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Incorporating Ecosystem Function Concept in Environmental Planning and Decision Making by Means of Multi-Criteria Evaluation: The Case-Study of Kalloni, Lesbos, Greece

Vera Oikonomou · Panayiotis G. Dimitrakopoulos · Andreas Y. Troumbis

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Abstract Nature provides life-support services which do not merely constitute the basis for ecosystem integrity but also benefit human societies. The importance of such multiple outputs is often ignored or underestimated in environmental planning and decision making. The economic valuation of ecosystem functions or services has been widely used to make these benefits economically visible and thus address this deficiency. Alternatively, the relative importance of the components of ecosystem value can be identified and compared by means of multi-criteria evaluation. Hereupon, this article proposes a conceptual framework that couples ecosystem function analysis, multi criteria evaluation and social research methodologies for introducing an ecosystem function-based planning and management approach. The framework consists of five steps providing the structure of a participative decision making process which is then tested and ratified, by applying the discrete multi-criteria method NAIADE, in the Kalloni Natura 2000 site, on Lesbos, Greece. Three scenarios were developed and evaluated with regard to their impacts on the different types of ecosystem functions and the social actors' value judgements. A conflict analysis permitted the better elaboration of the different views, outlining the coalitions formed in the local community and shaping the way towards reaching a consensus.

Keywords Ecosystem functions and services · Multi-criteria evaluation · NAIADE · Conflict analysis · Natura 2000 network

V. Oikonomou (✉) · P. G. Dimitrakopoulos · A. Y. Troumbis
Biodiversity Conservation Laboratory,
Department of Environment, University of the Aegean,
University Hill, 81100 Mytilini, Greece
e-mail: ecovera@env.aegean.gr

Introduction

Ecosystem functioning—the ecosystem's capacity to carry out its primary processes (capturing, storing and transferring energy, carbon dioxide, nutrients and water) —is in turn based on many more processes at the population and community level (Schulze and Mooney 1993; Hobbs and others 1995). These processes, which are directly related to biodiversity (Hooper and others 2005; Naeem and others 2009), do not merely constitute the basis for ecosystem integrity but also the direct and indirect source of services to human societies (De Groot 1992; Costanza and others 1997; Millennium Ecosystem Assessment-MEA 2003).

The growing awareness of and interest in this close inter-connection and inter-dependency, together with the continuous over-exploitation and degradation of environmental assets, have stressed the need for analysing the multiple benefits derived by ecosystems based on more synthetic, multi-dimensional conceptual frameworks and incorporating diverse values in decision-making (Habron and others 2004; MEA 2005; Egoh and others 2007; Raymond and others 2009).

To date, much attention has been paid to the development of economic valuation methodologies, whereas the assignment of economic values to ecosystem functions and services has been widely used and recognized as valuable for better informing environmental decision making (Pearce and Turner 1990; Freeman 1993; Costanza and others 1997; Scott and others 1998; Wilson and Carpenter 1999).

Nevertheless, ecosystem services' complex nature cannot always be treated adequately within an economic valuation framework as planning and management based on ecosystem services may involve multiple and conflicting objectives and values, high uncertainty and

incommensurabilities (Munda 1996; Sagoff 1998; Norton and others 1998; O' Connor 2000; Farber and others 2002; Chee 2004). However, relatively little elaboration of alternative means to incorporate multiple ecosystem services in environmental planning and decision-making has taken place.

Depending on the decision-making context and the motivation for which ecosystem services are being considered, different approaches can be employed and work either interchangeably or complementarily. Alternatively to ecosystem services or functions' economic valuation, the relative importance of the components of ecosystem value can be identified and compared by means of multi-criteria evaluation (MCE). In general, in MCE, complex, multi-dimensional decision-making tasks can be treated of, involving multiple conflicting objectives, a diversity of possible outcomes, with incommensurable or uncertain effects, many decision makers and social actors with different perceptions and values (Martinez-Alier and others 1998; Pereira and Quintana 2002; Munda 2004, Messner and others 2006). Extending the MCE approach in the ecosystem services context, questions like "how do different actions impact on ecosystem functions and the flow of services provided to society?" and/or "what is the importance of these multiple benefits for the different social actors?" could be addressed rather than the estimation of ecosystem services' value per se.

In this article, a conceptual framework is proposed that couples ecosystem function analysis, multi-criteria evaluation and social research methodologies for introducing an ecosystem function-based planning and management approach. The framework consists of five steps providing the structure of a participative decision making process which is then applied as an alternative approach to conservation planning of the Natura 2000 site of Kalloni Gulf in Lesbos, Greece.

Following the belated harmonisation of the Habitats Directive (92/43/EEC) with Greek Law in 1998, which together with the Birds Directive 79/409/EEC constitute the legal basis for the Natura 2000 protected areas' network, Greece implemented the designation of Greek Special Protection Areas and Special Areas of Conservation (i.e., 163 SPAs and 239 SACs accordingly). Though designation of protected areas is nearly complete (EU 2008; EC 2009a), establishment procedure and conservation planning is still pending for many Greek Natura 2000 sites (Apostolopoulou and Pantis 2009), including the Kalloni Gulf, while the conservation status of species and habitats, especially coastal ones, is critically 'unfavourable' (EC 2009b).

The Kalloni Gulf and the surrounding area of wetlands was one of the proposed Greek Sites of Community Importance (SCI), included in the National Inventory, as well as a defined Special Protection Area. Taking into account national law's prerequisites for protected areas' designation (Greek Law 1650/86), local authorities launched a Specific Environmental Study. This study would lead, after its approval by the competent Ministers, to a Common Ministerial Decision and finally to a Presidential Decree (signed by the President of the Democracy) establishing the protected area. It would also set a conservation plan regulating the activities (e.g., olive oil cultivation, sheep rearing, fishing, hunting and tourism) exercised within the Kalloni catchment.

The projected inclusion of the Kalloni Gulf to the European Natura 2000 network of protected areas along with the conservation plan (Mandylas and Kardakari 2000), submitted by the local competent bodies in 2001 for public deliberation, was met with intense demonstrations by the side of the opposing social actors. The conflict suspended any agreement on the preliminary plan and was followed by a long period of negotiations and delays that have led to the area still not having protected status.

Institutional analysis, participant observation and in depth-interviews were conducted in Kalloni Municipality in order to define the conflict, identify the related actors and reveal their perceptions concerning the ecological and socio-economic importance of ecosystem services, related problems and potential actions for their management. On the grounds of the collected information, three scenarios were developed and evaluated based on their performance on the selected ecosystem services (multi-criteria evaluation) and local actors' value judgements (social evaluation). Intersecting these two evaluations, performed by the selected multi-criteria method NAIADE, a starting point was defined in searching for a scientifically adequate and a more socially desirable perspective for conservation planning in the Kalloni Natura 2000 site.

Analysis of Methods and Tools

Ecosystem Function Analysis: Coupling Human-Ecological Systems

Semi-natural areas or ecosystems in general, are characterized by their specific components and structure, as well as by the natural and human induced processes that determine their functioning and hence the provision of services to human society (Fig. 1). A clear distinction or isolation of the ecological and social sub-systems concerning the generation of ecosystem services would not provide the broader perspective of the system that is essential when taking their linkages into focus (Berkes and Folke 1998; Kotchen and Young 2007; Asah 2008). Even if we accept the statement of Fisher and others (2009) that

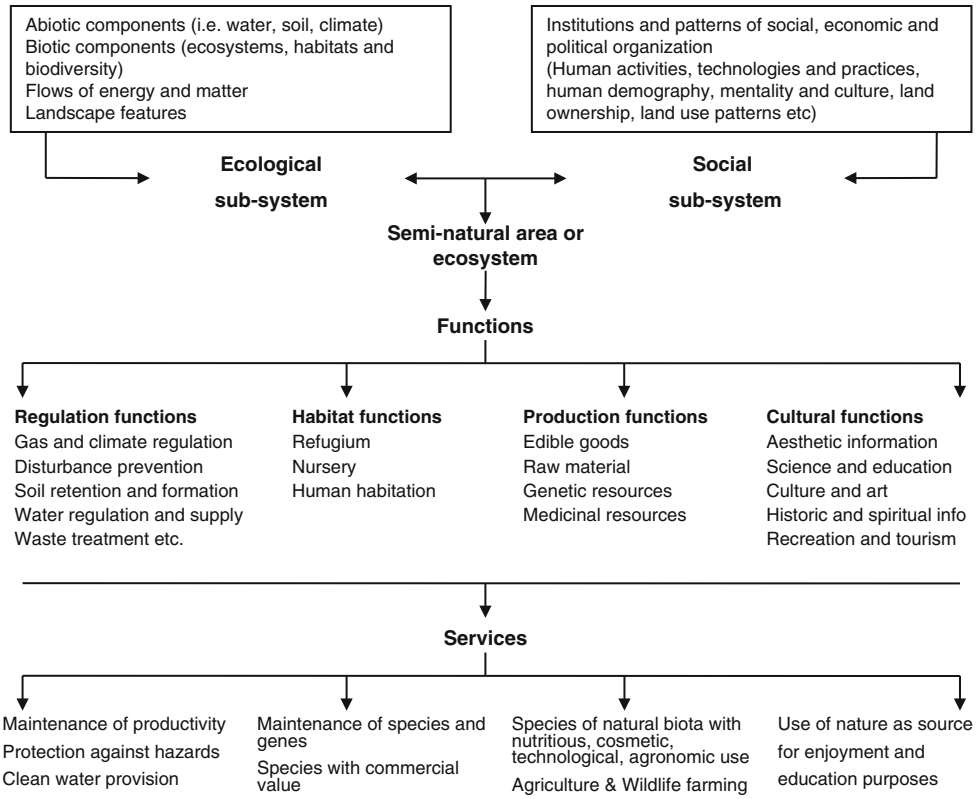

Fig. 1 Ecosystem function analysis framework in a semi-natural area or ecosystem; examples given based on De Groot and others (2002); MEA (2003); Troumbis and Oikonomou (2004). For reasons of simplicity the function of the ecosystem as a substrate for different purposes (waste disposal, human habitation, cultivation, recreation and tourism) is embedded in all function categories according to the purpose served

ecosystem services are exclusively 'ecological phenomena', they are still quite dependant on human induced processes that may allow, facilitate or distort their provision. In that sense, ecosystem services (such as fishes or clean water provision) are produced by human-modified ecological systems as their quality or quantity is highly dependant on both ecological and social sub-systems. Humans' intervention is not restricted to the transformation of a service into a 'benefit' or an 'end' (fishery, water for consumption) but also underpins the generation of the service itself. This close interrelation and interdependence of humans and ecological systems, is treated within this adjusted ecosystem function analysis framework and accordingly penetrates the planning or decision-making process.

Therefore, an important property within ecosystem function analysis is to identify ecosystem services—actual or potential ones—and to pinpoint the human processes that, being coupled with the provision of these services, often become the main reason for reducing their quality or quantity. For the facilitation of ecosystem services' identification and study, this article adopts a functional grouping based on De Groot and others (2002) and MEA (2003). Other classification schemes can be found in Pearce and Turner (1990); Daily (1997); Costanza and others (1997); Norberg (1999); Wallace (2007).

Given the complexity of the socio-ecological system and the incomplete, imprecise and subjective knowledge about its functioning and dynamic (Munda and others 1994; Limburg and others 2002), decision-making becomes a difficult task. Nevertheless, approaches that can deal with that complex nature of ecosystem services could contribute to a more effectual analysis and evaluation of the trade-offs between various management alternatives.

Combining Ecosystem Function Analysis with Multi-Criteria Evaluation

Following the generic form of a discrete multi-criteria evaluation problem, given the finite set $A = \{a_m\}$, $m = 1, 2,\ldots, M$, of potential alternative actions and a family of evaluation criteria $G = \{g_n\}$, $n = 1, 2,\ldots, N$, each potential alternative is associated to a performance vector $E: A \rightarrow R^n$, $g(a_1) = g_1(a_1) + \cdots + g_j(a_1) + \cdots + g_n(a_1)$. Considering that potential alternatives represent the actions that enhance or distort ecosystem capacity to generate services and evaluation criteria the multiple ecosystem services, it is then possible to build an *n x m* ecosystem-function based impact matrix (E), whose typical element e_{ij} ($i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$) represents the performance of the *i*th alternative action regarding the provision of the *j*th ecosystem service. An example of an impact matrix using criteria of different ecosystem function type (dimension) is presented in Table 1.

Alternative actions and criteria can be proposed and selected by relevant social actors like decision makers, any

Table 1 Ecosystem-function based evaluation matrix

Examples of ecosystem function criteria	Alternative actions	a_1	…	a_i	…	a_m
		Performance of alternative actions				
Regulation functions-*Water supply and regulation*	g_1	e_{11}	…	e_{i1}	…	e_{m1}
⋮	⋮	⋮	…	⋮	…	⋮
Production functions-*Production of edible goods*	g_j	e_{1j}	…	e_{ij}	…	e_{mj}
⋮	⋮	⋮	…	⋮	…	⋮
Habitat/Carrier functions-*Refugium and Nursery*	g_n	e_{1n}	…	e_{in}	…	e_{mn}

group or individual who affects or is affected by the decision, experts, planners, analysts and so on. Besides, social actors' integration in public policy-decision processes has been widely recognised as a necessity for normative, substantive and instrumental reasons (Banville and others 1998; Stirling 2006; Reed 2008). Opposing interests and perceived values on ecosystem services will induce different alternatives and objectives, thus creating competition and conflicts. For addressing the issue of the aggregation of the various conflicting evaluations and the choice of action(s), a great variety of mathematical techniques and corresponding methods have been developed (for a comparative analysis or selection aid see Guitouni and Martel 1998; Salminem and others 1998; Lahdelma and others 2000; Polatidis and Haralambopoulos 2006). Nevertheless, some authors emphasize multi-criteria methods' substantial contribution in structuring the problem and the evolution of the decision process itself, rather than in the final choice of action (Munda and others 1994; Roy 1996; Messner and others 2006).

The NAIADE (Novel Approach to Imprecise Assessment and Decision Environments) method, which was selected for the case of Kalloni conservation planning, is a discrete multi-criteria method that has demonstrated its strength, among others, in dealing with multiple conflicting objectives and values as well as inaccurate, unreliable or incomplete information (Munda 1995; De Marchi and others 2000; Gamboa 2006; Salgado and others 2009). Thus, perceived values on ecosystem services can be expressed using quantitative, qualitative, precise and fuzzy information. Mixed type evaluations are then homogenized and pair-wisely compared by means of fuzzy relations and 'semantic' distances (for further information on the technical characteristics of NAIADE see Munda 1995; JRC 1996). NAIADE also allows for two types of complementary evaluations: (i) the multi-criteria analysis, where alternatives are compared based on their performances on the selected criteria, and (ii) the social analysis, where alternatives are compared based on the social actors' value judgements. These two types of evaluations provide a ranking of the alternative actions according to their score on all criteria as well as information on the coalitions formed between the different social actors and the alternatives' rankings per coalition.

NAIADE results and the quality of the evaluation process can in general be enhanced when combined with social research methods. By means of social research techniques (Bryman 2008; Iosifides 2008), it is possible to get an improved information structure, a better framing of the problem and a clearer view of social actors' objectives, thus elucidating some specificities not easily traced through the NAIADE technical approach (e.g., social judgements on the alternatives according to each ecosystem service).

The Conceptual Framework

Following the previous analysis, a conceptual framework has been developed, coupling ecosystem function analysis, multi-criteria evaluation and social research methodologies for facilitating environmental planning and decision making. The distinct steps of the framework and the methods contributing to each one of them are depicted in Fig. 2.

Defining the ecological and institutional boundaries of the study area or ecosystem as well as being acquainted with its bio-physical characteristics, the institutions and patterns of social, economic and political organisation constitute the first step for also delimiting the "territory" of the analysis. The various social actors who interact with the area or ecosystem (exercising related activities, affecting or being affected by it) are also identified, gradually shedding more light on the core of the environmental issue(s) in dispute (step 1). Within ecosystem function analysis and with the contribution of several social research techniques (e.g., in depth-interviews, questionnaires, participant observation), ecosystem services generated in the area and the related pressures are examined and identified by the social actors (step 2). The identified ecosystem services and pressures along with the potential actions articulated by the social actors will provide the basis for developing the evaluation criteria and synthesizing alternative scenarios (step 3). These scenarios are finally evaluated by means of the NAIADE method (step 4). Decision making (step 5) refers to the intersection of results and recommendation procedure and not to the final choice itself. This step provides the decision-making process with a multi-criteria evaluation (technical analysis) and a social evaluation (conflict analysis). In this way, it can contribute to a further

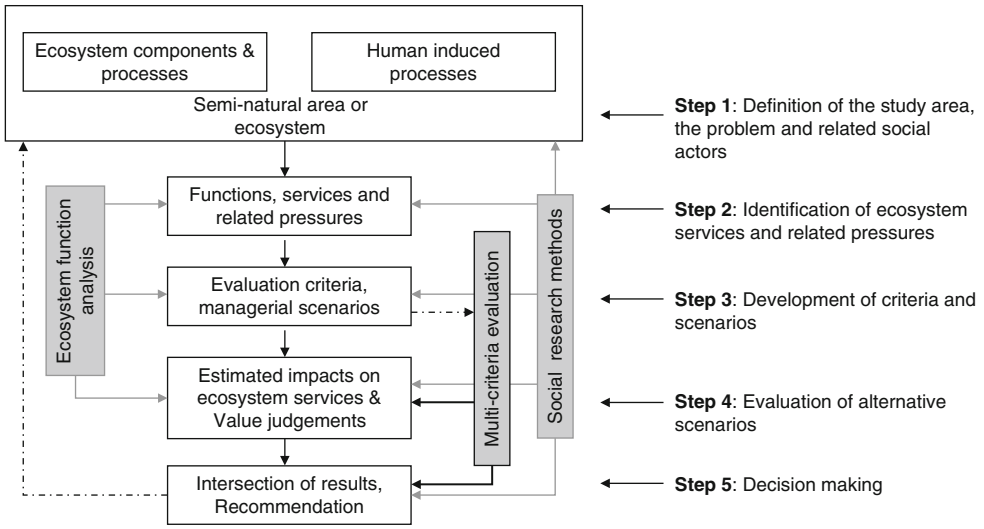

Fig. 2 The conceptual framework for incorporating the ecosystem function concept in environmental planning and decision making. The *white boxes* represent the different levels of information input to the decision-making process and the *grey boxes* the methods contributing to certain levels of it. The *solid arrows* indicate the information input flows and the *broken* ones the feedback flows

discussion around the issue in dispute and the co-development of an adequate solution.

Summing up, a decision making process can be structured based on five interrelated steps: (i) Definition of the study area, the problem and the related social actors, (ii) Identification of ecosystem services and related pressures, (iii) Criteria and scenarios development, (iv) Evaluation of the alternative scenarios and (v) Decision making.

Implementation of the Conceptual Framework in the Kalloni Natura 2000 Site

Definition of the Study Area, the Problem and the Related Social Actors (Step 1)

The Kalloni catchment, lying in the southwestern part of the island of Lesbos in Greece, takes up one third of the island's surface (49,260 ha) (Fig. 3). On the north and east coast of the Kalloni Gulf, wetlands have formed, while in the peripheral zone several small and medium size settlements are cited, composing three municipalities, with a population of around 15,910 inhabitants (National Statistical Service of Greece 2001).

Due to its landscape heterogeneity and cultural features as well as its importance as a wintering, reproduction and migration station for bird species, Kalloni constitutes a worldwide destination for bird watchers, scientists and visitors. The area, besides being a proposed Special Area of Conservation (SAC), has been characterized as an Important Bird Area of Greece, a Special Protected Area (SPA) based on Directive 79/409/ECC, a Biodiversity Hotspot

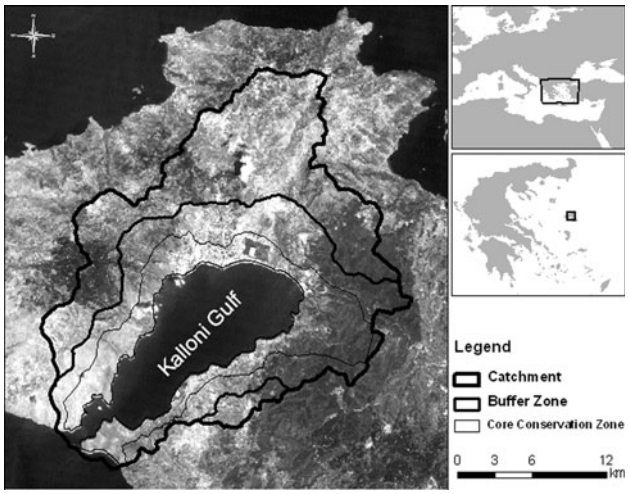

Fig. 3 Location of Kalloni catchment and conservation zones

and is included in the Inventory of CORINE biotopes (Troumbis and Dimitrakopoulos 1998). The Kalloni catchment is characterized by a great diversity of habitats consisting, in principle, of salt pans and marshes, shallow brackish zones, small freshwater marshes, olive groves, pine forests and shrublands. In total, there are 17 habitat types listed in Annex I of the Directive 92/43/ECC (four of which are classified as priority), with 252 species of avifauna observed and 39 species of flora classified as rare, endangered or protected (Mandylas and Kardakari 1998). In the wider area adjacent to the wetlands, the economically active population is mainly occupied with the prevalent economic activities of olive oil cultivation, sheep rearing, fishing and tourism.

For carrying out our analysis, a catchment scale was used as it offers a more holistic view of the system, capturing its essential environmental perspective (structure and processes), its interactions with broader forcing factors (natural and anthropogenic) and maximizes the ability to study the services' spectrum of values. The Municipality of Kalloni was chosen for conducting the social research, as it is a big municipality in size and population and there has been intense opposition from its residents to the environmental designation.

Initial Phase of the Social Research

Institutional analysis, participant observation and in depth-interviews with local actors at individual and group meetings were performed in Kalloni Municipality in order to define the conflict, identify the related actors and reveal their perceptions concerning the ecological and socio-economic importance of ecosystem services, related problems and potential actions for their management.

Initially, the researchers got a primary picture of the case record and the conflict through the examination of a rich archive material consisting of legislative and administrative documents, local press articles, election manifestos, audio-visual material from past public gatherings and private interviews as well as participant observation (in citizens' assemblies). This preliminary research also helped in the identification of the relevant social actors who had either held a prominent position in the ongoing dispute or were closely related to the decision context. 28 semi-structured interviews were conducted, all of which were recorded and lasted from one to three hours. The social actors selected were mainly representatives from various organisations at the local and regional-hyper local level but also, people who had no institutional role or access to the decision-making process. In addition, attention was paid to keeping a balance between the decision-makers at different levels of the public administration, the trade associations or businesspeople, the citizens' associations or individual citizens and the scientists or experts (Table 2).

The History of the Social Conflict and the Ineffective Negotiations

The Specific Environmental Study of Kalloni (1997–2000), apart from assessing the current state of habitats and species and related problems, proposed a management plan of the Kalloni catchment (henceforth the Natura plan) that would rearrange economic and other activities, based on the designation of three conservation zones (Fig. 3). In the core conservation zone, any activity considered to endanger the conservation status of habitats and species would be banned while in the other two, activities would be regulated so as to buffer the core zone. Moreover, the Natura plan projected the establishment of a management agency (as prescribed by Greek Law 2742/99 for designated protected areas), consisting of a consultancy board (of central and local administration, NGOs, local stakeholders and scientists) accountable to the Greek Ministry of Environment, that would be responsible for the planning and management of the Kalloni catchment area.

The Natura plan, which was officially announced in 2001 at a public gala for deliberation, did not receive full support by the local community. On the contrary, the opposition and the violent reaction of the social actors affected and other citizens suspended any fruitful deliberation or agreement on the preliminary plan.

Natura plan was perceived as clashing with the vested interests of several social actors or groups and to abrogate common practices or land-uses (i.e., hunting, practices in land cultivation etc.) which were considered to be compatible with environmental protection. Furthermore, the widespread criticism concerned the lack of participative procedures which underlined the top-down enforcement of a predetermined management plan, the insufficient representation of the local stakeholders in the management agency and the lack of information dissemination, leading to widespread confusion about the actual Natura plan. Nevertheless, the main problem was rooted in the classification of some private land as protected and the prescription of restrictive regulations concerning its use and exploitation; a fact that was considered to be tantamount to the complete depreciation of real assets and the violation of property rights. Statements such as: "We will be forced to sell our properties for a piece of bread" or "we are loosing our fortune" were frequently supported.

For Kalloni residents private land represents a part of the family's history and identity, the safety, independency, social status and political influence of its members and underlines their aspirations of a better future ("We live on land that was languished under feudalism and recently liberated, so property represents a valuable and nonnegotiable good"). The projection of a better future is widely associated with the building construction and the exploitation of the coastal zone ("The land overlooking the sea is valuable" or "we want to economically develop and build along the shore"). Even land that was traditionally left unexploited, because it was swampy or seasonally used for grazing, is now suitable ground for building and income production. Subsequently, the Natura plan represents a threat to the area's development as the "forbidden activities' zone" (core conservation zone) consists mainly of parts of the coastal area.

Vigorously against the Natura plan implementation were standing the residents of the nearby village of *Parakoila* (who formed the 'Joint Struggle Committee of Parakoila'

Table 2 Social actors identified and interviewed in Kalloni

Level continuum	Spatial scale	Social actors identified in Kalloni	Interviewees at the regional-local level
Macro-level	Global	NGO Friends of Green Lesbos	Public administration
		Visitors, scientists, researchers	Mayor
	National	Administrative competent bodies (Hellenic Ministry for the Environment, Energy and Climate Change, Ministry of Rural Development and Food etc.)	Municipal Councillors
			Presidents of Municipal Departments
		NGOs (Hellenic Ornithological Society, WWF Hellas etc.)	Trade Associations-Businessmen
		Visitors, scientists-researchers	Farmers' Association
		Investors-corporations (e.g., Hellenic Salt works S.A)	Fishermen' Association
			Commercial Shell Collectors
	Regional-Hyper local	*Region of North Aegean*	Hotel Owners
		Prefecture of Lesbos	Agro-tourism Women' Association
		NGOs (e.g., Naftilos)	Citizens Organisations-Citizens
		Visitors, researchers	NGOs (Friends of Green Lesbos, Naftilos in Action)
		University of the Aegean	Hunters' Association
	Local	*Residents (permanent, seasonal)*	Citizens' Committee against Natura 2000
		Farmers	Citizens
Micro-level		*Fishermen*	Scientists-experts
		Hunters	Person in charge of conducting Kalloni's Specific Environmental Study
		Owners of hotels, lodgings, restaurants etc.	University of the Aegean
		Municipality (Mayor, municipal councillors, presidents of municipal departments)	

Source: own elaboration based on Grimble and Wellard (1997); *italics* indicates that the study's focus remains, in priority order, at the local and regional-hyper local level

to represent their demands), private landowners within the proposed core conservation zone and the Hunters' Association of Kalloni.

For its supporters (some administrative officers, NGO's, the tourism industry, some members of the local and of the scientific community) the Natura plan represented the adoption of an eco-development perspective that would ensure the conservation of Kalloni's natural and cultural heritage and its parallel economic development in the future. They strongly believed that the natural wealth of Kalloni constitutes the only comparative advantage with which the area can compete and be differentiated worldwide. In addition, it was argued that "no landed property can be considered as a prospective building plot as this could be proved a grave mistake for the development potential of the area and thus for employment and income production" or "restrictions to property rights can override individual interests when it is for the benefit of society and the protection of public goods".

The conflict that evolved led to a long period of fruitless negotiations, which hindered the finalisation of the Natura plan and the subsequent issue of the Presidential Decree.

In the meantime, building intensified in the core conservation area, with people taking advantage of both the legal hiatus and the difficulty of public authorities to coordinate and exercise a transitive policy ("In the absence of a clear legal framework, there were cases where a charge of illegal construction work was issued by our department while another public department supplies the owner with a document proving the pre-existence of the constructions, in order to avoid undue conflicts between the authorities and their voters").

Serious degradation and damage of many wetland sites was discovered by NGO's who took an active role by means of introducing the subject in a tentative (at a local, national and international level), performing frequent patrols in the area and reporting over 40 law violations to the competent authorities. Nevertheless, it was argued that "the fine policy that the authorities were forced to apply for a short period didn't prove effective, as the accused either continued or didn't demolish the building, hoping to be acquitted of the charge in the future".

Identification of Ecosystem Services and Related Pressures (Step 2)

Kalloni's wetlands and the wider study area generate a great variety of supporting services to humans. Human activities, in turn, that are connected with the provision of

these services often become the main reason for the reduction in their quality or quantity.

For defining the current state of ecosystem services all available scientific studies and local knowledge were considered. Social actors identified the ecosystem services they use, benefit from or just deem as important as well as the processes or drivers distorting their provision, by answering questions such as: "In which way do you think that the ecosystem of Kalloni supports your life?"; "Through which activities you come into contact with it?"; "What do you think has changed in relation to the past?" and "What are the main sources of pressure on the provision of these supporting services?" No pre-formulated list was provided by the researchers.

The ecosystem services identified by social actors are presented in Table 3. The importance attributed to particular ecosystem functions was relevant to the benefits derived and/or their critical state. Thus, conflicts which evolved from the opposing interests and perceived values, mainly concerned some services' overuse at the expense of others. For example, substrate for housing, other construction and animal rearing had been increasing, degrading or irreversibly damaging wildlife habitats and landscapes of high aesthetic value as well as negatively affecting hunting activity and eco-tourism development. Table 4 presents some examples of the human activities identified as exerting pressure on particular ecosystem functions and the corresponding impacts on the environment and human welfare.

Criteria and Scenarios Development (Step 3)

On the basis of the ecosystem services and related pressures identified, social actors expressed their wants and expectations concerning their management and proposed potential actions that could facilitate their provision (either by restricting certain activities or encouraging others) (Table 5). They were asked questions concerning each particular service or Kalloni catchment as a whole in order to collect this information (i.e., How would you evaluate the current management of the particular function/service you mentioned?; What do you think about the proposed conservation plan?; What do you envisage for the future of Kalloni?).

Researchers elaborated the criteria and scenarios based on the ecosystem services, pressures and alternative actions identified by the social actors. This technical work, including the definition of criteria types as well as the thresholds only needed for the few quantitative criteria, was conducted with the help of the expert-scientific actors involved in the process. The edited list of the criteria and sub-criteria is depicted in Table 6.

Alternative actions were embedded in three broader scenarios based on the main differences between the social actors who wanted to either continue with the proposed plan, to make some changes or to reject the plan and do nothing. Scenario 1 (S1): Implementation of the Natura plan; Scenario 2 (S2): Partial implementation of the Natura plan; Scenario 3 (S3): Maintenance of the status quo. More specifically, scenario 1 encompassed all regulations and the three level zoning projected by the Specific Environmental Study (Fig. 3). The first level or core conservation zone covered a wider area than that initially defined for inclusion in the Natura 2000 network (total of SPA and SCI), ensuring the preservation and connectivity of all the ecologically important sites. Human activities that used to be exercised within that area such as hunting, farming or construction would be strictly regulated or even banned while "greener" activities or practices (i.e., eco-tourism, biological farming) would be promoted. In scenario 2, the core conservation zone is reduced (covering at the maximum the defined Natura 2000 area and at the minimum the updated SPA, not yet approved by the Ministry of Environment) without exceeding the permissible limits. Also some changes concerning the reduction of the minimum size of land required for building and several restrictions regarding particular socio-economic activities (e.g., land cultivation, animal rearing) were embedded. Under scenario 3, it was supposed that no further action addressing the identified problems would take place, except for the ones that, irrespective of any conservation plan, had already been launched by the local authorities and still were outstanding (i.e., development of a wastewater treatment unit and sanitary landfill, designation of the Kalloni Wildlife Sanctuary). Land uses and practices would be maintained until any change at the national or European level would be enforced.

Evaluation of Alternative Scenarios and Decision Making (Step 4 and 5)

By means of the NAIADE method, the aforementioned scenarios were evaluated based on their performance on the nine ecosystem-function criteria (multi-criteria evaluation) and the social actors' evaluations (social evaluation).

Multi-Criteria Evaluation

For performing multi-criteria evaluation, all specialised literature was used by the researchers and the expert-scientific actors who evaluated each scenario based on its expected contribution to the selected criteria and developed an impact matrix. Depending on the type of the available information (quantitative, qualitative) and the degree of uncertainty in the effects of the alternatives, the values

Table 3 Identification of Kalloni ecosystem services

Functions	Ecosystem services	Identifiability of ecosystem services by social actors[a]
Regulation functions		
Disturbance prevention	Fire protection, erosion control, flooding mitigation	Very low
Water regulation and supply	Drainage and natural irrigation, erosion and obstruction control	Low
	Provision of surface and underground water for irrigation, industries, households, livestock and tourism	
Waste treatment	Storage and recycling of organic and inorganic human waste	Very high
Habitat functions		
Refugium and Nursery	Habitat for wild plants and animals	Extremely high
	Wintering, reproduction and migration station for 252 bird species	
Substrate for human use	Substrate for housing, commercial and hospitality constructions	Very low
Production functions		
Edible goods	Hunting of birds, wild pigs, rabbits etc	Extremely high
	Fishing and shellfish collecting	
	Cultivation of crops, cattle and bees	
	Sea salt collection	
	26 species of natural biota are collected for food purposes	
Raw materials	Forage, fuelwood, materials for industrial use (sand and gravel)	Extremely low
	24 species of natural biota identified with 27 agronomic and technological uses	
Medicinal resources	72 species of natural biota identified with 135 medicinal uses and 13 cosmetic uses	Very low
Cultural functions		
Aesthetic information	Attractive landscape features enhancing housing, living conditions, encouraging relaxation, spiritual reflection etc.	Low
Culture, arts, science and education	Books, paintings, films, traditional customs and feasts motivated by nature	Medium
	Scientific research and education	
Recreation and tourism	Outdoor activities (trekking, diving, swimming, bird watching)	Very high
	Provision of opportunities for tourism (eco-tourism, agro-tourism)	

Source: Oikonomou and Dimitrakopoulos 2006; Antypa and Chanut-Musikas 2008; personal interviews; based on De Groot and others (2002) and MEA (2003) classification scheme; [a] extremely low (1): *min* extremely high (9): *max* corresponds to the number of social actors who identified the particular ecosystem service as important or/and critical (frequency occurrence)

assigned to the criteria for each alternative scenario have been expressed using numerical, fuzzy or linguistic variables (e.g., 2, 50–150 and very good accordingly). Considering the lack of information available expressed in accurate terms and the inherent uncertainty in evaluating actions that would be realised in the future, qualitative evaluations prevailed in the constructed matrix (i.e., all evaluations were qualitative except for "4.1 Priority species coverage"; "4.2 Area of core conservation zone"; "5.1 Area of building prohibition and minimum size of land required for building" and "6.4 Maintenance of hunting activity"; Table 6).

By applying NAIADE, a pair-wise comparison of the scenarios is performed and their overall ranking is generated. In the overall ranking (Table 7), S3 is worse than the others while S1 and S2 seem to be approximately equal, even though, according to some criteria S1 is slightly better than S2 (e.g., Criteria 4.3; Table 6) and slightly worse for some others (e.g., Criteria 5.1; Table 6).

A sensitivity analysis can be performed in order to evaluate the robustness of the results by means of changing the degree of compensation allowed between the different criteria (the degree of counterbalance allowed between good and bad performances) and the threshold value over which differences between scenarios' performances are taken into account by the model. Different compensation degrees and thresholds tested for Kalloni case-study were leading to either equal performance of S1 and S2 or the predominance of S2.

Social Evaluation

For performing social evaluation, a second matrix (the so-called "equity matrix" in NAIADE), was developed based

Table 4 Ecosystem functions, human pressure and related impacts on the environment and human welfare

Functions	Examples of human pressure	Examples of related impacts
Water supply and regulation	Over-pumping of underground water, Illegal drilling	Increased salination of underground aquifers, wild life habitats degradation, increased risk for flooding
	Banking up, diversion of streams, dumping of construction and demolition solid waste in the rivers and streams	
Waste treatment	Disposal of municipal and agro-industrial (olive oil extraction, cheese making) wastewater without processing in the rivers, streams or sewage network	Pollution of surface, underground and sea water, wildlife habitats and landscape degradation, extinction of commercial species
	Solid waste generated by population, seasonal visitors and tourists and disposal to rubbish dumps	
Refugium and nursery	Land clearing and draining	Habitat degradation, decrease in species populations, loss of services such as auto-purification of sea water by clams, income loss (reduction in ecotourism and populations of commercial species)
	Expansion of tourist settlements, private houses, shops in or at the borders of ecologically sensitive areas	
	Illegal hunting, over-fishing, fishing and agricultural practices, overgrazing	
Production of goods	Practices in agriculture, fishing, stock-breeding, hunting, agro-industry (concerning over-exploitation of natural biota, use of damaging inputs and tools, non-observance of rules and laws etc.)	Soil degradation and erosion, decrease in fish and shells, hunting and natural grazing stocks, income loss, abandonment of agricultural land, elderly population of farmers
	Reduced prices of agricultural products	
Aesthetic information	Expansion of urban areas, reduction of wetland and forested land	Landscape degradation, visual pollution
	Uncontrollable or illegal waste disposal to the environment	
Recreation and tourism	Lack of infrastructure and planning for the exploitation of natural and cultural resources in the development of recreational activities and tourism	Natural and cultural resources degradation, income loss for the local society

Source: Own elaboration based on Panayiotidis and Klaoudatos 1997; Mandylas and Kardakari 1998; unpublished material and personal interviews

Since the same human activities can affect multiple ecosystem functions and thence the services or disservices that they generate, the examples referenced were restricted to the main sources of pressure

on the social actors' preferences of the scenarios. Information on the social actors' evaluations was derived from the interviews conducted, while additional interviews took place where value judgements were ambiguous. In total, 16 actors evaluated the scenarios, as some refused to express any preference. Social actors' evaluations of the scenarios were expressed exclusively in qualitative terms, using linguistic expressions such as very good, bad etc. from a nine level scale (min: extremely bad - max: extremely good). For further analyzing and comprehending the results of the social evaluation, information from institutional analysis and the participation process had to be exploited as well.

By applying NAIADE, a coalition formation dendrogram (Fig. 4) is obtained, indicating the coincidence or distance between the different social actors' interests and perceptions based on the intensity of their preferences for the alternative scenarios. Thus, different credibility levels of coalition formation are giving vague indications on some points of agreement or disagreement between an actor and another actor, an actor and a coalition, a coalition and another coalition, which have to be further unfold with the contribution of institutional analysis, interviews etc. In addition, all the rankings of the scenarios for every formulated coalition are provided (Table 7 is an example of a ranking at 0.7329 coincidence level).

More specifically, the modelling results show that there is a high level of credibility of coalition formation (Point A, Fig. 4) between Hotel owners and NGOs. This signifies their quite common view on Kalloni's conservation issue. They both consider that there is an urgent need to proceed with a plan and designate protected areas as wild life habitats' degradation is very rapid, with a slight preference on S1. They could also vote for S2, if proposed changes would be consistent with conservation goals and include all Natura areas. At this point (Point B, Fig. 4) they are joined by Municipal Councillor 1, Municipal Dept. President 2 and Agro-tourism Women' Association who expressed a slight preference on S2 (see also Table 7, third coalition). Behind this coalition, despite the differences, there was the common belief that implementing a conservation plan would bear important profit for the future development of Kalloni and the wise exploitation of its natural and cultural resources. Less rigorously, S2 is supported by the representatives of Farmers' and Hunters' Associations who had come across the extended degradation of particular

Table 5 Social actors' expectations and suggestions on the selected evaluation criteria

Dimension/criteria	Social actors' expectations	Social actors' suggestions
Regulation functions		
1. Disturbance prevention	Hazards prevention (extended fires)	Fire protection system reinforcement in all forested areas, irrigating network modernisation, completion of wastewater treatment unit, control and restoration of landfills
2. Water regulation and supply	Increase the effectiveness of water management	
3. Waste treatment	Decontamination of Kalloni Gulf	
Habitat functions		
4. Refugium and Nursery	Restoration and prevention of further environmental degradation and species or habitat loss	Finalization of the Specific Environmental Study, all wetland areas protection, reduction of the core conservation zone boundaries, limiting protection to wildlife sanctuary area, protection area patrol and enforcement of higher fines, fund-raising for restoration, protection and expropriation, maintenance of current land uses and practices
5. Substrate for human use	Space retention for human use	
	Property protection	
Production functions		
6. Production of goods	Promotion of organic agriculture	BioPark creation, subsiding organic farmers, Kalloni Gulf management at a local level, hunting restriction in specific areas, periods and for endangered species, soft regulations for illegality evasion, introduction of documented regulations for effective management
	Enhancement of agricultural income	
	Preservation of hunting and fishing activity	
	Increase in game population	
Cultural functions		
7. Aesthetic information	Environment conservation for future generations	Law enforcement, knowledge dissemination and citizens participation, research development and interdisciplinarity, local and human resources exploitation, reinforcement of the University of the Aegean's role, management agency re-composition, urgent establishment of management agency and development of conservation strategy, protection of specific important wetlands, ownership redefinition, development of tourism infrastructure out of the core conservation area, promotion and use of local products in tourism industry, wetland-coastal areas exploitation for the development of big tourist units
8. Culture, arts, science and education	Development and exploitation of natural and cultural wealth	
	Alternative tourism development	
9. Recreation and tourism	Mass tourism development	
	Tourist period prolongation	
	Increased employment opportunities for young people, ensuring their staying in the area	
	Increase management effectiveness	

Source: Interviews

ecosystem services related to their activity (e.g., reduced natural grazing stocks, reduced populations of game species). However, they coincided with the coalition supported S3 (Point C, Fig. 4) on the grounds of not loosing "vested" interests such as free hunting and grazing areas. The Mayor shares the idea of Kalloni eco-development under S2 (Table 7) but his strong opposition to S1 and the ameliorated view on ecosystem services' current state that he held, differentiate him from the former groups of social actors (Point D, Fig. 4).

On the other hand, Parakoila citizen, Fishermen' Association representative, Municipal councillor 2, Kalloni citizen, Municipal Dept. President 1 and Citizens' committee against Natura 2000 supported S3 (Table 7) for different reasons. Parakoila and Kalloni citizens and Municipal councillor 2 (Point C, Fig. 4) highly evaluated Regulation, Habitat and Cultural functions and endorsed Kalloni's eco-development vision. However, they were opposed to S1 and S2 due to a widespread distrust towards implementing competent bodies, questioning thus scenarios' effectiveness, and solidarity feelings towards the people whose property would be confiscated. On the contrary, Fishermen' Association representative and Municipal Dept. President 1 clearly held a different vision for Kalloni, dictated by the augmentation of some ecosystem services such as "Production services", "Mass tourism" and "Substrate for human constructions" at the expense of all the others. However, they coalesce with other actors as their preferences differed in intensity. Finally, Citizens' committee against Natura 2000 fanatically objected to the implementation of any conservation plan, defending the interests of few people who owned land at the core conservation area. The former actors (G7, G4, G14) along with the Farmers and Hunters Associations' representatives had also in common the underlying belief that environmental degradation has been 'externally' driven (i.e., not provoked by themselves or the group that they represent) whereas "we have protected nature that was given to us from our grandfathers better than anybody or any plan".

These coalitions, displayed by NAIADE model, don't necessarily correspond to real-life community alliances though it is possible to overlap as, for example, NGOs and

Table 6 List of the selected evaluation criteria

Dimension	Criteria	Sub-criteria
Regulation functions	1. Disturbance prevention	1.1 Fire protection of forested areas
	2. Water regulation and supply	2.1 Projected regulations concerning the restoration, control and improved management of water bodies/resources
	3. Waste treatment	3.1 Wastewater management
		3.2 Solid waste management
Habitat functions	4. Refugium and nursery	4.1 Priority species coverage
		4.2 Area of core conservation zone
		4.3 Disturbance prevention
	5. Substrate for human use	5.1 Area of building prohibition and minimum size of land required for building
Production functions	6. Edible goods	6.1 Agricultural income preservation and attraction of young farmers
		6.2 Projected restrictions in exercising agricultural activity
		6.3 Conservation of fisheries' quality and quantity
		6.4 Maintenance of hunting activity
Cultural functions	7. Aesthetic information	7.1 Landscape preservation and restoration
	8. Culture, arts, science and education	8.1 Promotion of scientific, educational and cultural activities
	9. Recreation and tourism	9.1 Promotion of alternative tourism
		9.2 Promotion of mass tourism

Source: Reviewed and modified from Oikonomou and Dimitrakopoulos (2006)

Table 7 Multi-criteria and social evaluation rankings in NAIADE

Type of evaluation	Multi-criteria evaluation	Social evaluation (at 0.7329 coincidence degree)				
Coalitions		G15-G16-G13-G6-G7-G3	G14	G10-G12-G9-G11-G8-G2-G5	G4	G1
Rankings	S1 S2	S3	S3	S2	S3	S2
	S3	S2	S2 S1	S1	S2	S3
		S1		S3	S1	S1

Social actors		Scenarios
G1: Mayor	G9: Hotel owner 1	S1: Scenario 1
G2: Municipal Councillor 1	G10: Hotel owner 2	S2: Scenario 2
G3: Municipal Councillor 2	G11: NGO 1	S3: Scenario 3
G4: Municipal Dept. President 1	G12: NGO 2	
G5: Municipal Dept. President 2	G13: Hunters' Association	
G6: Farmers' Association	G14: Citizens' committee against Natura 2000	
G7: Fishermen's Association	G15: Kalloni citizen	
G8: Agro-tourism Women's Association	G16: Parakoila citizen	

Hotel owners in Kalloni case-study. For testing the robustness of social evaluation results, how slight changes to social actors' judgements affect the scenarios and coalitions' structure was examined. Slight changes to coalitions observed whereas scenarios' rankings remained the same.

Intersecting Multi-Criteria and Social Evaluations

Results from multi-criteria and social evaluation should be synthesized in order to define a starting point in searching for a scientifically adequate and socially desirable solution. In this case, S2 could be a defensible option based on its technical and social performance, as it is technically as good as S1 and it is the only scenario not vetoed by the coalition formed at the credibility level of 0.6345 (Fig. 4). This doesn't mean that S2 is desirable or acceptable by all social actors but it can be seen more as a base to build upon a co-created solution, negotiating the conditions under which a conservation plan could be approved without undermining its validity.

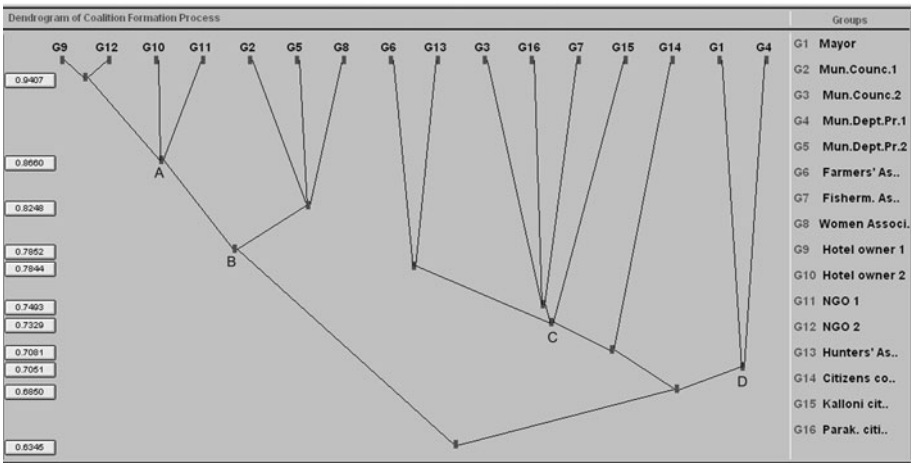

Fig. 4 Dendrogram of coalition formation process in NAIADE

Most of the social actors involved were willing to work on S2 in order to further unfold potential sub-options. Nevertheless, against the prime intention of the researchers and many of the participants, a discursive procedure was not possible to be upheld due to weak political will. It is interesting to note that local authorities, presumably due to the high political cost that they would have to undertake if supporting some social actors and neglecting others, decided to withdraw from the planning procedure and postpone the matter to the 'Greek calends' (i.e., forever).

Discussion

In this section, how the proposed methodological approach, contributed in overcoming the limitations or deficiencies of the prior conservation planning procedure in Kalloni, is discussed addressing key issues relevant to any evaluation process that has to deal with multiple objectives and values, uncertainty and lack of adequate information.

Framing of the Problem, Evaluation Process and Social Actors' Involvement

The Natura draft plan was submitted to the local community for approval at the end of the planning process, offering one single option which was not considered as 'transparent' or comprehensible by many of the social actors. The actual lack of a prior participative procedure and the insufficient dissemination of information allowed hidden background intricacies which were motivated by personal and political interests to take place, promoting a general confusion about the actual Natura plan. The extensive mistrust and the widespread disapproval and criticisms from the local community actually impeded the implementation of the proposed plan.

Taking into account this background, the methodology developed contributed to deal with some of these deficiencies. At the initial phase of the evaluation process, the ecosystem function framework provided the tool for approaching the complex system of Kalloni in an easier and more transparent way, decomposing it into its basic elements and identifying its important aspects and trends. Identifying important ecosystem services and related problems as well as proposing means to address these problems was a task familiar to the everyday life of the social actors involved. Moreover, this holistic approach of ecosystem function analysis gave 'food for thought' concerning other aspects of the Kalloni system and associated functions whose influence on human social structures, health and economy had not been consciously perceived before. Thus, this primary analysis served as the empirical basis to further reveal and articulate the underlying values and beliefs of local people and to outline the conflicts which emerged, so that problem framing result from a wider spectrum of perspectives.

Further on, this multiplicity of ideas, interests and expectations laid the foundations for developing the criteria and alternative scenarios. Criteria identification has been considered a difficult task for social actors due to its high complexity and specialized knowledge needed. This is why researchers initially propose a list of criteria which is then elaborated together with the social actors (e.g., Salgado and others 2009, Gamboa 2006). Ecosystem function framework facilitated the criteria selection by the social actors as the identified ecosystem services acted as the criteria. Thus, it was not necessary an initial criteria list to be provided by the researchers. Alternative scenarios were also created from social actors proposals. This condition of non-imposed 'remedies' encouraged a substantial dialogue and provided a mutual learning experience for both researchers and local actors. Moreover, it could be expected that such solutions would better respond to the 'real' problems generated under multiple value systems (Gamboa 2006).

Nevertheless, social values are relationally constructed among a multitude of actors, in relation to more permanent

structures in society (e.g., property rights) and in relation to ecosystem dynamics. As such social values are emergent and dynamic; thus social actors' preferences on the scenarios may change over time or during the decision-making process itself. New scenarios and criteria can emerge that will have to be incorporated and re-evaluated. Practically, the order of the different phases of the decision-making process is not strict and there are continuous feedback loops among them, as the nature of the evaluation process often dictates such circularity.

Concerning the contribution of the selected method NAIADE to the last phase of the decision-making process (i.e., the evaluation and comparison of the alternatives), it did not only perform a 'technical' comparison of the alternatives regarding some criteria, which is not always sufficient for the successful implementation of a plan, but also demonstrated a direction towards which a more socially desirable or acceptable solution can be found. Moreover, NAIADE was equally effective in dealing with the approximate evaluations of different social actors and not exclusively those of the experts, without having to be reduced to a common measure (e.g., monetary). In this way, it has been more transparent for the actors involved and facilitated their participation.

Dealing with the Socio-Ecological System's Complexity

Given the complexity of the socio-ecological system and the incomplete, imprecise and subjective knowledge about its functioning and dynamics (Munda and others 1994; Limburg and others 2002), statements concerning the description of its components and their interactions entail high uncertainty. According to Funtowicz and Ravetz (1994), under the concepts of post-normal science, uncertainty and ignorance cannot be managed by means of one-dimensional perspective and thus expressed in a single evaluating measure. The presented methodological approach presented attempts to deal with this inherent uncertainty by means of involving a plurality of legitimate perspectives and values as well as allowing it to be expressed in multiple metrics.

Extending multi-criteria into the concept of ecosystem services, the complex nature of ecosystem functions is subjected to multiple representations and evaluations. Thus, in contrast to the conventional valuation methods, perceived values on ecosystems functions and services do not have to be exclusively expressed in bio-physical or economic terms, as it is possible to use quantitative, qualitative, precise and fuzzy information.

In particular, by means of qualitative evaluations, NAIADE allows the intensity of impacts or preferences to be considered without having to define thresholds, or make excessive assumptions and forecasts which is even more difficult in highly uncertain environments characterized by extended lack of adequate information and when dealing with social actors' approximate evaluations. For example in the case of the Kalloni conservation planning, the lack of time series data, the vagueness and quite often the controversial nature of the available information and relevant conclusions deprived the analysis of finding accurate and quantifiable outcomes. A pertinent example is that of fishing activity where evidence (e.g., a ban in the collection of particular shells, point samplings, fishermen's considerations, disputes between fishermen and divers) indicates the degradation of fish and shell communities and the reduction of stocks. However, there are neither records of fish and shell annual production nor estimations for the reductions in fisheries and shell stocks.

Moreover, assessing the impacts of potential future actions on ecosystem services encompasses even higher uncertainty (referred to as stochastic uncertainty in Munda and others 1994). However, decisions have to be made even under such uncertain circumstances. The possibility to use qualitative information made it feasible to give a vague estimate of the performance of different actions in the future and to incorporate social actors' approximate evaluations, exploiting thus, both available scientific and local knowledge.

Integrating Different Tools

Extending multi-criteria evaluation into the concept of ecosystem services provided an alternative way to incorporate ecosystem services in environmental planning and decision-making, more suitable for cases where many decision makers are involved, uncertainty is high and values in dispute.

The contribution of social research techniques was considered vital for illuminating some specificities not easily traced by means of the NAIADE technical approach (considering even social evaluations' modelling). Similar intensities of some social actors' preferences and the corresponding coincidence degree indicated by the coalition dendrogram do not always reflect a coincidence on the motives of their evaluations. For example, Fishermen's Association representative (G7) and Citizens (G15, G16) did coalesce (Fig. 4) without sharing the same values on ecosystem services or the same motives. Thus, modelling results themselves could be misleading. Furthermore, information on the social actors' views concerning the comparison of the alternatives according to each ecosystem service is not provided by NAIADE. These specificities can be of high importance in conservation planning and decision making, as they can highlight the potential span for further intervention and changes on the alternatives.

Conclusions

Environmental management and conservation policy, embedded in the systemic concept of the unified socio-ecological system, is a scientific and technical as well as a political and social process. It can actually be seen as a conflict analysis of technical, environmental, socio-economic and political value judgements. However, conservation planning is often not treated this way within a Specific Environmental Study. Planning and evaluation results then, as in the case of Kalloni, justify the inefficiency of such exclusively technical approaches.

The conceptual framework presented and its application to the Kalloni case-study extended the multi-criteria evaluation to ecosystem services; a concept that is multi-dimensional itself and can capture a wider spectrum of values. These multiple and conflicting value judgements were then treated within multi-criteria analysis in order to facilitate decision-making process. The possibility of using vague and uncertain information made it feasible to perform this evaluation process in Kalloni and involve multiple social actors. Highlighting the knowledge gaps concerning certain ecosystem functions has given directions for future research.

The primary intention along with the final outcome of this evaluation process was to make the problem scope clearer, revealing the issues in dispute and the related trade-offs, as well as to reach some points of agreement between the different social actors as a base for the further co-evolution of ideas and potential options. So basically, this 'scientific exercise' should be considered to be only the beginning of a wider community dialogue, going beyond the results of a modelling process.

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