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Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes

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Abstract

In order to reconcile landscape conservation with changing demands on land use and natural resources, it is essential that the ecological, socio-cultural and economic values of the landscape be fully taken into account in planning and decision-making.

This paper presents a comprehensive framework for integrated assessment of ecological services and socio-economic benefits of natural and semi-natural ecosystems and landscapes. The framework can be applied at different scale levels to different ecosystems or landscape-units and basically consists of three steps: (1) *Function-analysis*: translates ecological complexity into a limited number of ecosystem (or landscape) functions, which, in turn, provide a range of goods and services; (2) *Function valuation*: includes ecological, socio-cultural and economic valuation methods; and (3) *Conflict analysis*: to facilitate the application of function-analysis and valuation at different scale levels, it is important to integrate analytical valuation methods with stakeholder participation techniques.

The framework presented in this paper facilitates the structured assessment of the (total) value of the goods and services provided by a specific area (landscape) and to analyze the costs and benefits involved in trade-offs between various land use options. The last section of this paper gives some conclusions and recommendations for application-possibilities of function-analysis and valuation to achieve more sustainable landscape use and maintenance of our “natural capital”.

Keywords: Landscape functions; Ecosystem goods and services; Ecological and economic valuation; Conflict analysis

1. Introduction

Natural and semi-natural ecosystems and landscapes provide benefits to human society, which are of great ecological, socio-cultural and economic value (e.g. Costanza et al., 1997; de Groot et al., 2002). These benefits consist of a mix of goods and services, both private and public, provided by multi-functional landscapes, which, therefore, are sometimes referred to as our “natural capital”.

In environmental planning and decision-making, however, these benefits are often not fully taken into account and productive, multi-functional landscapes continue to be converted into more simple, often single-function land use types (e.g. croplands) or turned into wastelands (e.g. eroded land after clear-cut logging or polluted and over-fished shelf-seas).

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Yet, increasingly studies are showing that the total value of multi-functional use of natural and semi-natural landscapes is often economically more beneficial than the value of the converted systems (e.g. plantations in tropical forests, shrimp farming in mangroves, intensive farming in drained wetlands and destructive fishing in coral reefs). As Balmford et al. (2002) put it: ". . . even when only a few ecosystem services are considered, their loss upon conversion typically outweighs any gains in marketed benefits".

The question then is, why do we continue to use multi-functional, productive landscapes in an unsustainable way, and destroy our "natural capital" at the expense of our own welfare and that of future generations? There are several reasons for this phenomenon (Costanza et al., 1997; Balmford et al., 2002). One reason for the continued under-valuation of the benefits of natural and semi-natural landscapes is that it is still difficult to express the (ecological, socio-cultural and economic) importance of the functions of these landscapes in monetary terms because most of the benefits are not captured in conventional, market-based economic analysis. There is still a considerable lack of data on the many functions and values of natural and semi-natural ecosystems and landscapes and, thus, we continue to take decisions on trade-offs between different land use options based on incomplete information. Market failures play a fundamental role in driving loss of ecosystems and landscapes because most of the benefits of natural and semi-natural landscapes are seen as non-marketed externalities, which accrue to local societies "at large" and at global scales. Conversion of these landscapes usually only makes narrow economic sense because the benefits from the land use change usually go to private or corporate interest groups while the costs (i.e. the non-marketed externalities) are burdened upon a diffuse group of stakeholders and future generations. The private benefits of conversion are often exaggerated by intervention failures because of tax incentives and subsidies. While over the short term these programs may be rational with respect to public or private policy objectives, over the longer term many result in both economic inefficiency and the erosion of natural services (Turner and Jones, 1991 as cited in Balmford et al., 2002). Globally, the subset of subsidies, which are both economically and ecologically perverse, totals between 950 billion and 1.950 billion each year, depending on whether the hidden subsidies of external costs are also factored in (van Beers and de Moor, 1999; Myers and Kent, 2001, in: Balmford et al., 2002, p. 952).

To achieve more balanced decision-making regarding sustainable use of landscapes and natural capital, it is clear that we need to overcome many obstacles and cross many disciplinary bridges. This paper only concentrates on the first two questions: (a) how can the importance of natural and semi-natural landscapes be expressed more fully in socio-economic and monetary terms; and (b) how can this information be used in analyzing trade-offs between land use options?

The problem of market failures (through externalities and perverse subsidies) is beyond the scope of this paper but repairing these failures is essential to achieve sustainable use of landscapes and natural capital.

Sections 2 and 3 will deal with the first question (function-analysis and valuation) while Section 4 presents an example of the application of these tools in analyzing trade offs regarding use options of a wetland area in the Dnestr Delta, Ukraine.

2. Framework for integrated analysis of landscape functions and values

Most landscapes provide a multitude of functions and are subject to many possible land uses. Usually different combinations of land uses are possible and to analyze the various planning and management alternatives for multi-functional landscapes, many aspects need to be considered (Fig. 1).

In this analysis, the concept of ecosystem or landscape functions is a central element.

The first step in the analysis involves the translation of ecological complexity (structures and processes) into a more limited number of ecosystem functions (Fig. 1). These functions, in turn, provide the goods and services that are valued by humans. In the ecological literature, the term "ecosystem function" has been subject to various, and sometimes contradictory, interpretations. Sometimes, the concept is used to describe the internal functioning of the ecosystem (e.g. maintenance of energy fluxes, nutrient (re)cycling, food-web interactions), and sometimes it relates to the benefits derived by humans from the properties and processes of ecosystems (e.g. food production and waste treatment). In this paper, ecosystem functions are defined as "the capacity of natural processes and components

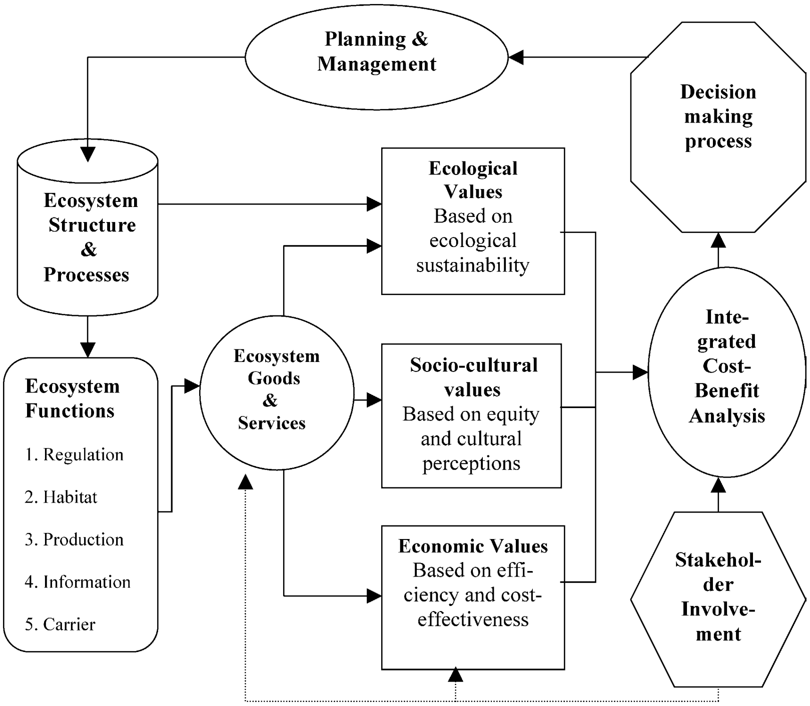

Fig. 1. Role of function-analysis and valuation in environmental planning, management and decision-making (after de Groot, 1992; de Groot et al., 2002).

to provide goods and services that satisfy human needs, directly or indirectly" (de Groot, 1992, p. 7).

A wide range of ecosystem functions and their associated goods and services have been referred to in literature (eg. Costanza et al., 1997; Daily et al., 2000; Millennium Ecosystem Assessment, 2003), often using different classification schemes. In this paper, ecosystem functions are grouped into five primary categories (based on de Groot, 1992; de Groot et al., 2002):

(1) *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 scale 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 unlimited, but for landscape planning, only those regulation functions are considered that provide services, 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).

(2) *Habitat functions*: Natural ecosystems provide refuge and reproduction-habitat to 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 biotic (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 ecosys-

tem size) of the natural ecosystems which provide them.

(3) *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. This biomass provides many resources for human use, ranging from food and raw materials (fiber, timber, etc.) to energy resources and genetic material.

(4) *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.

(5) *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).

Once the functions of an ecosystem or landscape are known, the nature and magnitude of value to human society can be analyzed and assessed through the *goods* and *services* provided by the functional aspects of the ecosystem or landscape unit.

Table 1 provides an overview of the main functions, goods and services that can be attributed to natural and cultivated landscapes. The first column gives a list of 30 functions and the second column lists the ecological structures and processes underlying these functions. The third column provides a more detailed list with examples of specific goods and services derived from these functions (this list is not exhaustive).

In Table 1, only those goods and services are included that can be used on a sustainable basis, in order to maintain the ecosystem functions and associated ecosystem processes and structures. Ecological sustainability can be defined as the natural limits set by the carrying capacity of the natural environment (physically, chemically and biologically), so that human use does not irreversibly impair the integrity and proper functioning of its natural processes and components (de Groot et al., 2000).

For production functions, for example, this means harvesting should be limited to natural regeneration rates, which range from several months (for certain biotic resources derived from fast growing plants or insects) to a time frame of 100–1000 years for tropical hardwood or some mineral resources, such as sand on beaches provided by dead coral and shells.

The sustainability criterion excludes the use of most of the so-called *carrier functions* in natural and semi-natural systems since they, by definition, involve the conversion of the original ecosystem into another type of land use (cultivation, habitation, transportation, etc.). With increasing technological capabilities almost any natural system can be converted to support human infrastructure. One way to determine the suitability of the original natural system or landscape for the use of these carrier functions is to calculate the amount of energy, resources, labor, and capital needed to carry out and maintain the conversion. The more energy and resources needed, the less suitable the original system apparently was to provide that function.

Another peculiarity of carrier functions is that, although these land use types focus on single-purpose (single-function) use (e.g. crop-production or habitation), they often also provide a mix of other goods and services (e.g. cultivated landscapes often maintain certain regulation services and have aesthetic qualities, and even urban areas provide habitat to a diversity of plant and animal species). In the case of a landscape with a mix of natural ecosystems and human-dominated land use types, a complete function-analysis should, therefore, be made for each main type of ecosystem or land use type.

3. Valuation of landscape functions and benefits

The importance (or 'value') of ecosystems can be divided in three types: ecological, socio-cultural and economic value (Fig. 1).

Table 1
Functions, goods and services of natural and semi-natural ecosystems Adapted from Costanza et al. (1997), de Groot (1992), de Groot et al. (2002)

Functions		Ecosystem processes and components	Goods and services (examples)
Regulation functions		Maintenance of essential ecological processes and life support systems	
1	Gas regulation	Role of ecosystems in bio-geochemical cycles (e.g. CO_2/O_2 balance, ozone layer, etc.)	1.1 UVB-protection by O_3 (preventing disease)
			1.2 Maintenance of (good) air quality
			1.3 Influence on climate (see also function 2)
2	Climate regulation	Influence of land cover and biol. mediated processes (e.g. DMS-production) on climate	Maintenance of a favorable climate (temp., precipitation, etc) for, for example, human habitation, health, cultivation
3	Disturbance prevention	Influence of ecosystem structure on dampening env. disturbances	3.1 Storm protection (e.g. by coral reefs)
			3.2 Flood prevention (e.g. by wetlands and forests)
4	Water regulation	Role of land cover in regulating runoff and river discharge	Drainage and natural irrigation
5	Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers)	Provision of water for consumptive use (e.g. drinking, irrigation and industrial use)
6	Soil retention	Role of vegetation root matrix and soil biota in soil retention	6.1 Maintenance of arable land
			6.2 Prevention of damage from erosion/siltation
7	Soil formation	Weathering of rock, accumulation of organic matter	7.1 Maintenance of productivity on arable land
			7.2 Maintenance of natural productive soils
8	Nutrient regulation	Role of biota in storage and re-cyling of nutrients (e.g. N, P and S)	Maintenance of healthy soils and productive ecosystems
9	Waste treatment	Role of vegetation and biota in removal or breakdown of xenic nutrients and compounds	9.1 Pollution control/detoxification
			9.2 Filtering of dust particles (air quality)
			9.3 Abatement of noise pollution
10	Pollination	Role of biota in movement of floral gametes	10.1 Pollination of wild plant species
			10.2 Pollination of crops
11	Biological control	Population control through trophic-dynamic relations	11.1 Control of pests and diseases
			11.2 Reduction of herbivory (crop damage)
Habitat functions		Providing habitat (suitable living space) for wild plant and animal species	
12	Refugium function	Suitable living space for wild plants and animals	Maintenance of biological and genetic diversity (and, thus, the basis for most other functions)
13	Nursery function	Suitable reproduction-habitat	Maintenance of commercially harvested species
Production functions		Provision of natural resources	
14	Food	Conversion of solar energy into edible plants and animals	14.1 Hunting, gathering of fish, game, fruits, etc.
			14.2 Small-scale subsistence farming and aquaculture
15	Raw materials	Conversion of solar energy into biomass for human construction and other uses	15.1 Building and Manufacturing (e.g. lumber
			15.2 Fuel and energy (e.g. fuel wood
			15.3 Fodder and fertilizer (e.g. krill
16	Genetic resources	Genetic material and evolution in wild plants and animals	16.1 Improve crop resistance to pathogens and pests,
			16.2 Other applications (e.g. health care)

Table 1 (*Continued*)

Functions		Ecosystem processes and components	Goods and services (examples)
17	Medicinal resources	Variety in (bio)chemical sub-stances in, and other medicinal uses of, natural biota	17.1 Drugs and pharmaceuticals 17.2 Chemical models and tools 17.3 Test and essay organisms
18	Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use	Resources for fashion, handicraft, jewellery, pets, worship, decoration and souvenirs (e.g. furs, feathers, ivory, orchids, butterflies, aquarium fish, shells, etc.)
Information functions		Providing opportunities for cognitive development	
19	Aesthetic information	Attractive landscape features	Enjoyment of scenery (scenic roads, housing, etc.)
20	Re-creation	Variety in landscapes with (potential) re-creational uses	Travel to natural ecosystems for eco-tourism and (re-creational) nature study
21	Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architect, advertising, etc.
22	Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features)
23	Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions, etc. Use of nature for scientific research
Carrier functions		Providing a suitable substrate or medium for human activities and infrastructure	
24	Habitation	Depending on the specific land use type, different requirements are placed on environmental conditions (e.g. soil stability and fertility, air and water quality, topography, climate, geology, etc.)	Living space (ranging from small settlements to urban areas)
25	Cultivation		Food and raw materials from cultivated land and aquaculture
26	Energy-conversion		Energy-facilities (solar, wind, water, etc.)
27	Mining		Minerals, oil, gold, etc.
28	Waste disposal		Space for solid waste disposal
29	Transportation		Transportation by land and water
30	Tourism-facilities		Tourism-activities (outdoor sports, beach-tourism, etc.)

3.1. *Ecological value*

To ensure the continued availability of ecosystem functions, the use of the associated goods and services should be limited to sustainable use levels. The capacity of ecosystems to provide goods and services depends on the related ecosystem processes and components providing them (Column 2 in Table 1) and the limits of sustainable use are determined by ecological criteria such as integrity, resilience, and resistance. The 'ecological value' or importance of a given ecosystem is, therefore, determined both by the integrity of the regulation and habitat functions of the ecosystem and by ecosystem parameters such as complexity, diversity, and rarity (de Groot et al., 2003). Since most functions and related ecosystem processes are inter-linked, sustainable use levels should be determined under complex system conditions (see Limburg et al., 2002), taking due account of the dynamic interactions between functions, values and processes (Boumans et al., 2002).

3.2. Socio-cultural value

In addition to ecological criteria, social values (such as equity) and perceptions play an important role in determining the importance of natural ecosystems, and their functions, to human society (Fig. 1). In many publications, social reasons are mentioned as playing an important role in identifying important environmental functions, emphasizing physical and mental health, education, cultural diversity and identity (heritage value), freedom and spiritual values (see Chiesura and de Groot, 2003 for a review). Natural systems are, thus, a crucial source of non-material well-being and indispensable for a sustainable society (Norton, 1987). The socio-cultural value mainly relates to the information functions (Table 1).

3.3. Economic value

The economic importance of a given good or service is usually measured in monetary terms. Monetary valuation methods fall into four basic types, each with its own repertoire of associated measurement issues: (1) direct market valuation; (2) indirect market valuation; (3) contingent valuation; (4) group valuation.

Direct Market valuation is the exchange value that ecosystem services have in trade, mainly applicable to the "goods" (i.e. production functions) but also some information functions (e.g. re-creation) and regulation functions. New York city, for example, has sought to use natural water regulation services of largely undeveloped watersheds, through purchase or easements costing about 700 million US$, to deliver safe water and avoid building a US$ 7 billion water filtration plant. This implies those watersheds are worth at least US$ 6 billion to New York city. Wetlands trading programs allow property owners to capitalize on the demand for wetlands banks, with wetlands being sold in banks for US$ 74,100 to US$ 493,800 per ha (Powicki, 1998).

Indirect market valuation is applied when there are no explicit markets for ecosystem services and one must resort to more indirect means of assessing values. A variety of valuation techniques can be used to establish the (revealed) 'Willingness To Pay' or 'Willingness To Accept' compensation for the availability or loss of these services. The 'Avoided Cost method' is applied when services allow society to avoid costs that would have been incurred in the absence of those services. Examples are flood control (which avoids property damages) and waste treatment (which avoids health costs) by wetlands. The Replacement Cost method is used when services could be replaced with human-made systems. An example is natural waste treatment by marshes, which can be (partly) replaced with costly artificial treatment systems. The Factor Income method is applied when ecosystem services enhance incomes. An example is natural water quality improvements, which increase commercial fisheries catch and thereby incomes of fishermen. The 'Travel Cost method' is used when the use of ecosystem services requires travel. The travel costs can be seen as a reflection of the implied value of the service. An example is re-creation area, which attracts distant visitors whose value placed on that area must be at least what they were willing to pay to travel to it. Finally, Hedonic Pricing is used when ecosystem service demand is reflected in the prices people pay for associated goods. An example is that housing prices at beaches usually exceed prices of identical inland homes near less attractive scenery.

Through *Contingent Valuation* service demand may be elicited by posing hypothetical scenarios that involves the description of alternatives in a social survey questionnaire. For example, a survey questionnaire might ask respondents to express their willingness to pay (i.e. their stated preference as opposed to revealed preference, see above) to increase the level of water quality in a stream, lake or river so that they might enjoy activities like swimming, boating, or fishing (Wilson and Carpenter, 1999).

Group valuation is another approach to ecosystem service valuation that has gained increasing attention recently, which involves group deliberation (Jacobs, 1997; Sagoff, 1998; Wilson and Howarth, 2002). Derived from social and political theory, this valuation approach is based on principles of deliberative democracy and the assumption that public decision-making should result, not from the aggregation of separately measured individual preferences, but from open public debate.

The extensive literature on ecosystem service valuation has shown that each of these methods has its strengths and weaknesses (see for example Farber et al., 2002; Wilson and Howarth, 2002).

Based on a synthesis study by Costanza et al. (1997), using over 100 literature studies, de Groot et al. (2002) established a relationship between the main function categories and the preferred valuation methods. Regulation functions are mainly valued through indirect market valuation techniques (notably avoided cost and replacement cost), habitat functions mainly through direct market pricing (i.e. money donated for conservation purposes), production and carrier functions through direct market pricing and factor income methods, and information functions mainly through contingent valuation (cultural and spiritual information), hedonic pricing (aesthetic information) and market pricing (re-creation, tourism and scientific information). Thus, for all types of ecosystem functions it proved possible, in principle, to arrive at a monetary estimation of human preferences for the availability and maintenance of the related ecosystem goods and services.

Balmford et al. (2002), for example, estimated that the overall cost-benefit ratio of establishing and maintaining an effective global program for the conservation of remaining wild nature is at least 100:1. Based on a review of 300 case studies, they estimated the annual value of the net-benefits of a (hypothetical) global network of protected areas between 4400 billion and 5200 billion US$. The cost of maintaining this network (on land and at sea) was estimated at 45 billion US$ per year (compared to the current budget of 6.5 billion US$). Also on an individual case study basis, Balmford et al. (2002) showed that the marginal benefits (expressed as net present value) of retaining natural habitats, such as tropical forests, mangroves, wetlands and coral reefs, was higher than converting these habitats for plantations, shrimp farming, intensive farming and destructive fishing, respectively. Another example is given by Barbier and Thompson (1998) on benefits from traditional floodplain use versus large-scale irrigated agriculture in Nigeria. They estimated that traditional use practices of the Hadejia-Jama'are floodplain in northern Nigeria provide higher benefits than crops grown on an irrigation project. Benefits derived from firewood, recession agriculture, fishing and pastoralism were estimated at US$ 32 per 1000 m^3 in comparison to US$ 0.15 per 1000 m^3 for benefits derived from the irrigation project. For the region, this evaluation is particularly important as more than one-half of the wetlands have already been lost to drought and upstream dams. The economic valuation of the goods and services these ecosystems provide indicate that the proposed increase in water diversion for large-scale irrigated agriculture is not beneficial. Even without accounting for such services as wildlife habitat, the wetland is more valuable to more people in its current state than after conversion to large-scale irrigated agriculture.

These examples show that if proper cost-benefit analysis are made, which include all the values of goods and services provided by ecosystems, large-scale development schemes often turn out to be less profitable than improving the (sustainable) management of the unaltered ecosystem.

4. Use of function-analysis and valuation in assessing land use conflicts: an example from the Dnestr delta, Ukraine

In landscape planning many different demands for often-limited space must be weighed against each other. In this weighing process, economic (especially monetary) information plays an important role and tends to dominate the decision-making at the expense of ecological and socio-cultural values. The framework presented in Section 2 facilitates the structured assessment of the (total) value of the goods and services provided by a specific area (landscape). To analyze trade-offs between various land use options and the involved ecological, economic and socio-cultural values, analytical valuation procedures must be combined with stakeholder participation techniques. An example of the application of function-analysis in a participatory conflict analysis is given below based on a case study done in the Dnestr delta (Ukraine). All information in the rest of this section is based on two reports from the European Post Graduate Course on Environmental Management (1997, 2000), unless indicated otherwise.

4.1. Area description

The Dnestr river is one of the main Eastern European rivers. Its delta forms extensive wetlands (400 km^2) along the northwestern coast of the Black Sea. The Dnestr delta wetlands include extensive reed beds, freshwater lakes, riparian forests, floodplains, swamps and swamp-meadow ecosystems spread over the whole area. There are rare plant species, nesting colonies of rare and migrating waterfowl and important populations of rare mammals, some of which occur in numbers of international significance. The river, lakes and adjacent swamps have high fish productivity.

The study area and its surroundings are characterized by a rural economy. There are no industries and no other significant commerce than trade of agricultural and fish products. Thus, the whole economy depends to a large extend on the wetland area for agriculture, cattle grazing, fishing and fish production (aquaculture) and forestry. In addition, hunting and firewood collection also play an important role as subsistence activities.

4.2. Problem analysis

During the past decades over 80% of the virgin natural habitats and wildlife of these wetlands has been degraded or destroyed as a result of anthropogenic pressure. The main human activities, which have had and continue to have a significant negative impact on this important wetland complex, are mostly related to hydropower plants upstream and freshwater abstraction.

The environmental problems and threats in the Dniestr delta wetlands are mainly related to a change of hydrological regime (due to dam-building), soil and water pollution, as a result of agriculture practices, and over exploitation, especially fishing and hunting.

The negative impact of human activities in the area is aggravated by the difficult socio-economic situation in the Ukraine, which causes insecurity and consequently a short-term perspective on the management of natural resources. In 1993 a regional nature reserve was created called “Dnistrovski Plavni”, covering 7620 ha of the territory of the Dniestr. Since then, plans are under preparation to establish a national park ‘Nijnednestrovskiy’ of 20,000 ha. However, the management plan does not sufficiently address the problem of combining nature conservation with the interest of the local community. Local non-government organizations, therefore, took an active role and developed a Strategic Action Plan for the northwest coast of the Black Sea, which was drawn up in 1993. One of the priorities of the Strategic Action Plan is to develop management plans based on the sustainable utilization of the natural resources. The process of the establishment of the national park is progressing very slowly, partly due to the economic problems, partly due to misunderstanding and distrust among stakeholders.

4.3. Conflict analysis

To obtain information on the perception of the problems of the different stakeholders various methods were used. These included open interviews and informal conversations with key informants, observation of stakeholder behavior, and a questionnaire-based survey. Fieldwork was carried out in the spring of 1997 and 2000, interviewing over 350 people. A local workshop was held in 1997 with all the stakeholders (varying from local fishers to representatives of organized users (farmers, water company, etc.), local non-governmental organizations and various ministries. In the first part of the workshop, the representatives of the stakeholder groups were asked to give a presentation of their own views on the problems in the wetland and identify possible solutions from their perspective. In the second part of the workshop, they worked in small groups discussing common solutions for the problems of forestry, sustainable use of resources, the national park and water management. During the speeches and the discussions, the interests of these groups towards certain issues were revealed. Four local cases were selected: fishing; fishponds; firewood collection; and agriculture on the riverbanks, and also an external case, flooding was analyzed because of its high importance.

Based on this analysis, an overview was made of the main issues, which were represented in a graphical way (Fig. 2) to facilitate discussion of different perceptions and common interest to try to find consensus on the main problems and possible solutions.

Each issue (function) is represented in Fig. 2 by a slice of the circular diagram and each slice can be related to one, or several, stakeholder groups. Based on analysis of interactions among functions (Section 2), it can be shown that over-use of some functions, for example over-fishing or stress on the water-purification function (=pollution), goes at the expense of other functions (e.g. biodiversity conservation and drinking water supply). Sustainable use levels should be determined for each function (represented by the edge of the circular graph) whereby over-use is indicated by functions moving outside the circle and functions that are under-used or damaged remain inside the circle. Ideally, the use of all functions should be at, or close to the edge of the circle.

By including economic information (Section 3) into the analysis, the benefits (profits) from over-use and the

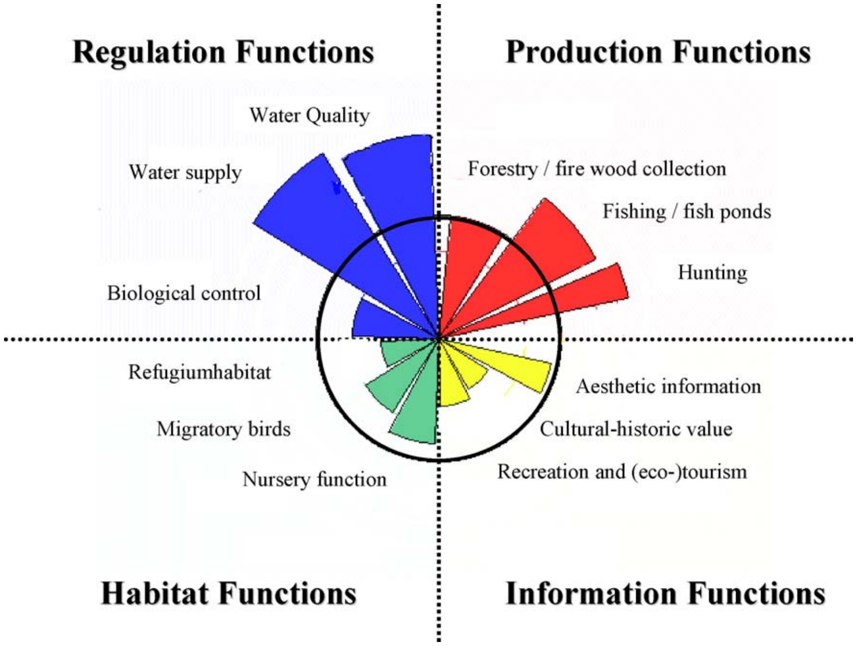

Fig. 2. Main issues at stake in the Dnestr delta conflict analysis.

costs of damaged or under-used functions can be calculated. If done for all functions, a complete picture emerges of the effects of (over-) use of one function on all other functions (and which stakeholders benefit from this over-use and who lose (financially or otherwise)).

4.4. Conflict solving and collaborative management

As in most conflict situations, most stakeholders see other stakeholders as their opponents, and as a result each party concentrates on maximizing single-function use. The function-analysis approach proved very useful to present all the different stakeholder positions, and their linkages, in a rather objective and clear manner and to facilitate discussion. At the beginning of the process, the environmental non-governmental organizations were seen with much suspicion by the other stakeholders (especially local resource users, organizer fishers (Kolchoz-members) and farmers). At the end of the day, it was recognized by all parties involved that the main stakeholder groups should all be involved in defining a common future for the wetlands and that the non-governmental organizations can play an important role as provider of information to create more awareness about al the wetland functions, as possible fund-raisers for sustainable development projects (e.g. stimulation of eco-tourism) and as facilitator of a stakeholder platform to discuss and develop a sustainable, collaborative management plan for the region.

Analytical tools, such as spatial analysis (GIS, mapping) and models to analyze interactions between function use are important instruments to support such a participatory management approach, whereby economic analysis (Section 3) is crucial to create awareness about the economic costs and benefits and to develop incentives for sustainable use (e.g. by internalizing externalities, compensation payments and abolishing perverse subsidies).

5. Conclusions and recommendations: bridging disciplines and assessment approaches

This paper is based on a presentation at a symposium on “sustainable landscapes and natural capital: bridging disciplines, approaches and applications” during the IALE 2003 World Congress: Crossing Frontiers – Landscape Ecology Down Under Darwin, Australia

(14–16 July 2003). During this symposium various issues were raised that need to be addressed in order to achieve more sustainable use of landscapes, and conserve our natural capital. Some of these issues are briefly discussed below.

5.1. Integrate ecological sustainability goals in economic theory and models

An important bridge to build (and to cross) is the link between ecology and economics. Since most landscape planning decisions are based on economic (especially monetary) data, better information on the economic and monetary importance of natural and semi-natural ecosystems and landscapes is crucial in order to achieve more sustainable use of our landscapes and conserve our natural capital.

There is a rapid growth in publications that show that the economic benefits of sustainable, multi-functional use of natural and semi-natural ecosystems and landscapes usually exceeds the gains of their conversion to single-purpose land use types (e.g. Balmford et al., 2002). However, in spite of the proven economic value of sustainable use of intact ecosystems and landscapes, humans continue to degrade and destroy natural habitats on a large-scale. More and better information on economic benefits of the services of multi-functional landscapes is necessary to: demonstrate the contribution of these systems to the local and national (and even global) economy; convince (potential) donors that benefits of conservation and sustainable use of ecosystems and landscapes outweigh the costs and, thus, attract investments; identify the users/beneficiaries of the landscape-services to secure financial streams for the maintenance of these services; adjust economic incentives to stimulate the conservation and sustainable use of natural and semi-natural ecosystems and landscapes.

An important example of a project that tries to implement some of the above concepts is the Guyana Shield Initiative, coordinated by IUCN (www.guianashield.org). This initiative aims at the conservation and sustainable use of biodiversity in the Guyana Shield region, which covers French Guyana, Surinam, Guyana, and parts of Venezuela, Colombia and Brazil. The Guyana Shield accounts for more than 25% of the world's remaining tropical forest, is particularly rich in biodiversity and most of the inhabitants are highly dependent upon the resources provided by the forests. One of the objectives of the Guyana Shield initiative is to set-up a broker agency that attracts funds from international donors, companies and other agencies that are interested in maintaining the global ecosystem services supported by the natural ecosystems of the Guyana Shield, and uses these funds to support local communities in maintaining these ecosystems.

5.2. Expand cost-benefit analysis beyond narrow market economics

Another bridge to cross is linking analytical and participatory approaches to landscape analysis and improving planning and decision-making instruments. Economists, ecologists and social scientists need to collaborate more to obtain better insights in the trade-offs involved in land use change decisions and make their work more accessible to collaborative planning and management. Increasingly, it becomes clear that traditional (monetary) cost-benefit analysis used in project evaluation to determine the positive and negative effects on the landscape and associated communities is failing. Especially for large infrastructure projects (such as dams, roads, clear-cut logging) better instruments are needed that give a true reflection of all costs and benefits involved in the landscape conversion.

The concept of ecosystem functions, goods and services is an important instrument in this process, since it helps identify and quantify the benefits of ecosystems and landscapes, and the full costs of their loss, and provides a communication tool to engage the main stakeholders in a constructive dialogue in this process.

5.3. Involve stakeholders in (collaborative) landscape management

To involve local people in ecosystem management, the outcome of scientific analysis must be communicated more effectively and structurally to policy makers, planners and managers and the general public. An important initiative in this respect is the Collaborative Management Working Group of IUCN (Borrini-Feyerabend et al., 2000). This working group promotes and supports field-based co-management initiatives, draws lessons and methods from experience, supports the development of collaborative management policies and advocates the inclusion of the principles and practices of collaborative management.

The above initiatives represent important and hopeful signs that landscape ecology as a scientific discipline is increasingly functioning as a bridge that crosses many frontiers and brings different assessment approaches together to achieve more sustainable landscapes and to conserve our remaining natural capital.

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