2. ECOSYSTEM SERVICES IN MOUNTAIN WATERSHEDS: SUPPORTING TOOLS FOR ADAPTIVE FOREST MANAGEMENT

2.1 Ecosystems services, decision support systems and participative approach in planning: experiences and lessons learned in the Alpine Region

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2.1.1. Introduction

After World War II, the dramatic socio-economic change, which had already begun in the industrialised world, significantly increased, bringing radical change in lifestyles and a progressive weakening of those close, direct connections that for centuries tied human communities to natural resources, a form of dependency essential for the very survival of mankind itself. The results of such change are evident in the transformation of the landscape characteristics.

The Alpine Region did not remain unaltered from the enormous socio-economic transformation to which Europe was subjected, but specific effects and implications arose as a result of its particular situation as mountainous territory. The Alpine Range constitutes the Europe's principal orographic system, extending from France to Slovenia, involving seven countries, and covering 190,000 square kilometres. The Alps are characterised by a great geomorphological and climatic diversity, but also by different histories, cultures and traditions.

People have always experienced an extremely strong, direct dependence on mountain ecosystems, and in particular, on forests. Although inhospitable and physically fragile, this environment has rendered it possible for local communities to survive thanks to their ability of profiting from landscape resources. Since long, human activities have, on the one hand, aimed at the production of food and raw material necessary to satisfy the needs of the local communities, and on the other hand, they have worked towards the construction of hamlets safe and protected from natural disasters. The mountain setting imposed diversified production strategies and appropriate forms of management with different intensities and well adapted to local circumstances. These management strategies guaranteed the continuity of production and had a stabilising effect on land even though within certain limits: all that resulted in the multiplicity of Alpine landscapes that we can still observe, where they have survived to the present days (Cantiani et al. 2013).

The new models of development, increasingly widespread in the Alpine area, disrupted the traditional modalities of interaction that characterised Alpine mountain societies and altered the relationships between mankind and nature. In a few decades, not only the balance in the ecosystems has been upset, but also that of the human communities, with severe depopulation effects in mountain areas. Among the many different problems that affect the Alpine region today, some are generating serious concerns, in particular: i) the vulnerability to climate change, due to the geographical position of the Alpine Range; ii) the effects of land-use changes; iii) the current economic-financial crisis (Cantiani et al. 2016).

In such a situation, new needs are being expressed by the communities and a new order of priorities of values often appears, whereas the Ecosystem Services (ESs), once demanded and appreciated, are today sometimes disregarded. More frequently, forestry professionals are quite isolated from the social context; at the same time, managers and decision-makers are confronted with new expectations and sometimes conflicting requests without the suitable tools to understand and manage these expectations. Will they be able to cope with such a messy and uncertain situation? Will they be able to adapt to change and shape a sustainable development for the Alpine areas?

In this paper, we describe a possible methodological approach, based on the realisation and implementation of a Decision Support System (DSS) for eliciting, evaluating in a spatially explicit form and balancing ESs. A great number of DSSs dealing with different topics is available in the literature. Some are used in modelling specific scientific topics while others are effectively used in management to help decision makers (Wolfslehner and Seidl 2010, Zambelli et al. 2012, Sacchelli et al. 2014, Acosta and Corral 2017). The inclusion of spatial dimension that characterises the GIS based DSSs adds a large amount of information and makes the results of the DSS more understandable. Nevertheless, many of these DSSs, especially those that deal with environmental issues, are designed to represent in detail a very specific theme and they often lack a multifunctional approach (Garegnani et al. 2015a). Many DSSs are designed to produce results at macro-scale (national or macro-regional level) and they represent the phenomena using large pixel units (square kilometres or more). For this reason, they are not easily usable by local decision-makers and communities. In our opinion, the greatest limitation of the available DSSs is tied to the fact that very few of them are really publicly usable due to license restrictions or to actual availability from the authors (Steinigera and Hay 2009, Sacchelli et al. 2013). This fact limits the possibility to improve the DSS models and to share them. Therefore, we decided to develop a model with a multifunctional approach, designed to be applied not only at a macro scale but also at a very local scale and using an Open Source platform to overtake the cited limitations.

Such a DSS has been realised by DICAM-UNITN, EURAC and CREA-FL within the existing Alpine Space project recharge.green financed by the European Union, in which a model to integrate ESs evaluation and energy production was developed, with particular attention to forest biomass (Ciolli et al. 2015; Garegnani et al. 2015).

The DSS presented here is the evolution of the former “Biomasfor” model (Sacchelli et al. 2013, Zambelli et al. 2012) and, like its predecessor, is entirely based on Free and Open Source Software and released with a license that allows free use and redistribution of the source code. Nevertheless, we followed a completely different approach than that used in the development of “Biomasfor model”, that can be described as a top-down model. In this new DSS a participative approach was carried out: experts and stakeholders were involved in both the process of software design and in the application of r.green.biomassfor through the project. The DSS was successfully tested in the recharge.green project (www.recharge-green.eu/).

2.1.2. Ecosystem services

The concept of ESs is particularly useful when dealing with the relationship that links human and natural systems. ESs refer, in fact, to the entire sphere of benefits that human societies obtain, directly or indirectly, from ecosystem functions, and shows how deeply human well-being depends on healthy ecosystems (Costanza et al. 1997).

Since the 1980s this concept has been largely discussed and studied and, in recent years, a big deal of work has been made in order to categorise ESs systematically. A great impulse to the conceptualisation came from the Millennium Ecosystem Assessment (MEA 2005) and the follow-up initiative The Economics of Ecosystems and Biodiversity Project (TEEB 2009).

Following the MEA assessment, the services are classified in four categories:

1) provisioning: the products humans acquire from ecosystems (e.g., food, timber and water);

2) regulating: the role of ecosystems in the regulation of ecological processes, (e.g., water and climate regulation);

3) cultural: the non-material benefits provided by ecosystems (e.g., recreational and spiritual values);

4) supporting: such as soil formation, photosynthesis and nutrient cycling.

Alpine ecosystems supply several goods and services useful both at local and global scale. Some services, in a recent past considered of major importance (e.g., timber/fodder production), are today considered less important, particularly in some geographical contexts. Other goods and services, on the contrary (i.e., regulating services), are more regarded. However, their supply may be threatened, mainly because of a high level of habitat loss and fragmentation. Moreover, in our post-industrial society, cultural and spiritual values happen to be particularly emphasised, over subsistence needs.

A sustainable development of the Alpine areas requires that priorities are clearly recognized and economic and ecological issues are carefully taken into account and balanced. To this aim, the consideration of ESs shows great possibilities, provided that it is applied to the right scale of analysis. The regional watershed scale makes it possible to address landscape management and planning issues with a sound and realistic approach (Cantiani 2012). Actually, at this level, local communities – people and institutions – may show a strong proactive approach to the natural resources management. In this context, in fact, management is heavily linked to governance mechanisms, being the focus of political debate and economic activity.

Whatever the approach chosen for the ESs assessment, either economic or non-economic, we stress the importance of a participatory process. This is actually an important prerequisite in order to supply credible and well-structured information to the decision makers.

An essential condition for the preservation of landscape and biodiversity, for the physical protection of land and for the conservation of all those values associated with local culture and traditions is to mitigate migration flows in mountainous areas, a common problem for the entire Alpine region. Actually, in order to make this possible, it is necessary that the population is involved in the land planning, listening carefully to their needs and expectations, and thoroughly understanding the values they attribute to the mountain ecosystems.

In order to evaluate the current status of ESs, to assess potential changes in their demand and provision, and to better address policy makers and improve decisions, we stress the importance of a suitable ES-based Decision Support System.

2.1.3. The ES-based Decision Support System realised

The DSS r.green aims to evaluate the spatial explicit potential of the four main renewable energy sources (i.e., Solar, Wind, Hydropower and Biomass). The DSS identifies and quantifies the areas suitable for the installation of renewable energy systems based on criteria of sustainability and land conservation. The aim of the developers is to highlight Alpine biodiversity, land use patterns and related ESs, and to model the carrying capacity of the Alpine ecosystems with respect to all aspects of renewable energy production and consumption. It requires a set of input data and can be applied at a multiple scale level. The core of the DSS r.green was programmed in GRASS GIS (Garegnani et al. 2015a, Grilli et al 2017b) taking advantage of python libraries and pygrass. GRASS is an Open Source GIS developed since 1984 (https://grass.osgeo.org/) and is supported by an international team of developers (Zambelli et al. 2012). GRASS procedures and modules are strongly reliable and tested and the software comes with a consistent and complete documentation, as it happens for those Open Source projects that are carried out in the frame of the Open Source Geospatial Foundation OSGEO (http://www.osgeo.org/). The DSS is organised in a set of add-ons (additional modules) that can be run independently. The main r.green modules are r.green.wind, r.green.hydro, r.green.solar, r.green.biomassfor that deal with each specific renewable energy, and r.green.impact that gives feedback on the impacts. Regarding Biomass, the main focus is on forest biomass, especially on forest residues and wood chipping. In fact, the logical structure in which r.green is developed was borrowed by the software Biomasfor that the DICAM-UNITN, CRA-MPF and GESAAF developed in the frame of the BIOMASFOR project, co-funded by the CARITRO Foundation in 2011. Each module is structured by a set of sub-modules that represent a series of operational steps in an ideal flow of operations directly related to the level of exploitation that is taken into account. Each main module is composed by five sub-modules – theoretical, legal, technical, economic, recommended – as well as modules specifically oriented to the analysis of impacts and assessment of the ESs, although the general structure may slightly vary among the different modules. Taking r.green.biomassfor as an example, "theoretical" calculates potential energy from forest biomass in an area using the periodic (year) forest yield, "legal" estimates the energy available from forest biomass using prescribed yield, "technical" calculates the energy available from forest biomass that is actually exploitable depending on different mechanization level, "recommended" introduces bonds and biomass production limits, "economic" calculates the energy that can be produced with a positive net revenue of all the production chain. The model allows to estimate energy availability from woodchips taking into account variables tied to landscape morphology, extraction methods, roads infrastructures, production costs, costs for transport and wood sale. For example, changing the parameters can produce different economic scenarios or different positioning scenarios of a power plant. The r.green DSS, already available as a GRASS add-on, can be used through the link command of Grass console or running the standard GUI within Grass or finally through QGIS.

The Open Source DSS r.green was designed to incorporate the impact of ESs evaluation coming from a process of participation and involvement of local experts, stakeholders and public at large.

To achieve this involvement, it is necessary to carry out meetings and consultations as described in Balest et al. (2015a). The DSS was tested in the project r.green in different pilot areas: Mis and Mae Valleys in Veneto (North East of Italy), Alpi Marittime Natural Park in Piedmont (North West of Italy), Triglav National Park (Slovenia).

2.1.4. Model testing, applicability and potentialities

Although the models were run in all the pilot areas, the most accurate tests were carried out in each pilot area selecting only the "suitable energies". In each Pilot area, the suitable energies were selected after a consultation of experts (Balest et al. 2015a).

The model r.green.hydro was mainly used in the pilot areas of Mis and Mae Valleys in Veneto and in the Gesso and Vermenagna Valleys in the Alpi Marittime Natural Park in Piedmont (Garegnani et al. 2015b). Different scenarios were performed and the outputs of the module r.green.hydro, that is maps with energy production and relative costs, were discussed in several meetings with stakeholders in order to produce planning alternatives through a participative approach. The meetings allowed to identify feasible, sustainable and acceptable proposal of hydro power development (Garegnani et al. 2015b).

The model r.green.biomassfor was tested in three pilot areas: Mis and Mae Valleys, Alpi Marittime Natural Park and Triglav National Park (Ciolli et al. 2015).

In Mis and Mae Valleys and in the Alpi Marittime Natural Park different scenarios with different wood chip prices were combined with existing/planned bioenergy plant locations. Scenarios were produced (an example of such scenarios in Alpi Marittime is showed in Figure 3) and a first public event was organized to show the results to Regional administrators and stakeholders (Balest et al. 2015a). This started a discussion on the optimization of bioenergy plants and in general on biomass opportunities. Further meetings with Regional administrators, public and local stakeholders of the valleys were organised to discuss the scenarios and to modify them according to their indications. During the process, we were able to discuss the software feature and also to introduce some modifications following the stakeholders' indications. Finally, the DSS was used to produce alternative scenarios and to identify planning alternatives (Grilli et al. 2017).

In Triglav National Park, through a different approach, different biomass production scenarios were created and a comparison with the Wisdom model, previously used by the Triglav Park managers to produce scenarios, was carried out.

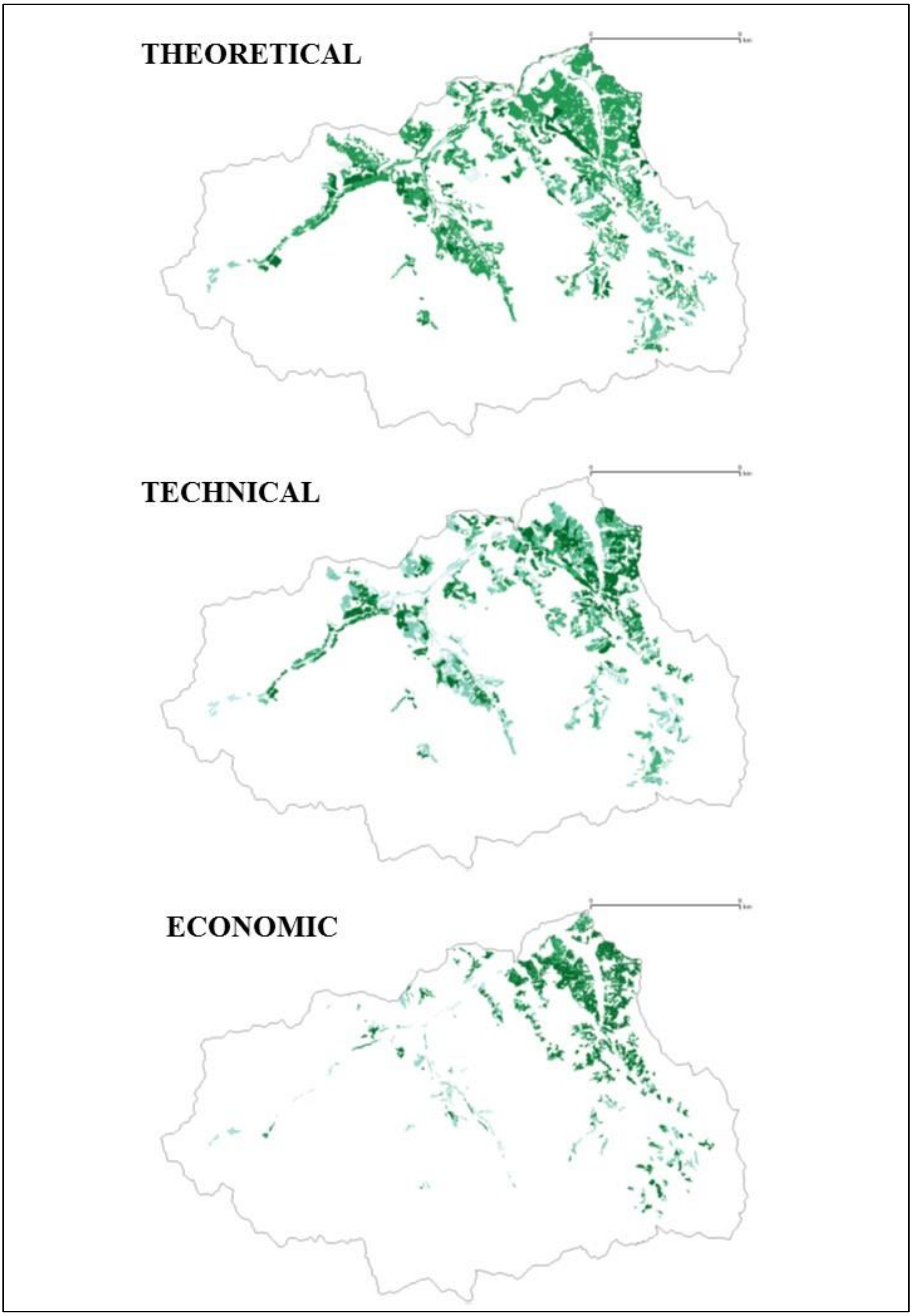

Figure 3. An example of the application of r.green.biomassfor to derive forest biomass potential scenarios in the Alpi Marittime Natural Park in Piedmont (North West of Italy). Three biomass scenarios are presented: Theoretical (40502 Mwh/y), Technical (25246 Mwh/y) and Economic (12862 Mwh/y) (Ciolli et al. 2015).

2.1.5. Conclusions and perspectives

The first tests of the holistic spatially explicit DSS r.green carried out in the frame of recharge.green project were successful. In fact, the DSS not only fostered discussions and produced scenarios that were judged plausible and useful but also produced results that were used immediately by local stakeholders and decision makers (Balest et al. 2015b, Grilli et al 2017).

Moreover, the involvement of stakeholders in DSS application increases social acceptance of the tools and decisions and reduces the potential conflicts between groups of interests.

Although the DSS is already usable, the complexity of the topics treated and consequently the complexity of the software suggests that there is a large space for improvement (Grilli et al. 2017b). The experience of the application in the project highlights also that it is useful to apply a DSS in a participative process since it gives a considerable added value; it is in fact important to take into account the feedback coming from the public in order to improve and tailor the DSS itself. In this way, also the development of the software takes advantage of the participative process and makes it more suitable to be used in further applications. The software is released with an open-source license to encourage further development and to spread and share knowledge and science.

The results of our research, carried out by means of the regional case studies illustrated, are expected to have not only a local, but also a broader relevance for the Alpine area. This is thanks to the fact that such results can be easily generalised and applied to similar contexts, wherever new models of development are desired as an alternative to those based on the waste of land and of its resources.

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