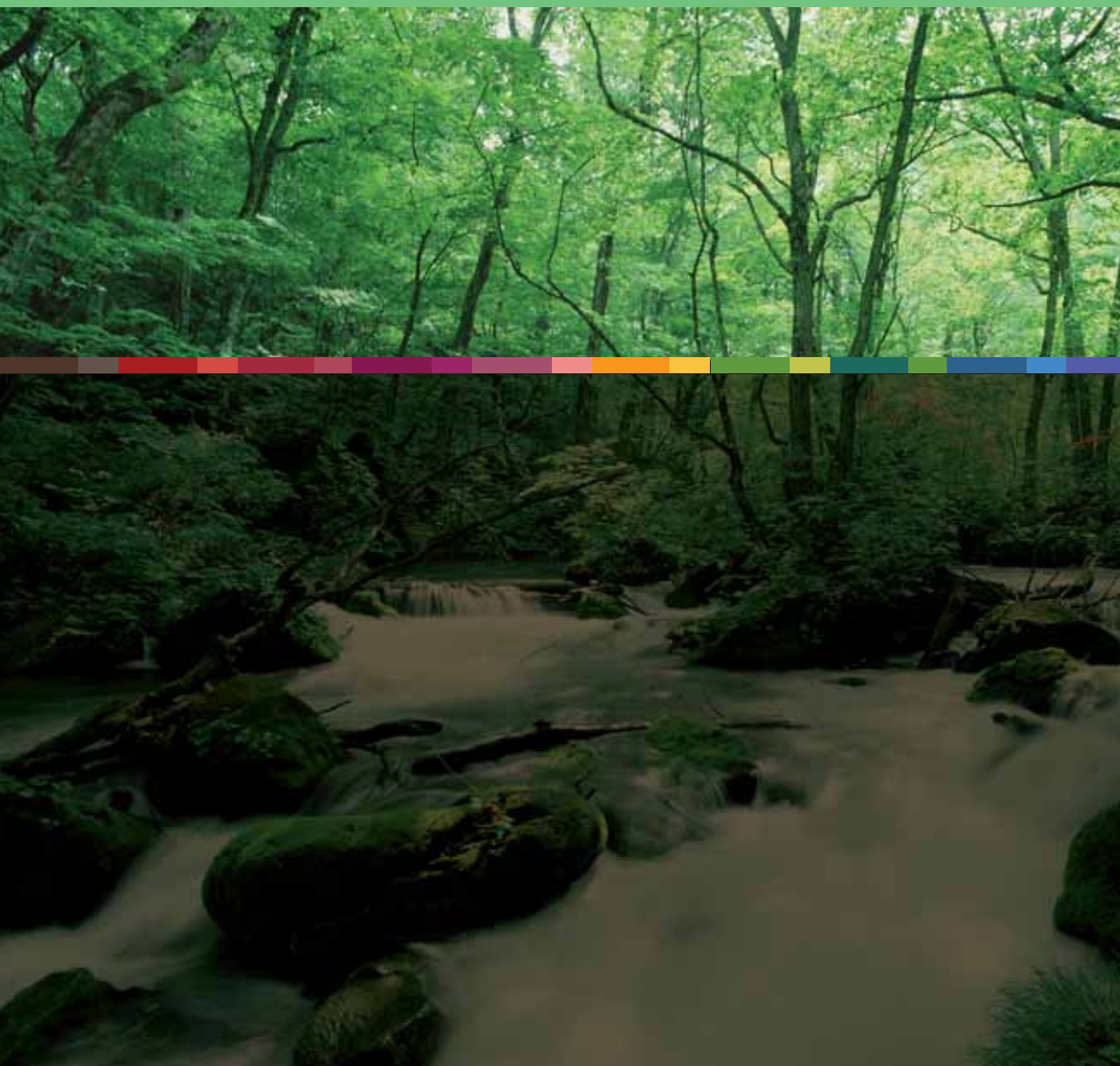
Borrowing services from nature

Methodologies to evaluate ecosystem services focusing on Hungarian case studies



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CONCEPTUAL EVOLVEMENT OF THE LANDSCAPE FUNCTIONS ASSESSMENT

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1. Introduction

In environmental sciences, descriptive and analytical research is increasingly being replaced by the system-approach, concentrating on the analysis of interactions; and cause and effect relationships. That is especially true for studies focusing on spatial systems. Both natural units (habitats, ecosystems) and administrative units (land, region, county) have various functions. Every landscape, natural or transformed, provides many services for both nature and for human society. Research dealing with the assessment of the territorial functions and services focuses on the interactions of the natural and human systems. These studies could play a fundamental role in decision making, by representing the possible environmental and the social consequences of policies.

Based on a survey of the literature, this paper gives an overview of the evolution of the concept of landscape functions and proposes a new, coherent classification system for its assessment. This can offer a suitable base to survey multifunctionality and to measure each function and be used in landscape/regional impact assessments and planning.

2. The roots of the landscape function concept

The roots of the landscape function concept go back to the recognition of the multifunctionality of forests and green spaces. The idea of the positive environmental and social impacts and direct and indirect services of vegetated areas emerged in connection with the rapid expansion of built-up areas and the degradation and the endangerment of the natural systems. It became clear that beyond economic welfare, the physiological and psychological services that ecosystems provide are important for our well-being.

The first papers on the environmental role and the beneficial functions of forests are originated from the 1960s. They pointed out the medical and recreational benefits of forests and their positive impact on climate, air quality, water management and soil protection *(Héder and Mészöly 1969; Keresztesi 1968; Mészöly 1981)*. Hungarian foresters defined three basic functions (economic, environmental and recreational) of forests and proposed to acknowledge them as a basic concern in forest management planning. That proposal was accepted at the World Forestry Congress organized in Buenos Aires, in 1972 *(FAO 1972; Lett 2007)*.

The description of the functions and services of green spaces can be found in the literature of landscape architecture *(Jámbor et al. 1982; Radó 1981; 2001)*, from the 1980s. Based on these sources, the multiple functions of green spaces was presented in an extended form in the book Environmental Planning *(Konkolyné-Gyuró 2003)* explaining the special ecological conditions of settlements and their various demands for use of green spaces.

The three main function groups of green spaces are: environmental regulation, recreation and provision of information, and aesthetic qualities.

- Environmental regulation: A vegetated surface positively affects the ecological conditions of all living creatures in the settlements (local climate, noise prevention, air and water quality, water management, prevention of qualitative and quantitative soil degradation). The extent of these benefits depends on the extent of the vegetated surface and the quantity of the photosynthesizing leaves.
- Recreation: Another important function of green areas is the provision of adequate space and facilities for outdoor recreation (playing, sports, hiking, relaxing, hunting, fishing, bathing, and healing) in parks, gardens and in urban forests. Nowadays ecotourism has an increasingly important role in providing natural, semi-natural areas away from human settlements.
- Information, aesthetics: Gardens, parks, cemeteries, arboretums, botanical and historical gardens, forests, greenways and study trails along waters and across different habitats play an important role in education, scientific research, dissemination, and perception of landscapes as well as in preservation of the cultural heritage and traditions. The aesthetic role is also significant in all of the green spaces. The aesthetic role is generally understood as an embellishment of the environment, although it has a much broader sense. Aesthetics means a cognitive process through the perception and understanding the place that results in getting information about the place and the whole landscape. It also refers to a positive psychological effect, provided by the pleasant scenery of the vegetation and water, the soft sounds, the climate comfort, and the spiritual associations *(Konkolyné-Gyuró 2003).*

The third precedent has been the concept of agricultural multifunctionality, originated from the first reform of the Common Agricultural Policy of the European Union in 1992 *(Ángyán et. al. 1999).* In this approach (similarly to the three basic functions of the forests) the production, the social/cultural and the landscape/nature-conservation role of agriculture was acknowledged *(EEC 1992).* The European Charter of Rural Areas is an important document, which emphasises the importance of multifunctionality in agriculture. Aside from food production, the document points out the significant role of agriculture in landscape management, in the preservation of rural traditions, heritage and cultural properties as well as in social cohesion *(Szakál 1996).*

A further series of papers has been recently published on this topic. Huylenbroeck's article, published in 2007, gives a comprehensive overview of them. It mentions two main approaches for interpreting and defining agricultural functions. One describes the opportunities and the services that agriculture provides and the other shows its functions from the point of view of social demand.

The author outlines four main function groups of opportunities and services.

- The first one is the „green function" including habitat and biodiversity preservation, the carbon- and nutrient cycle regulation and landscape management.
- The second is the "blue function" comprising the benefits related to waters and energy generation. The most important are: water retention, water quality control, and flood-prevention, as well as generation of hydropower and wind energy.
- The third group is the "yellow function", the cultivation, contributing to the rural areas vitality and cohesion, the utilization and maintenance of rural cultural heritage and traditions as well as the preservation of regional identity. The "yellow function" includes hunting, agro-tourism, and other forms of recreation.
- Finally several authors mention the "white function", which means food safety.

Looking at the multifunctionality of forests, green spaces and agriculture, their common ground becomes evident. All three are vegetated spatial units and ecosystems even if they are not all natural. Diversity within and between habitat types of a region plays an important role in multifunctionality. The more elements the system has, the more functions it can provide. Therefore attention should be turned towards ecosystem services and landscape functions.

3. Ecosystem services and functions of rural areas

Recommendations for the survey and evaluation of ecosystem functions and services were published in the Millennium Ecosystem Assessment *(MEA 2003).* The core idea of this report is the recognition of the strong connection between the condition of ecosystems and human well-being. Based on several previous studies, it summarizes the functions and services that ecosystems can provide for humans. These include the role of sustaining biophysical systems on Earth that create suitable living conditions for all living creatures and provide natural and social benefits for humanity. All these goods and services are called natural capital *(e.g. Costanza et al., 1997; de Groot et al. 2002).*

The existence of human society is inherently linked to landscapes or regions. Therefore, the investigation of ecosystem functions has to address all services provided by both natural and transformed ecosystems in a certain landscape or region. This idea led to the assessment of landscape functions. At the beginning, landscape multifunctionality studies focused on rural areas and applied unchanged function groups formerly used for assessing ecosystem services. In rural landscapes, where land cover is mostly semi-natural, ecosystem and landscape functions are highly similar to the services provided by natural areas.

A wide range of goods and services are reviewed in publications concerned with ecosystem and landscape functions *(de Groot 1992; 2000; Bastian 1996; Costanza et al. 1997; Daily et al. 2000; MEA 2003).* Despite some differences, the classifications distinguish three main function groups: regulation and conservation (environmental regulation, habitat protection); production and provision (primary biomass production and provision of territory for different human activities); and recreation, information (mental and physical recreation, aesthetic values and information about the cultural and natural heritage). Based on his former publications *(de Groot 1992; de Groot et al. 2002)* de Groot describes five function groups:

- Regulation functions: This group of functions relates to the capacity of natural and semi-natural ecosystems to regulate essential ecological processes and life support systems through biogeochemical cycles and other biospheric processes. Regulation functions maintain a 'healthy' ecosystem at different levels and, at the biosphere level, provide and maintain the conditions for life on Earth. In many ways, these regulation functions provide the necessary pre-conditions for all other functions. Thus, care should be taken not to double count their value in economic analysis. In theory, the number of regulation functions would be almost infinite. But for landscape planning, only those

regulation functions, which have direct and indirect benefits to humans (such as maintenance of clean air, water and soil, prevention of soil erosion and biological control services) are considered to provide services,

- Habitat functions: Natural ecosystems provide refuge and reproduction-habitats for wild plants and animals and thereby contribute to the (in situ) conservation of biological and genetic diversity and evolutionary processes. As the term implies, habitat functions relate to the spatial conditions needed to maintain biological (and genetic) diversity and evolutionary processes. The availability, or condition, of this function is based on the physical aspects of the ecological niche within the biosphere. These requirements differ for different species groups, but can be described in terms of the carrying capacity and spatial needs (minimum critical ecosystem size) of the natural ecosystems.
- Production functions: Photosynthesis and nutrient uptake by autotrophs converts energy, carbon dioxide, water and nutrients into a wide variety of carbohydrate structures, which are then used by secondary producers to create an even larger variety of living biomass. That biomass provides many resources for human use, ranging from food and raw materials (fiber, timber, etc.) to energy resources and genetic material.
- Information functions: Because most of human evolution took place within the context of undomesticated habitat, natural ecosystems provide an essential 'reference function' and contribute to the maintenance of human health by providing opportunities for reflection, spiritual enrichment, cognitive development, re-creation and aesthetic experience.
- Carrier functions: Most human activities (e.g. cultivation, habitation, transportation) require space and a suitable substrate (soil) or medium (water, air) to support the associated infrastructure. The use of carrier functions usually involves permanent conversion of the original ecosystem. Thus, the capacity of natural systems to provide carrier functions on a sustainable basis is usually limited (exceptions are certain types of shifting cultivation and transportation on waterways, which, on a small scale, are possible without permanent damage to the ecosystem)" *(de Groot 2006).*

Although de Groot's concept of functions and services provided by rural landscape is becoming crystallized and many research projects have been carried out on this basis, there are still several methods for the assessment and valuation of landscape functions. One possibility is the participative function valuation controlled by experts. The other is the dynamically developing GIS assessment. A good example for the first one is the landscape function valuation in Ukraine in the delta of the Dniestr River. In this research the significance of each landscape function has been defined at a workshop with the participation of local people and stakeholders. The possible future changes in the functions has been also revealed and used for the presentation of land-use conflicts (Figure 1).

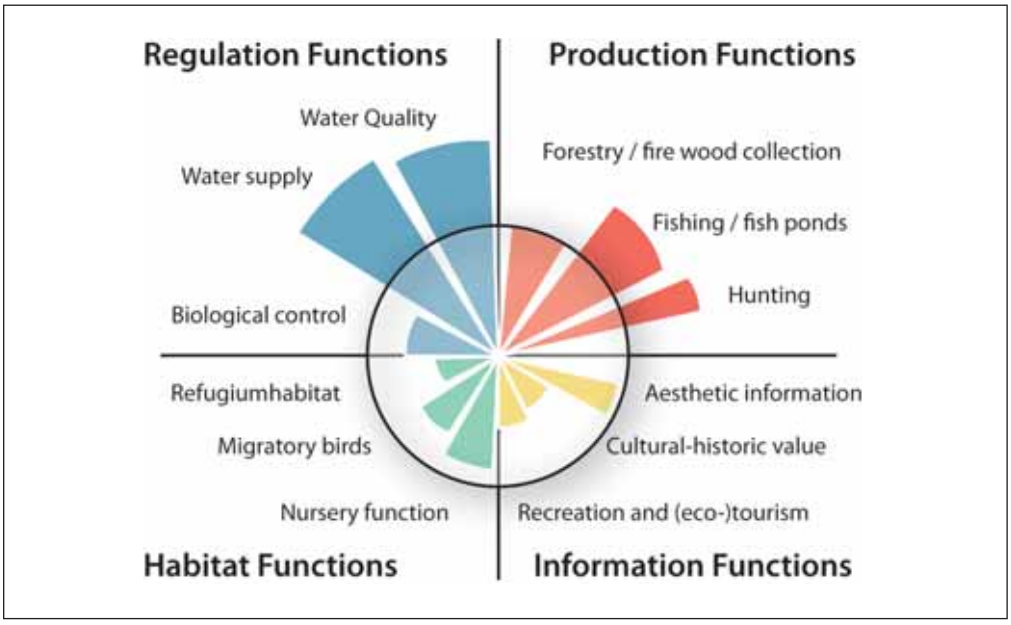

Figure 1: Main issues at stake in the Dniestr delta conflict analysis *(de Groot 2006).*

Some recent papers focus on GIS methods for assessing landscape functions. These studies do not take into account all functions but focus on some selected ones related to land use potentials and changes *(Willemen et al. 2008; Verbung et al. 2009).*

Knowledge about ecosystem services and landscape functions might effectively support decision making and planning because it provides transparent information about the changes and threats of the natural and cultural goods and services provided by living systems (Figure 2).

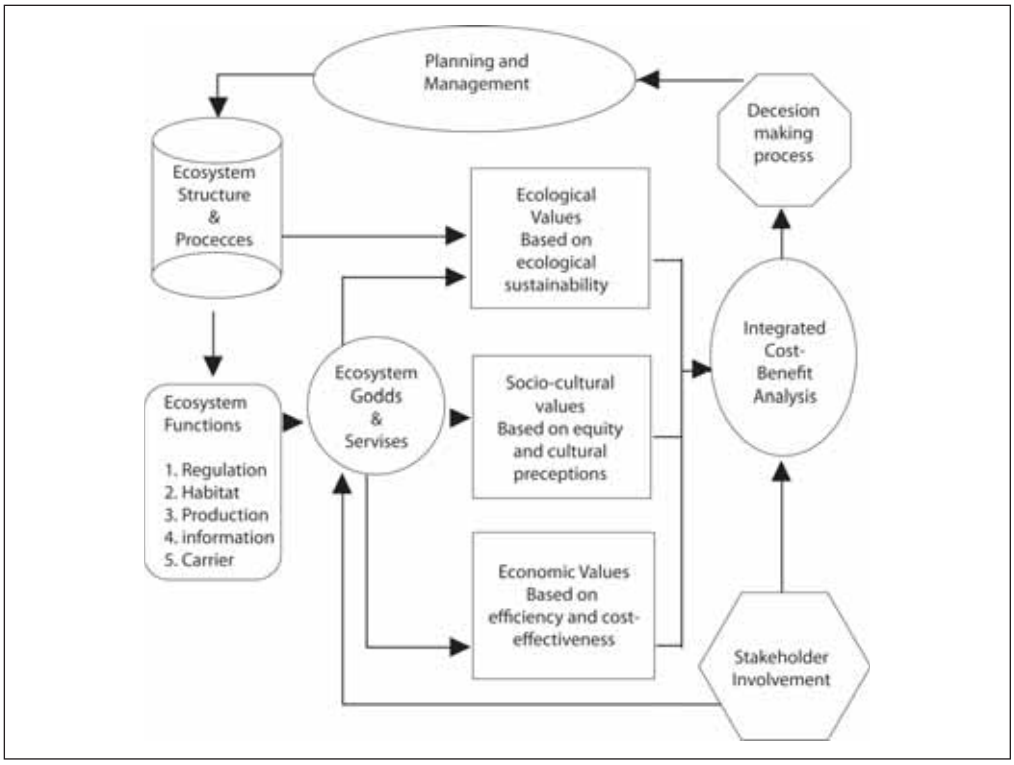

Figure 2: Role of function-analysis and valuation in environmental planning, management and in decision-making after de Groot 1992; de Groot et al 2002 *(de Groot 2006)*.

4. Land use functions

An overview of the presented functions makes it obvious that some of them, e.g. production provision of space and recreation, are inherently linked to the human use. Without human activities, they exist only as potentials. In the landscapes that are transformed by human activities, the role of different land uses and artificial surfaces have to be taken into account beyond the ecosystem services. It is not only goods and services are present in the landscape, but also the driver functions of the land uses and the related land cover types. They are called "land use functions" in research reports and papers *(SENSOR 2009; Perez-Soba et al. 2008)*. This concept has been established within the European integrated research project SENSOR, aiming to develop an ex-ante sustainability impact assessment tool. Nine land use functions (Table 1) have been chosen that refer to three function-classes: "mainly societal" "mainly economic" and "mainly environmental" land use functions.

Functions Mainly **SOCEITAL**	Functions Mainly **ECONOMICAL**	Function Mainly **ENVIRONMENTAL**
Provision if work	Residential and Land-Independent production	provision of abiotic resourses
Human health & recreation	Land-based production	Support and provision of biotic resourses
Cultural	Transport infrastructure	Maintenance of ecosystem processes

Table 1: The nine land-use functions, LUFs *(SENSOR 2009).*

"The definitions of the LUFs are as follows:

Mainly societal LUFs

- LUF 1 Provision of work: employment provision for all in activities based on natural resources, quality of jobs, job security and location of jobs (constraints e.g. daily commuting).
- LUF 2 Human health & recreation (spiritual & physical): access to health and recreational services, and factors that influence the quality of services.
- LUF 3 Cultural (landscape identity, scenery & cultural heritage): landscape aesthetics and quality and values associated with local culture.

Mainly economic LUFs

- LUF 4 Residential and land-independent production: provision of space where residential, social and productive human activity takes place in a concentrated mode. Utilisation of space is largely irreversible due to the nature of activities.
- LUF 5 Land-based production: provision of land for production activities that do not result in irreversible change, e.g. agriculture, forestry, renewable energy, land-based industries such as mining.
- LUF 6 Transport infrastructure: provision of space used for roads, railways and public transport services, involving development that is largely irreversible.

Mainly environmental LUFs

- LUF 7 Provision of abiotic resources: the role of land in regulating the supply and quality of air, water and minerals.
- LUF 8 Support and provision of biotic resources: factors affecting the capacity of the land to support biodiversity, in the form of genetic diversity of organisms and diversity of habitats.
- LUF 9 Maintenance of ecosystem processes: the role of land in the regulation of ecosystem processes related to the production of food and fibre, the regulation of natural processes related to the hydrological cycle and nutrient cycling, cultural services, and ecological supporting functions such as soil formation" *(SENSOR 2009)*.

Different indicators have been introduced to measure the performance of land use functions in the different land use change scenarios in each European region. The result of these valuations is presented in spiderweb diagrams. An example is shown in Figure 3.

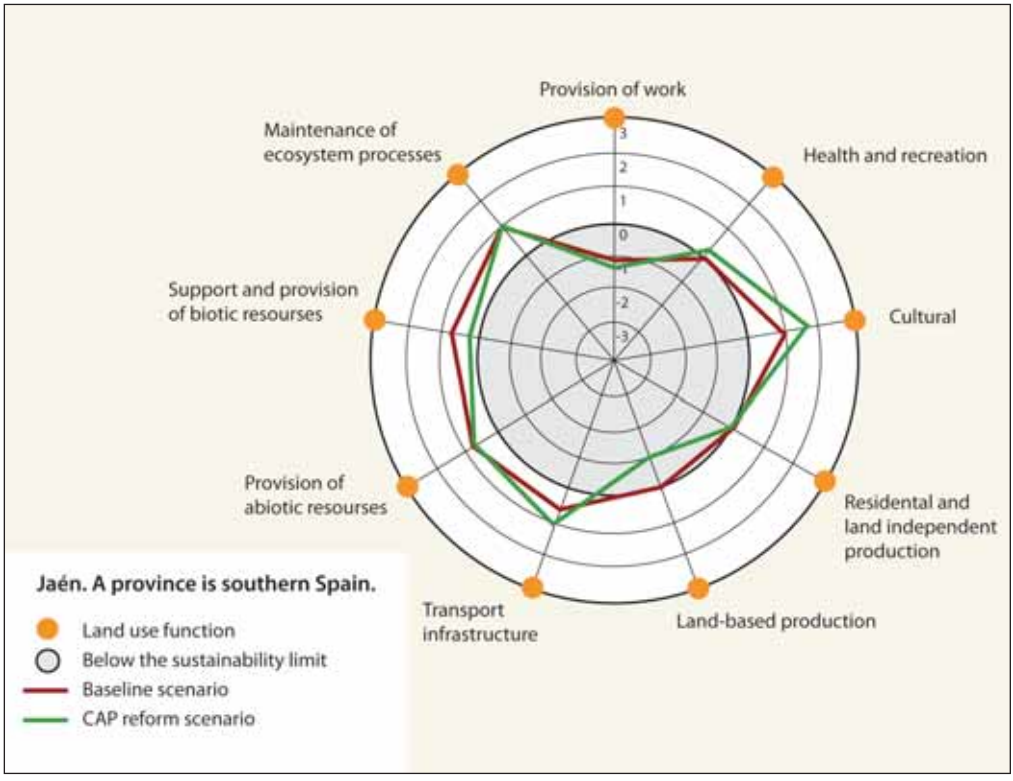

Figure 3: Sustainability assessment can be represented by a spiderweb diagram that shows the performance of the nine LUFs under different scenarios (SENSOR 2009).

5. Active and passive functions

Looking at the core idea of these approaches, an important aspect emerges, namely the existence of or lack of human contribution to these functions. Accordingly, we can distinguish between three types of roles. Firsts are the regulation and life sustaining functions of the natural systems (environmental regulation, habitat protection). Second are the potentials of the landscape (biomass, raw material production and opportunities for different land uses as well as provision of information and aesthetic qualities). They exist as goods or potential goods provided by the nature that have significance only due to human use. The third group of functions includes the services provided by human activities (settlements, infrastructure, recreational facilities and farm land etc). The basic difference between the first two and the third group is the human contribution. Natural systems are able to function independently from people. The potentials exist without any social utilization. Therefore functions of the first two groups are called passive functions, whereas functions in the third group, originating from the use of their potentials are called active functions.

In this chapter we recommend a system for the valuation of ecosystem services ("rural landscape functions"), land use and landscape functions by introducing the terms of active and passive functions. The passive and active functions exist together both in the cultural and natural landscapes.

5.1. Passive functions

Passive functions are potentials of nature, which can exist without human activity and act through the processes of natural systems. They are goods and services arisen from ecosystems.

5.2. Active functions

Active functions exist only through active human contributions. They are land-use functions of the transformed landscapes in artificial areas (settlements, agricultural areas and mines, recreation and infrastructural areas). In addition to the passive functions, these active landscape functions are equally important for human life.

I.1. Biophysical functions

I.1.1. Atmospheric regulation, air protection
- I.1.1.2. Gas, ozone regulation
- I.1.1.3. Climate regulation

I.1.2. Water regulation, protection
- I.1.2.1. Water protection and retention
- I.1.2.2. Provision of water supply
- I.1.2.3. Flood prevention

I.1.3. Soil protection
- I.1.3.1. Soil formation
- I.1.3.2. Soil water management regulation
- I.1.3.3. Erosion control
- I.1.3.4. Deflation control

I.1.4. Conservation of biological system and biodiversity
- I.1.4.1. Refugium
- I.1.4.1. Habitat
- I.1.4.2. Pollination
- I.1.4.3. Biological control

I.1.5. Production of biomass
- I.1.5.1. Food
- I.1.5.2. Raw materials for industry
- I.1.5.3. Medical materials
- I.1.5.4. Energy source

I.1.6. Complex functions
- I.1.6.1. Regulation of material flow
- I.1.6.2. Disturbance prevention
- I.1.6.3. Natural regeneration

I.2. Information, psychological functions

I.2.1. Information
- I.2.1.1. Scientific information, education
- I.2.1.2. Reference for functioning of biological systems
- I.2.1.3. Genetic information

I.2.2. Psychological conditioning
- I.2.2.1. Aesthetic experience (cognitive, artistic)
- I.2.2.2. Historical, spiritual information
- I.2.2.3. Human psychological recreation

Table 2: Passive landscape functions

II.1. Settlement

II.1.1. Living
- II.1.1.1. Urban living
- II.1.1.2. Rural living

II.1.2. Central, administrative
II.1.3. Defence
II.1.4. Human infrastructure/services
- II.1.4.1. Culture, heritage protection
- II.1.4.2. Education
- II.1.4.3. Science
- II.1.4.4. Health care

II.2. Production

II.2.1 Agricultural production
- II.2.1.1. Arable land cultivation
- II.2.1.2. Grassland pasturage
- II.2.1.3. Viticulture
- II.2.1.4. Horticulture
- II.2.1.5. Fishery, reed extraction
- II.2.1.6. Hunting

II.2.2. Forestry
II.2.3. Industry – mining
- II.2.3.1. Industrial production
- II.2.3.2. Energy production
- II.2.3.3. Raw material extracting

II.3. Infrastructure, communication

II.3.1.Transport
- II.3.1.1. Road transport
- II.3.1.2. Railway
- II.3.1.3. Navigation
- II.3.1.4. Aviation

II.3.2. Technical infrastructure
- II.3.2.1. Public utilities
- II.3.2.2. Waste management

II.4. Recreation, tourism

II.4.1. Water related recreation
- II.4.1.1. Recreation at lakes
- II.4.1.2. Recreation at rivers and streams
- II.4.1.3. Spa recreation
- II.4.1.4. Recreation at sea

II.4.2. Recreation in green areas
- II.4.2.1. Recreation in forest
- II.4.2.2. Recreation at agrarian and horticultural area
- II.4.2.3. Recreation in parks

II.4.3. Special recreation/ tourism forms
- II.4.3.1. Ecotourism
- II.4.3.2. Rural tourism
- II.4.3.3. Cultural tourism
- II.4.3.4. Cycling tourism
- II.4.3.5. Winter-sport/recreation
- II.4.3.6. Wine and gastro-tourism

Table 3: Active landscape functions

6. Conclusions

Natural and socio-economic systems work together inseparably. Every landscape, parish or region is multifunctional, providing numerous services to sustain nature as well as human society. The diversity of functions and their relative importance can greatly differ amongst landscapes with different bio-physical characteristics and land uses types. The diversity of the functions in different territories has to be maintained and harmonized in policies, especially in planning and management. We continuously seek to resolve conflicts, to generate beneficial co-existence of utilizations resulting in a cooperative prosperity. Landscape function analysis is a useful tool for balancing interests and provides important information for decision making and planning, mainly for sustainable development strategies.

According to these concepts, it is clear that till today the functions and services of natural, semi-natural ecosystems and areas transformed by human activities used to be analyzed and evaluated separately. Nevertheless in reality, they interact with each other. Application of the proposed classification of active and passive functions provides a logical framework for analyzing the landscape functions in a coherent system.

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