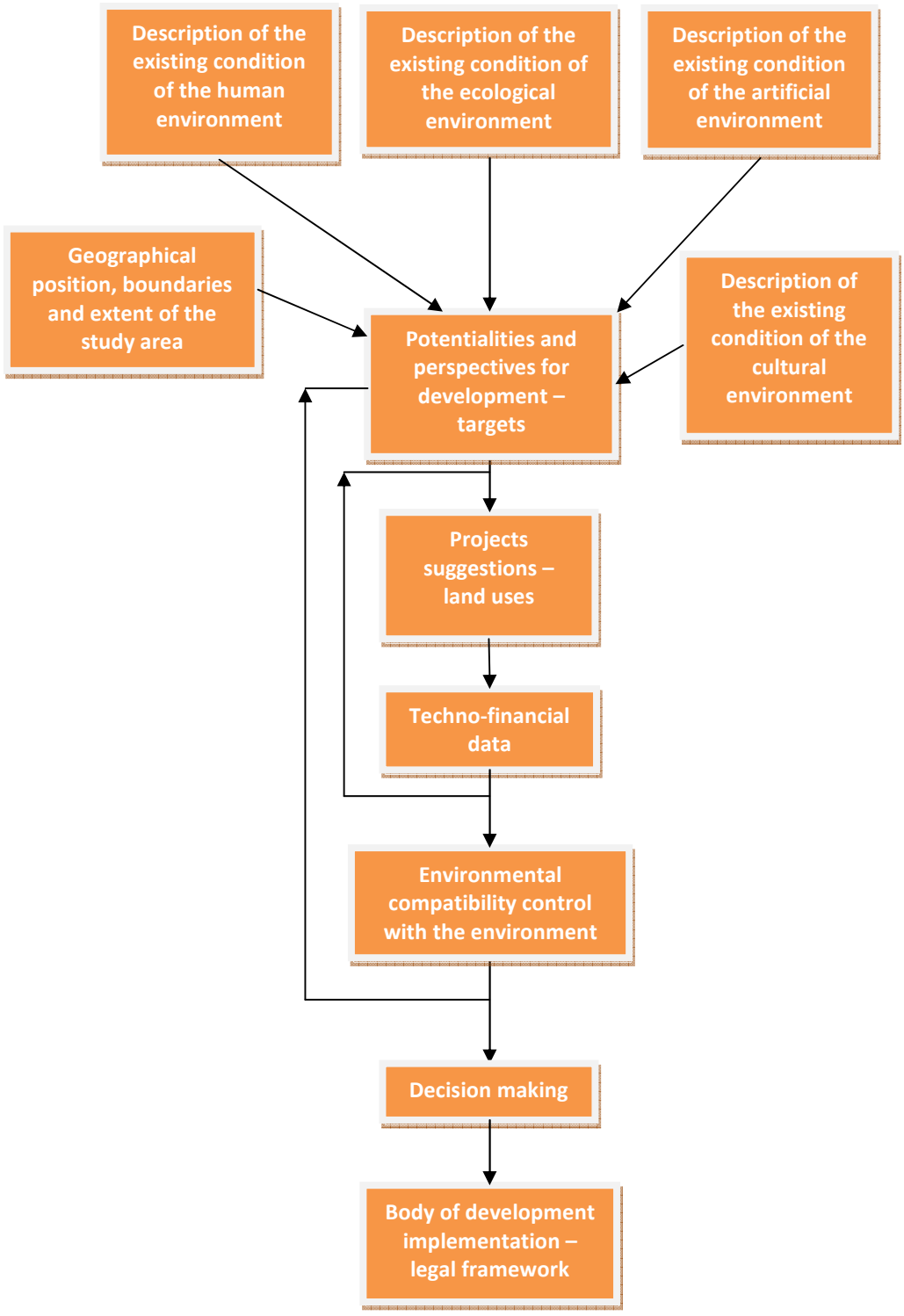

Fig. 2. *Spatial planning diagram of forest areas*

The indicators that were used to the opening up of a forest are [4, 5]:

- *Road density* is the ratio of the length of the region's total road network to the region's land area; the road network includes all roads in the area: main or national roads, secondary or regional roads, and other forest and rural roads [m/ha];
- *Road spacing* is the ratio of 10,000 to road density [m];
- *Skidding distance* is the ratio of 2,500 to road density [m];
- *The opening up percentage;* this indicator is the percentage [%] of the area in relation to the total area of the forest opened by the forest roads network; the opening up percentage is substantially affected by the terrain configuration; in Table 3 is shown a classification of opening up percentages into groups [1].

Table 2

Needs to be served by forest opening up

A / a	**Needs to be served by Forest Opening Up**
1	The forest management form
2	The topographic morphology of the forest area
3	The density and allocation of vegetation
4	The quantity and quality of woody capital
5	The transport of staff
6	The moving of timber (skidding-transportation of timber)
7	The requirements of forestry

Table 3

Forest opening up percentage classification

A / a	Opening up percentage	Opening up condition
1	Up to 65%	Unfavorable
2	Up to 70%	Partly favorable
3	Up to 75%	Favorable
4	Up to 80%	Very favorable
5	Greater than 80%	Unusually favorable

3. Results and Discussion

The indicators which characterize the opening up of a forest are:

1. The road density;
2. The road spacing;
3. The skidding distance;
4. The opening up percentage.

These indicators are also expressed with characteristic numbers that show the magnitude of their impact on the forest opening up, while the last indicator is also expressed cartographically. Essentially, the last indicator characterizes the quality of the spatial distribution of the roads and thus is the most important indicator of the efficiency of the network in a forest complex.

In the theoretical model with parallel forest roads with equal distances from each other, the opening up percentage

takes the maximum value E = 100%, but in practice in mountainous areas, it is impossible to happen.

Below are shown in the two mountainous areas with different management data, the opening up percentage and therefore the quality of the opening up efficiency.

According to the Table 2 the opening up of Farmakas (Figure 3) is unfavorable as the opening up percentage is less than 65%. Construction of tractor roads is needed up to a total road density (Roads and tractor roads) of 50 m/ha, with a road distance of 10000/50 = 200 meters, in order to achieve the mechanization of skidding. This would mean a burden on the environment.

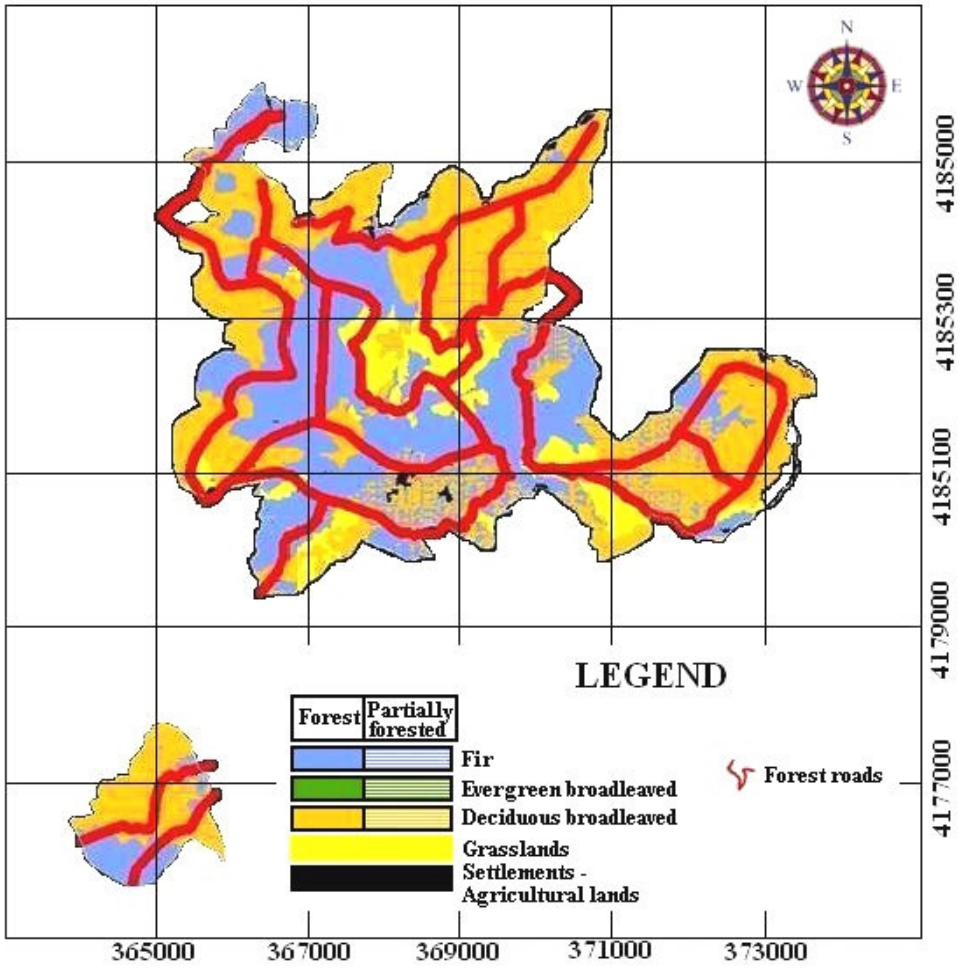

Fig. 3. *Map of opening up of Farmakas*

Regarding the spatial distribution of the road network, this is satisfactory because:

- With the optimum road distance of 800 m (300 uphill and 500 downhill) a forest protection percentage of 90.00% was calculated (Figure 4);
- The existing road density (D_{ex} = 46.50m/h) exceeds the limit of 12.5 m / ha and the road distance is less than 800m. So, the spatial distribution exceeds the fire protection target, with local problems in the NW of the complex, as shown in Figure 4.

It is observed that with the development of the indicators related to the opening, the goal can be set up, and one can think on how to measure whether the goal was achieved after the activity or the implementation of the project or not.

The indicators should reflect public, economic and sociological issues / activities and their real impact.

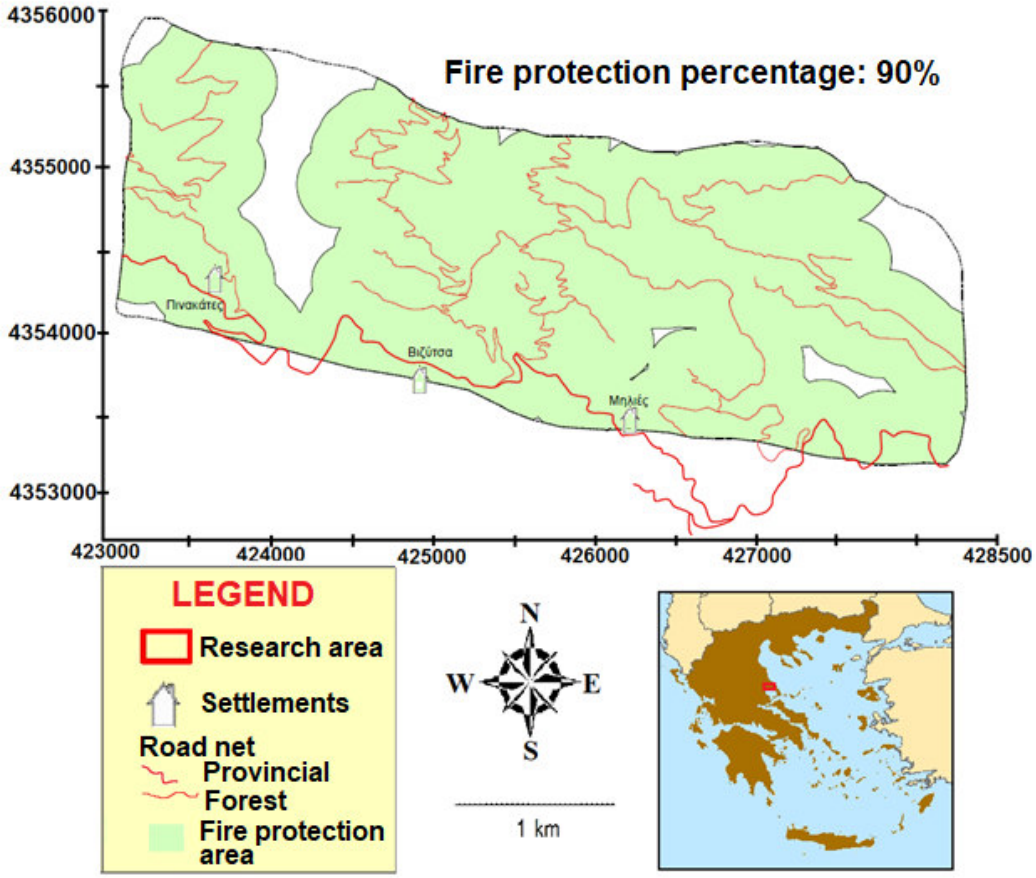

Fig. 4. *Map of Pinakates – Milies – Vyzits a opening up and fire protection percentage*

5. Conclusions

These indicators were selected, in order to have the best results based on the strategic objectives which were time set up in relation to the monitoring of networks of residential development and the singularity of mountainous forest areas.

Elements of paramount or crucial importance that can lead to safe conclusions for investment decision-making in mountainous areas are spatial planning and forest maps in combination with EIAs for the protection of the natural environment. The criteria-indicators, however, must be measurable and lead to certified objective decisions. The indicators use measurable quantities that give a measure of the state of the environmental, social and developmental characteristics of the residential systems that contribute to the creation problems to the quality of life in the local community. They include traditional environmental variables but also other that are not directly related to the environment.

The development of local sustainability indicators for mountainous areas, with the goal of keeping the rational support of a spatial planning in decision-making process, is important and necessary. Necessary conditions for the prosperity of mountainous areas remain the broad social acceptance of the idea of sustainability and the need to accelerate progress towards sustainable development. This is helped by the political leadership guidelines and the effectiveness and efficiency in dealing with the needs of the mountainous population.

It is observed that with the development of the indicators related to the opening, the goal can be easily set up, one can think on how to measure whether the goal was achieved after the implementation of the project or not. The indicators should reflect public, economic and sociological issues / activities and their real impact.

The creation of an Observatory of Mountainous areas Development (OMD) covering Greece, will contribute to the sound mapping of the identity of Greek mountainous residential system. Also, it will help the creation of a standard framework for the monitoring indicators of mountainous residential system's development.

The renewal of the components of OUD contributes decisively to update and support policies on matters which are selected as critical to a residential area. Therefore, national infrastructure needs updated geospatial information.

A standard pattern of the opening up of forest areas is impossible, since each forest area is something special that requires special design and handling. The techno-economic study of the opening up of each forest area is achieved after a thorough study of traffic, soil and climatic, forest-economic and ecological conditions of the region. The assessment of the indicators with the key factor reflected by the opening up percentage is necessary for the evaluation of spatial distribution of forest roads.

The opening up percentage is the most important indicator of forest roads planning and the sustainable development of mountain regions should take into account this indicator.

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