SUSTAINABLE MANAGEMENT OF NATURAL PRODUCTIVE SYSTEMS
(A CASE STUDY ABOUT THE DIAGNOSTIC ANALYZE OF SILVOPASTORAL SYSTEMS IN COMMUNAL FORESTRY)

Arsen PROKO, Ilir MYTEBERI

Department of Forestry; Agricultural University of Tirana, ALBANIA

E-mail: *aproko@hotmail.com*

Abstract

A case study has been conducted in Aranitas Commune, compound by 6 villages with c.a. 4500 inhabitants and extended in c.a. 4669ha, in order to determine contribution of forestry to sustainable development and analyze forest-village relations. With this study, a forest resource in Aranitas, which is located on Southern Albania, was investigated. Two main elements, human and forests are subject of this study. The main goal was the study of the coexistence of these two elements, reciprocal benefits and the improving of situation for both forest and society. In the frame of sustainable development, the concept of the sustained yield principle cover whole ecological system and include non-timber products and values (for instance biodiversity, erosion protection, recreate and grazing values) in the objectives of forest management. The main objectives of this study are: the identification of the best managerial alternative for the sustainable management of natural resources, coordinating silvicultural measurements with socio-economic situation of forest users and the rehabilitation of degraded ecosystems, increasing the forest productivity and restriction of the erosion and desertification as well as conservation of the biological diversity. We will show how a mathematical model (expert system) can assist on the decision-making process, in terms of sustainable forest management, considering the multi-functionality of natural productive systems. To establish a silvopastoral system and to ensure sustainable use of forest and pastures resources, the opinion of local people, forestry staff, environmentalists and other stakeholders, who have interest, in natural resource management have been received by using a participatory method. Natural ecosystems, together with society and economy are considered as the components of a natural economic productive system. The detailed analyses of the three components (multivariable analyzes), as the part of a unique system, analyzed of the conflicts within this system and their resolve, in a sustainable way, through the most appropriate scenarios (mathematically determine), is the methodological principle of this study. The factors which affect sustainable management of the ecosystems (ecosystem, social and economic) based on the suitability and relative weight, in four interval classes are classified. New software, concepts and terminologies are used to conduct this study.

Key-words: Natural productive system, sustainable forest management, multi-functionality,

biodiversity, vegetation type, FAC, Cluster and GIS analyses.

Introduction

Silvopastoralism is an ancient way of managing forestland and more recently a way of managing pastureland. It leads to increases in production from forestry in the short, medium and long term and, as a structurally diverse ecological system and a multiple product system, often is a sustainable use of land (1). They increase productivity in the short, medium and long terms, compared with forestland, and have a higher level of biodiversity than farmland. A silvopastoral system is a complex system and therefore requires of wise management strategies to combine the different components in a balanced way.

The establishment of silvo-pastoral systems, as productive economic system, is becoming more and more important in the identification of management system or the most appropriate alternatives for a sustainable development of regions where they are implemented. Silvo-pastoral systems are very complex and influenced by considerable biologic, social and economic factors. Meantime, as renewable systems, they are distinguished for their multi-functionality and effectiveness, if appropriately managed.

Presently in Albania communal forest or silvopastoral systems are managed with the same principles as the timber-production forests or so called classical forestry. However, there are many reasons which make indispensable the methodological improvement of the forest management plans in case of communal forestry:

– Society is an important component to consider, which interact on the development of silvopastoral productive system together with ecosystem and economy (2)

– Multi-functionality and integrated forestry call for the implementation of new principles and new methodologies (2).

– Utilization of new techniques of computation, satellite imagery, GIS, offers the possibilities of analyzing in a short time and with high quality, unlimited attributes for a considerable number of variables.

– Different types of factors affecting the silvopastoral systems.

– Principles of the division of territory in management unit are different on the case of sylvopastoral system.

The objectives are: (i) identification of forest types (Braun Blanquet-sensu strictu) (3) as spatial unit, which encompass the relationship through the vegetation, ecological conditions (climate, soil) and the traditional use of the natural resources. (ii) identification of the suitability and relative weight of the factors, which affect on the sustainable silvo-pastoral system; (iii) mapping of the territory based on the main factors and management units. The final aim of this study was the identification of the management scenarios, for a sustainable development of silvopastoral system, sustained on the best scientific experiences and adapted on the community traditions, thus helping the decision-making process.

General location information

The Aranitas Commune is located c.a 7 km on the East of Ballshi. Latitude ranged from 19045’94” to 19052’30” East and 40035”44” to 40040”45” North. The altitude is from 200 m (Factory of Petrol Processing) up to 688m (Gorica Mountain). The variability of climate factor is one of the reasons of the high variability in biological forms and vegetation types. Aranitas Commune is located on the both sides of Gjanica’s river, which is formed by the conflux of two main springs: Lumara and Metohu.

There are living, in this commune c.a. 4478 inhabitant or 967 families, distributed per village shown in the table.

Geologically, the territory is extended over the flishy and sandy rock, because of intensive cutting and overgrazing, often prone of the erosion and the desertification. The most common soil types are those of grey-drab covered mostly by the typical Mediterranean shrub, typical brown covered mostly by the broadleaves oak forests and hornbeam shrubs.

The study area is extended on two vegetation belts: (i) sclerophyllous evergreen vegetation (or typical.

Mediterranean forest and shrub) and, (ii) termophyllous vegetation of broadleaves oaks. The communal area is c.a. 4888.67 ha, divided per land use: agricultural land (46.5%), forest stock (33%), pastures and meadows (18%) and bare area (2%); meantime forest stock is divided in coppices (44%), shrub area (22%), pastures (21%), and high forest (5%). It can be seen that the common management forms are coppices and shrubs, preferable from the farmers for fire wood production and grazing. Step slopes, degraded vegetation and terigenous character of the rock make this territory prone of the erosion.

Using GIS techniques geological, soil, erosion risk and biodiversity maps are provided.

The climate is typical Mediterranean, characterized by c.a. 3 months summer dry period. On the graph below the Gaussan index (4), per meteorological station of Ballshi is showed.

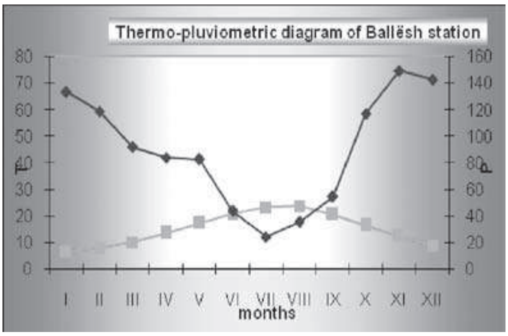

Fig. 1. Termo-pluviometric diagram (Gaussen Index)(4)

The study area is well known for the high value of the biodiversity, not only on species richness (265 vascular species divided per 55 families or 8.2% of Albanian flora), but for the variability of biological and chorological forms as well.

Based on the suitability and relative weight of the factors that affect on the biodiversity the "hot spots", "warmish spot" and "cold spots" are identified and mapped.

The forest stock covers an area of 2390.37 ha with an annual harvesting possibility of c.a. 2500 m^3/year (5).

The most important economic activity for the indigenous people is agriculture and husbandry. Agriculture is not intensive because the small area of the farms (from 1 to 2.5 ha). Farming is another very important activity on the area, which encompasses: 2700 sheep, 2200 goats, 950 cows and 850 horses, producing milk 2325 T, and meat 110 T. The request of the community for fire wood is c.a. 3385 m^3. (5)

It is clear that the needs of the community per forest production, fire wood and pasturing are higher that the annual possibility of harvesting or annual growth of the forests. If the traditional methods of forest use will continue in the future, the degradation of the vegetation would continue and bring erosion and desertification. For this reason the elaboration of another methodology for the establishment of a forest and pastures management plan is necessary. All the information given below is used as factors on multivariable analysis for the sustainable management of silvopastoral system or identification of the best managerial practices.

N.	Village	Surface	Average growth m^3/ha/year	Volume (m^3)	Total Biomass (Ton)	Dry wood (Ton)	Carbon (Ton)	CO^2 (Ton)	TonCO_2/ year
1	Aranitas	885.9	1.4017963	33582.26	1008669	605201.59	302600.8	1119622.9	1736.2432
2	Kalenjë	318.4	3.5097164	28619.14	495342.6	297205.55	148602.8	549830.26	1014.4251
3	Panahor	370.9	2.3150067	60317.4	2166856	1300113.7	650056.8	2405210.3	1843.0877
4	Çyçen	197.5	1.4058718	7209.552	184474.7	110684.79	55342.4	204766.87	623.44007
5	Metoh	363	1.4724073	8781.878	149053.4	89432.032	44716.02	165449.26	675.73422
6	Cfirë	254.7	2.6202881	32113.28	899498.3	539698.96	269849.5	998443.07	1099.1018
	Total	**2390**		**170624**	**4903894**	**2942337**	**1471168**	**5443323**	**6992.032**

Table 1. The productivity of the forest area and per village

METHOD

In this study we consider the natural resources (ecosystems), as a component of production economic system, together with the society and the economy. Silvopastoralism can be applied in forest, grazing and arable lands in a sustainable way for diversification and multipurpose land use. It can increase biodiversity, protect the environment, combat and prevent desertification, promote the landscape, improve health and increase rent income in the short, medium and long term for managers when the social, cultural and economic benefits are accounted for. Silvopastoralism promotes land sustainability, integrated land-use management and offers benefits to managers, local communities and the public.

As can be depicted from figure 2, the natural production system can be considered as the output of interaction between three components; human component, ecosystem and the impact of the market economy's laws (6). Thus, the sustainable use of the natural sources is not only a technical question but social and economic as well.

Releves (sample plot) is defined as the unit area for data collection and plant association (Braun Blanquet *sensu stricto*) (3) as management unit.

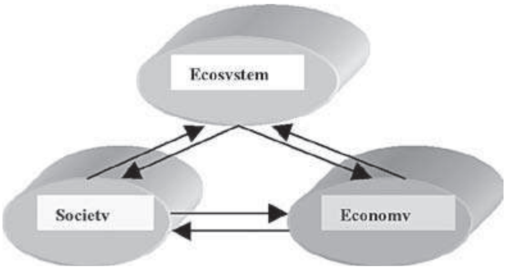

Fig. 2. Natural production system (Silvopastoral system)

The study is realized through three different phases:

1. Preparatory phase
2. Analytic phase of data gathering
3. Synthetic phase or data elaboration

Almost hundred thirteen relevés (floristic inventory plots) were sampled and more than hundred interviews are performed and analysed. Figure 3 shows schematically, the steps followed during the study.

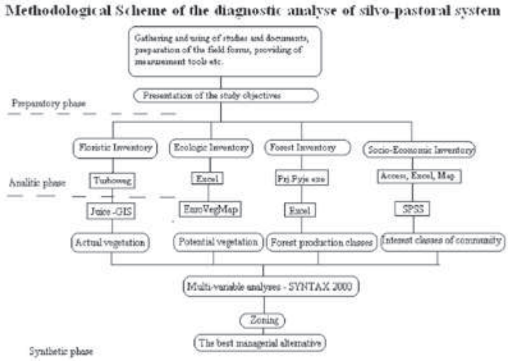

Fig. 3. Methodological scheme of the study (5)

The analytic phase has been an inventory of physical, biological, dendrometrical and silvicultural data. Particular care was paid on the historical and spatial change of vegetation within the study area. Existing information, including special information from the photos was used and relevés (inventory plots) were established based on the principles of "sample design". A database with all information and GIS with sustainable geo-references were established and for each described theme (layer of information) a digital map was provided.

The identification of vegetation types was based on the principles of Braun-Blanquet school (3). As a study unit the plant association is used: "complexity of species having the same historic, ecologic, dynamic, statistic and conjugate from the same traditional use" (7). According to the concept of Braun-Blanquet (*sensu stricto*) (3), the position of plant association within the framework of a hierarchical system is given and the dynamic position, within vegetation series may be defined as well. The size of the relevé (inventory plot) was identified with the "minimum area", while the position was defined by the method of "marshrut" (8).

The identification of the degradation stages within vegetation series has been an important aspect of the study considering that this could serve as a basis on choosing the best managerial practice.

For the identification of vegetation types, based on Braun Blanquet (3) and multivariable analysis, several specific software and a series of statistical analyses, which are briefly described below, have been used.

The computer software package TURBOVEG (9; 10) was used for designing the storage, selection, and export of vegetation data (relevés). JUICE (11), a statistical program optimized for use in association with TURBOVEG, offers the possibility for editing, classification and analysis of large phytosociological tables and databases. This software, with a current maximum capacity of 30,000 relevés in one table, includes many functions for easy manipulation of table and header data. The data from TURBOVEG (Vegetation archive) are exported to JUICE for clustering of the similar relevés according to Euclidian Distance. SYNTAX programs were also included (12). Lastly, the "Map of the Natural Vegetation of Europe" was used on identification of the potential vegetation (13).

The methodology for the identification of vegetation types is considered crucial, because it is strictly connected with the evaluation of fuel wood production capacities and grazing capacity, as well as non-timber production. The methodology is based on the principles of forest inventory and on the cast of the data gathered through the relevès. Using the GIS technique, the above-mentioned information was used in the preparation of vegetation types' maps. In linking the forest productivity with the vegetation types we used the principles of phytosociological school (7). The analysis considers the relationship between the plant species and surface of relevè and classifies them in the index of A-D (3).

Actual vegetation types (plant association) are identified based on the synoptic analysis per fidelity of the characteristic species and nomenclature of phytosociology (3). The degree of degradation was determined by comparing the results of JUICE (11) analysis with potential vegetation types (13) and later the degradation scheme for each vegetation series was drawn. All factors which affect the sustainable forest and pastures management are classified in four interval classes, based on the suitability and relative weight of each factor. They were analysed together (multivariable analysis) to identify the best managerial alternative.

ANALYSE OF THE RESULTS

According to the methodology, data collected from the 118 relevès were archived on TURBOVEG programme. For each relevè, both, general data about the ecology, geo-morphology, etc., and the list of species with A-D index as well as biological forms were collected and registered. Data from Turboveg are exported to JUICE. Identification of Fidel species (significant or characteristic species of association) was based on the synoptic analysis from the synthetic table.

Cluster analysis was performed with SYNTAX 2000 (12). The ecological analysis was an important step for the classification of the vegetation types.

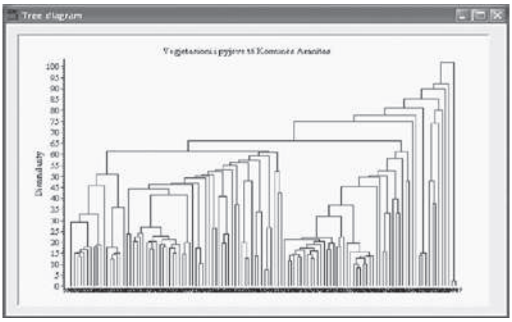

Fig. 4. Cluster analyse (Podani 1993)

Vegetation types must to be clearly distinguished on the context of ecological factors and historic traditional use. Ellenberg's factors are identified for each vegetation type, temperature, light, moisture and continentally (14).

The result of phytosociological analysis showed the presence of 12 plant associations and 2 communities with the following hierarchical classification:

Class: *Quercetea ilicis* Br-Bl 36.

Order: *Quercetalia ilicis* Br.-Bl. 32

Alliance: *Quercion ilicis* Br.-Bl. 38

Association: *Arbuto-Quercetum ilicis* Br.-Bl. 36

Association: *Orno-Quercetum ilicis* Horvatić 1958

Association: *Orno-Cocciferetum* Horvatić 1958 in Horvatić 1963

Association: *Pistacio lentisci-Rhamnetalia alaterni* Rivas-Mart. 1975

Class: *Querco-Fagetea* Br.-Bl. et Vlieger 37

Order: *Quercetalia pubescentis* Br.-Bl.31

Alliance: *Ostryo-Carpinion orientalis* Br.-Bl. 32

Association: *Quercetum-Ostrya carpinifolia* Horvat 38

Association: *Fraxino-Carpinetum orientalis* Horvat 1946

Alliance: *Quercion frainetto-cerris* (Horvat 1939).

Association: *Quercetum frainetto-cerris* Oberd. 48 et Horvat 59

Association: *Orno-Quercetum* (Soó 1928) Horansky, Jakucs & Fekete 1958 Association: *Quercetum trojanae macedonicum* Em 1958 em. Horvat 1959 Order: *Prunetalia spinosae* Tx. 52

Alliance: *Prunion spinosae* Fab. et Fukarek 68

Association: *Pruno-Juniperetum* Fab. et Fuk. 68

Order: *Populetalia* Br.-Bl. 31

Alliance: *Populion albae* Br.-Bl. 31

Association: *Equiseto-Platanetum orientalis* Em. et Dekov 61

Class: *Brachypodio-Chrysopogonetea* Horvatić 58

Order: *Scorzonero-Chrysopogonetalia* Horvatić et Horvat 58

Alliance: *Chrysopogoni-Saturejon* Horvat et Horvatić 34

Association: *Chrysopogonetum gryllus*

Order: *Cisto-Micromerietalia julianae* Oberd. 1954

Alliance: *Micromerion julianae*

Mediterranean Pine community

Locust community

Vegetation types which represent the vegetation associations having the same ecological condition, species composition, historic development and traditional use, are mapped.

Potential vegetation was identified based on the European Vegetation Map (13). Dynamic vegetation series and stages are defined by comparing actual vegetation (based on phytosociological analyses) with potential vegetation (13).

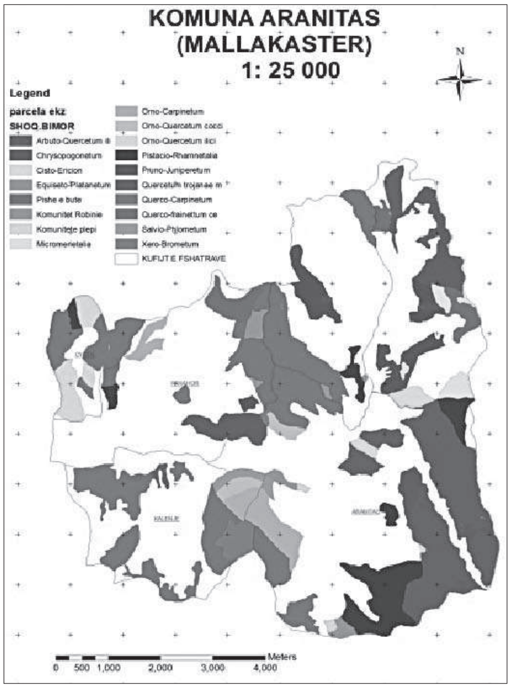

Fig. 5. The map of plant associations

Conclusions

Data are classified into four interval classes (15): forest origin and naturalness, endemic, rare and endangered species, actual state of open landscape, timber and fuel wood production classes, annual growth, medicinal and aromatic plants, grazing capacity, biomass production and productivity, and CO_2 sequestration level. A matrix of factors which affect the managerial alternatives was built and statistically analysed.

The forests of climax stages (high dynamic stages) are suitable for fuel wood production and narrow timber wood. In addition, these forests can be used for the sheep grazing. The lower-central group represents azonal vegetation with protective and recreation functions. The upper-central group represents shrub vegetation stage (second and third stage of degradation) which could be used grazing area from goats. The group of the upper-right represents very advanced degradation stages of the vegetation, prone of the erosion. The priority on these areas should be the aforestation/reforestation activities.

The same methodology was used on defining the best managerial alternatives for every village. If preparing the matrix of factors which affect the managerial alternatives, in addition to the data collected for plant associations and types of vegetation, we collected data also about the society demands, husbandry, and agriculture. Figure 6 shows the results of multivariable analyses based on village. As can be seen on the dendrogram only the villages of Çyçen, and Cfir could get benefits from the forestry activities. Aranitas would not benefit from the forestry because of the high pressure from the husbandry activities and high level of degradation. They should work on forest rehabilitation and reestablishment of vegetation by the forestations and coppicing. Kalenja could be considered as agricultural zone. Part of the forest area could have a protective and recreation function, rather than fuel wood production (16).

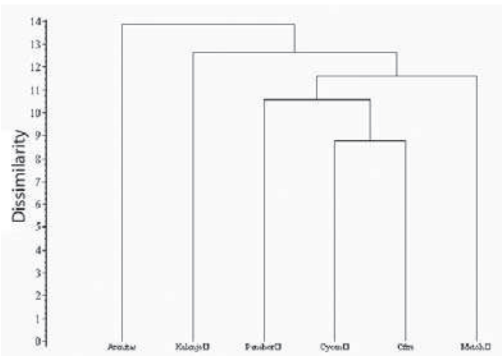

Fig. 6. Dendrogram of the development priorities per village

Panahor and Metohu share an intermediate position. These villages should consider forest harvesting as well as rehabilitation through thinning and coppicing. Biaxial analysis shows that only Cfir, Çyçen, and to little extend, Panahor have good conditions for forestry development as an economic sector.

BIBLIOGRAPHY

Mosquera-Losada M.R., Riguerio A., Mcadam J., (2005) *Silvopastoralism and Sustainable Land Management*. Kabi Hardback 432 pages

Papanastasis V., *Silvopastoral systems and range management in the Mediterranean region*. Western European Silvopastoral Systems. INRA Edition. 1996 Paris p. 143-156.

Braun-Blanquet, J. (1936) *Über die Trockenrasengesellschaften des Festucion vallesiacae in den Osalpen*. Bulletin della Sociètè Botanique Suisse 46: 169-189.

Gaussen H. (1967) *Bioclimats du sud-est asiatique*. Imprimerie de la maisson France. p.13-23

Proko A. *Management plan of Aranitas Communal forest and pastures*. Tirana 2007, p. 30-56.

Proko A. *Vegetation forestiere et la sylviculture*. Options Mediterranean's Serie B/n 15 1997 Albania, an Agriculture on the way to Transition. Montpellier p. 125-142.

Géhu, J.M., Rivas-Martínez, S. (1981). *Notions fondamentales de Phytosociologie*, Berichte der Internationales Symposien der Internationalen Vereinigung fur vegetationskunde. Syntaxonomia (Rinteln, 19880): 5-33.

Pirola, A. (1970). *Elementi di fitosociologia*. CLUEB Bologna, Italy. pp. 153.

Hennekens, S.M. (1995). *TURBOVEG(VEG). Software package for input, processing, and presentation of phytosociological data*. User's guide. Instituut voor Bos en Natuur, Wageningen, NL and Unit of Vegetation Science, University of Lancaster, Lancaster, UK.

Hennekens, S.M., Schaminee, J.H.J. (2001). *TURBOVEG, a comprehensive data base management system or vegetation data*. Journal of Vegetation Science. 12: 589-591.

Tichy, L. (2002). *JUICE, software for vegetation classification*. Journal of Vegetation Science. 13: 451-453.

Podani, J. (1993). *SYNTAX: Computer Programs for Multivariate Data Analysis in Ecology and Systematics*. Scienta Publishing, Budapest.

Bohn U., Gollub G., Hettwer Ch., *Map of the Natural Vegetation of Europe*. Bonn-Bad Godesberg 2000 p. 69-72, Ellenberg.

Gatzojannis S., Stefanidis P., Kalabokidis K. (2001). *An Inventory and Evaluation Methodology for Non-timber functions of Forests*. Mitteilungen der Abteilung fur Forstliche Biometrie. Universität Freiburg. pp. 49.

Aranitas Commune. Archive 2007