Project N°: 036992

ACRONYM : **S**cience **P**olicy **I**ntegration for **Co**astal **S**ystems **A**ssessment

REPORT

Defining Economic Dimensions of Coastal Systems

A guide to including economics in a modelled coastal zone system, with examples from study site applications

Rémi Mongruel, Harold Levrel & Melissa M. Mathews

March 2011

Ifremer, UMR Amure, Marine Economics Department,
Plouzané - France

How to cite: Mongruel R., H. Levrel and Mathews M., 2011. Defining Economic Dimensions of Coastal Systems: a guide to including economics in a modelled coastal zone system, with examples from study site applications. Spicosa Project Report, Plouzané – France, Ifremer.

Integrated Project funded by The European Community
Under the Sixth Framework Programme
Priority 1.1.6.3
Global Change and Ecosystems

Summary

This paper presents guidelines and examples for the inclusion of economic dimensions in the integrated assessment and system dynamic modelling approaches which are developed by the SPICOSA System Approach Framework (SAF) in support of Integrated Coastal Zone Management. Economic dimensions should be considered all along the different steps of the SAF implementation. During the "issue resolution" step, the coastal zone sustainability problem should be described according to the dominant policy perspective (ecosystem preservation, water quality, eutrophication, fishery management or aquaculture production). Later, the integration of economic dimensions in the coastal system design process will make possible to translate the sustainability problem into one or several classical environment and resource economics cases, such as: pollution (external effect of a Human activity on the environment), overexploitation (trend toward resource depletion), competition (for the allocation of space and resources to exclusive uses), congestion (lack of space in a public access regime), coordination ("soft" problem of competition and/or congestion), conservation (risk of biodiversity losses) or remediation (needs for the mitigation of impacts and damages).

In relation to the chosen policy issue, the capital approach helps to identify the main components of the coastal system from an economic point of view by considering natural, physical, human and social capitals. Economic actors of the coastal system may include the private sector (primary, secondary and tertiary sectors plus the non-productive private sector), the public productive sector (which furnish infrastructures and energy), the individuals (households, associations and lobbies) and the public institutions. The ecosystem services approach allows for identifying the main interactions between people and the Nature, which can be classified into three categories: pressure, dependency and remediation relationships. This framework can then be used to characterise the pressures and drivers of changes in the coastal zone. In addition to external drivers of changes (environmental change, demography, international markets, legal framework), drivers of change internal to the system include the stakeholders' economic objectives, such as profit maximisation (individual rationality), public good production (environmental policy) or benefit distribution (social concern for equity).

All these economic objectives being potentially contradictory, the last section of the paper considers the issue of trade-offs between economic interests and the related rules and social agreements. The relationships between economic actors may be classified into conflicts, dependency, cooperation, authority and negotiation. The institutional analysis suggests that the adaptation of social-ecological systems which face sustainability problems may privilege one or several of the following responses: regulation of access to resources (co-management, institutional arrangements), property rights shift (privatisation/collectivisation), public management rules (standards and norms), economic incentives (compensation, subsidies), restoration (technical intervention on the natural system) and deliberation for the definition of shared approaches, objectives, methods, means and measures. Finally, the limitations of the standard economics approach for assessing economic dynamics and interactions in the coastal zone are discussed, in order to enlighten the choice of the pertinent methodology for the provision of economic indicators and economic assessment in relation to the policy issue.

TABLE OF CONTENT

1 Introduction

Social-ecological interaction models can provide a common language between stakeholders to facilitate sustainable management of social-ecological systems (Arias and Fischer 2000; Boulanger and Bréchet 2005; Etienne et al. 2003; Low et al. 1999). Among the various classification of models, system modelling approaches are well-adapted for providing an integrated assessment of sustainability issues, as emphasized by Boulanger and Bréchet (2005). Ideally, capital stocks (human, social, physical and natural), ecological processes (resilience and productivity), economic processes (production and consumption), social processes (institutional changes) and social-ecological interactions (human pressure and ecosystem services needs for well-being) should be taken into account by these models (Arrow et al. 2000; Berkes et al. 2003; Costanza et al. 2001; Daily 1997; Dietz et al. 2003; Gunderson and Holling 2002; Ludwig et al. 1993; Millenium Ecosystem Assessment 2005; Ostrom 1990; Pretty 2003). In addition, system approach is often recommended in the context of expert advising for Integrated Coastal Zone Management (ICZM) implementation (van der Weide 1993; Fabbri 1998; Varghese et al. 2008). The purpose of this paper is to provide a methodology for incorporating economic dimensions in integrated assessment and system modelling approaches which are developed in support of policy-research joint initiatives toward ICZM.

While dealing with the economic dimensions of system modelling applied to coastal zone management, this support paper is designed for the use of scientists and managers who come from various disciplinary backgrounds. Even if “integrated approaches” for “sustainable development” on the policy side or for “multidisciplinary research” on the science side have flourished during the recent years, economic concepts and methods still fail to be properly integrated by non-economists from both the policy and research communities of practitioners. This may be due to the ability that economists have demonstrated to develop their own integrative concepts, like the “total economic value”, or integrative methods, like the “cost-benefit analysis”, which often lead to the illusion that the “economic science” alone can sort out of many choices the only best one, without any risk of mistake. On the other hand, the standard economic approach which is at the roots of these concepts and methods has turn out to face a lot of shortcomings, and sometimes failures, when environment and natural resources are at stake. Thus, from a practical point of view, economic valuation or cost-benefit analysis should be considered as some indicators among many others, including ecological and social ones, especially in the context of holistic approaches for the integrated assessment of dynamic complex systems. In addition, economic analysis is not limited to the estimation of value, costs and benefits and it may encompass many other dimensions and questions which could be useful for the building of integrated system approaches: the identification of actors, their status and their objectives, the understanding of social concerns and choices, the functioning of a local economy searching for more wealth, quality of life, social justice, the problems of natural resource uses and allocation, the trade-offs between ecosystem goods and services. From that perspective, this support paper will introduce basic economic concepts which will be adapted for the understanding of sustainability problems in the coastal zone, and illustrated by their application in the 18 study sites applications (SSAs) of the SPICOSA project.

2 Rationale of the approach

There are various economic dimensions within the System Approach Framework: they include the economic dimensions of the policy issue which is the starting point of the process, the economic dimensions of system representations and models which may be used as a support for discussion and decision-making, and the economic dimensions of the integrated assessment of the system under various possible scenarios for the future. In this support paper, we will focus on the economic dimensions of the policy issue and the system representation, even if the choices that would be made in these matters will definitely influence the methodologies to be used for integrated assessment. However, integrated assessment and scenarios methodologies are at the core of other sections of the SAF e-handbook.

2.1 Economic dimensions of the system approach

From an economic point of view, sustainability problems in the coastal zone may raise questions such as: environmental protection from polluting activties, natural resource uses and allocation, ecosystem goods and services supply (protection, conservation, restoration) and demand (amenities, recreational activities, environmental concerns), or welfare maximisation and distribution within a (mostly) local economy (economic development, quality of life, social justice). Thus the first step of the SAF implementation, which consists in defining the policy issue, is already a subject for the economic analysis as any sustainability problems is likely to include specific economic dimensions and even to be translated into one or a series of economic questions.

As regards the modelling tasks, the economic dimensions of a social-ecological system could be found both in its different components, which can be divided into natural components (mainly environment and resources) and social components (actors and institutions), and in the interactions between these components. The purpose of making explicit the economic dimensions of coastal system is thus simply to provide an economic view of the components and the interactions which are included within the system. Following our first broad definition of components of the system, three kinds of interactions occur: resource-resource interactions, actor-resource interactions and actor-actor interactions. To keep it simple at first, the socio-economic dimensions of the System Approach Framework (SAF) deal mainly with the two latter kinds of interactions[1]. Further complexity of interactions could be taken into consideration as long as the SAF design will move toward the inclusion of actor behaviours, social concerns, drivers of changes and feedback loops, especially into the sphere of governance. In parallel, as long as it will move toward a more complex representation of the system subject to the policy issue at stake, the participant group should select and announce which fields are intended to be covered during the next steps of the SAF implementation.

[1] Nevertheless the first kind of interactions, which is *a priori* purely an ecological interaction, can also become an actor-resource interaction as soon as there is at least one actor who considers this former resource-resource interaction as an economic or social stake; in the end the concerns about internal ecosystem interactions will certainly generate social debates and then enter the category of the “actor-actor interaction about Nature”.

The rationale of the System Approach Framework (SAF) is to depict how Nature and Society interact in a limited area, in relation to a specific issue, and to depict it with basic language that is understandable for scientists from various disciplines but also for stakeholders. At this stage, the exercise is rather simplistic as the objective is not to explain the functioning and the dynamics of the system, but to **correctly describe the system in an integrated way**, so that it will be possible to later adopt a more complex characterisation without removing any dimension of the SAF, especially economic and social dimensions. Because the approach relies on one specific policy issue, it should not provide a comprehensive system design, but because the approach has to be balanced as regards the three ecological, social and economic components, it is not recommended to use pre-existing approaches from different disciplines.

In order to make explicit the economic dimensions of the SAF, it may be suggested to adopt a step-by-step approach, along which economists from the participant group will have the responsibility to clarify two basic questions.

Question 1 - The first basic role of economic analysis will be explicating as clearly as possible the way people interact with the ecosystem (this dimension is fundamental for the clear representation of the economic part of the SAF). The mainstream economic approach to ecosystem valuation has clarified this point by adopting an instrumental approach which is based on uses (Turner et al. 2001; Turner et al. 2003): following this approach, the interaction between the beneficiary and the ecosystem that provides the benefit will be either a case of direct use, or a case of indirect use or a case of non-use[2]. To adopt a more generalized conceptual framework, it is possible to take into account the Millennium Ecosystem Assessment framework, which articulates the ecosystem services approach with the capability approach by Amartya Sen (Sen 1999; PNUD 2007) for linking ecosystem services with human well-being. The contribution of ecosystems to social welfare derives from their four main functions: provisioning services, regulating services, cultural services and support services.

Question 2 - The second basic contribution of economic analysis will be the translation of the interactions which appear to be at the core of the sustainability problem of the policy issue at stake into well identified and specific economic problems: problem of resource overexploitation, of pollution, of user's conflict or congestion, of conservation or of restoration, etc. This wording of the economic problem may help to define the boundaries of the governance component of the system and also to sort the questions that will be raised when assessing current and future states of the system. According to the kind of economic problem, appropriate economic analytical methods could be selected for understanding and estimating variations in the goods and services production or any other economic concerns in relation to the policy issue.

The choice of an assessment methodology to explore the future states of the coastal system is out of the scope of this support paper: it depends above all on the policy issue, the scenarios and the overall concerns of the evolving community that

[2] The non-use value obtained from surveys is always an instrumental value as it refers to people's preferences (demand) for resources and ecosystems conservation; it should not be considered as the intrinsic value of these resources or ecosystems, but rather as an indicator of people's preferences.

stakeholders and researchers should constitute during the SAF implementation. However, in a participative process, the way the economic dimensions of the system will have been designed in order to tackle with the policy issue at stake will certainly play a role in raising questions that may drive the integrated assessment procedure toward one method or the other. In order to discuss this point, this support paper will also provide a synthesis of the economic assessment methods that have been chosen by SSAs according to the economic dimensions of their system representation.

2.2 The "step-by-step" approach for describing the economic dimensions of coastal systems

In practice, the implementation of the SAF consists in exploring the issues associated with a sustainability problem and aims at building a virtual system which 1) depicts the ecosystems components, the human components and their interactions through ecosystem services, institutions and broader social processes (Figure 1) and 2) characterizes them with entities such as stock (except for interactions), flow, control and attribute variables. For each element (components, interactions) a limited set of variables should be selected according to the natural processes and policy issues at stake. A step-by-step approach is particularly adapted to develop such models. Work can be based on simple questions inspired by the Integrated Natural Resource Management approach (Lal et al., 2001), which can be implemented through the ARDI (Actor-Resource-Dynamics-Interactions) methodology (Etienne 2005; Levrel et al. 2008):

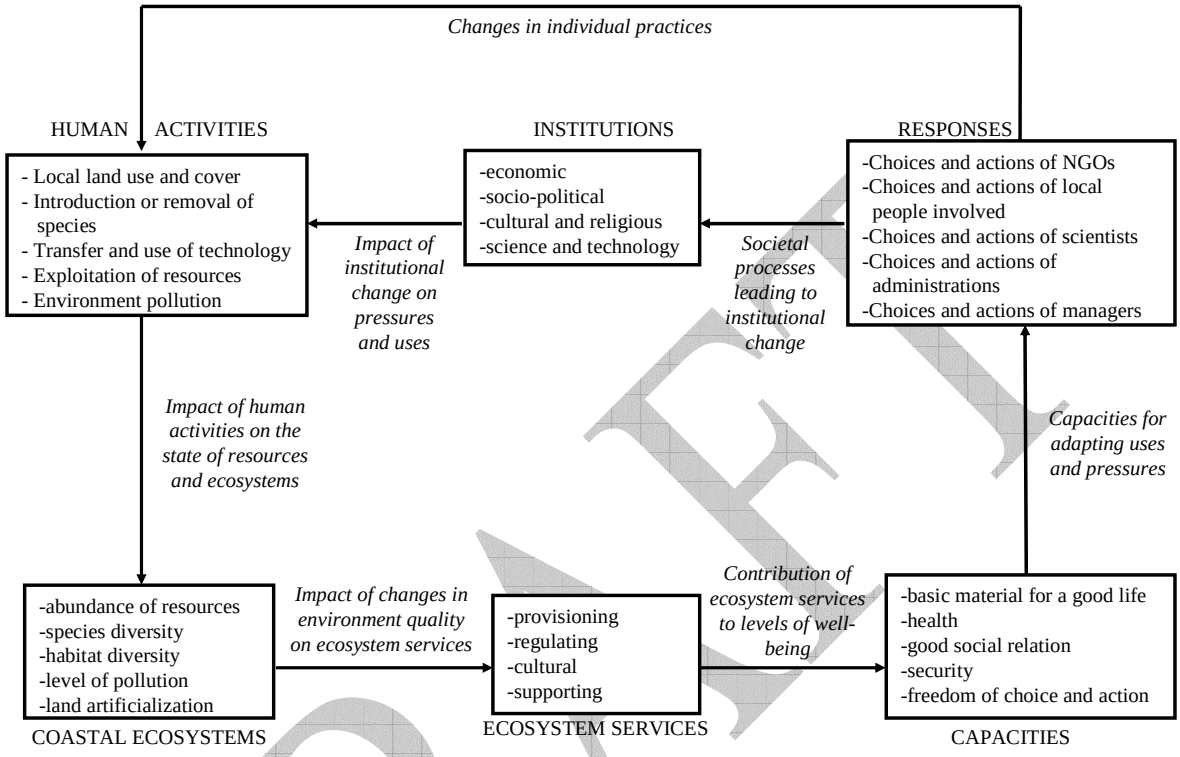
- Make a list of the main "actors" which are involved (as drivers, as impacted groups, as regulation bodies) in the specific question to be addressed in the study site;
- Draw up an inventory of the "resources" or key ecosystem services which encompasses the main uses of the site by actors, (or the main concerns of actors) as regards the policy issue;
- State ecological "dynamics" and the different transition phases for them;
- Describe "interactions" between human activities (or concerns) and ecosystem goods and services using a list of "sense-making verbs" describing the human action and a list of "sense-making signs" revealing the evolution of the status of ecosystem goods and services due to these human activities;
- Describe social "interactions" between actors as regards the policy issue (this is to make the problematic explicit, or the social concerns, associated with the policy issue: e. g. water quality means which level, for what, for whom…).
- In the end, it is required to identify the spatial and temporal reference scales regarding all these elements.

In addition to that, a focus on the economic dimensions of the system would require detailing the following points:

- Statement regarding the natural, human-made physical and human capital on a specific spatial scale,
- Statement regarding the relative weights of these capitals in their contribution to human well-being (supply of goods and services, source of employment),
- Statement regarding the distribution of costs and benefits delivered by these types of capital,

- Statement regarding substitution between different forms of capital, of goods and services, especially ecosystem services,
- Statement regarding the source of pressure leading to these substitutions,
- Description of interactions explaining these substitutions.

Figure 1. A social-ecological dynamic system in the coastal zone.



The last step of the step-by-step approach is to describe the adaptive decision-making process for each actor or sector (the individual choices, the rules in use, the institutional arrangements and the "social feedback loops"). To model individual adaptive behaviours, it is necessary to capture the cognitive models used by agent. One way is to use a storytelling methodology. Through storytelling, the representative of a particular stakeholder would draw a description of his activity and the information used during the activity itself. "Use information" are identified from the answer to the question "*how do the stakeholders procure, collect and/or make use of these resources ?*". "Decision criteria information are selected from the answer to the questions "*on the basis of what information, criteria and constraints do the stakeholders make decisions concerning their activities ?*" and "*what do they do with these resources ?*". Next, it is possible to identify the main institutions and convention which shape the social interactions and embodied power-relationships.

Trade-offs which are necessary to carry out this step-by-step work are facilitated by the use of mediation tools – diagrams, maps of the reserve, icons, figurines, arrows – that make it possible, step by step, to illustrate the results of discussions (for instance through C-map tools). By proceeding this way, a conceptual framework can be developed, consisting of an interaction diagram (between actors and resources). The fact that the agreements may be adopted without having all the information is not, as such, a major issue, since the model has to evolve along with knowledge and

representations. The model is not developed to describe reality but to explore it. In practice, a mediator is certainly needed in many case as he could play a neutral role in the step of scaling: to tackle this difficult task, the mediator may list the entities managed by the actors selected in the model, and the group could reach an agreement as to the best spatial and temporal scales to account for these management entities.

2.3 Defining the context: coastal system sustainability problems

Even if some sustainability problems are due to rapid changes, thresholds effects or accidental events and may therefore seem very new, no operational management initiative can be realistically considered as starting from zero. Whatever the specific policy issue at stake, the broader context of the existing sustainability problems and public policies should be taken into account. Table 1 provides a list of the main policy domains which are relevant for the purpose of Integrated Coastal Zone Management, together with the associated sustainability problems and social concerns. In many coastal areas, different social concerns interact with each other as the sustainability problem has many drivers and consequences: this classification should help to identify the main social concerns and policy domains to be taken into account when building a representation of an integrated system including the ecological, social and economic dimensions. Table 2 shows the contextualisation of policy issue of the SPICOSA study sites.

Table 1. Policy domains, social concerns and policy issues in the coastal zone.

Policy domain	Sustainability problem	Social concerns and policy issues
Environment protection	Pollution mitigation	Non-point source pollution, eutrophication
	Biodiversity preservation	Protected areas, species protection, containment of invasive species
Living Resources	Agriculture practices	Soil exhaustion, water pollution, irrigation
	Aquaculture management	Aquaculture production, sanitary norms
	Fisheries management	Fish overexploitation, local communities
Mineral and Energy resources	Hydrocarbon supply	Oil and gas exploration and production
	Sand exploitation	Beach replenishment, erosion control
	Renewable energy development	Wind-farms installation, wave energy
Water policy	Water treatment	Water treatment plants, sewage networks, industrial treatment facilities
	Water supply	Water allocation, tanks and river dams
Leisure policy	Recreational activities	Recreational fishing, beach frequentation
	Cultural activities	Landscape and patrimony protection
Land planning and public infrastructures	Land reclamation by households and tourism industry operators	Natural areas destruction, urbanisation, land and real estate market regulations
	Transport and communication	Port, harbours roads and bridges
	Civil Security	Protection against storms and inundations
Other public policies	National defence	Military restricted areas, military operations
	Education and research	Oceanography, biology, human studies

Source: after Clark 1996, Cicin-Sain and Knecht 1998, Turner et al 1998.

Table 2. Sustainability problems, social concerns and policy issues in the SPICOSA study sites.

NO	SSA	POLICY ISSUE	SOCIAL CONCERN	SUSTAINABILITY PROBLEM
1	**Riga**	Pikeperch Stock Management in Parnu Bay	Fisheries overexploitation	Fisheries Management
2	**Gulf of Gdansk**	Eutrophication and bacteria along three beaches	Beach quality	Water Management
3	**Oder Estuary**	Eutrophication management in the Oder Estuary	Agriculture pollution	Eutrophication Management
4	**Himmerfjärden**	Nitrogen management (in 3 drainage basins to Himmerfjärden SSA, the study site is divided into three catchment areas in the model to correspond to the three basins in the fjord; Himmerfjärden basin, Hallsfjärden basin and Näslandsfjärden basin)	Urbanization	Eutrophication Management
5	**Limfjorden**	Interactions between Eutrophication and mussel production in Limfjorden	Aquaculture production	Aquaculture Management
6	**Sonderledfjord**	Maximising local economic benefits from tourism while minimising impacts on local cod stock and minimizing conflicts with local users	Pressures from Tourism	Ecosystem preservation
7	**Firth of Clyde**	Impact of the number of yachts using Loch Fyne on the local mussel aquaculture industry	Water Quality	Water Management
8	**Cork Harbour**	"How to optimize the potential for expanding the leisure boat sector in the context of Cork Harbour's multiuse environment?" Policy issue concerns remain (a) the negative impacts on water quality and good environmental status of the Harbour (b) spatial impacts on natural habitat arising from the development of new infrastructure such as marinas in the harbor.	Pressure from Various Human Activities	Ecosystem preservation
9	**Scheldt Delta**	The apportionment issue of nitrogen in the Scheldt Watershed	Agriculture pollution	Eutrophication Management
10	**Pertuis Charentais**	Quantitative management of the freshwater in the Charente river basin	Water Allocation	Water Management
11	**Guadiana Estuary**	Water quality management in Guadania Estuary	Water Quality	Water Management
12	**Barcelona**	The effects of changes in water quality on the aesthetic and recreational aspects of the Barcelona beaches.	Beach quality	Water Management
13	**Thau Lagoon**	Management of the microbiological contamination of Thau Lagoon	Aquaculture (un)safe products	Aquaculture Management
14	**Taranto Mar Piccolo**	How to include mussel culture in a management plan for sustainable use of the Mar Piccolo resources	Urbanization	Eutrophication Management
15	**Venice Lagoon**	Sustainable clam farming in Venice Lagoon	Fisheries overexploitation	Fisheries Management
16	**Thermaikos Gulf**	Sustainable management of the mussel farming activity in the area of Chalastra	Aquaculture production	Aquaculture Management
17	**Izmit Bay**	Improvement of Water Quality in Izmit Bay	Water Quality	Water Management
18	**Bulgarian Black Sea CZ -Varna Bay**	How to maintain a good quality of bathing waters in Varna Bay?	Water Quality	Water Management

3 Economic components within coastal systems

Three steps will lead to the identification of the economic components of coastal systems: 1) to get an overall economic view of the coastal system based on the capital approach, 2) to identify the actors within the system and 3) to list the economic functions of the ecological sub-system according to the ecosystem services approach.

3.1 An economic view of coastal system: the capital approach

A simple way to give an economic picture of a social-ecological system is to assess the level of wealth in this system, that is, the total amount of capital. This total capital can be divided within three categories: man-made physical capital, human capital and natural capital (Dasgupta and Mäler, 2000; Dasgupta, 2001; Mäler, 2008). The man-made physical capital is composed of what is conventionally named "capital": factories, tools, machines, buildings. The human capital can be assessed by the health of population, the level of literacy, of skills, or life expectancy. The natural capital is founded on biodiversity, and more broadly on renewable and non renewable natural resources. These natural components contribute to the provision of ecosystem services for social-economic systems. According to conventional economics, these three capitals are sources of well-being through the goods and services they allow to provide. There is however a huge difference between the natural and human capital on the one hand, and the man-made physical capital on the other hand. The two firsts have a value by themselves. They are not only defined through an economic goal. They represent an end and not only a mean. Nature can be conserved for many other reasons rather than economic ones. Life expectancy and literacy have certainly more importance for human well-being than economic goods.

The sum of these three capitals is called genuine wealth. Assessing change in a system's genuine wealth is done by measuring change in the genuine saving. According to the World Bank, it presents "a nation's genuine savings rate after taking into account the depreciation of produced assets, the depletion of natural resources, investments in human capital" (The World Bank, 1997, pp. 1-2, quoted by Vanoli, 2002, p. 431). By definition, most of economic models assume that it is possible to substitute any capital by any other in order to produce a same level of wealth (Atkinson and Pearce, 1993). This assumption imply that one can destroy natural or human capital if this destruction enables to create man-made physical capital in a way that total amount of capital is higher than before. The underlined idea is that you can compensate or mitigate the decrease of one capital by the increase of another. It is why it is often highlighted that this assumption supplies an indicator of *weak sustainability*. Beyond the ethical problem raised by this assumption, the concept of natural capital has been criticized because it does not take into account the critical natural capital, which is the minimum natural capital required to maintain the basic functions of ecosystems (Ekins, 2003). Without this critical natural capital, there is a risk of collapse due to the existence of unknown ecosystem thresholds. The concept of critical natural capital is based on a principle of *strong sustainability*, which presupposes that a decrease of natural capital cannot be completely compensated

by the increase of man-made physical capital human capital. The critical character of this capital can thus be connected to the concept of resilience (Holling, 1973). The underlying idea is that the disappearance of this critical natural capital would generate ecological imbalances which would in turn lead to virtually irreversible social and economic crises (Gunderson and Holling, 2002).

Whatever the difficulties which are raised by the valuation of capital, the capital approach may help to identify the components of the system which are concerned by one local sustainability problem. This is illustrated in Table 3 which provides a list of the broad components of coastal systems which have been identified in several SPICOSA study sites. This table shows that the “natural capital” is merely envisaged according to the definition of “critical natural capital”, as the components which are listed in this category are directly impacted by the local sustainability problem. The man-made capital appears to be responsible for pressures on the environment or for mitigation of impacts. At last, the human capital consists merely in revenue and jobs, but also in the existence of collective actions or values.

3.2 Identifying key stakeholders

Many human activities exist in the coastal zone, from which a lot, but not all, depend directly on coastal ecosystems or are related to them. The people who are dependant on coastal ecosystems and those who are concerned by them may carry out various activities, which may lean on various motivations, such as economic, recreational, managerial, or even cultural and ‘ethical’ ones. The purpose of this paragraph is to identify, from an economic perspective, the human activities and the stakeholder groups which may be affected by the potential changes in ecosystems goods and services.

Basically, the economic analysis distinguishes three categories of actors: the producers, the individuals mainly seen as consumers, and the public agents. The producers are often depicted by a ‘representative-firm’ of a particular economic sector, which offers goods and/or services and tries to maximise its private profits according to the costs of production on the one hand and the conditions of the market on the other hand, especially the way the price reacts to changes in the supplied quantities. Due to the wide ranges of production cost structures and of market conditions which may exist in particular in the primary sectors, it is often necessary to distinguish sub-categories of producers into one economic sector (each sub-sector being depicted by a more narrowly defined representative-firm), according first to the size of the enterprises which is often strongly correlated with equipments and technical skills, and second to the outlets of the production and the consecutive prices. In addition, the objective of profit maximisation may not be achievable because of too much uncertainties or imperfect information, and businesses may rather target intermediate objectives, such as maximising global turnover, or searching, for a given objective of production volume, to minimise production costs or reach the breakeven point.

Table 3. Broad components of coastal systems according to the capital approach in SPICOSA study sites.

SSA	NATURAL CAPITAL	MAN-MADE PHYSICAL CAPITAL	HUMAN CAPITAL
Barcelona Coast	Water quality, beach	Local bars, restaurants, shops, waste water treatment plants, storm collectors	Revenues and employment
Cork Harbour	Water quality, nutrient	Marina infrastructure, recreational boats, marine recreational activities supporting infrastructure (slipways, moorings, berths, access points)	Income and employment, cultural capital, amenity values, availability and generation of local labour and skills
Firth of Clyde	Local Mussels	Yachts (boats), equipment for mussel aquaculture industry (mussel farm and mussel lines) and yachting, marina	Jobs/employment and households depending on marina and aquaculture, capital and labour
Himmerfjärden	Nitrogen, freshwater, water quality, wetlands, catch crops	Himmerfjärden sewage treatment plant, private sewers, buildings, engines, industries	Farmers participation to pollution mitigation programmes
Limfjorden	Blue mussels, water quality, nitrogen and phosphorus loads, eelgrass (*Zostera marina)*	Line mussel aquaculture, land-equipment of aquaculture companies, houses, house on land, fishing vessels	Amount of labour (fishing or farming effort), managerial skills and knowledge
Pertuis Charentais	Freshwater, wetlands, cultivated crops, coastal waters, cultivated oysters	Water Supply Plants, irrigation equipment, dams	Farmers income, amenity values, farming system
Scheldt Watershed	Nitrogen, riparian buffer strips (wetlands), water quality	Waste Water Treatment Plants	Income
Sondelerdfjorden	Wild and coastal cod stock (*Gadus morhua*), landscape – environmental quality, cod spawning stock, eelgrass, seals, birds	Second homes, fishing tourist accommodation and tourist accommodation (excluding 2nd homes and fishing), artificial beaches, aquaculture plants for juveniles	Conflict level, interaction values
Thau Lagoon	Shellfish, Water Quality	Water treatment plants, housing, harbour, boats equipment and infrastructure	Employment, regional added value, willingness to preserve traditional activities
Venice Lagoon	Clams – wild stock, nitrogen and phosphorus	Boats, equipment, engines, gasoline, materials, rake	Jobs, Income, profit

Table 4. Key stakeholders in the coastal zone: examples from SPICOSA SSAs.

Activity domain and stakeholders	SSA4 Himmer-fjärden	SSA5 Limfjorden	SSA6 Sonderled-fjorden	SSA7 Firth of Clyde	SSA8 Cork harbour	SSA9 Scheldt delta	SSA10 Pertuis Charentais	SSA12 Barcelona coast	SSA13 Thau lagoon	SSA15 Venice lagoon
Private sector (businesses and firms)										
Primary sector										
Fisheries		X	X							X
Aquaculture		X	X	X			X		X	X
Agriculture	X					X	X		X	
Forestry							X			
Secundary sector										
Food processing										
Biotechnology										
Polluting industries	X					X			X	
Tertiary sector										
Hotels and campsites			X					X	X	
Vacation homes			X					X	X	
Restaurants, pubs								X	X	
Tourism services (transportation, sport)				X	X			X		
Other services										
Non productive private sector										
Land owners			X							
Real estate owners			X							
Public productive sector (managers)										
Harbour infrastructures and services				X	X					
Water treatment plants	X							X	X	
Hydrological settlements (dams)							X			
Roads, railroads and airports										
Cultural services (parks, museums)										
Other public services										
Individuals (households)										
Recreational fishermen							X			
Landscape tourists	X			X	X					
Beach visitors	X					X		X	X	
Consumers of other public goods				X	X	X				
Consumers of private goods		X	X				X		X	
Consumers of private services				X	X					X
Environment lobbyists							X			
Social lobbyists										
Industrial lobbyists	X	X			X					X
Public institutions										
Fish and Sea management body	X	X	X	X			X			X
Agriculture management body							X			
Water management body						X	X	X	X	X
Environment management bodies		X		X	X	X	X			
Land management and spatial planning				X	X				X	
Research institutes							X		X	
Towns authorities	X		X		X			X	X	
Counties authorities					X	X				
Region authorities				X						
State authorities		X		X	X	X	X			
European authorities		X				X				

Source: list of activity domain and stakeholders adapted from Cisin-Sain 1998, Leafe et al. 1998, Turner 2000, Ledoux and Turner 2002, Smith 2002, Buanes et al. 2004.

The individuals are usually considered at first as consumers, who purchase marketable goods and services in order to maximise their utility. Obviously, the motivations of individuals are also likely to encompass wider concerns than material consumption: indeed, people act also either as household-leaders or as citizens, and as such they require infrastructures, health and education services and also amenities which may derive either from the 'social patrimony' (which provides cultural goods) or the 'ecological patrimony' (which provides environmental amenities). In that perspective, individuals formulate a demand-function (or a vector of needs) which

includes market goods and services but also public goods (see paragraph 4.3.1), to which belong most of the ecosystem functions. Finally, it appears that individuals may try to satisfy their needs either through their purchasing behaviour on markets, through their recreational behaviours, and through their demands expressed as voters or as lobbyists.

At last, public agents are usually depicted by the economists under the (fascinating) character of the 'social planner', whose role is to allocate resources in order to satisfy the objectives of each individual (producer, consumer and citizen) and finally to maximise the social welfare, in a never-ending search for Pareto-optimum situations. The Pareto-optimum is a (mostly theoretical) situation in which it is not possible to improve the welfare of an individual without making another individual worse-off. To put it short, the social planner searches in practice for an acceptable if not an optimal allocation of resources between the production of (a vector of) marketable goods (some of them being essential to support Human-life) and the production of (a vector of) public goods. In real-life, several social-planners are likely to intervene, sometimes with overlapping competencies, and in most cases with different perceptions of the general interest. However, it should be feasible to associate to each management body or public agent a more or less precise vision of the social welfare and the consecutive objectives.

In order to ensure the provision of public goods, the public bodies may not only engage into ruling and management but also engage into the production of common goods and services. That is why there exists a public productive sector, whose main role is to provide infrastructures (harbours, roads, railroads, airport, hospitals, schools, etc.) and immaterial services (transport security, health, knowledge), some of which being likely to play a key role in the implementation of the management of the ecosystems and the environment in the coastal zone. All these issues are related to the way society would like to evolve; therefore, these collective issues may be better reflected into the multi-dimensional concept of well-being than in the single-dimensional and purely economic concept of welfare.

Finally, of course, the motivations or 'objective-functions' of each actor may be far more complex: this issue will be further examined when considering the key-role of objective-functions as economic-driving forces of the system (see paragraph 4.1.2). For the purpose of identifying the stakeholder groups that belong to the targeted coastal system, we propose at this stage a list of human activities, which are likely to take place in the coastal zone and present a significant relationship with the natural system. Actually, it is difficult to suggest a more precise and exhaustive list of economic stakeholders in the coastal zone, because this list depends on the main policy issue to be discussed, the zone where this issue is analysed, the activities which are really represented in this area (aquaculture can encompass different kinds of activities depending on the coastal area, the countries, the cultural heritage…) and the level of implication of each stakeholder group. Thus a scoping methodology like stakeholder mapping (Buanes et al. 2004; Reed et al. 2009) or DPSIR (Brouwer et al. 2001) is often useful to make explicit which human activities have strong relationships with the ecosystems and the environment. For illustration, Table 4 provides the list of the key stakeholders which have been included in the system representations of the SPICOSA study sites.

The identification of key local actors is necessarily a subjective task which should be carried out in a participative way to avoid missing and misunderstandings. Even in relation to a specific coastal issue, individuals remain very broad categories which could be more easily depicted by their demand function (for goods, as expressed on the demand side of a market, or for social concerns, as expressed by votes or through lobbying). Selecting the (groups of) individuals to be taken into account, but also all the other actors, implies to identify the limit of the relevant population according to the issues at stake. For example, some governance bodies will have to be included in the system-design because they exert relevant competences in the considered coastal area, or some social groups (associations, NGOs) will have to be included as they express a specific concern in relation to the coastal system. In addition to the institutional and "active" stakeholders, other stakeholders whose views and interests are less influent on common collective views (claimant or latent stakeholders) could also be integrated (Buanes et al 2004). At this stage, the selection of actors should work in parallel with the identification of interactions which are meaningful regarding the policy issue.

3.3 Ecosystem services (ES) in the coastal zone

The classification of ecosystem services adopted by the MEA distinguishes the following four categories: provisioning services, regulating services, cultural services and supporting services (MEA 2005). **Provisioning services** are the products obtained from ecosystems, including food derived from animals, plants and microbs, biological material for medicines or food additives, material such as wood and energy derived from biological material. **Regulating services** are the benefits obtained from the regulation of ecosystem processes, including climate and water regulation, erosion control, water purification and waste treatment, regulation of human diseases, biological control and storm protection. **Cultural services** are the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. At last, **supporting services** are those that are necessary for the production of all other ecosystem services; they differ from the formers in that their impacts on people are either indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people.

The strengths of this approach are the following:

- It is a clear logical framework based on a comprehensive list of ecosystem services organised into four categories.
- The concept of ecosystem services is directed equally to the social sciences and to the natural sciences.
- It provides a benchmark for analysing the interactions between issues of environment conservation and economic development.
- It offers an original way for using scenarios through which interdependencies between political choices, conservation goals, human uses and well-being can be highlighted.

Table 5. List of ecosystem goods and services in the coastal zone.

Support (7)	**List of services**
1	Primary productivity
2	Secundary productivity
3	Oxygen and carbon cycling
4	Nutrients cycling and mineralization
5	Water cycling
6	Bioturbation (sediment mixing)
7	Production of habitats for animals and plants (soil formation)
Provisioning (14)	**List of services**
8	Renewable energy
9	Fish, shellfish, crustaceous, alga and by product for human food
10	Non renewable energy (oil, gaz)
11	Seed and broodstock to aquaculture
12	Fish meal, fish oil and fodder for animal food
13	Fertilizer
14	Drugs and pharmaceuticals
15	Chemical models
16	Test organisms
17	Genetic support
18	Construction materials (sand, granule)
19	Materials for manufacture industry (for fashion, handicraft, jewelry…)
20	Molecule for industrial production (cosmetics, glues…)
21	Support for the transport of commodities and people
22	Fresh water storage (estuaries)
Regulating (20)	**List of services**
23	Soil fertility dynamics
24	Control of phytoplankton dynamics
25	Control of zooplankton dynamics
26	Control of fish, crustaceous, shellfish, cephalopods, mammals populations dynamics
27	Spawning area for biodiversity
28	Refuge area for biodiversity
29	Resilience and resistance against natural and anthropogenic disturbances
30	Pest and human virus control
31	Mitigating eutrophication
32	Detoxification, decomposition and bioremediation of waste
33	Energy transfer toward high trophic level
34	Maintaining the hydrological stability and mitigate flood
35	Water turbidity control
36	Purification of water
37	Control of wave and current energy
38	Erosion and siltation control
39	UV protection
40	Purification of air
41	Gaz regulation, carbon storage and regulation of global climate
42	Gaz regulation, carbon storage and regulation of local climate
43	Support for transport of carbon, minerals, nutrients, species (marine corridors)
Cultural (19)	**List of services**
44	Support for local traditional professional activities
45	Cultural identities of coastal human populations
46	Views and landscape
47	Eco-tourism
48	Vision tourism
49	Hiking
50	Bathing
51	Beach game
52	Recreational fishing
53	Boating
54	Scuba diving and snorkeling
55	Surf and windsurf
56	Inspiration
57	Source of well-being (feel good, good health)
58	Support for religious believes
59	Conservation of marine and coastal biodiversity by ethical choice
60	Source of knowkedge
61	Scientist uses (marine models in fundamental research)
62	Scholar trips
63	Laboratory for monitoring of environmental global change

Source: Beaumont et al. 2007; Costanza et al. 1997; Duarte 2000; Holmlund and Hammer 1999; Jackson et al. 2001; Kaiser et al. 2005; Kremen 2005; MEA 2005; Rönnbäck et al. 2007; Solan et al. 2004; Wilson et al. 2004; Worm et al. 2006.

Ecosystem services are delivered by natural capital. However, if a part of natural capital disappeared through the decrease of biodiversity, it is sometimes possible to compensate this loss by human capital and man-made physical capital. However, this option raises several problems: it is costly, it is not possible to compensate all ecosystem services supported by natural capital destroyed and it is not possible to compensate the population equitably for all the losses incurred. For coastal and marines areas, it is possible to list ecosystem services from the existing literature on this topic (Table 5).

Human societies have been interested in the production of provisioning ecosystem services but not by regulating, supporting or cultural ones until now. It is why for a long time all techniques and human efforts were invested to improve the productivity of provisioning ecosystem services. This policy was a source of huge substitution dynamics:

- first with the increase of man-made physical capital (artificial fertilizer, pesticide, tractor, agricultural machines…) into the production of provisioning ecosystem services at the expense of human and natural capitals,
- second with the increase of ecosystem and species dedicated to the production of provisioning ecosystem services (productive species, intensive agricultural areas, genetic selection…) at the expense of cultural, regulation and support ecosystem services.

However, since environmental issues and needs of the leisure society are raising, these last three categories of ecosystem services become a new important question for human society. Investing into natural capital to deliver cultural services makes sense for all the tourism sector because a large part of recreational activities during free time are based on a clean and adapted natural environment. For regulation ecosystem services, there is an important investment in natural capital from ecosystems restoration program which are important for the quality of certain products such as drinking water. To pump freshwater, many counties invest in the restoration of water basins. To be able to benefit from a quality label some bottled water firms restore ecosystems around the water source. There is nowadays a huge challenge for reconciling development and conservation goals. The “ecosystem services” entry can be useful for it because it enables to explicit concretely different management options and to underline tradeoffs in terms of capital and types of ecosystem services.

All the aforementioned ecosystem goods and services (Table 5) could be found in any coastal system. According to the policy issue which will be addressed by an SSA, but also considering internal interactions within the system, it should be possible to progressively restrain the scope of the system design to a limited number of ecosystem goods and services to make it easier to handle.

4 Economic interactions in the coastal zone

This section depicts first the “pressures and drivers” which shape the interactions between stakeholders and natural systems in the coastal zone and second the “conflicts and institutional arrangements” which shape the interactions among stakeholder groups about Nature in the coastal zone. The last part of this section goes further in the analysis of the economic dimensions of these interactions by considering the variety of economic goods which co-exist in a social-ecological system, the way a sustainability problem may be formulated into a typical economic problem and finally how to reach an agreement on an economic assessment methodology, according to the scope and limits of different economic approaches.

4.1 Pressures and Drivers: interactions between stakeholders and ecosystems in the coastal zone

This section deals with the economic drivers of changes in the coastal zone. Depicting economic dynamics, including social groups and individual behaviours, is the main challenge for the integrative system approach. The difficulty is twofold. The first difficulty is that the behaviour of stakeholders is both a source of pressure on the ecological part of the system and a source of social responses to the possible consecutive ecological problems of the system. The second difficulty, is that the behaviour of stakeholders may be depicted assuming the hypothesis of ‘substantive’ rationality, which means that each individual has a full pre-existing knowledge of what is his best desirable future, or the hypothesis of ‘procedural’ rationality, which means that no one has such a knowledge and thus ‘learning-by-doing’ approaches dominate the society. These difficulties will be examined in the following paragraphs. However, the multidisciplinary approach which is required to represent complex social-ecological systems may offer the opportunity to balance those two hypotheses.

4.1.1 Pressures for changes in the coastal zone

Various inventories have been made of the major anthropogenic pressures and the consecutive management concerns in the coastal zone (Cicin-Sain and Knecht, 1998 p.42; Turner, 2005, p.264). Besides environmental problems (climate change, sea-level rise, pollution), the main drivers of changes in the coastal zone are population growth, increasing demand for tourism and recreational activities, exploitation of natural resources and spatial planning initiatives that intend to cope with all these issues. As a result, the following generic problems due to anthropogenic pressures are likely to occur in one coastal system:

-Natural Resource depletion
-Pollution (due to agriculture, industry)
-Hazards (accidental events)
-Ecosystem damage, including eutrophication and biodiversity losses
-Sea-Level rise and coastal erosion
-Land use: harbours and related industries development, trade, tourism
-Population growth
-Climate change

-Economic opportunities and new human activities

Table 6. Pressures exerted on the coastal system in the SPICOSA study sites.

SSA	Pressures on the social-ecological system
Barcelona Coast	*Heavy storms, microbiological contamination*
Cork Harbour	*Nitrogen loadings in the marine ecological subsystem and sustainable development of new marina capacity, facilities and related service infrastructure*
Firth of Clyde	*Antifoulant on the hulls of the yachts and sewage from yachts and step-ashore facilities*
Himmerfjärden	*Nutrient loadings from agriculture, private sewers, Himmerfjärden sewage treatment plant and recreational activities (minor role)*
Limfjorden	*Mussel fishing, mussel farming, nitrogen and phosphorus influx as an independent variables where it comes into the fjord*
Pertuis Charentais	*Water shortage and demands from: 1) good ecological status of the coastal ecosystems; 2) availability of drinking water for households (and tourists); 3) other private uses (agriculture, shellfish farming, etc.).*
Scheldt Watershed	*Agriculture, private sewers, pipeline building, and recreational activities*
Sonderledfjorden	*Fishing efforts by tourists, recreational fisheries by locals, commercial fisheries, fishing mortality of seals and birds on fish stock, building and maintenance of 2nd homes*
Thau Lagoon	*Nine types of microbiological sources due to human activities or wild life are considered in the model. Seven of them impact the watershed: housing with individual sewage system, waste water treatment plants (WWTP), pumping stations, surface run-off, camping grounds, storm water basin, industrial run-off and animal breeding. Two are directly active in the lagoon: harbours/boating and birds.*
Venice Lagoon	*Clam farming, clam fishing, industrial activity*

In addition to the direct pressures exerted by human activities, other interactions may exist between stakeholders groups and the ecosystems: some stakeholders may be dependant on the ecosystem relative good status while other ones try to restore ecosystems. All these interactions may be made explicit using a list of “sense-making verbs” and “sense-making signs”. The rationale of this approach is to describe precisely and concisely the human action in relation to the ecosystem goods and services, and to reveal the evolution of the status of ecosystem goods and services due to human activity. Hereafter are some examples of human actions in relation to ecosystem goods and services in the coastal zone: fishermen *extract* fish from natural stocks, agriculture *pull water* for cultures (input) and *put fertilizer* into water (pollution), tourists and residents *consume* water for drinking, washing, cleaning, environmentalist organisations *seek to protect* resources and natural assets.

4.1.2 Drivers of changes in the coastal zone

According to the hypotheses of the substantive rationality, economic behaviours are lead by the following objectives: maximisation of profit (producers), maximisation of utility (individuals) and inter-generational maximisation of social welfare (social-planner). These objectives may be made more precise, and be translated into specific or operational objectives, eventually by considering first-rank (optimum situation) and second-rank objectives (in the case of imperfect competition, information asymmetries, limited knowledge, remaining externalities, etc.). The difference between the second rank objective and the first one is that the second rank objective should be considered as the “achievable” objective (for example minimising costs rather than maximising profits, because it is easier to control internal drivers, than external ones, even if some costs are driven by external factors). The achievable objective may be defined as the objective that a stakeholder will appear to target once the most unrealistic standard hypotheses have been removed.

Table 7. Relationships of "Pressures, dependencies and remediation" between Human activities and ecosystem services in SPICOSA study sites.

STUDY SITE	HUMAN ACTIVITY	ECOSYSTEM SERVICES: SUPPORTING	REGULATING	PROVISIONING	CULTURAL
Sonderledfjorden	Fishing (tourist, recreational and commercial)	Production of habitats for animals and plant [dependency]	Eel grass area as habitat for biodiversity [dependency] Eel grass for fish juveniles to grow [dependency]	Commercial fish [pressure and dependency – too much fish removal causes the it to pressure and dependency as it needs fish to be able to do fishing]	Size of cod stock and density affects the environmental index [dependency] Perceived aesthetic value [dependency]
	Building and Maintenance of 2nd homes and other construction activities	Production of habitats for animals and plant [pressure]	Eel grass area as habitat for biodiversity [pressure from sediments and land reclamation etc]	Commercial fish [pressure as the activity affects the habitat and size of food stock]	Landscape and aesthetic values [pressure and dependency]
	Aquaculture – Marine Hatchery * water source from land			Commercial fish [remediation as fish production instead of from the open sea]	
Pertuis Charentais	Drinking water demand from Households and Tourists	Biodiversity maintenance (pressure as water is drained away)		Drinking water supply irrigation of crops (pressure as water irrigation conflicts	
	Agriculture/Irrigation,	Coastal productivity (pressure due to increase in agriculture pollution) Biodiversity maintenance(pressure due to increase in agriculture pollution	Sediment control in the wetlands (pressure due to increase in agriculture pollution) Saline water for Oyster growing (pressure- may change due to changes in pH because of agriculture pollution)	Drinking water supply (pressure due to increase in agriculture pollution and competition for allocation) Irrigation of crops (dependency – for agricultural activities and pressure due to agriculture pollution)	Recreation and tourism (pressure as the effects of agriculture may influence the aesthetics enjoyed by tourist)
	Aquaculture (Shellfish Farming) – requirement of nutrients	Coastal productivity (dependency on nutrients) Biodiversity maintenance (pressure as water is drained away)	Saline water for Oyster growing (dependency)	Drinking water supply (pressure as water allocation conflicts) Irrigation of crops (pressure as water allocation conflicts)	
	Recreational activities	Coastal productivity (dependency for tourism maintenance) Biodiversity maintenance (dependency as tourists treasure biodiversity)		Drinking water supply (pressure as water allocation conflicts) Irrigation of crops (pressure as water allocation conflicts)	Recreation and tourism (dependency and pressure – need the activities but may produce factors that could repel the tourists)

4.1.3 Drivers of changes in the coastal zone

According to the hypotheses of the substantive rationality, economic behaviours are lead by the following objectives: maximisation of profit (producers), maximisation of utility (individuals) and inter-generational maximisation of social welfare (social-planner). These objectives may be made more precise, and be translated into specific or operational objectives, eventually by considering first-rank (optimum situation) and second-rank objectives (in the case of imperfect competition, information asymmetries, limited knowledge, remaining externalities, etc.). The difference between the second rank objective and the first one is that the second rank objective should be considered as the "achievable" objective (for example minimising costs rather than maximising profits, because it is easier to control internal drivers, than external ones, even if some costs are driven by external factors). The achievable objective may be defined as the objective that a stakeholder will appear to target once the most unrealistic standard hypotheses have been removed.

Table 8 presents a list of human activities in the coastal zone with their main objectives and the standard economic methods that allow to assess these activities and also to suggest some adaptive behaviours or management measures whose implementation would help to drive the system toward a more desirable state. The adaptations that economic agents may implement are numerous (see paragraph 5.1). One stakeholder' adaptive behaviour may depend on his objectives, including his perception of the desirable future of the ecosystem.

Implicitly, it is considered here that there exist at least some 'social incentives' which call for taking the ecological status of the system into account (that explains the adaptive behaviours and measures). An opposite example would have been the application to fish stocks of "pure capital" theory (Clark 1973): when a renewable resource has a low rate of reproduction, it may be rationale to extinct the stock, depending on the evolution of the value of money over time, which is fixed by the discount rate. This strategy would be feasible only if exists no social demand exists for fish stock conservation. Nevertheless, despite it is not realistic, this example emphasizes that the time horizon according to which each category of stakeholders usually makes its decisions should be considered. Generally, individuals and private bodies show a preference for short-term maximisation criterion, while collective groups or social planners are more likely to consider the long-term effects of their actions. Formally, the time horizon for individual preferences or collective decision-making may be incorporated into economic assessment through the discount rate.

The possible discrepancies between private objectives and social objectives may occur especially when there are indirect consequences of the pressure that individuals exert on the environment. For instance, this issue has been addressed by new bioeconomic models which consider the competition of different species for the same resource and try to estimate the differences between private and social optimums in such situations (Brock and Xepapadeas, 2002). A typical example of such complex ecological interactions resulting from Human pressures is the case of multispecies fisheries in which competing or interdependent populations (within a predator-prey relationship) of fish are harvested (Clark 1990), leading eventually to discards due to technological externalities (Singh and Weninger 2009).

Table 8. Stakeholders and their economic objectives in the coastal zone.

	Objectives 1	Objectives 2	Assessment
Private sector (businesses and firms)	Profit maximisation	Turn-over maximisation or Costs minimisation Breakeven point	
Primary sector			
Fisheries	Optimisation annual	Race for fish	Bioeconomic analysis
Aquaculture	Optimisation 3-4 years	Productivity	
Agriculture	Optimisation annual	Productivity	
Forestry	Optimisation 10 to 30 years	Productivity	
Secundary sector			*Other methods :*
Food processing	Profit maximisation	Product differentiation	Financial analysis
Biotechnology	Profit maximisation	Innovation rent	Supply-chain analysis
Polluting industries	Profit maximisation	Cost externalisation	Market integration analysis
Tertiary sector			Business strategy analysis
Hotels and campsites	Profit maximisation	Frequentation	
Restaurants, pubs	Profit maximisation	Frequentation	
Touristic activities (excursions, sport)	Profit maximisation	Frequentation	
Other services	Profit maximisation	Frequentation	
Non productive private sector			
Land owners	Annual rent maximisation	Speculation	Land-market analysis
Building owners	Annual rent maximisation	Speculation	Real-estate market analysis
Public productive sector		(Support to industry, tourism and households)	
Harbour infrastructures and services	Public good production	Access facilities	
Water treatment plants	Public good production	Water supply (quality and quantity)	
Roads, railroads and airports	Public good production	Access facilities	Cost-benefit analysis (CBA)
Cultural services (parks, museums)	Public good production	Life-quality and entertainment	Cost-effectiveness analysis (CEA)
Research	Public good production	Support to management bodies	
Other public services	Public good production	Supports: energy, health, education	
Individuals			
Households	Utility maximisation	Private and Public goods	Micro-economic analysis Public economy (norms and taxes)
Environment lobbyists	Environment protection	Norms or incentives	Stated preferences Revealed/observed preferences
Social lobbyists	Social equity	Welfare distribution, access-rights, privileges	Political economy Theory of justice
Industrial lobbyists	Economic efficiency	Rent-seeking	Political economy Imperfect competition
Public institutions			
Fish and Sea management body	Sectoral policy objectives	MSY, food supply, jobs	Bioeconomic analysis
Agriculture management body	Sectoral policy objectives	Food supply, jobs, landscape	Cost-benefit analysis (CBA)
Water management body	Sectoral policy objectives	Water quality, water supply	Cost-effectiveness analysis (CEA)
Environment management bodies	Sectoral policy objectives	Protected areas, norms/standards	Multi-criteria analysis (MCA)
Land management and spatial planning	Sectoral policy objectives	Spatial planning	
Towns authorities	Public policy objectives		CBA, CEA, MCA, Multi-criteria analysis Input-Output analysis Computable general equilibrium model (CGEM)
Counties authorities	Public policy objectives		
Region authorities	Public policy objectives		
State authorities	Public policy objectives		

4.2 From conflicts toward institutional arrangements: interactions between stakeholders about Nature in the coastal zone

Usually, interactions between stakeholders in the context of a sustainability problem are most of the time seen as conflicts. This is indeed the case when people compete for resources and space or when some of them generate environmental damages (pollution, ecosystem destruction) which are detrimental to other stakeholders. On the other hand, some interactions may also take the form of mutual beneficial interactions (Cicin-Sain and Knecht 1998 p.31), or at least one of activity may generate a positive externality for another one: for instance, wind-farms may serve as support for off-shore shellfish farming settlements (Buck et al, 2010). However, it

would be closer to reality to consider dependency relationships. Starting from these two situations (conflict and dependency), stakeholders may engage into different forms of collective actions: decentralised cooperation, the call for the intervention of public authorities or negotiations. Table 9 depicts interactions between stakeholders in the SPICOSA study sites. In most cases, the intervention of authority is followed by negotiations with some user groups, what constitutes a typical situation of co-management (Plummer and FitzGibbon, 2004).

One social-ecological system is generally placed under a complex frame of national laws and regional plans which deals with various policy domains such as Environment Policy, Water Policy, Agriculture and Fisheries Policy and Spatial Planning. In each domain, the institutional framework encompasses European or national laws, which are declined into local collective rules, which themselves are subject to operational agreements between users and the administrative bodies, or among users themselves (see table 10). The identification of the formal organisations, the rules in use and the institutional arrangements will help to better understand the rationale and the context of the ongoing or proposed changes in the Human parts of the social-ecological system. In practice, improving the management devices toward sustainability will typically consist in implementing policy options such as:
-changes in user practices (technology, intensity);
-shift in use-rights (reallocation of resources);
-economic incentives (taxes);
-standards and norms (e. g. WFD);
-new public infrastructure (water treatment plants);
-protection measures (MPA);
-mitigation measures (private treatment systems).

The feasibility, the enforcement and the effectiveness of each change of this kind which could occur in the management framework will always depend on various other dimensions of the governance system. In practice, any change regarding one aspect of the governance system will generate innovations such as new management bodies, new rules-in-use or new institutional arrangements, which should be considered when testing, or at least when interpreting governance scenarios.

Table 9. Interactions between stakeholders in the coastal zone: examples from SPICOSA study sites.

	CONFLICT	DEPENDENCY	COOPERATION	AUTHORITY	NEGOTIATIONS
Barcelona Coast		First line businesses dependent on tourist and residents whose frequency depends on water quality of the beach			
Cork Harbour	Conflict due to physical resource allocation, resistance from locals, failure comply regulations and competition space and access rights			Politicians authorities decision on development	
Firth of Clyde	Competition conflict between marina business and mussel farmers				
Himmerfjärden	Arising conflict in terms of sewage treatment capacity as more and more nitrogen are released		Farmers to volunteer to construct wetlands in their agricultural landscapes	There is a possibility for Government are paying the investment costs, operating costs and subsidies for farmers to be compensated for wetland creation	County Board holds an information campaign to persuade farmers to build wetlands
Limfjorden			Mussel farmers cooperate in a sales cooperation, where they plan to meet obligations to a purchaser	Food agency carries out the closing of the fisheries and harvesting/marketing ban on mussel farming and mussel fishing when there are harmful algal blooms.	
Pertuis Charentais	Conflicts between different extractive uses of the water from the Charente river,		Some cooperation between farmers in upstream sub-basin	Representatives of the prefecture sets restrictions: Agriculture administration distribute access rights for water	Negotiations between farmers and public authorities regarding authorized volume of water per activity
Scheldt Watershed			Negotiations and compromise between governments of France, Brussels and Netherlands. Farmers and industries are subject to the laws including nitrogen limitations.	The European Commission in Brussels holds the authority over the countries to comply to the EU regulations such as Water Framework Directive for the Scheldt Basin	
Sondeledfjorden	Conflicts between local users and tourists due to the seasonal overcrowding and tourists not spending money. Conflicts between commercial fishers and tourist fishing operators and anglers interest groups due to the cod distribution				
Thau Lagoon	Shellfish farming industry conflict over space allocation and ecological blight Mortality of business due to sanitary closures leading to acquisition by wealthier companies.			Sanitary closures of shellfish farming by authorities	Shellfish farmers negotiate with public authorities regarding the subdivision of the area as regards to the sanitary monitoring
Venice Lagoon	Conflict between clam fishermen, local authorities, fishermen, consumers, fishery cooperatives and illegal fishermen on productive water basin, sanitary issues, resource allocation, non-compliance of rules			Fishermen cooperatives pay an annual fee to Water Authority (management of clam activity) to manage the harvesting of clams within restricted lagoon areas	

Table 10. Institutions: Formal organisations, rules, regulations and institutional arrangements in the SPICOSA study sites.

		Rules and regulations		
SSA	***Formal organisation***	***International Laws/EU Directives***	***National or Regional Laws***	***Local rules and institutional arrangements***
Limfjorden	European Union, Ministry of Fisheries, Ministry of Environment, Food Agency, Sales Cooperation	European Union (EU) Water Framework Directive and EU Natura 2000 (reductions of nitrogen and phosphorus levels to the target levels), Habitat Directive, Food Safety regulations (oxygen and nutrients)		Quotas (self regulation among mussel fishermen; maximum daily quotas, maximum weekly quotas, maximum weekly harvest, total yearly harvest of 45 tons/week and seasons with closed fishing), State regulations, quotas, license allocation, access regulations (closed and open seasons), Licenses on vessels on fishing and license on mussel aquaculture (mussel aquaculture – restricted to the area allocated) – state regulations
Sonderledfjorden	Ministry of Fisheries, Risør Municipality		Norwegian Directorate of Fisheries 2008: The Free Access Right Allemannsretten)	Planning and Building Act/Marinas and Second Home: regulation of construction of sandy beaches and marina Salt Water Fishing Act: Rules covered are minimum cod size, total allowable catch, limitation fishing periods and use of gears Restrictions on tourist fishing and export
Firth of Clyde	Scottish Central government, local government, agencies: SEPA, SNH, CE, Argyll and Bute Council (A&BC), Scottish Sustainable Marine Environment Initiative (SSMEI)	Water Framework Directive	Scottish Marine Bill 2010 Scottish Sustainable Marine Environment Initiative (SSMEI): Draft marine spatial plan for the broader region	External sources and sinks of money via taxes, grants, rents, repayment loans, depreciation and investment Argyll and Bute Council (A&BC) : primary planning responsibility o statutory local development plan that zones local development uses and facilitates development permissions. o ICZM plan for Loch Fyne, spatial reference to permitted uses in Loch Fyne and facilitates future development trends, which includes mussel farming and marina development
Cork Harbour	National Parks and Wildlife Service (NPWS), Environmental Protection Agency (EPA), The Office of Public Works	Water Framework Directive and Urban Wastewater Treatment Directive	National Spatial Plan	Cork Harbour Integrated Management Strategy The Docklands Development Strategy Marina development: Applicable laws and regulations affecting site selection, development and operation. Foreshore licensing, other permits and marine consents requiring approval of local, county and national agencies. Cork Main Drainage Scheme Implementation of an integrated sewage treatment facility at Carrigrennan. Improve sewage facilities in the lower part of the Harbour.
Pertuis Charentais	EPTB: Territorial Public Agency for the Management of the Charente River	Water Framework Directive (2015), Common Agricultural Policy, Implementation of the new agro-environmental measures (MAET)	Regional plan for water management (SDAGE) Shellfish farming decree	"Water shortage Management Plan" (PGE) : Crisis Management Focus Freshwater management system: Annual, inter-annual and crisis management shortage Restrictions: annual water volume available, allow drinking water supply throught the year, protection of biodiversity
Thau Lagoon	Local Water Committee ("Commission Locale de l'Eau (CLE)"), Syndicat Mixte du Bassin de Thau (SMBT), municipalities	Water Framework Directive, Shellfish Farming Water Directive, Bathing Water Directive		Territorial management plan (ScoT): objectives for the future of the Thau lagoon Local water management plan (SAGE) Shellfish farming regulations: commercial bans for the shellfish farming industry Sanitary classification of the Lagoon Access regulation for shellfish farming

4.3 Economic dimensions of interactions in the coastal zone

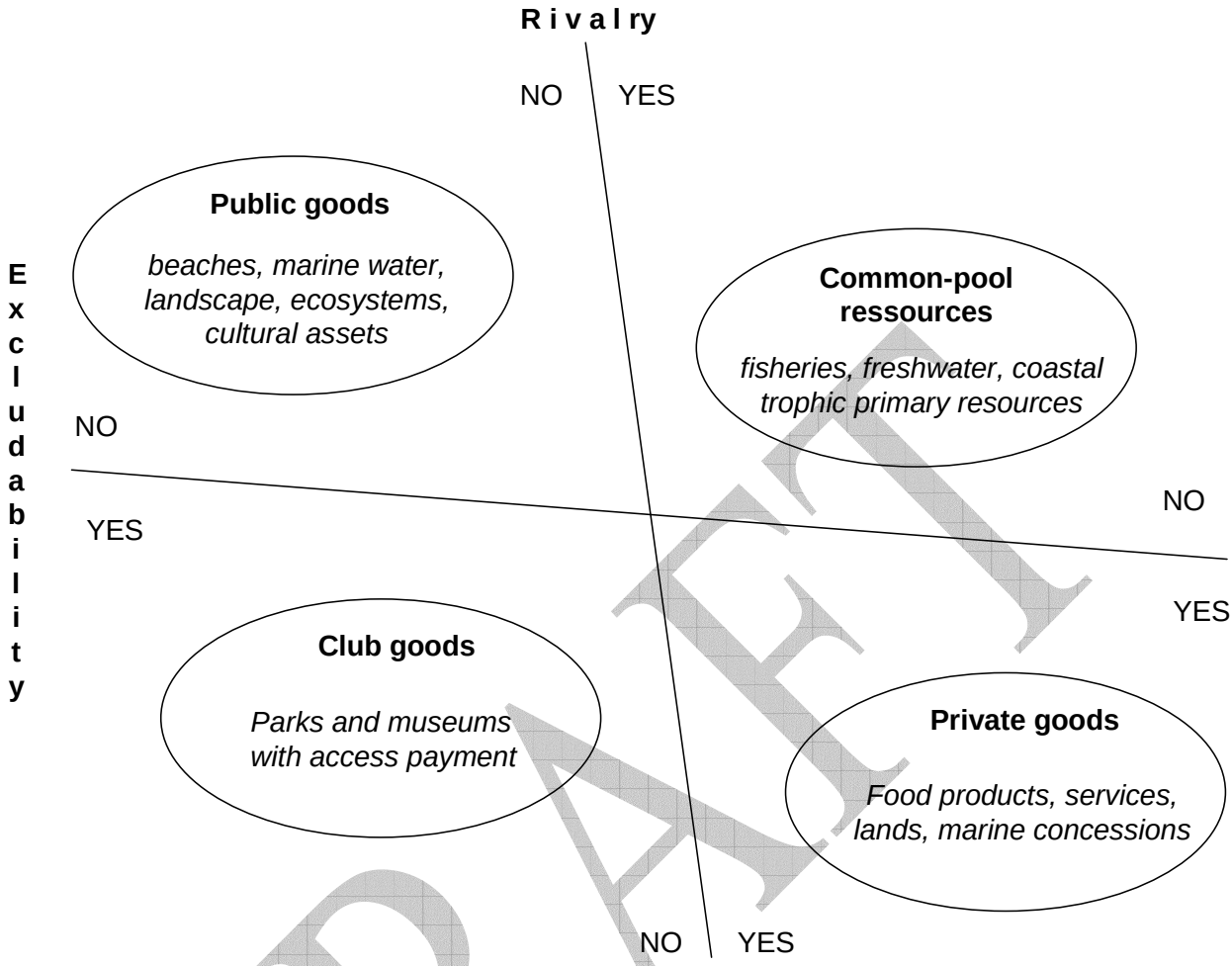
4.3.1 Dealing with various economic goods

The way people interact together about ecosystem goods services indicates if the uses are more or less competitive and the access more or less restricted. Thus, two criteria should be considered to qualify these human interactions: rivalry, which means that the consumption of the good by one individual reduces availability of the good for consumption by other individuals, and excludability, which means that it is possible to prevent someone from using the good (in general because it is possible to introduce a fee or a permit). Those two criteria of rivalry and excludability are commonly used for the classification of economic goods into four categories, which will therefore raise different economic questions. Depending on changes in social rules, one good may switch from one category to another.

Two categories are easy to identify: private goods, which are submitted to rivalry and excludability, and public goods, which are non-rivaled and non-excludable. Private goods are subject to individual property rights and may be exchanged on a market, while public goods are produced (or preserved) by the collectivity for the benefit of the collectivity. Paul Samuelson is usually credited as the first economist to develop the theory of public goods. In his classic 1954 paper *The Pure Theory of Public Expenditure*, he named a public good a "collective consumption good", as follows: "...[goods] which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtractions from any other individual's consumption of that good...This is the property that has become known as Non-rivalness. In addition a pure public good exhibits a second property called Non-excludability: that is, it is impossible to exclude any individuals from consuming the good".

Between private goods and public goods, there exists two intermediate categories. The first category encompasses the "club goods", which are non-rival but excludable. In the coastal zone, "club goods" are basically "public goods" which remain non-rival but have been made excludable: this is the case for example of museums or certain natural parks. As regards ecosystems goods and services management problems, club goods may be considered as public goods which have been protected against the impact of congestion. The second category encompasses the "common-pool resources", which are rival but non-excludable. In the coastal zone, the common-pool resources are the fish stocks and also the limited primary natural productivity which supports shellfish growth in the shellfish farming basins. Because of these two characteristics, those goods are often said to be subject to the overexploitation mechanism known as the "tragedy of the commons" (Hardin, 1968), even if in the real world they may be exploited in more sustainable way because of various "institutional arrangements" (Ostrom, 1990), which in fact tend to reduce the manifestation of both rivalry (through limited individual use) and non-excludability (through the limitation of participants to the exploitation). Figure 1 presents a typology of economic goods derived from ecosystem services in the coastal zone according to the two criteria of rivalry and excludability.

Figure 2. Economic goods derived from ecosystems in the coastal zone



Source: after Mongruel, 2002.

According to their economic status, those different kinds of goods provided by coastal ecosystems will raise specific sustainability problems and social concerns which will determine the choice of the management solutions.

4.3.2 Formulating an ecological problem into an economic issue: an analytical framework based on uses

The way the beneficiaries of ecosystem goods and services interact with the ecosystem has been clarified by environmental economics thanks to the adoption of an instrumental approach. Following this approach, each human activity may be sorted regarding the way it uses the ecosystem functions. This now classical typology of uses is also interesting for the purpose of choosing the economic methodology to be used for a possible future valuation of each ecosystem goods and services. This classification distinguishes direct uses, indirect uses and non uses (Turner et al. 2001; Turner et al. 2003).

The direct uses encompass consumption of ecosystems services for the purpose of extractive or non extractive activities; basically the direct use means that the revenue of an enterprise (or the utility of any economic agent in general, included individuals) depends on the ecosystem service. Extractive activities correspond in most cases to the exploitation of natural resources, which can be renewable, like for fisheries (either professional or recreational), or not renewable, like for mining. Extractive users derive their profit, utility or welfare directly from the provisioning services of the ecosystem. Non extractive activities derive their welfare from the direct use of the ecosystem for recreational purposes (bathing, sea-viewing, bird-watching) or to the direct use of the ecosystem as a recipient for pollutants. Recreation is a way to use the cultural services of an ecosystem, while pollution is a way to use its regulating services. Indirect uses are targeted toward the functions of the ecosystem that are necessary to ensure and sustain the functions which support not only direct uses but also possibly general ecological equilibrium: in that sense indirect use is often the expression of the need for some regulation or limitation of extractive activities, recreational frequentation and pollutants emissions. The non-use relation to the ecosystem is the one of some social groups who simply wants the ecosystem and its functions to continue to exist, or possibly be maintained or restored in their original state: in that sense non-use is strongly linked to conservation. Indirect use or non-use relationships between the beneficiaries and the ecosystem may be found for all categories of services provided by the ecosystem. Depending on the uses (or non-use) considered, the beneficiaries of the ecosystem functions correspond to different social categories which may of course overlap in some (many) cases.

As regards the possible uses of coastal ecosystems goods and services (direct uses, indirect uses, non-uses), three main categories of human activities may be defined: the activities of people who are actively involved in resource direct uses, the activities of people who are passively affected by resource depletion and environmental damages, and the activities of people who feel actually or potentially concerned by resource management and environmental protection (for present and future generations welfare). Basically, whatever its priority, each stakeholder group is likely to take into account several functions of coastal ecosystems; for instance, direct users of one ecosystem service (for example fishers, hunters or inhabitants who practice recreational activities) are also usually involved in the management of the uses (fisheries management, frequentation regulation for recreational sites).

For economists, all sustainability problems result mainly from market failures due to externalities, and raise the problem of social costs (Bower and Turner 1998). Thus, remediation may be achieved with different economic tools and approaches: incentives, taxes and the minimisation of transaction costs. The main economic issue (raised by intra- and/or extra- industry externalities) associated with one sustainability problem in the coastal zone depends on the way it is perceived by stakeholders (and the different kinds of user's conflict). These economic issues may be the following:
-pollution (external effect of a Human activity on the environment)
-overexploitation (risk of resource depletion)
-competition (for the allocation of space and resources to exclusive uses)
-congestion (lack of space in a public access regime)
-coordination ("soft" problem of competition and/or congestion)
-conservation (risk of biodiversity losses)
-remediation (needs for improved environmental quality)

In response to these economic concerns, different solutions may be considered:
-Regulation of access to resources (co-management, institutional arrangements)
-Property rights shift (privatisation/collectivisation)
-Legal management rules (standards and norms)
-Economic incentives (taxes, subsidies, compensations)
-Restoration (technical intervention on the natural system)
-Deliberation for the definition of shared approaches, objectives, methods, means and mesures

Of course, the system design should clearly identify both the economic issue and the problem solutions as they are actually perceived by stakeholders.

Table 11. Environmental problems, economic issues and management responses.

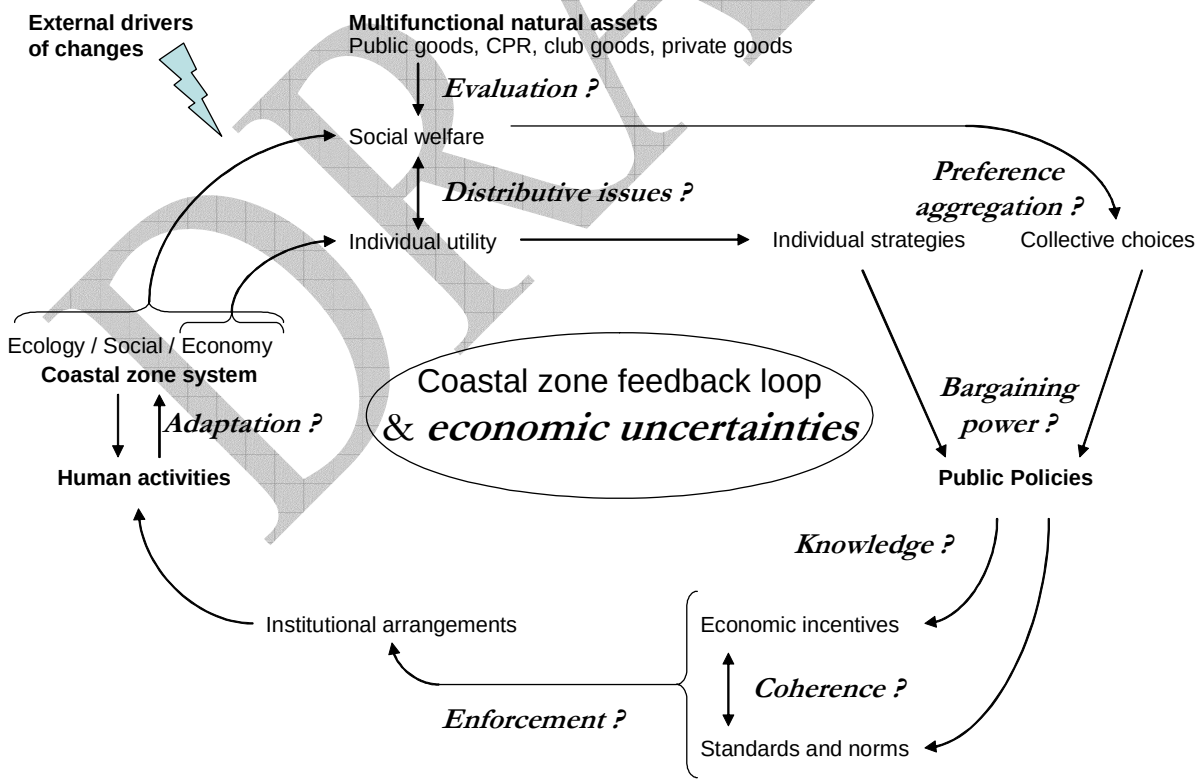
PRESSURES	IMPACTS (1)	IMPACTS (2)	RESPONSES (1)	RESPONSES (2)
Human activities ←	**Environmental problem** →	**Economic issues** →	**Political concerns**	**Management options**
Agriculture, Industries, Urbanisation Recreational activities	Pollution of the environment (organic and chemical effluents, microbiological contamination, accidental pollution, oil-spills)	Externalities	Public good production, sanitary policies, polluter pays principle	Norms, taxes, permits technological innovation (including incentives), public treatment installations
Fisheries, Aquaculture, Agriculture	Ecosystem degradation (by-catch, other side-effect)	Externalities	Damage mitigation, damage avoiding	Practices and technologies (including incentives)
	Overexploitation of resources (overfishing, freshwater wasting)	Rent dissipation	Access regulation	Use-rights, taxes, practices and technologies (including incentives)
		Competition and conflicts	Distributional issues	Use-rights and coordination (institutional arrangements)
Recreational activities	Overexploitation of resources (recreational fishing, hunting)	Competition and conflicts	Distributional issues	Use-rights and coordination (institutional arrangements)
	Overfrequentation of natural sites	Congestion	Information and Education	Public information, participative approaches
Urbanisation, Tourism	Land use, landscape degradation	Externalities	Spatial planning	Zoning, land-use management real estate market regulation
	Biodiversity and habitat losses	Critical natural capital	Nature conservation	Protected areas, restoration measures
All coastal and marine human activities	Solid waste accumulation	Externalities	Waste disposal policy	Public information, control and penalties

4.3.3 Choosing a framework for coastal system assessment

The methods for characterising the behaviours of stakeholders based on their 'economic objective' which have been listed in Table 8 can of course not be implemented altogether. Indeed, it is feasible to make explicit the various internal contradictions which would be induced by any attempt to represent the entire economic dynamics of a coastal system, according to the usual assumptions of standard economics. In Figure 1, the question marks indicate the social processes which are not easily depicted by standard economic approaches.

Basically, the weakness of the standard economic approach is that it is not adequate to deal simultaneously with the following problems:
-valuation of multi-functional environmental assets (public goods, private goods, etc)
-divergence between private utility and social welfare (externalities)
-aggregation of individual preferences and the problem of collective choices
-bargaining power
-coherence between policy instruments (norms and incentives)
-enforcement of the collective decisions of the management systems (transaction costs)
-distributional issues (intra and inter-generational)
-limited but improving knowledge

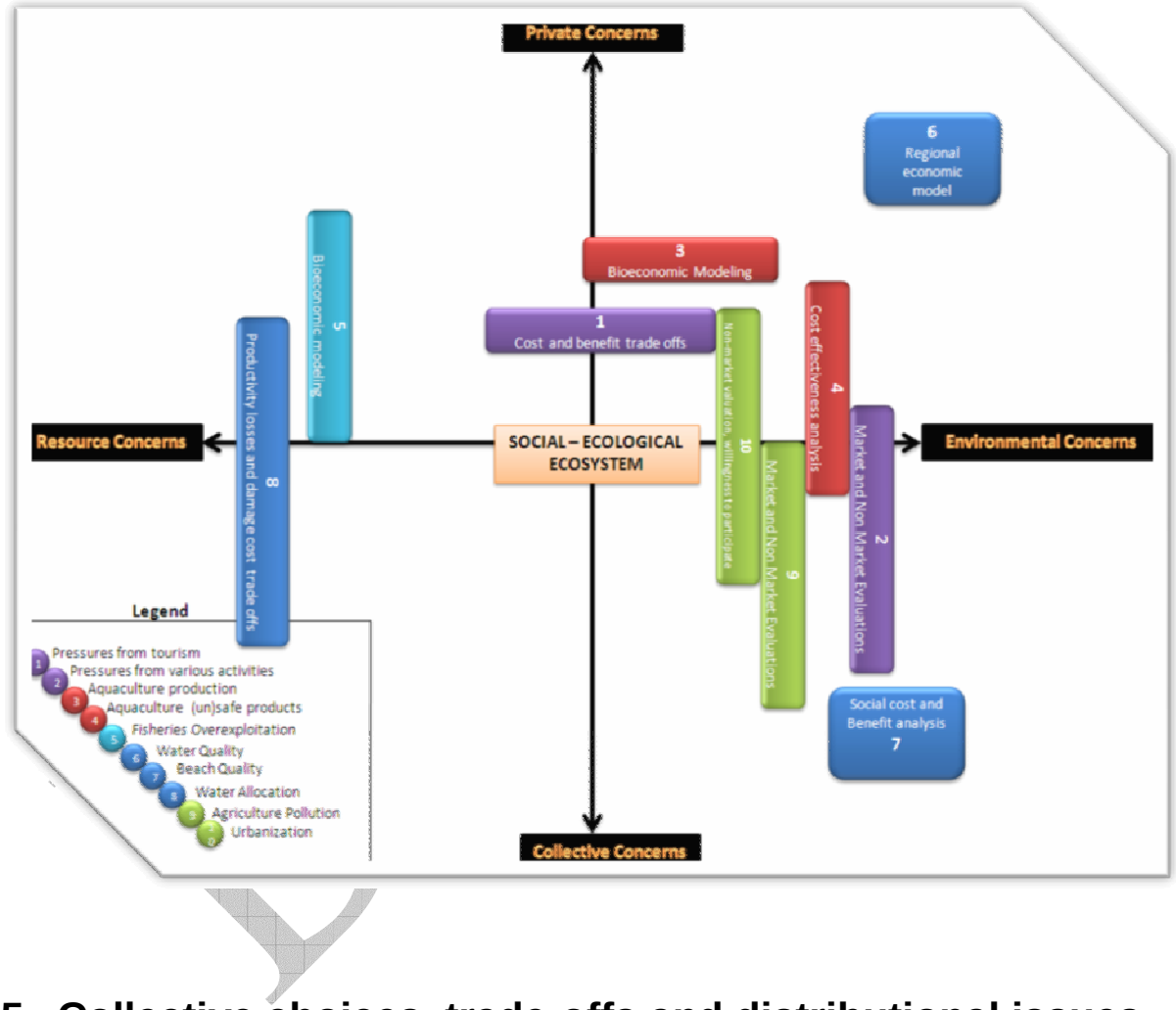
Figure 3. Complex social processes in the coastal zone and the limits of standard economics.



Source: after Mongruel, 2002.

As a result, the representation of the economic dynamics of a coastal system is always partial because it is unable to address all the economic processes simultaneously. Thus the economic dimension of a complex system is always represented according to some methodological assumptions regarding the necessary simplifications, which depend on the kind of economic problems that are at the core of the policy issue to be addressed. This could lead to adopt a representation which focuses either on distributional issues, market failure, imperfect competition, management inefficiency, enforcement problem or on information asymmetries. In particular, pragmatic approaches are necessary to properly address the problems of wealth distribution and of adaptive decision, which are crucial social concerns.

Figure 4. Economic assessment methods and sustainability problems in SPICOSA.



5 Collective choices, trade-offs and distributional issues

5.1 From adaptive individual behaviours toward collective choices

According to Holling (1995), an adaptive behavior corresponds to a dynamic concept where humans adopt innovation to respond to ecological changes due to human resource uses. This perspective requires to be able to perceive these changes through signals, to treat them and to adopt individual or collective decision in order to maintain sustainability of social-ecological system. Concretely, adaptive behavior is

an adaptive process during which new experiences lead to cognitive dissonance and then to symbolic system reorganization in order to adapt preferences and decision processes. We can name it “learning-by-doing” processes. Even if adaptive behavior refers to agent relations with his environment (social and natural), learning-by-doing processes is always, after all, an individual cognitive process which requires to adopt firstly an agent-based approach (North 2005).

Individual choices are based on mental models. Mental models allow to anticipate future events and to make a decision according to them. In order to build such mental models, people use information about their environment. This information is perceived and stored through everyday activities and is difficult to capture for scientists. However, it supplies the schemes from which choices are taken by agents.

Connection between mental models and individual choices can be captured from two types of information more or less implicitly used by agents: the “use information” and the “decision criteria information”. The “uses information” enables to describe precisely the practices and to go over simple pressure information. They reflect the “what do they do” as well as the “how do they do”. The “decision criteria information” provides a better understanding of why stakeholders do something or don’t do it, why they make that specific choice, what sense such an action would have. This information allows to monitor the essential driving forces that are the very source of human practices and to better understand what the main incentives for people to make a choice are. The decision-making criteria include motivations (finding food, warmth), technical limitations (lack of means for more intensive farming, lack of means of transport), ecological limitations (scarcity of certain resources, lack of water), regulatory constraints (boundaries of the natural reserve, size of mesh for netting), incentives (price, demand, risk), conventions (priority for certain activities), institutions (local “traditions), rules of behaviour (eating habits), representations (“tourism” as a source of profit). This is information that stakeholders use in a more or less conscious way when making decisions about their activities. This information refers to the ‘capacities’ available to them, and concerns the use of resources, but also possible adaptive responses. These capacities are mainly linked to acting institutions and state of ecosystem services. If such capacities are limited (self-consumption, lack of substitution techniques, no alternative resources), it is difficult to change practices without offering new opportunities to the concerned stakeholders.

For the last fifteen years, we can considered that the “collective decision issue” in the social-ecological system is mainly based on the adaptive co-management which has become one of the most influential approaches for understanding and managing complex social-ecological systems (Lal et al., 2001; Olsson et al., 2004; Ostrom et al., 1994). There are actually several definitions of what is called “adaptive co-management”. Yet two basic criteria that any adaptive co-management programme should respect remain: first, the core importance of the learning-by-doing (learning by experimenting) processes (Holling, 1978; Walters and Hilborn, 1978), and second, a collaborative management aspect (Ostrom, 1990; Pretty, 1995, 2003) with the involvement of multiple stakeholders and disciplines. To make a long story short, “novelty of adaptive co-management comes from combining the iterative learning dimension of adaptive management and the linkage dimension of collaborative management in which rights and responsibilities are jointly shared” (http://www.resalliance.org/2448.php). Then, it is necessary to consider that decision

represents both an individual and a collective process where interactions between heterogeneous stakeholders are of utmost importance.

This decision theory is based on the assumption that there is a symmetry of ignorance (Arias and Fischer 2000), contrary to neo-classical economic assumption, which requires that all the communities of practices directly or indirectly concerned by a common problem should be taken into account. The result is that, in this context, all the stakeholders can legitimately speak about any subject since there is an element of truth in all the different points of view, even those which may initially appear as being "irrational". It contrasts with the concentration of technical control in the hands of authorities or experts who could take decision finally without taking the system into account. In real life, decision-makers usually adopt tradeoffs from implicit social conventions. There is no unique social and economic desirable state. On the contrary there are many alternatives.

All the social-ecological interactions lead to collective choices which represent finally compromises and trade-offs regarding uses, norms, regulation systems, subsidies or taxes, etc. The processes from which these compromises have been adopted are shaped by power relationships, information asymmetries and pre-existing governance system (Levrel et al., 2009). Whatever these possible distortions in the adoption of collective choices, it is necessary to correctly understand the fundamental objectives (the goals), as well as the secondary objectives (the means) which have motivated them (Gregory and Wellman 2001). Basically, the multiple uses of natural resources calls for the analysis of current and future trade-offs (Brown et al. 2001).

5.2 Trade-offs and the integrated assessment of the system

Information concerning the evolution of the status of ecosystem goods and services may be addressed on the basis of signs of evolving resources perceived by stakeholders as they carry out their activities ('*which signs reveal that resources are more abundant or more scarce in the area?*'). Most of the time, local stakeholders are more or less dependent on the resources surrounding them and keep track of various signs that provide information about any changes to such resources. Therefore, they have specific information about the evolution of a given resource (Moller et al., 2004). Some of these signs indicate non-viable use (intensive techniques), while others are indirect signs (such as species that indicate soil erosion) or direct signs (species extinction). All these signs provide ecosystem services monitoring information that is both simple and relevant for local decision-makers. For the participants, they translate into negative or positive trends concerning their future and their children's future, and thus relate to sustainability information.

In addition to their ecological concerns, stakeholder groups may express specific points of view as regards the economic and social status of the system. Then, it is often needed to make the assessment methodology evolve from the purely rationale (substantive) approach which consists in searching for the maximum individual satisfaction or the optimum collective situations as defined by 'scientists' (experts), and to adopt holistic (procedural) approaches, which consists in negotiating the

assessment methodology of our complex coastal systems: the latter approach implies to identify indicators for the purpose of multi-criteria analyses.

Whatever the approach that is chosen, the economic assessment of the system will use indicators. The usual economic indicator is the money (or 'welfare'); nevertheless, more specific indicators may also depict the economic status of the system. Each stakeholder activity has an economic function for the society, which citizens, lobbyists and politicians describe in other terms than their contribution to utility or welfare. As well as ecological sustainability is a matter of resilience but is not considered in those terms by system assessment indicators; economic sustainability, which is basically a matter of social welfare maintenance over time (and may then be translated in the coastal zone as the maintenance of the regional total income), may be interpreted as more practical intermediate objectives, like the revenue of producers in each industry per se, the number of jobs in one industry, the quality of jobs, the quality of life, the cultural importance of traditional activities, the contribution of the environment to leisure or to spirituality. The principle-criteria-indicator is a method that allows for the definition of shared objectives regarding the evolution of the coastal system (including the coastal society), and the consecutive assessment framework: which objectives are shared, which methodology allows to compare the situation of the system as regards these objectives, and which bracket values for indicators may correspond to a positive judgement.

Table 12. Principles, criteria and indicators
for the multicriteria analysis of scenarios in the Thau Lagoon.

Principles	***Criteria****		***Indicators***
Improving water quality	Bathing water quality	+	Number of bans (days)
	Shellfish farming water	+	Number of bans (days)
	Lagoon reputation	+	Lagoon classification
Maintaining local employment	Shellfish farming vulnerability	-	Number of businesses facing negative results
	Employment in traditional activities	+	Number of full-time equivalent in traditional activities
	Total employment	+	Number of full-time equivalent
Economic development	Goods and services production	+	Total turn over of all sectors
	Economic dependency	-	Imports/Exports trade ratio
Public budget savings	Public expenses for water treatment devices	-	Investment and running costs

** The sign +/- indicates if the criteria is expected to be maximized (+) or minimized (-).*

5.3 Costs and benefits distribution among stakeholders

In economics, cost benefit analysis is based on the fact that any decision-maker (consumer, firm, State, citizen…) can make a rational choice from balancing the cost he supports and the benefit he gains. This analysis works only if the parameters which enable him to do it are "under control", that is, the decision-maker is able to assess exactly how his system works. It is not really the case when we attempt to carry out such a methodology in the environmental domain. Indeed, there are two

major problems: the absence of price for many ecosystem services and the existence of externalities. The missing of price for most ecosystem services is due to the *lack of market for them*, to the *limits of economic valuation techniques* and to the *complexity of natural capital assessment* (Heal, 2000).

The lack of market for ecosystem services is easy to explain. The main part of biodiversity represents public goods and the ecosystem services are delivered by this natural capital for free. There is no market value for most part of biodiversity. This is a source of inefficiency from an economic point of view, because the lack of property rights doesn't encourage people to manage them in a sustainable way. On the other hand, one highlights that, from a social point of view, this public property gives a fair access to these ecosystem services. Regarding this lack of market for biodiversity and ecosystem services, it is possible to use the nonmarket valuation which are mainly based on hedonic prices, replacement costs, travels costs and contingent valuation (Environmental protection agency, 2009; Barbier et al., 2009).

Economic valuation techniques have some limits due to the fact that it is difficult to capture the indirect use value (recreational activities in a natural ecosystem for instance), the option use value (based on future potential uses) and the non use value of nature (value of nature for itself).
Non use value based on contingent valuation is most of the time debated and US judges, for example, are more and more sceptics when some contingent valuation methodology are used to argue about an environmental injury (Thompson, 2002). Geoffrey Heal is very critic regarding the abusive use of contingent valuation and writes about the famous Costanza et al. publication on Total Economic Value of the Biosphere: "Unfortunately this study is flawed, so seriously as to be of no use, precisely because its authors were not sensitive to the point just made: it does not make sense to ask about the value of replacing a life-support system. One economist described the numbers resulting from this study as 'a serious underestimate of infinity' (Toman 1998). Finally, giving a value to one ecosystem service is scientifically robust only if it is in a specific social-ecological context. The value ecosystem services delivered by 1hectare of wetlands is not the same whether this ecosystem is isolated or in the water basin allowing to supply freshwater to a big city.

The last point is about the complexity to measure natural capital changes. Everybody agrees that biodiversity represents an important part of natural capital. However, it is difficult to propose simple indicators from which it could be possible to identify its evolution. Maybe the most consensual way is to state that the good functioning of an ecosystem is the best way to perceive the capacity of this ecosystem to deliver ecosystem services. But, it is today really difficult to assess these good functioning. Biodiversity changes come from multiple sources and are complex to tackle. The decrease of only one key species can be a source of ecosystem collapse while hundreds of species can be removed without apparent consequences on the ecosystem services provision or after many years be a source of an unpredictable collapse (Gunderson and Holling, 2002). This argument is all the more right if we are at the microbiological level. These non linear and complex dynamics represent a huge difficulty to capture what is natural capital and to provide a value to its changes. We don't have enough information on interactions between ecological components and give a monetary value to each ecosystem services in order to sum them is pointless if we are not able to assess interactions between them.

When economists speak about costs and benefits based on ecosystem services valuation, they do not pay a lot of attention to the distribution of costs and benefits into the society. However, a large audience is aware of this question of distribution and that is the reason why it is important to pay more attention to the distribution of costs and benefits among a population. The distribution of costs and benefits among a population can be assessed from different points of view:

- spatial: local/global, North/South, town/country, coastal zone/water basin;
- social: poor/rich, executive/labour, minority/majority, native/immigrant;
- temporal: long-term/short-term, economic time scales/ecological time scales;
- economic areas: private/public, primary sector/tertiary sector, firms/consumers, State/citizens.

One point to underline is that damages are often supported by people who are not able to move, who depend on free public ecosystem services, who have not enough power to defend their stakes, or who are not able to pay to mitigate ecosystem services impacts on their private life. It is most of the time poor people who are not able to pay for moving toward another place or having access to private ecosystem services. It is why free access to public ecosystem services is a source of social equity as well as the physical restoration of damages in order to take into account all the stakeholders in the protection policy.

All that allows to explain that it is often more efficient to assess costs and benefits in non monetary units (multi-criteria analysis ecological physical parameters, employment) (Nelson et al., 200ç) or in cost to restore or mitigate a damage (Roach et Wade, 2007). This has been justified by two main arguments: natural environment got an intrinsic value which justify to have to maintain it for itself; restore physically the initial condition allowing to deliver ecosystem services is the only way to compensate all the losses supported by all the unidentified stakeholders (in particular those who are not able to prove an economic loss such as people who benefit from free recreational ecosystem services). Hence, restore, mitigate and compensate allow to take into account all the shadow costs and all the stakeholders.

To be brief, when one uses the ecosystem services valuation methodology, the final goal is to assess “how much is the value of ecosystem services loss (market + non market prices) ?” and when one uses the ecosystem services cost assessment methodology based on physical restoration/compensation the final goal is to assess “How much to pay for restoring the loss of ecosystem services (primary + compensatory restoration) ?”. In the first case one estimates the losses of benefits coming from loss of ecosystem services, and what are the levels of monetary value of human, natural or physical capital required for compensating the environmental injury. This approach is connected with the weak sustainability criteria (due to his “value to value” equivalence system) (Atkinson et Pearce, 1993). In the second one, one estimates the costs to support the production of ecosystem services, and what are the levels of biodiversity required to restore/compensate the regulation, provisioning or cultural ecosystem services lost. This approach is acknowledged as a strong sustainability criteria (due to his “ecosystem services to ecosystem services” equivalence system) (Ekins, 2003).

When a social-ecological system is subject to such antropogenic pressures that its resilience is threatened, it makes definitely sense to assess and compare the costs of the current situation (damage costs) and the costs associated with possible future situations (remediation costs and residual damage costs), as long as such estimates provide a clear view of the distribution of those costs, what gives indications whether the future trade-offs are likely to be acceptable or not. To put it short: for operational purpose and practical reason, we argue that environmental management decisions are more likely to be facilitated by estimates of damage rather than estimates of value and by comparisons of the distribution of costs among stakeholder groups rather than comparisons of aggregated costs and benefits ratios.

6 Concluding remarks

For the purpose of the integrative modelling of social-ecological systems, the economic dimensions are required to be present during all the steps of the building of the model: it seems of particular importance that the model integrates economic dimensions such as the intensity of the uses of resources, the level of the demand for ecosystem services or the objective functions of producers and other user strategies. The main interest of the model is therefore not necessarily to contribute to the estimation of synthetic economic indicators such as total economic value or cost-benefits ratios, especially because such indicators tend to end with a final classification of management options based on the sole economic criterion, what is in contradiction with initial objective of carrying out a multi-criteria assessment from a multi-disciplinary perspective. The model is meaningful for the purpose of economic assessment because it encompasses the objectives and the behaviours of stakeholders, be they private firms, non-for-profit associations, consumers or citizens. When based on a holistic system approach framework, a dynamic ecological-economic model should be expected to provide, not an integrated economic assessment, but relevant economic information for an integrated assessment. We suggest that the assessment of damages and cost and their distribution between stakeholders is the most useful economic information for comparing alternative management options in the frame of an integrated assessment of coastal systems.

7 References

TO BE COMPLETED

Arias, E.G., and G. Fischer. 2000. Boundary Objects: Their Role in Articulating the Task at Hand and Making Information Relevant to It. *International ICSC Symposium on Interactive and Collaborative Computing*, University of Wollongong, Australia, December 11-15. Academic Press, Wetaskiwin, Canada, pp. 567-574.

Arrow K.J., Daily G., Dasgupta P., Levin S., Mäler K.G., Maskin E., Starrett D., Sterner T. and Tietenberg T., (2000), "Managing Ecosystem Resources", *Environmental Science and Technology*, 2000, 34(8), 1401-1406.

Atkinson G. and Pearce D.W., (1993), "Capital Theory and the Measurement of Sustainable Development: An Indicator of Weak Sustainability", *Ecological Economics*, n°8, pp.103-108.

Barbier E.B., Baumgärtner S., Chopra K., Costello C., Duraiappah A., Hassan R., Kinzig A., Lehmann M., Pascual U., Polasky S., Perrings C., 2009. The Valuation of Ecosystem Services, in Naeem S., Bunker D.E., Hector A., Loreau M., Perrings C., (eds.), *Biodiversity, Ecosystem Functioning & Human Well Being*, Oxford University Press, pp.248-262.

Berkes F., Colding J. et Folke C. (eds.), (2003), *Navigating Social-Ecological Systems. Building Resilience for Complexity and Change,* Cambridge, Cambridge University Press.

Boulanger P-M and Bréchet T., (2005), "Models for policy-making in sustainable development: The state of the art and perspectives for research", *Ecological Economics,* Volume 55, Issue 3, pp. 337-350.

Clark R. J., (1996). *Coastal zone management handbook*. Boca Raton, Lewis Publishers, 694 pp.

Costanza R., Low B.S., Ostrom E., Wilson J., (eds.), (2001), *Institutions, Ecosystems and Sustainability*, Lewis Publishers, 270 pp

Daily G.C., (ed.), (1997), *Nature's Services. Societal Dependence on Natural Ecosystems*, Washington D.C., Island Press, 392p.

Dietz T., Ostrom E., Stern P.C., (2003), "The Struggle to Govern the Commons", *Science*, vol.302, number 5652, Issue of 12 Dec 2003, pp. 1907-1912.

Ekins P., (2003), "Identifying Critical Natural Capital. Conclusions about Critical Natural Capital", *Ecological Economics*, 44: 277-292.

Environmental Protection Agency, 2009. *Valuing the protection of ecological systems and services*. U.S. Environmental Protection Agency, Office of the Administrator, Science Advisory Board. 139 p.

Etienne M., Le Page C. and Cohen M., (2003), "Role-Playing Games, Models and Negotiation Processes: part I. A Step-by-step Approach to Building Land Management Scenarios Based on Multiple Viewpoints on Multi-agent System Simulations", JASSS, vol.6, issue 2, http://jasss.soc.surrey.ac.uk/6/2/2.html.

Gunderson L.H. and Holling C.S., (eds.), (2002), *Panarchy. Understanding Transformations in Human and Natural Systems*, Washington D.C., Island Press, 507p.

Holling C.S., (1995), "What barriers? What bridges?", in Gunderson L.H., Holling C.S. and Light S.S., (eds.), *Barriers and Bridges to the Renewal of Ecosystems and Institutions*, New York, Columbia University Press, pp.3-34.

Lal P., Lim-Applegate H. and Scoccimarro M.C., (2001), "The adaptive decision-making process as a tool for integrated natural resource Management: Focus, Attitudes, and Approach", *Conservation Ecology*, 5(2): 11. http://www.consecol.org/vol5/iss2/art11.

Low B., R. Costanza, E. Ostrom, J. Wilson and C. P. Simon, 1999. Human–ecosystem interactions: a dynamic integrated model. Ecological Economics, 31(2), pp 227-242.

Ludwig D., Hilborn R., Walters C., (1993), « Uncertainty, Resource Exploitation, and Conservation : lessons from history », *Science*: 260(2) : 17-36..

Millenium Ecosystem Assessment, (2005), *Ecosystem and Human Well-Being: synthesis*, Island Press, 137p.

Millenium Ecosystem Assessment, (2003), *Ecosystem and Human Well-Being. A Framework for Assessment*, Island Press, 212p.

Moller H., Berkes F., O'Brian Lyver P. and Kislalioglu M., (2004), "Combining Science and Traditional Ecological Knowledge: Monitoring Populations for Co-Management", *Ecology and Society*, 9(3): 2. http://www.ecologyandsociety.org/vol9/iss3/art2

Nelson E, Mendoza G, Regetz J, Polasky S, Tallis H, Cameron D.R, Chan K.M, Daily G.C, Goldstein J, Kareiva P.M, Lonsdorf E, Naidoo R, Ricketts T, and Shaw M.R., 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment* 7(1):4-11.

North D., (2005), *Understanding the Process of Economic Change*, Princetown, Princeton University Press.

Ostrom E., (1990), *Governing the Commons*, Cambridge, Cambridge University Press.

Pretty J., (2003), "Social Capital and Collective Management of Resources", *Science*, vol.302, number 5652, Issue of 12 Dec 2003, pp. 1912-1916.

Roach B., Wade W.W., 2006. Policy evaluation of natural resource injuries using habitat equivalency analysis. *Ecological Economics* 58 :421-433.

Turner R. K., I. J. Bateman and W. N. Adger, 2001. "Economics of coastal and water resources: valuing environmental functions". Kluwer Academic Publishers, 342 p.

Turner R. K., J. C. J. M. Van den Bergh and R. Brouwer. (ed.), 2003. "Managing wetlands: an ecological economics approach". Edward Elgar Publishing Ltd, UK, 318 p.

Turner R. K., 2005. Integrated environmental assessment and coastal futures. In: Vermaat JE, Brouwer LM, Salomons W, Turner RK (ed.), Managing European coasts: past, present and future. Springer, Berlin, pp 255-270.

Sen, A.K., 1999. *Development as Freedom*. New York, Anchor Books.

United Nations Development Programme, (2007), *Human development report 2007. Fighting climate change : Human solidarity in a divided world* , New-York, United Nations Development Programme.

Arias and Fischer 2000
Arrow et al. 2000
Beaumont et al., 2007
Berkes et al. 2003
Boulanger and Bréchet 2005

Bower and Turner 1998
Brouwer et al., 2001
Brown et al. 2001
Buanes et al., 2004
Cicin-Sain and Knecht 1998
Colin Clark XXX
Costanza et al, 1997
Costanza et al. 2001
Daily 1997
Dasgupta and Mäler, 2000
Dasgupta, 2001
Dietz et al. 2003
Duarte, 2000
Ekins, 2003
Etienne et al. 2003
Etienne, 2005
Fabbri, 1998
Gregory and Wellman 2001
Gunderson and Holling 2002
Hardin, 1968
Holling 1995
Holling, 1973
Holmlund et Hammer, 1999
Jackson et al., 2001
Kaiser et al., 2005
Kremen, 2005
Lal et al., 2001
Leafe et al 1998
Ledoux & Turner 2002
Levrel et el., 2008
Low et al. 1999
Ludwig et al. 1993
Mäler, 2008
MEA 2005
Millenium Ecosystem Assessment 2005
Mongruel 2002
North 2005
Ostrom, 1990
Plummer and FitzGibbon, 2004
PNUD, 2007
Pretty 2003
Reed et al., 2009
Rönnbäck et al., 2007
Samuelson Paul 1954 *The Pure Theory of Public Expenditure*
Sen, 1999
Smith 2002
Solan et al., 2004
Turner 2000
Turner et al 1998
Turner et al. 2001

Turner et al. 2003
Turner et al. 2003
van der Weide, 1993
Vanoli, 2002
Varghese et al 2008
Wilson et al., 2004
Worm et al., 2006