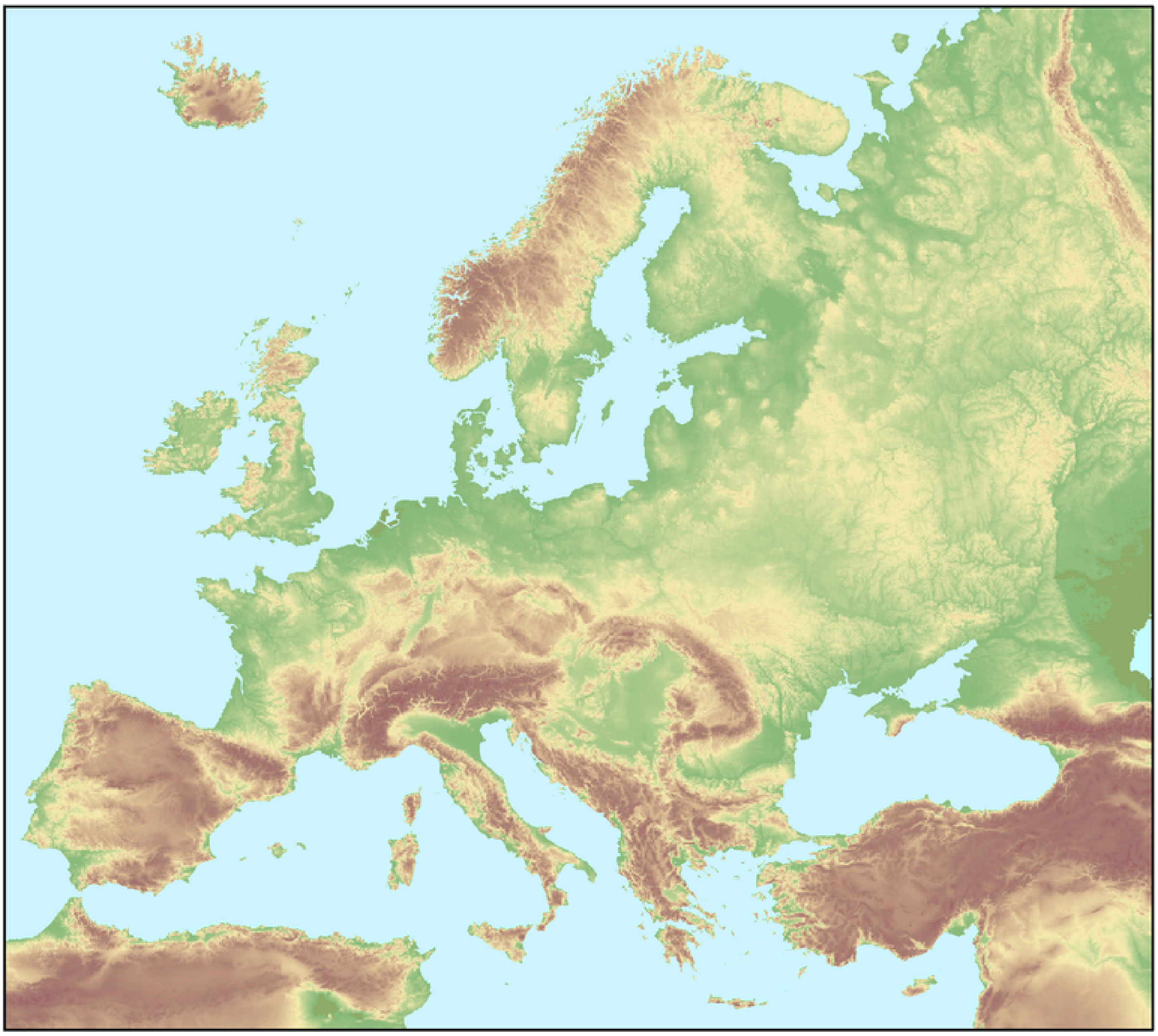
LEAC methodology for coast and marine accounts



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Notes:

This is a working paper and work in progress, it will develop further over the next year. This document reflects the views of the authors and not those of the funders or PEGASO Partners.

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No	Title
1	The Development of Scenarios for the UK National Ecosystem Assessment. Interim Report, 5/10.
2	The utility of existing scenario frameworks for the National Ecosystem Assessment. Interim Report, May 2010.
3	Scenarios for the UK NEA (a sub-global MA): A transparent and flexible methodology. Poster Presentation at Salzau/Germany, June 2010.
4	Assessing User Needs of the UK NEA Scenarios through Focal Questions.
5	UK NEA Scenarios: Narratives. February 2011.
6	UK NEA Scenarios – Final Chapter. February 2011
7	Integrated Coastal Zone Management and the Ecosystem Approach
8	Integrated Coastal Zone Management and the Ecosystem Approach: International experience.
9	Ecosystem Service Terminology. An attempt of a Glossary
10	LEAC methodology for coast and marine accounts
11	Developing an accounting method for Species of European conservation importance

Contents

1. Introduction

1.1. Context

Coastal ecosystems are amongst the most productive and valuable but also the most threatened ecosystems on Earth (MEA, 2005). Their degradation lead to a decrease of goods and services they provide to human wellbeing. This is especially true for the coast of Mediterranean Sea which has been historically one of the most densely populated regions on Earth (Airoldi and Beck, 2007). This population, the associated activities and infrastructures have led to growing pressure on terrestrial and marine coastal ecosystems which have resulted in a considerable loss of biodiversity and habitats especially in the more industrialized North-western part (Coll et al., 2010: Lotze et al., 2006).

Since Rio 92, the concept of "Ecosystem based" or "integrated" strategies which should mitigate degradations, is gaining importance and is more and more included on new policies. The Mediterranean ICZM protocol calls for better management within an ecosystem based framework at international, national, and local scales. Ratified in March 2011, the objectives of the ICZM Protocol are:

a) Facilitate, through the rational planning of activities, the sustainable development of coastal zones by ensuring that the environment and landscapes are taken into account in harmony with economic, social and cultural development;
b) Preserve coastal zones for the benefit of current and future generations;
c) Ensure the sustainable use of natural resources, particularly with regard to water use;
d) Ensure preservation of the integrity of coastal ecosystems, landscapes and geomorphology;
e) Prevent and/or reduce the effects of natural hazards and in particular of climate change, which can be induced by natural or human activities;
f) Achieve coherence between public and private initiatives and between all decisions by the public authorities, at the national, regional and local levels, which affect the use of the coastal zone.

The Pegaso Project aims to facilitate the implementation of the ICZM Protocol in the Mediterranean basin and the development of similar policies in the Black Sea.

1.2. The PEGASO Project

The main objective of Pegaso is to build on existing capacities and develop common novel approaches to support integrated policies for the coastal, marine and maritime realms of the Mediterranean and Black Sea Basins in ways that are consistent with and relevant to the implementation of the ICZM (Integrated Coastal Zone Management) Protocol for the Mediterranean. Pegaso seeks to do this through three innovative actions:

a) Constructing an ICZM governance platform (WP2) as a bridge between scientist and end-user communities.
b) Refine and further develop efficient and easy to use tools for making sustainability assessments in the coastal zone (WP4). These tools include indicators, environmental accounting, scenario construction, participatory approaches and valuation. The aim is to create a suite of tools and techniques that can be used to make a multi-scale assessment in the coastal zone in the Mediterranean and Black Sea Basins. They will be tested and validated in a multi-scale approach for integrated regional assessment through a basin wide diagnostic and a number of relevant pilot sites.
c) Implementation of a Spatial Data Infrastructure (SDI), to organize, harmonize and standardize spatial data (WP3). This interactive web portal will support information sharing as well as manage communications, normalisation and dissemination of consortium spatial and statistical information datasets.

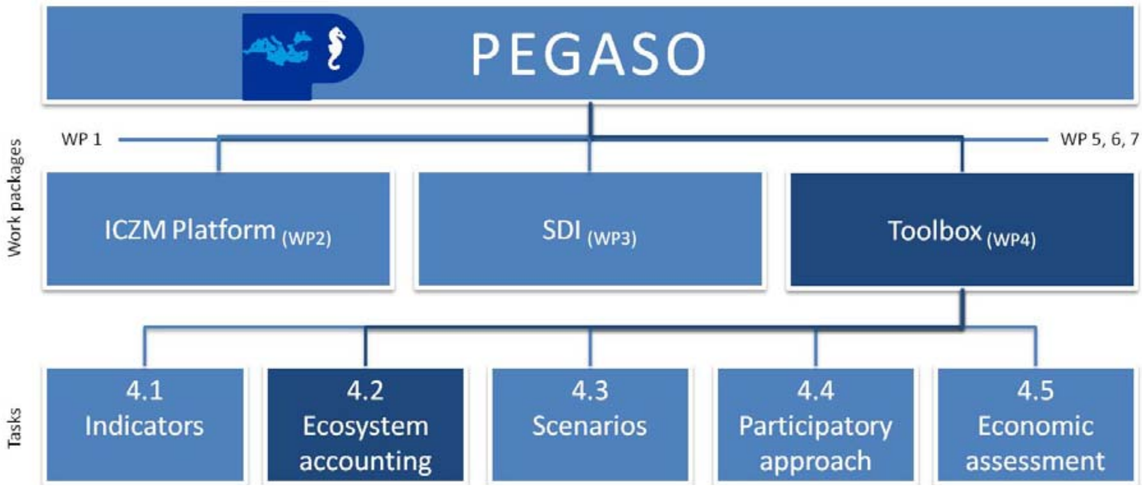


Figure 1: PEGASO general organization, work packages and tasks.

In fact, these three innovative actions are linked: Developing a good governance platform help the improvement of the objectives of the project through the exchange of experience and data. Moreover the building of the SDI which is a basic PEGASO service will allow technically, countries and stakeholders to share and use SDI information as they need. Finally, the toolbox will use data from the SDI but in turn feed it with new data, indicators, accounts, etc. So the three actions are interactive along the project life.
The following report elaborates on the ongoing process for data assessment and use for the ecosystem accounting tool (Task 4.2) in the Work Package 4 Toolbox.

1.3. Ecosystem accounting approaches

The ecosystem accounts are an exercise serving to streamline a number of discourses and developments. It is jointly driven from statistics (System of National Accounts), sciences (ecosystem services valuation) and policy-making (climate change abatement, biodiversity conservation) towards (quantitative) assessment of ecosystem resources (capital) and their human uses, impacts and benefits. It contributes towards expressing these relationships in an index such as Green DGP, the need for which comes because traditional economic accounts did not take into account the environment, and the cost of tackling ecosystem degradation. The United Nations Statistical Division (UNSD) has initiated a process of integrating the economic and environmental accounts more than two decades ago, by drafting and revising a handbook 'System of environmental and economic accounts' (SEEA, http://unstats.un.org/unsd/envaccounting/seearev/), which includes a separate chapter on ecosystem accounts, and will help set out international standards.

"The SEEA was launched by the United Nations and the World Bank in 1993 as a response to recommendations of the 1992 Rio conference on sustainable development. The initiative sought to address the problem that the environment was not fully taken into account in the System of National Accounts (SNA) which is the framework used to calculate GDP. A revision of the SEEA was published in 2003 (SWWA, 2003) and work continues to establish the SEEA as an international standard. The importance of such work has recently been emphasised by the outcomes of COP10, which endorsed the development of national accounting systems for biodiversity and ecosystem services[1] (Strategic Goal A, Target 2). "

1.4. Introduction to the European ecosystem accounting approach LEAC

Land and ecosystem accounting (LEAC) is a method and approach being led and promoted currently by the EEA. The original ideas have been developed by Jean-Louis Weber for nearly 30 years. Since 2002 these ideas were put into practice in cooperation between the EEA and the European Topic Centre on Terrestrial Environment by producing the first Land accounts of Europe. Later on the land accounting method was extended into an ecosystem accounting framework with the participation of the University of Nottingham. The LEAC method was first published in the Journal of Ecological economics, in a Special Issue on Environmental Accounting by Weber in 2007. At present, we are producing a European example of ecosystem accounts as a proof of concept as well as testing other applications with more specific purpose as the case of PEGASO.

LEAC is a generic tool useful for different purposes of environmental assessment and monitoring and in a spatially explicit way. In particular it can provide spatial indicators for regional assessment of the status and degradation of natural capital due to the over-use of

[1] http://www.cbd.int/nagoya/outcomes/

natural resources. Therefore the LEAC approach strives to address the biophysical or ecosystem condition part; the human use and derived socio-economic values and benefits at an equal footage. The human benefits, of course, often incur ecosystem condition degradation, which needs restoration efforts to maintain the initial biophysical assessments. Currently, a major emphasis is on the bio-physical assessments however, for mapping the major ecosystem properties aiming to assess a degree of ecosystem integrity or health, as well as main degradation signals when and where present. This makes the LEAC approach distinctive from other assessment approaches. It involves a broad geographical approach at the start – top-down and holistic. It also aims to account for what is first obvious and most ecologically meaningful by collating widely available evidence, including scientific data, statistics and expert valuations.
LEAC is intended also to provide multi-scale (hierarchical) outputs, to facilitate the assessment of processes that manifest on different levels e.g. continental, country, region and local level. So far the European application has been well demonstrated in a report titled 'Land accounts for Europe 1990-2000' (EEA report, 2006). Regional applications were tested for exploratory assessments of Mediterranean Wetland areas of Europe, as well as more site specific applications for assessing four cases of Wetlands of major conservation importance in Europe: Danube Delta in Romania, Amvrakikos lagoon in Greece, Camargue delta in France and Doñana protected area in Spain. Major strengths and applicability of the method have been shown at larger scales e.g. for Europe due to the possibility to match multi-source and multi-theme data per country (as medium resolution remote sensing, country statistics etc). However, major difficulties were observed in applying LEAC at local levels (e.g. for the four wetland cases) where multi-variate assessments require high quality data inputs (sampling, measurements) and sophisticated modelling of the relations between the very complex structures in an ecosystem.

Currently the LEAC application in PEGASO addressing the Mediterranean and Black Sea countries is steered along possible applications in other areas from Australia, Canada and Colombia. The latter applications are result of the on-going developments at the EEA in promoting the method globally. The overall intention is to streamline the method into a global application with intended inputs for a UN standard. However, these applications do not have the same purpose, and so the approaches will differ. While in PEGASO the main objective is to deliver regional assessments of past and present states (that should feed into future scenarios) for support to decision making in the other areas it will contribute more to national environmental accounting initiatives.

This report is structured in two parts:

- the first one explaining the LEAC approach as an umbrella framework including a number of methods to address the main ecosystem subjects and
- the second part explaining the concrete developments and applications in PEGASO.

Part I: Ecosystem accounting methodology

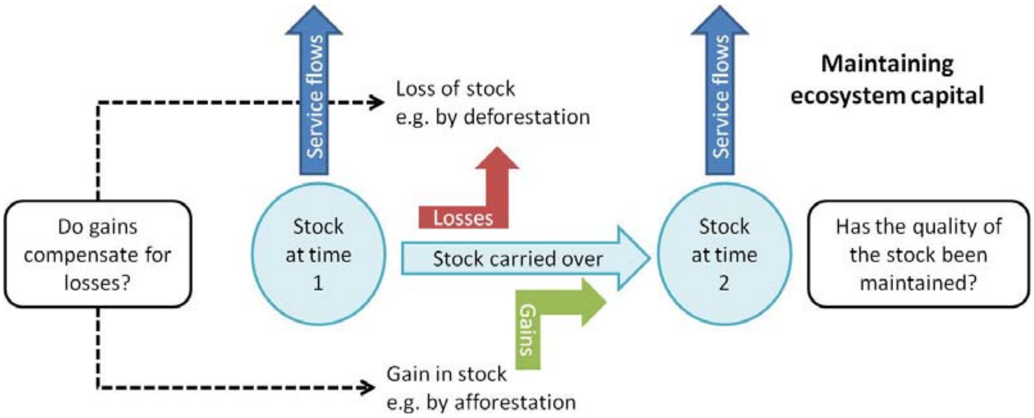
2.1 Elements for constructing ecosystem accounts

Essentially the ecosystem accounts aim to register properties or state of natural resources and ecosystem components in terms of quality (for example type of land-cover); quantity (volume of biomass, area of certain land-cover, number of species etc) and change in quality and quantity in time and space. The quantity and quality features are basically termed and accounted as physical "stocks", while the change features are accounted as "flows".

- Definition of stock – a mass or volume of something or area
- Definition of flow – flow is a rate of some kind

The inputs for characterizing stocks and flows are various, but generally they need to cover a unit of area, be it a country, region or continent, in a harmonized way (as coverage, signal and precision), otherwise one cannot compare the outputs.

For distinguishing differences in stock either as quantity or quality, the inputs are interpreted and classified into entities with clear, simple and transparent meaning that provides insights about conclusions regarding the integrity or health of the ecosystem/environmental resource in question. The interpretation and classification relies on predefined logical systems or filters for example land-use classification system, or water quality classification system. Likewise, the flows are also classified into most likely transitions which therefore allow one to track and explain what entities change to another entities and also how much of each entity was transformed. Concrete examples are given



below when reviewing the details the concrete accounting subjects.

Figure 2. Ecosystem capital accounting: stocks and flows. (adapted from Haines-Young and Weber, in EEA, 2006)

The ecosystem accounting addresses multiple dimensions of inputs which aim to characterise the different properties of an ecosystem (abiotic, biotic and antropic), the major ones being productivity and biomass accumulation, richness of life forms (or habitats and biodiversity), dynamics, biotic regulation and stability, different environmental elements as water, topography, biotopes, different human presences and impacts (such as pollution, erosion, invasive species sprawl). The conception of such a complex ecosystem reality is underpinned by classical ecological works (Odum, 1971; Holling 1978, 2001) and also related large-scale applications such as the Millennium Ecosystem Assessment.

To synthesise all these different aspects as a coherent description of a single holistic entity, the ecosystems need to be defined as accounting unit. There are multiple attempts to define ecosystem and in a hierarchy of scales, e.g. in a chorological order –biotope, ecosystem, landscape, biome. All of these orders are now influenced by human presence and impacts, but often it is the landscape level where human and natural interactions produce a concrete result – the landscape. The notion of ecosystem accounting then allows the introduction of other elements (apart from land), like the sea and ocean (*seascape*), or even the atmosphere (*airscape*, where air pollution, noise, flight traffic, etc. take place). Air and ocean are used and transformed by humans like land. Ecosystem accounting is therefore a very relevant method to tackle wide range issues and environmental elements, including also management of the rivers, the land, the coast and the sea through a common ecosystem based framework.

To build an ecosystem account one needs to define and apply a unit able to incorporate a mixture of all those elements. Certain advances in this aspect are derived from the Socio-Ecological Systems (SES) approach. "A social-ecological system consists of a bio-geo-physical unit and its associated social actors and institutions. Social-ecological systems are complex and adaptive and delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context" (Glaser et al., 2008). To be relevant for ecosystem accounting, it needs to be translated into a statistical category. This leads to the proposal of defining a proxy unit of SES for observation, statistical collection and economic-environmental accounting named socio-ecological landscape unit (SELU), as proposed by the UNSD and EEA and their expert group (EEA expert Group meeting, 2011). This definition is very useful for traditional modes of resource appropriation, where all is done locally or regionally. But in a global liberal system we can have enormous transfers of investments and benefits from natural capital extraction, where externalities remain locally, affecting or even destroying the living conditions of local population, leading to local conflicts (and even wars, etc). These new dimensions in resource management need to be addressed by the SELU framework.

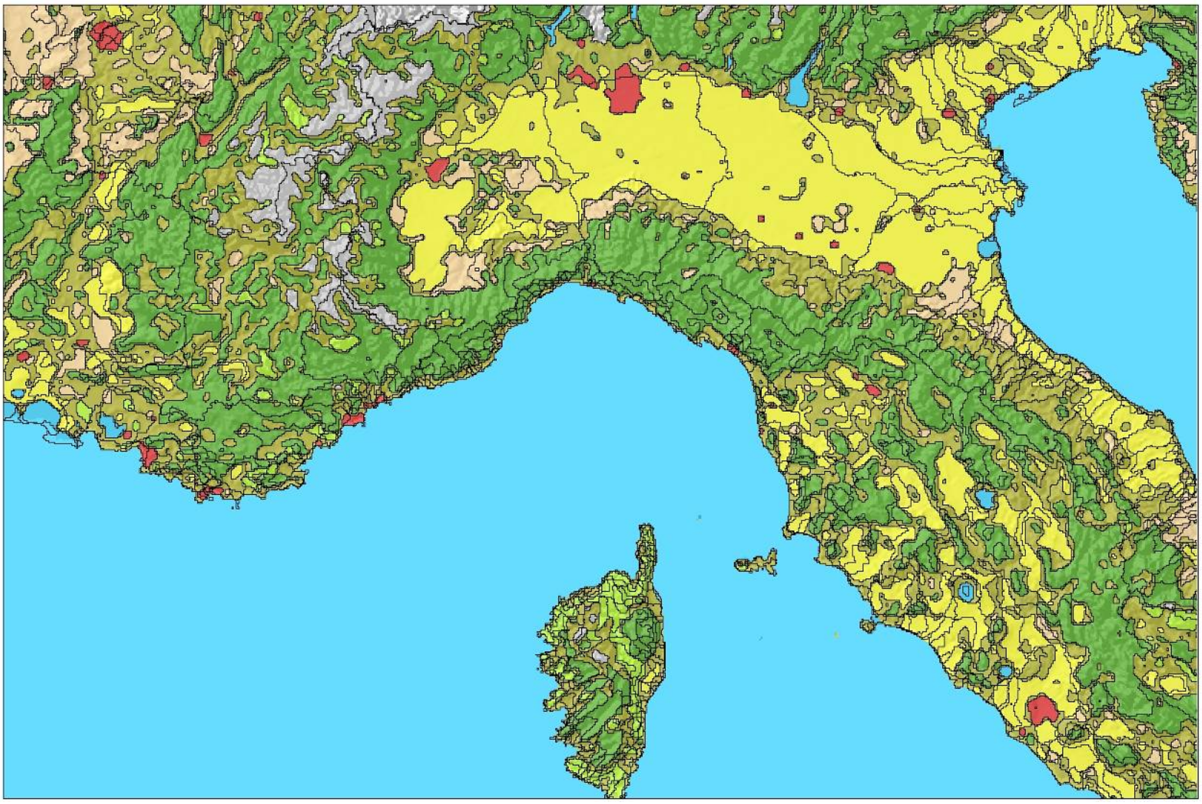


Figure 3. Defining the ecosystem accounting units for Europe (Weber and Ivanov 2011, EEA-CEM)

For developing ecosystem accounts the challenge is to match the different bio-physical and societal variables in relevant territorial units to understand how they interact in terms of resource management. The societal ones are readily and widely available as statistics for administrative units (NUTS), while the biophysical ones – more relevant for naturally defined units - as river catchments, different types of landscapes such as mountains, highlands, lowlands and different types of ecosystems, as forests, steppes, wetlands, etc. For all of these the human product of land-use needs to be added (e.g. pasture lands, croplands, residential areas etc.) in such a way that the appropriation modes upon the ecosystems are made more transparent, such as flows of private benefits made on common natural capital better known as well as the degradation rates of the basic ecosystem functions.

2.2 Conceptual framework of the European ecosystem accounts

Although proposed nearly three decades ago the concepts of ecosystem integrity and dynamics (Odum, 1971; Holling, 2001; Rapport, 1985) have not been widely operationalized and applied, and this is still due to the difficulty to accomplish holistic, overarching and large-scale studies able to produce convincing and explicit results on ecosystem health. Recent accumulation of widely available and large-scale datasets as those resulting from remote-sensing, national statistics and expert valuations have now provided new opportunities to revive the ecosystem health assessment perspective. The EEA approach on Land and Ecosystem Accounting has pursued this perspective though developing an accounting concept and framework and has also produced first examples as a proof of concept. It aims to address the three key properties of productivity, richness and resilience by formulating concrete subjects to assess and produce quantitative accounts. The work is based on the fundamental ecological functions and factors such as primary productivity (carbon sequestration, biomass accumulation and nutrient turn-over rates), biodiversity (species abundance and distribution) and ecosystem stability (successional stages and equilibrium).

Essentially, these fundamental ecological considerations and derived spatial indicators are reviewed within a wider socio-economic context of policy-making and translated into a selection of key indexes as suggested by Weber (2009) following a "cubist approach". In this way the accounted ecosystem properties are translated for outlining environmental considerations of primary interest such as:

a) Landscape index – reflecting on the area and changes in land-cover, that is the result of human land use. This allows on one hand to assess the resulting pressures of certain land (and sea or space generally) uses on natural capital, or protected areas, etc., and on the other – the resulting ecological effects as connectivity and fragmentation (corridors, patch and matrix structures).

b) Carbon/biomass index – reflecting on the processes of accumulation of biomass and productivity (annual net primary production), the human use of both, and the resulting balance to assess maintenance of the ecosystem's vitality

c) Water index – reflecting on the quantity and quality of water resources linked to the available resources (aquifers, rivers, source, etc), their uses by sector, the social access to water, etc, the water resources managements and their impacts on the key ecosystem functions.

d) Biodiversity index – reflecting on the richness of species, the species community structures (food-webs and their disruptions) and their conservation status and prospects (endemic and threatened species versus invasion from aliens.

e) Dependency index – when ecosystem functions are under high inputs dependency to continue producing (e.g. water, nutrients, fertilizers, pesticides etc), that produce also high "toxicity" in the ecosystems. Generally this management dependency is linked with the production mode (intensive versus extensive, depredation from external agents versus local food subsistence, etc). Beach ecosystems are also in high dependency from sediment arriving after damming processes, then dependent on beach nourishment actions or other kind of protection that have important impacts on the land-sea interface. Protection actions for management of certain species can lead also to dependency of some species on human presence.

f) Health index – is intended to address issues of the health of species populations as well as human populations (e.g. bird flue, dispersal of new diseases by species affecting human health

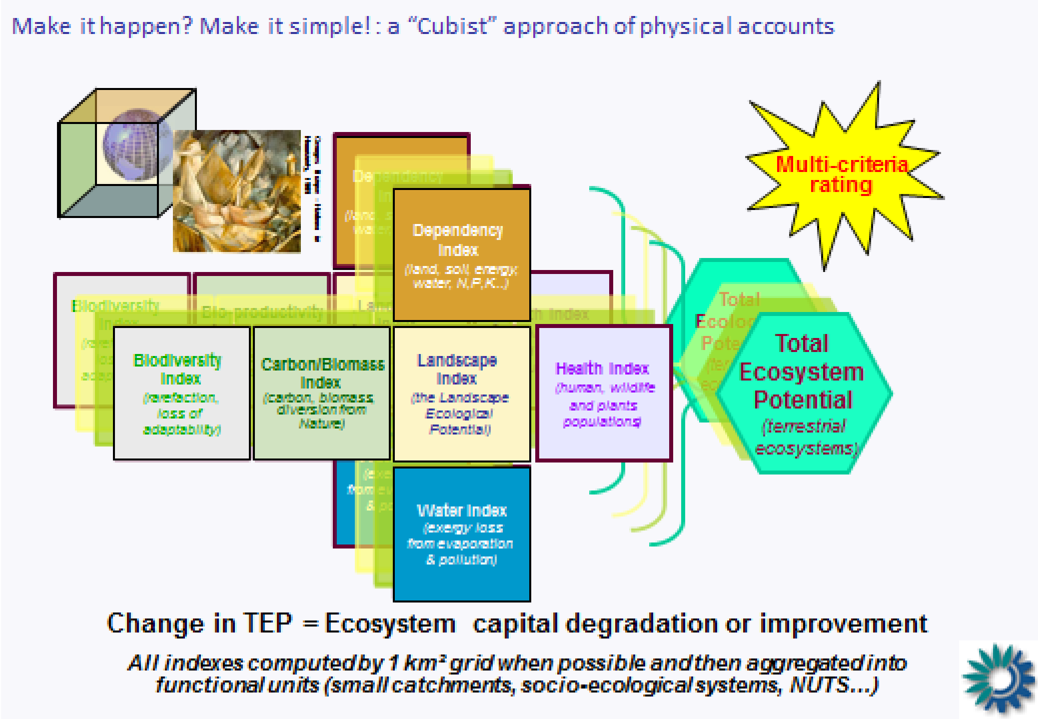


Figure 4. The ecosystem capital accounting cube, designed by J.L. Weber (EEA)

The above order of listing these indexes (each one representing a facet of the ecosystem cube) also shows the degree of their development.

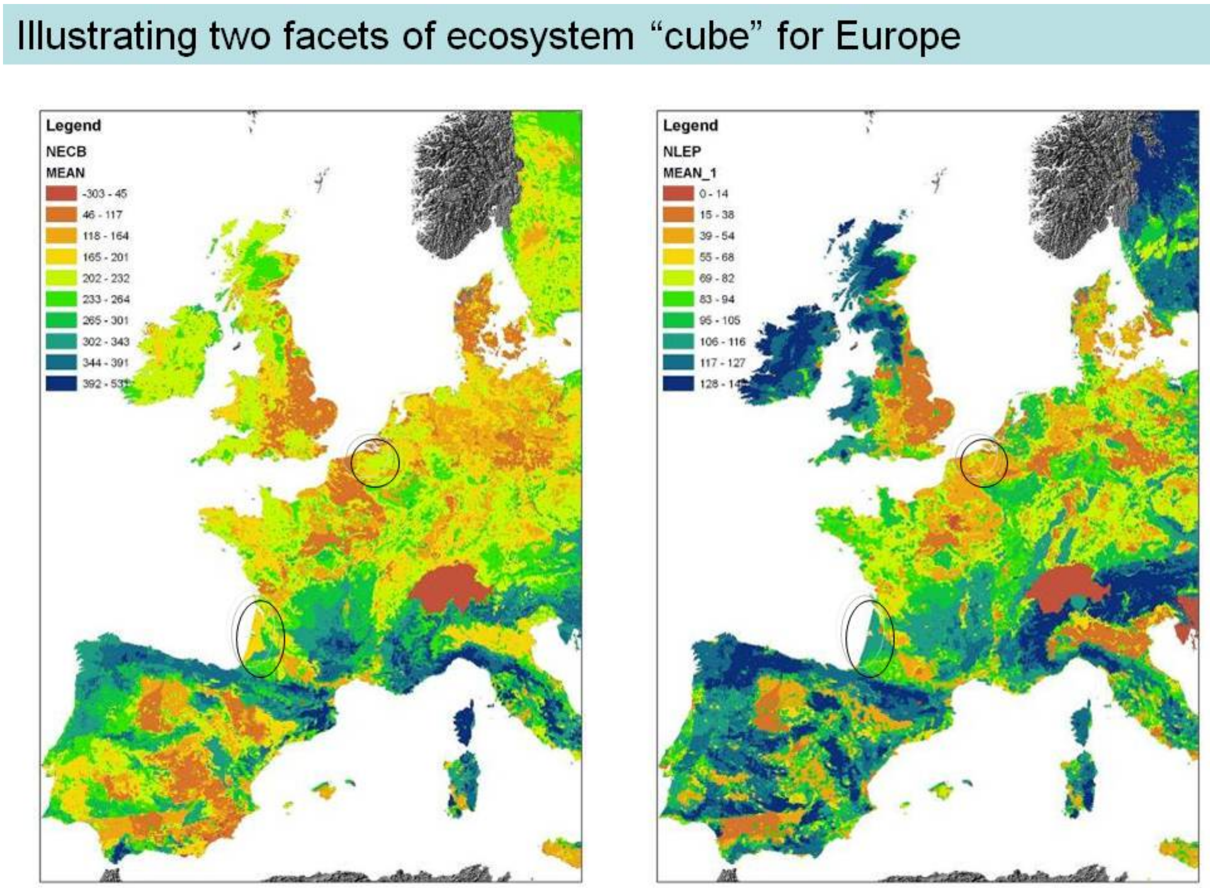


Figure 5. Net ecosystem carbon balance (left image) and Net Landscape ecological potential (right image) (Weber and Ivanov 2011, EEA-CEM)

The landscape index was first elaborated. The EEA (No 11/2006) report ¨Land accounts for Europe 1990-2000 written by Roy Haines-Young presents the first application of this method, demonstrating detailed characterisation (including quantitative estimations) of major land-use patterns and changes in EU – the urban, agricultural, forest and semi-natural land-cover classes.

The carbon/biomass index was calculated and mapped for the EU countries for year 2000 as a coarse demonstration and proof of concept. It will be soon reproduced as a time-series and then will be further improved and validated. Technical details and examples of the European land accounts are presented in Annex IV. The water and biodiversity indexes are still under development, but first results should be presented in May, 2012.

2.3 Data inputs for developing ecosystem accounts

Spatial data:

The spatial data includes continuous coverage, multisource, mainly medium resolution data for mapping phenomena of interest on wide geographical scales. Various data inputs are

matched applying fuzzy logic and proper techniques (see below) for this purpose. Point data and more precise local data are used for cross-check and partial validation so far.
The spatial data, mainly derived from satellite remote sensing sources, that is used as inputs for LEAC includes a number of themes, land-cover being a key one. Vegetation biomass and primary production on land (derived from NDVI) and in water (derived from Chlorophyll-a estimations); habitat maps both on land and water; human impact maps including transport, settlements, agriculture and aquaculture etc are increasingly produced and improved sources of information on large geographical scales. See Annex 5 for detailed list of data inputs identified for PEGASO T4.2. The European CORINE LC, the GlobCORINE, MODIS land cover are key inputs. Medium-resolution satellite image providers (as MERIS and MODIS, SPOT-vegetation) are widely explored and applied for the vegetation productivity-related estimations with certain limitations such as saturation of the signal they carry. RADAR image providers as ALOS-PALSAR are still expected to provide better inputs on the near future, for improved biomass and habitat mapping.

Statistical data:

Statistical data and related estimations reported for various territorial units (such as municipalities, regions, countries, groups of countries) during the last five decades provides readily applicable multi-subject information to address a wide range of mainly human influence aspects related to the state and change of the ecosystems. EUROSTAT and FAOSTAT are the main sources explored so far, for estimations of annual production and harvest of crops, timber and livestock. Additional categories to be used include fisheries, fertilizers and pesticides use in agriculture, water use etc.

Expert judgements and valuations:

Include mainly subjects related to wide-scale biodiversity assessments. Such were produced for the EU countries and explored so far for the European ecosystem accounts e.g. the data reported for the Article 17 of the Habitat Directive on the distribution, conservation status and future prospects of selected species of European Conservation importance (excluding birds). IUCN data on threatened species, data from Birdlife international, Mediterranean Wetland Observatory and others is yet to be explored.

2.4 Methods, tools and techniques used for developing ecosystem accounts

Three broad categories of tools are applied for designing and implementing ecosystem accounts: spatial data exploring and assessment for selecting best inputs to produce accounts; spatial data processing and modelling for producing stock and flows of the accounts; multi-criteria analysis and assessments to derive information on ecosystem capital state and degradation. In addition several tools are designed to assist the exploration of the produced stocks and flows in an interactive way.

For fast and efficient exploration of the quality of the available data inputs, these are normally extracted using GIS (ArcMap) and/or Image processing tools such as RSI-ENVI. Then the data is integrated in a grid (of 1 km most often) using ArcMap, and afterwards the relationships between the different variables explored. Finally, accounting indexes are extracted per grid-cell using Excel pivot tables and/or statistical software such as SPSS. The assessment of the quality and reliability of the available data to be applied for large (continental) scale assessments is often visually assessed and approved or improved for assuring consistent geographical and landscape patterns on the basis of expert knowledge and judgements. New emerging tools and processes for harmonization and sharing of spatial data, such as SDIs are expected to greatly facilitate data sources exploration and selection.

Once the best data sources are selected, spatial data processing is done suing GIS (ArcMap), Matlab and a multi-dimensional database is constructed provided that the needed inputs are sufficiently available and of a good quality. When these inputs are missing or existing but need to be improved, then also image processing tools are applied again (such as the above mentioned RSI-ENVI and ERDAS IMAGINE).
Spatial modelling and transformation of the original data is done to derive various products, such as smoothed, more course versions which facilitate interpretation (such as agricultural pressure, urban pressure etc), or to derive specific indexes (like terrain map, or elevation breakdown) or which are needed for subsequent calculations (such as percentage of given land cover class in 1 km2 grid). These processes are designed and done using automated calculation scripts with ArcMap.

Another spatial data processing technique which is widely applied is the downscaling of the statistical data (on crops, timber, livestock) reported per unit area (country) to a spatially explicit map (in 1 km2 grid). The downscaling is a complex process including many steps. The downscaling procedures are first designed to produce satisfactory downscaled products, such as spatially explicit intensity of cropping, or timber harvest applying step-by-step calculations with ArcMap and assessments. Once approved, the whole process is then translated into an automated GIS calculation model.

Through the above techniques, the ecosystem accounts are produced including estimations of stocks and flows and related indexes (such as potentials, intensities etc). The latter are then included in interactive exploration tools such as OLAP cubes and pivot tables, online map overlay viewers and others.

Finally, all of the above tools provide single subject outputs which allow to portrait one aspect or element of the ecosystems. For assessing their complex properties in an integrated manner, a novel approach was designed by Haines-Young et al. (2010, 2011a, b). It applies probabilistic (loose) modelling with sets of variable and produces multi-criteria assessments.

Bayesian Belief Networks (BBN) are explored for this purpose, they allow to make use of wide range of data in different forms and in a transparent way.

2.5 Summarising the accounting method

The ecosystem accounting methodology is a novel approach for integrated and large scale ecosystem assessments relying exclusively on available inputs. The exercise is data-driven. In accordance with the limitations of data availability it can provide several outputs: a complete numerical account (satisfying a number of criteria of what an ecosystem capital account is e.g. calculated stocks and flows); a map of a relevant spatial indicator or even a qualitative assessment (such as high-medium-low pressure of a human action).

According to our present experience, the process of developing an ecosystem account can be summarised in six steps:

	Step	Note, clarification	Example (problem-oriented)
1	Define, or sketch a proposition (pre-concept)	Choosing a row from the above matrix to develop a line of reasoning	The effect of urban sprawl on coastal ecosystem
2	Perform a quick test with available and pertinent datasets	- Identified and collected for the above matrix; - this may already allow to derive *preliminary exploratory accounts* (version 0). - If the data available does not allow to extract complete stocks and flows, it can be applied to map at least some relevant spatial indicators at this stage - next option would be try to improve it/develop it or to choose another *reasoning line*	- MODIS land-cover 10 year time-serie allows to extract areas of Urban land cover. - Stock would be the area in hectares within a coastal region for ex. and a flow, the change till next year(s). - However if the change cannot be validated as true (so no complete account can be derived), the information on current urban pressure can still be a relevant spatial indicator of coastal pressure to support ICZM
3	Define a detailed concept of work (jointly, in a teamwork)	Involving all partners with relevant inputs, according to their expertise (data, models, information at hand)	MODIS urban land has been assessed as not sufficiently sensitive to reflect on actual urban sprawl, therefore other sources are identified to enhance it (GlobCover, nightlight)
4	Develop an accounting model and database (jointly, in a teamwork)	- This includes a set of data processing and modelling tasks which allow to extract accounting tables and plot maps on the stocks and flows as defined in the previous steps	For example, the EEA's method for land-cover accounts contains procedures to extract and structure the information from CORINE LC in a form allowing to quantify and map urban sprawl and assess its effect

		- the models need to be just fit for purpose (help convey information from existing data to decision-makers)	on Venice lagoon for example. This is particularly useful to assess and map main pressures and impact on the coast.
5	Assess, validate and improve the models and databases	- via tests in the CASEs and the sub-regional assessments - applying additional data	
6	Produce final ecosystem capital accounts	Version 1 or spatial indicators (if no account can be derived) or even qualitative assessment ...	

The above presented methodology built for Europe is currently being extended and adapted for the purposes of the Mediterranean and Black sea coastal areas' management. The following part explains the main lines of work initiated so far.

Part II: Ecosystem accounting applications in PEGASO

3.1 Setting up working sub-themes and ecosystem accounting applications

This part reflects on the efforts to built applications of ecosystem capital accounts specifically addressing the coast and marine parts of the wider coastal zones, by drawing on the experience of the land accounts. There were a number of initiatives, discussions and workshops, (after the General meeting in Romania, July 2011) to define and proposal several feasible applications. During a meeting at JRC-IES (Ispra, July 2011), certain difficulties of applying the EEA approach for *land accounts* were underlined, and alternative approaches were considered (e.g. upscaling the outcomes developing ecosystem accounts for selected cases (for example the north-Adriatic case). Yet additional efforts, to further develop elements of the EEA approach were also discussed, for example incorporating data on fires, crop irrigations, non standing forest biomass etc to better reflect the Mediterranean environment. Relevant approach for the sea part was suggested, targeting to analyse the influence of land-based activities, through river run-off (catchment approach) on coastal waters quality, eutrophication risk etc. The sea part of the work may also include analysis of the physics of the water column in relation to sea currents, temperature, upwelling events etc. The work needs an improved land cover map for the African and Near eastern parts of the study area. For this GlobCover or GlobCorine can be tested and compared with Corine land cover, and afterwards improved with additional data. This work is expected to deliver adequate accounting outputs spanning the entire Mediterranean and Black sea coastal region but still leaving empty the sea part. Consequently major efforts were devoted to address this gap, at the UAB, and a complementary approach termed SEAC was proposed, conceptually rich yet outlining major difficulties for its practical development, due to lack of data and far more complex marine system to be assessed and modelled. To address this problem a meeting was organized in Nottingham (December 2011). It was identified then that e a common vision for the accounts is needed and that the division between LEAC and SEAC was probably unhelpful. PEGASO should rather speak of ecosystem accounts and include within them integrated approaches covering land coast and sea. Aside, it was also identified that a more iterative and flexible working approach for developing ecosystem accounts was needed, and that at this stage 'right approach' was identified as more important than concrete calculations and mapping of accounts.

3.2 Building accounts for the coast and sea environment

Ecosystem accounts should provide statistics, values and maps which inform policymakers of environmental and natural resource availability, use, depletion and degradation over time and help identify the drivers. In Europe, the physical part of the account has been applied to the terrestrial environment using LEAC methodology and one of the goals of PEGASO is to extend this methodology to the marine part of the coastal zone for the Mediterranean and Black Sea.

For the purpose of the task, an inventory of ecological assets and human activity data including land and sea uses, both at a regional and local scale will be provided, first step for a multi-scale assessment on the state and threats on main relevant ecosystems at coast and sea in the Mediterranean and the Black Sea.
This work will allow to:

(1) Start the construction of a green/blue inventory (land/sea) at the basin scale which will feed into the Spatial Data Infrastructure (SDI) developed by PEGASO WP3.

(2) Test and develop a series of tools (maps, statistics, spatial indicators of pressures, models, etc), publicizing and making useful existing data for helping decision making, a starting point for the construction of an ecosystem based assessment at the basin scale identifying hotspots, potential for ecosystems to be degraded or to evolve in a sustainable direction (inputs to PEGASO WP5),.

(3) Produce a number of targeted physical ecosystem accounts (together with UNOTT, EEA) where data exist or expert judgment can provide qualitative information..

(4) Start a participative process in order to apply the ecosystem based assessments for policy-support purposes, for example at the basin scale identifying hotspots, potential for ecosystems to be degraded or to evolve in a sustainable direction (inputs to PEGASO WP5).

These results will be a basis for other PEGASO tools such as participative scenarios and indicators, as well as economic and social valuation of some activities using relevant services of certain ecosystems. Inputs to the PEGASO toolbox (WP4), will allow a common knowledge shared and agreed by the PEGASO governance to support implementation of the ICZM Protocol in the Mediterranean and similar figure in the Black Sea. Stakeholders and users will be able to use these tools to discuss and take consensual decisions.

Therefore they will serve ICZM ecosystem based purposes becoming a necessary basis for Marine and coastal planning, but they will also be useful for future implementation of legislation such as the Marine Strategy framework Directive in the two basins.

Given the novelty of this approach and the lack of data for the marine environment, the methodology will be tested and developed at different scales following relevance of issues and constrains of data availability, but also in partnership with specific areas (AMPs, wetlands, islands, etc) which are not in the PEGASO partnership but are interested and relevant to this developments. This process will involve countries and PEGASO governance as an opportunity for us to understand better their needs and for them to understand our goal and therefore the usefulness of sharing data.

(1) Following the ICZM protocol, ICZM is:
"... a dynamic process for the sustainable management and use of coastal zones, taking into account at the same time the fragility of coastal ecosystems and landscapes, the diversity of activities and uses, their interactions, the maritime orientation of certain activities and uses and their impact on both the marine and land parts."

(2) According to the CBD, the Ecosystem Approach (EA) seeks to:
"…places human needs at the centre of biodiversity management. It aims to manage the ecosystem, based on the multiple functions that ecosystems perform and the multiple uses that are made of these functions. The ecosystem approach does not aim for short-term economic gains, but aims to optimize the use of an ecosystem without damaging it."

3.2.1 Rational

PEGASO and specifically task 4.2 should provide tools that help the implementation of an Ecosystem Approach [(1)] of ICZM [(2)] process following the Mediterranean ICZM protocol and a similar juridical tool in the black sea coast.

Starting from the common understanding of what the concept of ICZM and EA suppose, there is a wide recognition in scientific, grey literature, experts and guidelines that:

- Spatially explicit accounts on the distribution and changes of endangered habitats and communities are strongly needed for a sound implementation of ecosystem based strategies such as ICZM (Claudet and Frashetti, 2010; Frashetti et al., 2011).
- Improve the qualitative and quantitative understanding of how human activities both at land and sea impact coastal ecosystem (Halpern et al, 2008)
- Land sea linkage must be strengthened both at level of data (available and uniform for both part and their interface), planning and governance (include both land and marine stakeholders as Marine Protected areas managers).

Relying on those statements and on the ongoing reflection process in our team and with PEGASO partners, different issues/steps related to the task 4.2 has been defined.

3.2.2 Data issue

Mostly for accessibility reason, more information is generally available for the terrestrial part than for the marine part. Indeed, the development of satellite imagery, which associated to

definition of a scheme of habitat classification such as Corine has lead to the possibility to have continuous maps of terrestrial proxy for ecosystems (CLC classes) and produce tools such LEAC in Europe. For this reason of accessibility, in the marine part, the habitat distribution and changes, biodiversity monitoring, etc, are very difficult and costly to assess and are far away from being achieved at the Mediterranean scale. Therefore, in a next future, it will be necessary to collect further seabed, marine biodiversity information and develop common monitoring protocol to fill the gap between land and sea data availability.
However the first step is to make best use (or re-use) of already existing information and maps and to properly publicize and disseminate it to the stakeholders, support decision making and to create a framework for enlarging future data collection, harmonization and sharing across the Mediterranean sea.

For those reasons a green blue inventory will be done as a first step for 4.2 tools development.

Green Blue Inventory
The existence of the governance platform and the SDI developed by PEGASO are an opportunity to start a first assessment of the data availability and develop a framework for a common understanding of data needs and the way to share them and make them useful. The effort of data gathering will be focus principally on:

Ecological features:

- Relevant land cover classes which support high biodiversity: small islands, deltas, lagoons, estuaries, dune fields, natural beaches, heritage landscapes, sea grasses including *Posidonia oceanica* meadows, etc.
- Places where important species (fish, coral, marine mammals, etc) have been detected as well as migration routes and sanctuaries hotspots, identifying most important corridors.
- Species richness index covering the whole Mediterranean and vulnerability spots
- Measurable stocks that can be monitored over time
- Priority areas for conservation and management

Level of protection and legal uses

- Denominated coastal areas of the Mediterranean and Black Sea Basins, including EEZ and other political boundaries and obligations (areas that have a political protection obligation)
- MPAs and other protected areas
- Water quality of the rivers discharging into the Mediterranean and Black Sea

Pressures

- Drivers and pressures from sea and land (boat traffic, aquaculture, fisheries, land use, ports, etc.)

Make data useful; improve the visibility and understanding of pressures and changes:

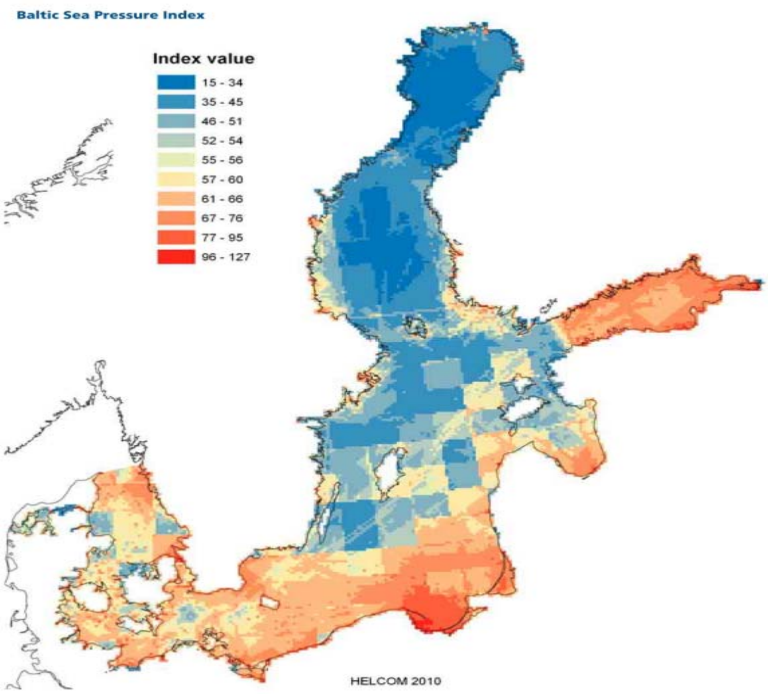


Figure 6: Map of cumulative potential pressures in the Baltic Sea based on the Baltic Sea Pressure Index. The blue color indicates low cumulative impacts and the red color indicates high cumulative impacts. (HELCOM, 2010)

Potential Impact Mapping

Transnational, national, and local management of coastal areas requires spatial data of the intensity of human pressures and potential impact on overlapping ecosystems or protected areas.

There is a recent effort to estimate and map in a transparent and systematic way the cumulative impact of pressures on each ecosystem. The paper from Halpern et al, 2008 gave one of the first spatial visualization of cumulative impact (from land-sea) at global level and was followed by other papers at smaller scale with refined data (see figure 3, Korpinen et al, 2012, Ban et al, 2010, HELCOM Project).

This kind of model needs spatial data on human activities and ecological features which are generally difficult to collect or not available at large scale. However the collaboration with PEGASO partners and other projects like MEDINA cumulated with the outputs of the green blue inventory should allow applying the methodology at least in the western Mediterranean.

This work should be seen as the first step towards more comprehensive impact assessments and better validated quantification of impacts.

It will feed and be fed by indicators and modelling where relevant in a way that should allow a better understanding of the situation of local areas such as PEGASO CASES, MPAs or wetlands in relation to a broader Mediterranean or global context.

Toward continuity between Land and Sea and between countries; harmonizing the information:

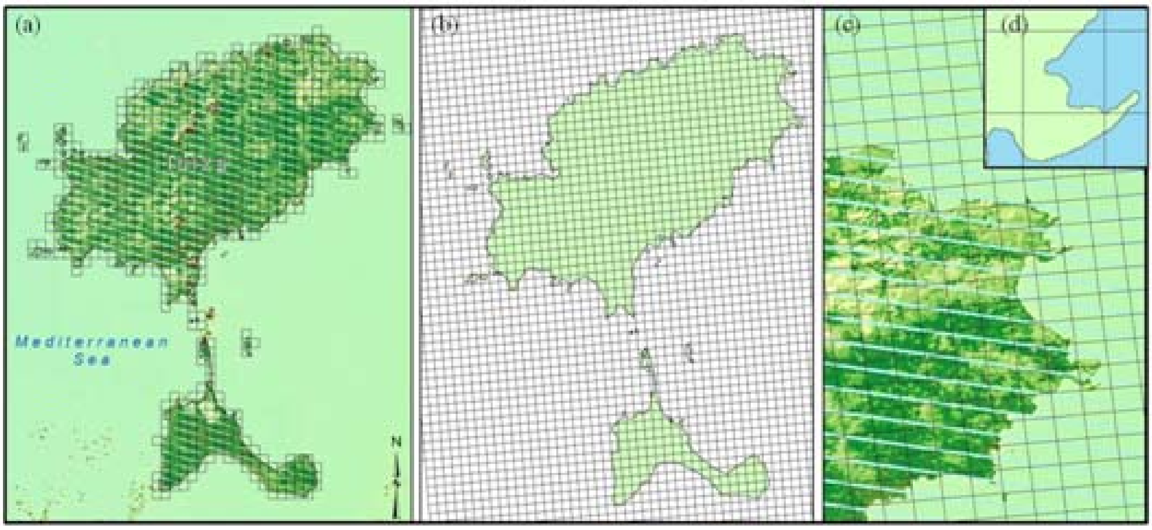


Figure 7: Example of proposed SEAC grid for the island of Ibiza. (a) The current LEAC grid is only available for land. SEAC intends to extend this grid into the sea (b). This will insure continuity and comparable ecosystem accounts for the coastal zone (c) at spatial resolution of 1 km^2 grid cells (d)

The grid approach

Land-sea continuity in management and planning is greatly facilitated by comparable and continuous data on this interface.

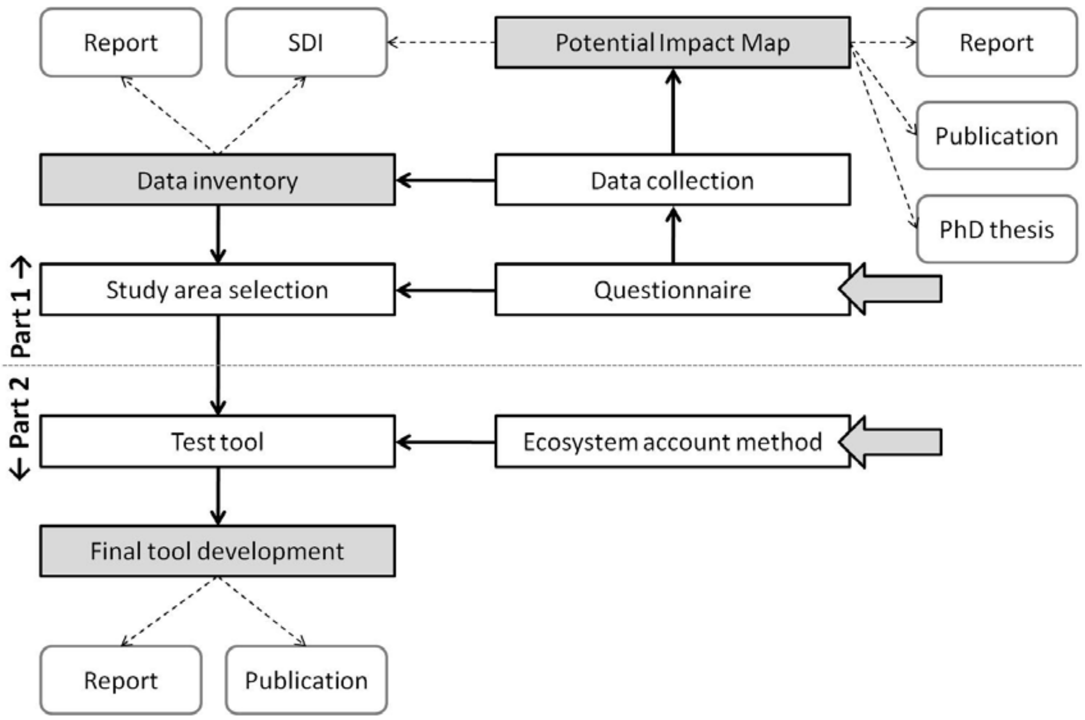
Utilisation and harmonisation of existing data, strengthening the land-sea link will be achieved by extending the 1km^2 grid system currently used for LEAC, to cover the Mediterranean and Black Sea (see Figure 2). This Grid system will be coherent with INSPIRE directive.

The grid system allows for data from different times and/or geometries (e.g. NUTS 2003, NUTS 2006) to be combined with continuous (such as CLC) and/or discrete data (e.g.species distribution)(EEA, 2010). In other words, complex spatial, statistical, qualitative and quantitative inputs provide comparable, meaningful outputs.

This gridded approach will serve directly the potential impact and accounts exercises allowing a common data format for analysis and integration both between land and sea and between PEGASO tools.

3.2.3 Method

Study design



This project will consist of two main complementary parts, namely the 1) data inventory and mapping, and the 2) development of an ecosystem accounting tool. The objective of Part 1 is to identify what data is available at regional, sub-regional, national and local scales. This inventory can be used to identify important areas for marine spatial planning, as well as knowledge gaps. A questionnaire completed with expert judgement methodology will be used to achieve this objective. The results will help to identify data sources for both the SDI and the Potential Impact Map. A report listing the data that is available (and the data sources) will be made available for Mediterranean stakeholders facilitating localization of data or needed research efforts. Additionally, the availability of data is the most important criteria in the selection of study sites needed in Part 2. Part 2 aims to develop an integrative ecosystem accounting tool for coastal zones and their marine interface. Study sites selected in Part 1 will be used to test the tool. The development of this tool is currently underway by Pegaso team at the University of Nottingham. At UAB the methodology will focus on Part 1, even though we participate also in the part 2 discussion on the method elaboration together with UNOTT.

Data inventory

Goals:

- Assess what data is available at different scales for both ecosystem and social uses that can affect them.
- Identify knowledge gaps (at all scales)
- Identify study sites for ecosystem accounting tool testing (incl. Regional if feasible)
- Collect data for the Potential Impact Map

Outputs:

- A report listing available data at each scale and data sources
- Potential data layers and geonodes for the Spatial Data Infrastructure (SDI)
- Provide data needed for the Potential Impact Map

Questionnaire

A questionnaire will be sent to institutions and entities involved in the management, governance and/or scientific research in the Mediterranean and Black Sea Basins. The main target stakeholders for the questionnaire will be the partners and contacts already established by the Pegaso Project. These stakeholders include regional programs (e.g. IUCN), sub-regional (e.g. INFREMER), national (e.g. government) and local projects (e.g. Pegaso CASEs, MPAs). Other projects, institutions and entities identified in a literature survey will also be contacted. The objective of the questionnaire would be to evaluate what data is available, at what scales and how willing the stakeholder would be to participate in this study. The answers to the questionnaire (both quantitative and qualitative) will be used to select the study sites based on the criteria outlined in the following section.

Several questionnaires and surveys have already been done with the Pegaso partners and stakeholders in the past. The results and types of questions already asked will be assessed to reduce repetition so that questionnaire fatigue can be avoided. Key contact people will be established prior to sending out the questionnaires. These contacts will be fully informed of the objective of the questionnaire and what is expected in terms of a response. Follow-ups will be performed telephonically to ensure that the stakeholders respond and that they understand the questions asked. The questionnaire will be also completed by a number of interviews with experts to assess the best judgment (on data quality if they exist, and on the ecosystem status and changes if no data is available.

Assessment of available data

The results of the questionnaire will be used to compile a list of data that is available from the stakeholders.
It will be completed by data search on internet considering:

- Relevant scientific literature

- Ongoing and past projects
- Relevant Database

In addition to the availability of the data, information on the scale, extent and temporal resolution will be recorded.

The list of data for land and sea will be grouped into 3 categories as discussed previously:

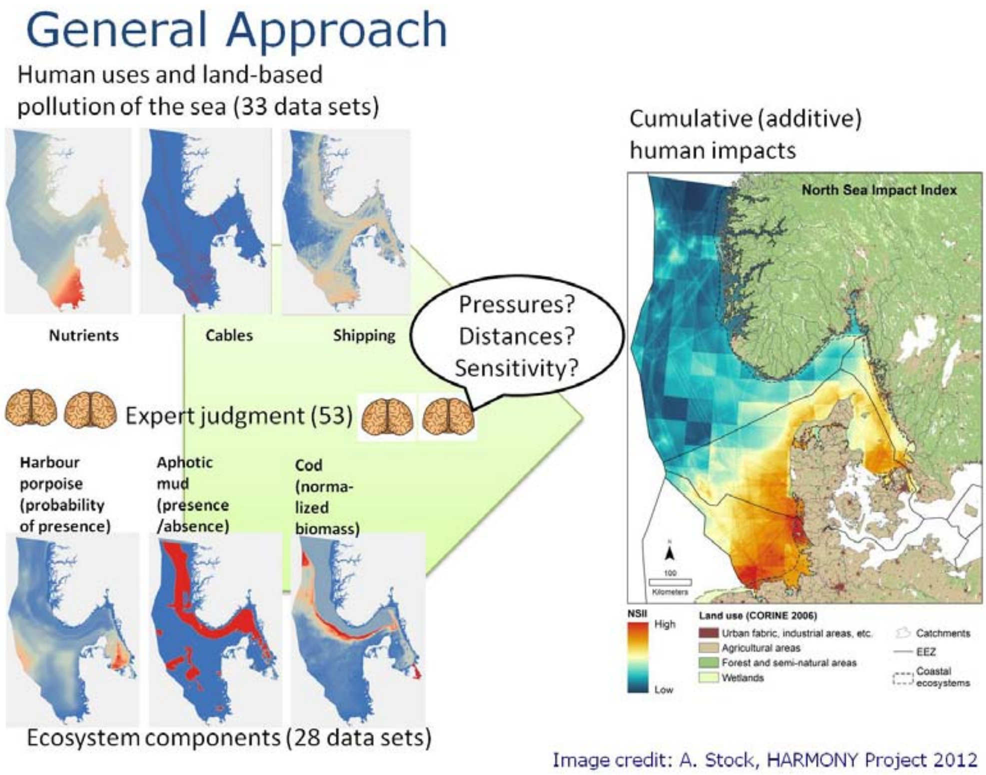
1. Ecological data (biological, geological, oceanographic, etc.), including habitat and ecosystem mapping
2. Coastal and marine levels of protection and legal uses
3. Data on anthropogenic activities

The output of this inventory will be a report listing the data that is available within each category at a regional, sub-regional, national and local scale. The source of the data will also be included. This inventory can be used by stakeholders to identify knowledge gaps where further research is required as well as for marine spatial planning and identifying areas that need to be protected. The inventory will also be useful for the Spatial Data Infrastructure (SDI) to identify potential geonodes for data sharing.

3.2.4 Mapping activities

Potential Impact Map at (sub)regional scale

The Potential Impact Map will be based on the model designed by Halpern et al. (2008) and 2009 and later developments (Selkoe et al., 2009; Ban et al., 2010, Korpinen et al., 2012). These models are used to evaluate the potential impact of anthropogenic pressures on different marine ecosystems in a systematic way. The resulting impact index value will be indicative of the cumulative impact on a given ecosystem and can be used to identify priority areas for action and conservation as well as predominance of sea based or land based pressures.



The determination of weighting coefficients needed to transform the pressures into potential impacts on a given ecosystem will be done through expert survey, as was done in the study by Korpinen et al. (2012). Due to the specific data requirements, a study area will be selected with the availability of data and presence of environmental experts as the predominant selection criteria.

As explained before data will be obtained from the inventory but also from work of other PEGASO partners (Nutrients input, chlorophyll a, transparency /turbidity, primary production, final scale modeling (ACRI, JRc). The specific methodology will be taken from the last development in literature and projects and adapted to the specific needs and constrains (e.g. data availability) of the Mediterranean region.
For more information on the methodology please refer to:

- http://www.nceas.ucsb.edu/globalmarine
- http://www.helcom.fi/stc/files/Publications/Proceedings/bsep125.pdf

The main output of this section will be a spatial map of the cumulative impacts on (sub)regional area chosen. This map will be published and represent a section of a UAB /PEGASO PhD thesis. The map will also be made available on the SDI so that stakeholders can include impact information in marine spatial planning and policies process.

3.2.5 Concerns and considerations

About the use of the grid

The feasibility and relevance of gridded information for looking at stock and flows in the sea is questionable (3-dimensional environment etc.). One of the concerns is how to accommodate the three dimensional character of the sea with the two dimensional land accounting method. The sea has an additional dimension (see Figure 3) that is not present for land ecosystems, namely depth. This means that sea properties and uses may vary at different levels of the water column.

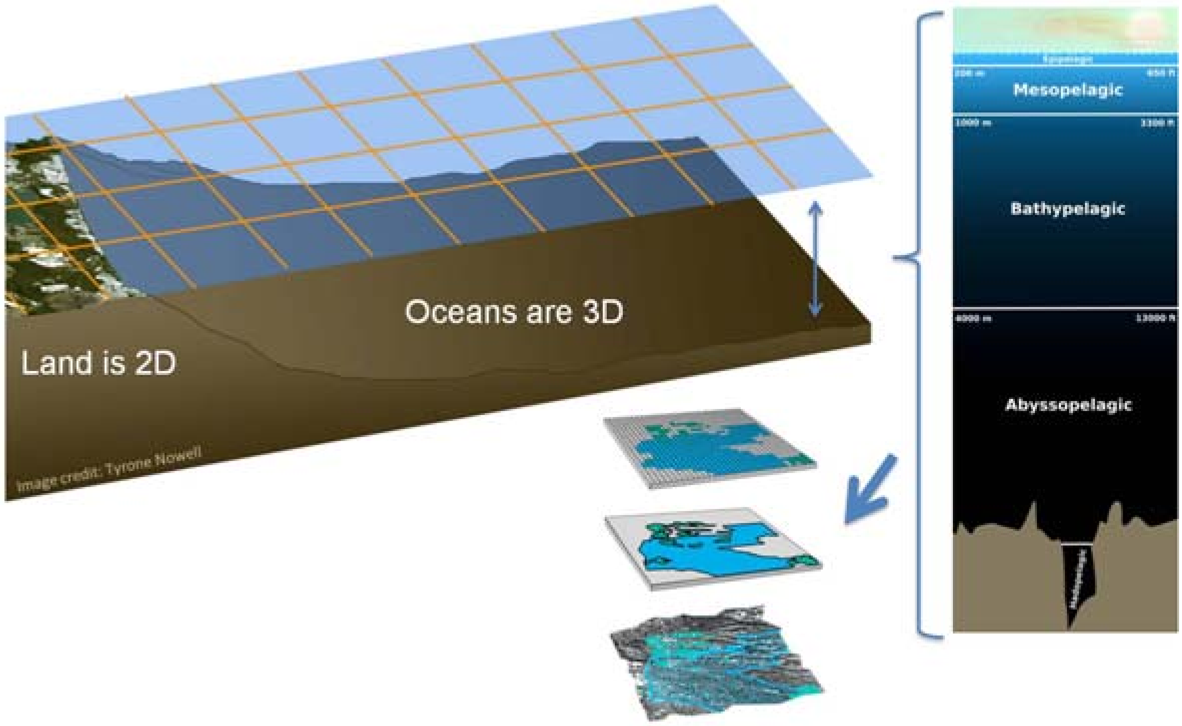


Figure 8: The 3-dimentional nature of oceans can be incorporated into a 2-dimansional grid by dividing the water column into zones and overlaying each zone and a 2-D layer

A way to include this aspect of the sea in the grid system is currently being explored by PEGASO. It has been suggested that ecological thresholds based on depth could be determined to divide the water column into zones (e.g. epipelagic, mesopelagic, bathypelagic, etc.). Information for each zone would be included in the grid as a two dimensional layer.

Standardization of the method

In order to enhance data sharing and collaborations, PEGASO will aim to use standardized boundaries, terminology, delineations and other methods and techniques that follow the Marine Strategy Framework Directive guidelines and other guidelines agreed upon in conjunction with the European Environmental Agency and European Topic Centres involved. These standardized approaches include:

- Standardized regional and sub-regional sea delineation following MSFD boundaries
- Standardized grid using the INSPIRE directive
- Standardized typology for marine and coastal ecosystem services (available at http://transfer.eea.europa.eu/download/13f4de52018e9ca029f22fb391d38d65)
- Delineation of coastal zones is not yet defined, but will be discussed further among the relevant community
- A reference coastline has not yet been decided

3.3 Linking land and sea processes in specific applications

A working agreement was reached between UNOTT, JRC and UAB to pursue joint work on modelling and assessing relations between:

- the intensity of land-use (agricultural, urban) at the coastal catchments using the Land and Carbon accounts
- Nutrient loads in major rivers (using JRC data)
- Chlorophyll-a and sediment loads in the river plumes and continuous coastal waters applying the remote sensing data from JRC and ACRI

The input data for this application will include climatological variability of a number of parameters mainly remote sensing products in water as chlorophyll-a concentrations, transparency, backscattering, temperature. On land the data input include land-cover, crops and timber harvest, livestock grazing and net primary production. The analysis will be done for pre-defined units including the terrestrial catchments, the main rivers, delimitation of the river plumes and delimitation of coastal water bodies (an example exist for the Baltic sea).

This application is inspired by the case of the Nile delta, where fisheries have totally collapsed after the construction of the Aswan dam in 1965, due to the cut of the natural flow of nutrients. Research however, uncovered the recovery of fisheries around two decades later and even at rates exceeding the pre-dam times at present times, and explained these changes with the supply of human-origin nutrients when farmers started applying fertilisers which leaked into the river and coastal waters.

4. Conclusion

This report presents a revised approach to applying the ecosystem accounting methodology for coast and sea environment in PEGASO. LEAC is a generic tool able to address different needs, but particularly for PEGASO is aims to resolve problems related to the lack of spatial indexes and indicators to measure ecosystem improvements after ICZM policies. Spatial indexes and indicators are needed both for defining ICZM intervention targets and for monitoring of ICZM programmes' success.

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Annexes

Annex I. Implementation of LEAC for coast and sea according to PEGASO DoW

Task 4.2.
Land and Ecosystem ACcounts (LEAC) are used to characterise change in the terrestrial environment. They are an effective set of tools that can be used to systematically describe the processes by which land based resources are transformed over time, and as a framework for spatially explicit indicator development and policy appraisal.
The work undertaken in this task will therefore extend the accounting methodologies into the coastal zone using new data for land (e.g. GlobCover 2006 V2), data derived from the mapping of the sea bottom communities, and data on trends in water quality and key species provided by the project participants: IFREMER, IUCN, ACRI-EC and others.

The hierarchical classification frameworks presently employed in LEAC will facilitate a multi-scale approach to the production of statistical data for different parts of the coastal zones and marine areas. The work will proceed in close partnership with T4.1 to evaluate critically the role that accounting methodologies can play in providing operationally effective indicators. It will also link to the work on scenarios (T4.3), participatory methods (T4.4) and valuation (T4.5), to explore how accounts can be used as a framework for modelling plausible futures with stakeholders, and assess marginal change in values for the stocks of natural assets and the benefit flows associated with them.

- Test GlobCorine and its classification system for the dry coast in a buffer of 30 km associated to an elevation model to define coastal areas on land.
- Build consistent km grid for Back Sea and Mediterranean sea.
- Review classification for the marine strip and identify main boundary lines at sea
- Make basic layers with administrative boundaries, river catchments, etc
- Review available satellite images to inform about a number of processes (ecosystem health, fragmentation, HANPP, etc
- Identify attribute to fill the cells of the grid with information (fishing grounds, maritime activities, land and sea uses, sea bottom mapping, quality of water and habitats, data on species, etc)
- Generation of initial accounting fact sheets (tables and maps) and their communication through the portal web
- Presenting result on accounting to the ICZM Platform and discuss them
- Operational training on how to use the tools in general Meetings and CASE Workshop
- Evaluation of testing and validation, implementing next phase from comments and needs

Annex II. Clarifying main concepts

The following definitions were written to introduce the main themes and subjects, being all very open ones that should be discussed and developed by the whole team

Organizational complexity refers to amount of *social, ecological and economic* capital and number of components per unit area
Each of the three needs to be comparatively assessed across time and space dimensions for the study area, using broadly available spatial indicators; hence a kind of standardized view, method and outcomes should be pursued
Listing the available social, ecological and economic variables, presenting the available indicators and prioritising top, most useful, and critical ones
Social – culture, ethics, traditional and historic values on nature, species, landscape also to be explored to understand how much local processes can mitigate global pressures

Examples of *ecological* complexity components – food-chains (predator-prey relations), invasive and expansive species, ecological succession and climax communities

Integrity can be seen as ¨health¨ of ecosystems, implying well ordered landscape (lack fragmentation, pollution, toxicity and other distress syndromes see the box above) also good productivity and vigour of the system. Integrity is based on the existing links between the above mentioned components, the *social, ecological and economic capital*, their tightness and mutual dependences, casual relationships and influences at different scales as well as nature of these relations and trade-offs (for example strong ecological potential might be developing because of lack of economic activity pressures; because of strong existing social potential that prevents external perturbations; or because of strong economic potential that is being developed using external environmental resources thus protecting/sparing the domestic ones …

Resilience refers to the ability to maintain function in periods of stress as well as to recover (original) integrity after stress or even develop higher integrity and organizational complexity…

Many of the parameters referring to ecosystem syndromes, integrity and complexity can be inferred through existing remote sensing, statistics and expert assessment information sources. These inputs allow to start elaborating maps and statistics organized by analytic units with which socio- environmental processes can become more transparent as they are being organized and assessed in environmental accounts.

Production of Environmental accounting tools refers to the process of standardizing information flows as in conventional economic accounting, to allow for scrutinized registry and monitoring of key parameters, subjects and indices aiming to detect and depict changes in ecosystem capital, notably degradation of this capital and the resources needed to restore it after degradation. Ecosystem capital roughly refers to the potential of the ecosystems to maintain a range of ecosystem services to humans as well as to biodiversity. For this work we rely very much on the experience of the EEA, UAB/ETC-LUSI and UNOTT while developing European land and ecosystem accounts, the LEAC approach (EEA, 2006; Weber, 2007).

Annex III: Applied concepts of holistic and integrated studies and diagnostic assessments of ecosystem 'health'

Odum (1971) introduced the ideas of the holistic nature of Earth's ecosystems. He introduced the ecosystem as an entity normally comprised of six components, e.g. inorganic elements (water, CO2, N, P etc); organic elements (proteins, fats etc); climatic elements (precipitation, temperature etc); primary producers (green vegetation), macro consumers (animals, people etc), micro-consumers (bacteria). Odum explained that the ecosystem as a whole is something more than the sum of its elements and it displays emergent properties such as stability, resilience and adaptability. He also explained that ecosystem change and exhibit dynamics (e.g. seasonal, cyclic changes every few years etc), and described also regular patterns of change termed succession changes. An example of natural succession is the gradual growth of shrubs and later trees on abandoned croplands.

Holling elaborated further the view of the dynamic nature of the ecosystems. He explained observable repeating change in the landscape, summarised in four stages, with a classical example of forest ecosystem evolution (Holling 1978): exploitation (pioneering fast growing trees take over), conservation (establishment of mature climax forest where biomass and energy accumulates), release (forest fire, storm or pest destroys the forest and makes materials and energy available for a new structure to start developing) and reorganization (if the same conditions are preserved, depending on the controlling factors a new forest starts taking over, if resources are depleted then another ecosystem develops, like grassland).

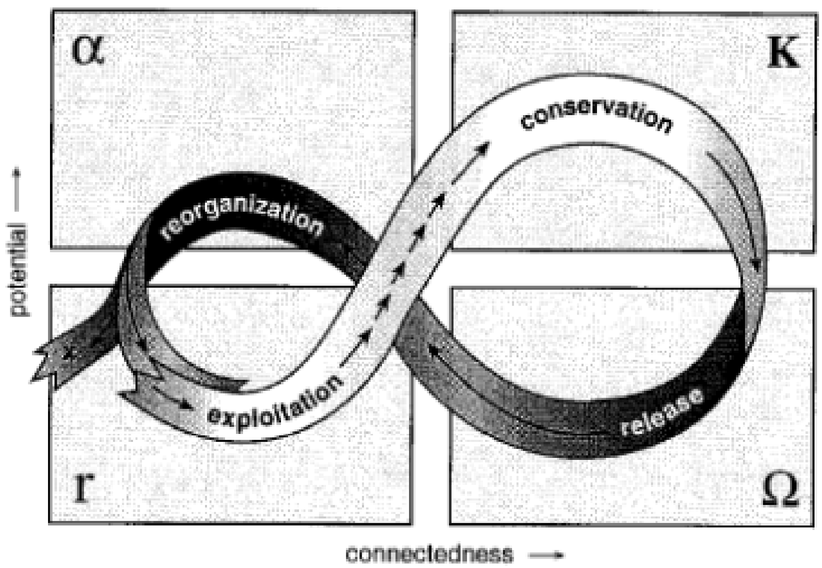

Figure AII.1. Four stages of ecosystem dynamics (Holling, 2001)

This same model was also extended later (Holling, 2001) to present narratives of evolving and collapsing socio-ecological systems.

Brand and Jax (2007) provide a useful review of the different meanings ascribed to the term resilience. They contrast usage in the ecological literature, with that from the social sciences, and then trace the evolution of a more hybrid concept that deals with problems at the interface between people and nature. Holling (1973) initially proposed the idea as a 'measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables'. Brand and Jax (2007) suggest that this formulation has been refined by subsequent work, especially that of Gunderson and Holling (2002), Walker and Pearson (2007) and, Folke et al. (2002). Thus the term is now used to refer to two distinct ideas, namely:

- The magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behaviour; and,
- The capacity of a system to experience shocks while retaining essentially the same function, structure, feedbacks, and therefore identity.

The importance of the debate about the resilience has been highlighted by recent initiatives such as the Millennium Ecosystem assessment (MA), which showed how the well-being of people is linked to the well-being of biodiversity (MA, 2005). The MA concluded that globally ecosystems are experiencing growing external pressures from drivers such as climate change, land use change, pollution and invasive species, which will impact on the functioning of ecosystems and on the provision of ecosystem services. In the wider research and policy literatures there is now increased concern that losses in biodiversity may lower resilience to and/or recovery from disturbances (e.g. Loreau et al., 2002; van Ruijven and Berendse, 2010), although the relationship is yet to be confirmed. However the evidence that biodiversity and resilience are closely linked is growing. Thus Isbell et al. (2009) have shown that species richness and more diverse patterns of species interactions can promote ecosystem stability and thus sustain the output of ecosystem services.

Carpenter et al. (2001) and Cummings et al. (2005) they advise that when speaking about 'ecosystem resilience' or 'ecological resilience' we must be clear about what kind of ecosystem property we are considering by specifying the resilience 'of what to what'. In this respect accounts have much to offer in terms of helping operationalise the concept. Linked accounts describing changes in stocks and flows and especially the trajectory and sensitivity of the relationships between them, can clearly go a long way to defining the 'of what' and 'to what' components that need to underpin any analysis of resilience.

Rapport et al. introduced the concept of ecosystem health or ecohealth in the eighties (Rapport et al., 1985), as a way to portrait the strongest concern of impairing the capacity of ecosystems to sustain life while generating human welfare. It is proposed in an analogy with human health considerations. Rapport elaborated the ecohealth perspective by articulating three key indicators of health: vitality (productivity), organization and resilience. The high degree for those three is related to the absence of ecosystem distress syndrome. The ecosystems are viewed as macro-organisms or higher levels of organization that regionally and locally may exhibit great diversity, but show pronounced similarities in the response to stress and disturbance from human actions. The three health indicators are emergent properties of the ecosystem:

- *Vitality* (or vigour) can be measured in terms of activity, metabolism, or primary productivity. It is linked with the capability of the system to make use of the natural elements – light, water, minerals etc to produce biomass, create habitats and regulate favourable living conditions including micro-climate, water cycle regulation etc.
- *Organization* can be assessed in terms of the interactions between biota and their environment. In healthy ecosystems, there are many specialized interactions that link

species together (such as predator–prey relationships, food chain, symbiotic relationships, parasitic relationships, etc.).

- *Resilience* or capacity, is a measure of the capability of ecosystems to recover from disturbance, either human or natural perturbations. If the health of the ecosystem has been compromised owing to anthropogenic stress, recovery from natural perturbations will, in many cases, be slower and less complete (Rapport, 2007).

Common signs of ecosystem distress syndromes (EDS) are:

- *loss of biodiversity* (to which we may also add, in many cases cultural diversity)
- *reduced productivity* (or system ''vitality'')
- leaching of soil nutrients
- shifts in community composition to favour *smaller life forms*
- *reduced symbiotic relationships* amongst biota
- increased success of *invasive species*
- loss of *endemic species*
- Increased presence of *contaminants* (particularly toxic substances that bio-accumulate in the food web)
- increased *disease* prevalence in various component species (including Homo sapiens)
- reduced efficiencies in *nutrient transport*, and,
- Reduced *productivity/respiration ratios* (Rapport et al., 1985; Rapport and Whitford, 1999).

The focus of ecosystem health practice is twofold, namely to:

(1) ''diagnose'' through indicators, situations in which ecosystem function (and structure) has become compromised, owing to anthropogenic stress or other causes;
(2) devise diagnostic protocols to assess the causes of dysfunction and propose interventions that may restore ecosystem health.

The framework of ecosystem accounting is largely based on the ideas of ecosystem health or integrity.

Annex IV: Overview of land accounting methodology and examples

The ¨land¨ component is a central subject of the LEAC framework. Land account is one component that explains the use of the space generally and its resource management resulting in the construction of a landscape. Land (and space, viewed as a resource) can provide some hints on the following issues:

- Where things are happening
- Intensity of changes
- Some proxies on land/nature degradation (e.g. increase of artificial areas near or at cost of forest). i.e. rough ideas on changing the quality of the systems
- Connectivity of land elements,
- Trends and paths
- Drivers of changes and pressures, impacts, responses

Land cover accounts of Europe

The European land accounts were developed on the basis of the CORINE LC direct applications, as well as definition and extraction of stock and flows. The land cover maps were made in a semi-automated way based on the visual interpretation of remotely sensed satellite imagery to define the land-cover of land cover parcels of a minimum size of 25 hectares. The work covered all the countries affiliated to the EEA. A key point is that for building land accounts all land cover and other inputs are integrated in a 1 km^2 grid that covers the whole European territory.
Land cover stock is the area of certain land cover type within a unit of measurement, be it administrative region, river catchment, a country etc. The stocks can also be extracted as a percentage of each land cover class in each cell of the 1 km^2 grid and these percentages are used for a number of applications consequently, the product is shortly called 'C0'. The stock derived from the CORINE LC maps can be represented in three hierarchical levels on European scales; level three being the most detailed containing 44 classes (see nomenclature in Annex III).
The CORINE LC maps were so far produced for three years on European scale: 1990, 2000 and 2006. Along with each update e.g. in 2000 and 2006 a change map was also produced. The change map was not simply based on a subtraction of the current from the previous map, but rather was done by overlaying the imagery for the two years to identify change; change units at a 5 ha resolution were identified. The change layer was then used to define land cover flows. All possible combinations between the 44 classes of CORINE LC were grouped into 64 meaningful transitions between them, and labelled as Land-cover flows (see nomenclature in Annex IV)..

Land cover smoothing - CORILIS

CORILIS, from CORIne and LISsage (smoothing in French), is a methodology developed jointly by the French Environment Institute (IFEN), the Hypercarte Research Group and the French National Institute for Statistics and Economic Studies (INSEE) that provides technical specifications for the smoothing of CORINE Land Cover Data. The purpose of CORILIS is to calculate "intensities" or "potentials" of a given theme in each point of a territory. A

Gaussian type statistical function (called BiWeight) is used to weight this information according to the distance from the considered point in kilometres. CORILIS results into probability surfaces (varying from 0 to 100) for the presence of a certain CLC class within a smoothing radius. Individual CORILIS layers from a given level can be aggregated to upper levels by simple addition.
Smoothed land cover application were calculated to define a probability to find a certain object in neighbourhood. CORILIS method is useful to capture buffering effects. For example the physical boundary of a city is well defined by the CLC but its fuzzy impacts such as mobility, noise, pollution or other inherent processes coming from the city can be well reflected and weighted by CORILIS.

Through smoothing possible pressures can also be mapped, for example from urban, intensive agriculture on surrounding or neighbouring areas, like NATURA2000 or wetlands etc.

Spatial smoothing (applying different radii – 5 km, 10 km) in a 1 km^2 grid of selected CORINE LC maps has been developed for facilitating environmental interpretations of the land-cover data. In this way land-cover maps are prepared for expressing:

- Potentials – green background of the landscape (GBLI); connectivity between protected areas – NATURILIS, landscape ecological potential
- Probabilities - dominant land-cover types shown on large-scale i.e EU
- Intensities – urban pressure and intensive agricultural pressure

Smoothed applications of land-cover

1. *Intensities*

The intensities can be interpreted as a positive effect when representing an ecologically favourable element as for example – forest cover; or a negative effect when representing a land use pressure, two examples are provided below.

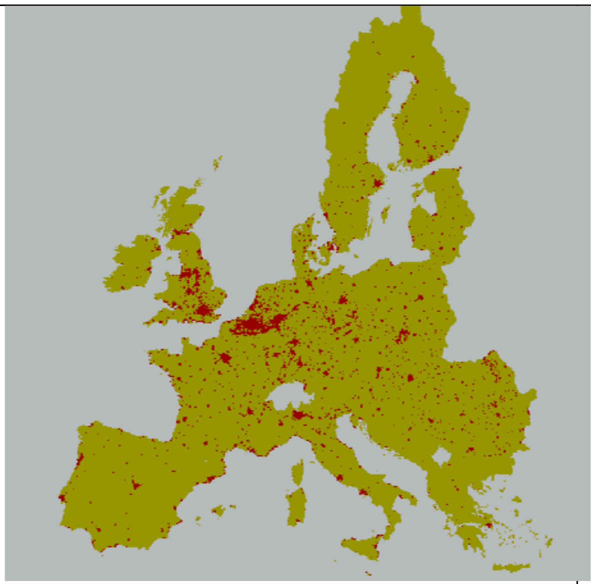	Smooth map of artificial areas – C1 A spatial aggregation of all CORINE LC classes included in the ¨Artificial surfaces¨ category – CLC level 1, class 1It reflects in a general view the total of pressures which the Urban land-uses exert on ecosystems and open space. For definition of the respective land-use classes see CORINE methodology. Note that diffuse urban areas include urbanisation density above a threshold of 30 % sealed land. Exploratory applications have been performed for assessing pressure on NATURA2000 sites. An index of urban “temperature” has been calculated. It reveals that wider radiation of pressures comes from the diffuse urbanizations (not necessarily from dense and most populated areas).
	Smoothed intensive agriculture areas – C2a A spatial aggregation of CLC class 2.1 Arable Land , 2.2 Permanent crops and 2.4.1 Annual crops associated with permanent crops (see Annex I) It reflects in a general view the total of pressures the above-mentioned agricultural land-uses exert on ecosystems and open space. For definition of the respective land-use classes see CORINE methodology. Parcels of croplands under 25 ha are not included even if intensively cultivated. These would be rather included as mixed, mosaic agriculture.

Figure 7. Land use pressures: from urbanization (above), from intensive agriculture (below)

2. *Probabilities*

As mentioned above the smoothing allows the estimation of probability of finding a certain object within a predefined radius around the concrete land cover type, or other element.

Dominant land cover type and dominant landscape type

A map of the European dominant land cover types was constructed by grouping the 44 classes into 7 broader categories defining the following dominant types of cover:

The land cover dominance is then adjusted for relief variations to produce a dominant landscape type

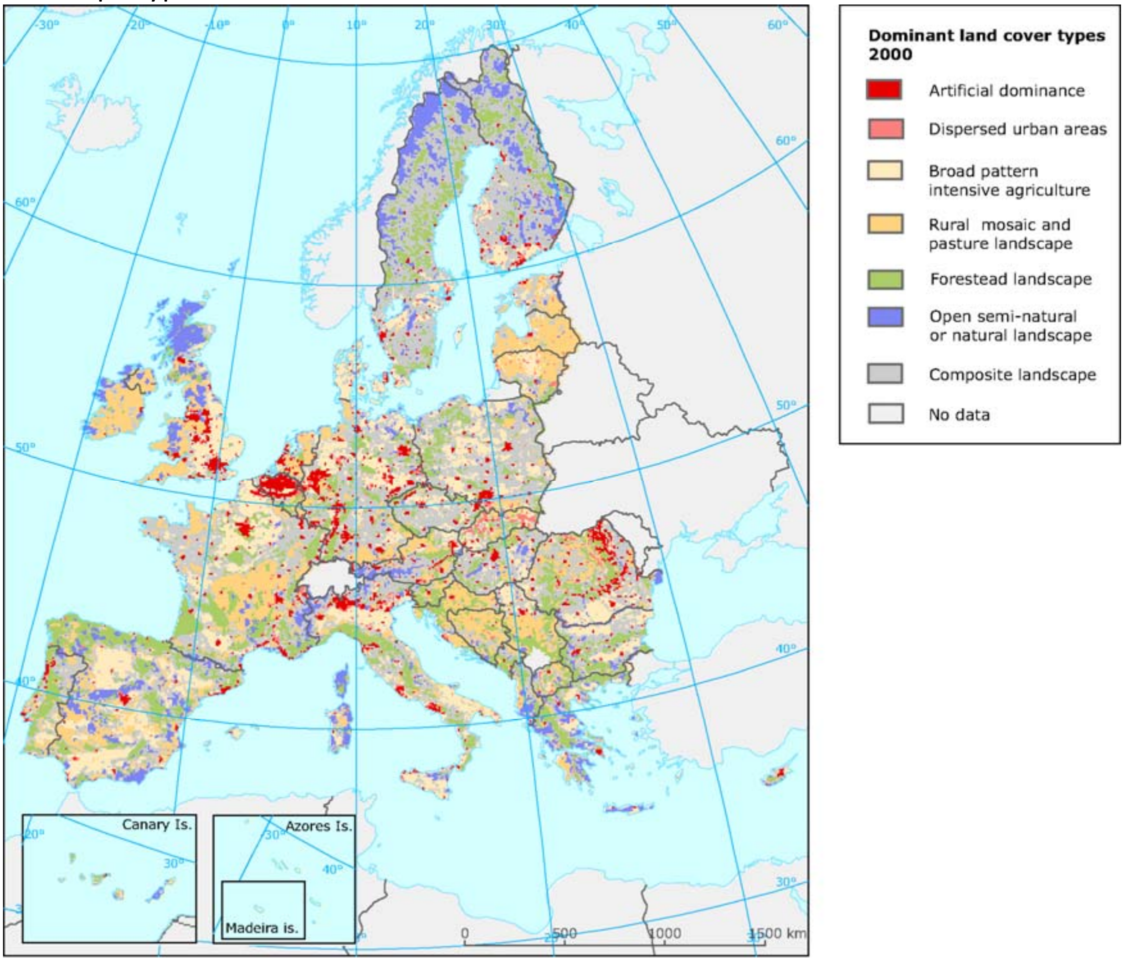

Figure 8. Dominant land cover types

Indexes on favourability of land use

A Green background (GBLI) index was calculated by summing up the classes representing land-use types deemed favourable for supporting ecological functions. These include agro-systems with pastures and/or mosaics of parcels, forests and other semi-natural or natural dry land, wetlands and water bodies.

An index of the *areas of high ecological value*, called NATURILIS index was calculated by merging the map of nationally designated protected areas and the European NATURA2000 network of areas all resampled to the 1 km2 grid. The map was done by applying also smoothing with a 5 km radius. By analogy to CORILIS, the database of smoothed values of designated areas of high ecological value is called NATURILIS.

Effective meshsize or MEFF (Jeager, 2000) was calculated to represent the level of landscape fragmentation in Europe merging a map of the transport network map from Teleatlas with urban morphological zones map (EEA). The size of meshes is calculated as the Effective Mesh Size (MEFF), a geo-statistical measure, which converts the probability that randomly selected points in an area are connected into the size of an un-fragmented patch. Smaller mesh size means less landscape connectivity and higher landscape fragmentation, which is the inverse of connectivity. Effective mesh density (seff) is the reciprocal value of meff (seff = 1/meff)

Combining the three above inputs produces an index of Net Landscape Ecological potential.

<u>The Making of LNEP</u>:

- GBLI = Aggregation of CLC classes 2B, 3, 4 & 5, smoothed at 5 km. Range [0-100]
- NATURILIS_COMB or COMB = Union of N2K and CDDA, smoothed at 5 km. Range [0-100]
- Gross_LEP or GLEP= GBLI + COMB. Range [0-200]
- GLEPscaled = (GLEP * 255) / max(GLEP). Range [0-255]
- ln(MEFF). Range [0-255]

and

NLEP = sqrt(GLEPscaled * lnMEFF). Range [0-255]

The NLEP is a macro-indicator which allows to outline a range of land-use conditioned ecological states – from most favourable where 3 main factors are at their best – nature respecting land-use, little or no fragmentation from human artefacts, and areas designated for nature conservation (NATURA2000 and other nationally designated protected areas) … to the opposite high fragmentation, no protected area designated and very intensive land-use (urban, agriculture, transport). However at regional scale high intensity of land use and fragmentation are often (partially) compensated with denser network of (smaller) protected areas. Therefore additional indicators are needed, at present ecotones are being extracted by the CORINE LC (A. Oulton and J.-L. Weber, personal communication, 2011).

<u>Land accounting tools</u>

To facilitate the use and exploration of ecosystem accounting outputs, the ETC-LUSI has developed several tools to query land cover data and land cover changes information among other datasets in two different years (1990 and 2000; 2000 and 2006). These tools work with an on line Analytical Processing (OLAP) database, accessible through the Internet. The database is structured in accordance to a multi-dimensional approach for retrieving land cover using different analytical reporting units (LARU). Currently it retrieves land-cover outputs only, however the system it is not closed to other kind of data (population, nature protection, transportation, water assets etc). Main advantage of the LEAC tools are that they allows efficient processing and retrieval of data at a country and continental scale and the implementation of spatial-based queries without needing access to Geographical Information Systems (GIS) software.

Annex V: CORINE Land Cover Hierarchical Nomenclature

1. Artificial surfaces
1.1. Urban fabric
1.1.1. Continuous urban fabric
1.1.2. Discontinuous urban fabric
1.2. Industrial, commercial
1.2.1. Industrial or commercial units and transport units
1.2.2. Road and rail networks and associated land
1.2.3. Port areas
1.2.4. Airports
1.3. Mine, dump and
1.3.1. Mineral extraction sites construction sites
1.3.2. Dump sites
1.3.3. Construction sites
1.4. Artificial, non agricultural
1.4.1. Green urban areas vegetated areas
1.4.2. Port and leisure facilities

2. Agricultural areas
2.1. Arable land
2.1.1. Non-irrigated arable land
2.1.2. Permanently irrigated land
2.1.3. Rice fields
2.2. Permanent crops
2.2.1. Vineyards
2.2.2. Fruit trees and berry plantations
2.2.3. Olive grives
2.3. Pastures
2.3.1. Pastures
2.4. Heterogeneous
2.4.1. Annual crops associated with agricultural areas permanent crops
2.4.2. Complex cultivation patterns
2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation
2.4.4. Agro-forestry areas

3. Forest and semi-natural areas
3.1. Forests
3.1.1. Broad-leaved forest
3.1.2. Coniferous forest
3.1.3. Mixed forest
3.2. Scrub and/or herbaceous
3.2.1. Natural grasslands vegetation associations.
3.2.2. Moors and heathland
3.2.3. Sclerophyllous vegetation
3.2.4. Transitional woodland-scrub
3.3. Open spaces with

3.3.1. Beaches, dunes, sands little or no vegetation
3.3.2. Bare rocks
3.3.3 Sparsely vegetated areas
3.3.4. Burnt areas
3.3.5 Glaciers and perpetual snow

4. Wetlands
4.1. Inland wetlands
4.1.1. Inland marshes
4.1.2. Peat bogs
4.2. Maritime wetlands
4.2.1. Salt marshes
4.2.2. Salines
4.2.3. Intertidal flats

5. Water bodies
5.1. Inland waters
5.1.1. Water courses
5.1.2. Water bodies
5.2. Marine waters
5.2.1. Coastal lagoons
5.2.2. Estuaries
5.2.3. Sea and ocean

Annex VI: DEFINITION OF LAND COVER FLOWS

LCF1 Urban land management: Internal transformation of urban areas

LCF11 Urban development/infilling: Conversion from discontinuous urban fabric, green urban areas and sport and leisure facilities to dense urban fabric, economic areas and infrastructures

LCF12 Recycling of developed urban land: Internal conversions between residential and/or non-residential land cover types. Construction of urban greenfields is not considered here but as LCF11

LCF13 Development of green urban areas: Extension of green urban areas over developed land as well as, in the periphery of cities, over other types of land uses

LCF2 Urban residential sprawl: Land uptake by residential buildings altogether with associated services and urban infrastructure (classified in CLC111 and 112) from non-urban land (extension over sea may happen)

LCF21 Urban dense residential sprawl: Land uptake by continuous urban fabric (CLC111) from non-urban land LCF22 Urban diffuse residential sprawl: Land uptake by discontinuous urban fabric (CLC112) from non-urban land

LCF3 Sprawl of economic sites and infrastructures: Land uptake by new economic sites and infrastructures (including sport and leisure facilities) from non-urban land (extension over sea may happen)

LCF31 Sprawl of industrial and commercial sites: Non-urban land uptake by new industrial and commercial sites

LCF32 Sprawl of transport networks: Non-urban land uptake by new transport networks (note that linear features narrower than 100 m are not monitored by CLC)

LCF33 Sprawl of harbours: Development of harbours over non-urban land and sea

LCF34 Sprawl of airports: Development of airports over non-urban land and sea

LCF35 Sprawl of mines and quarrying areas: Non-urban land uptake by mines and quarries

LCF36 Sprawl of dump sites: Non-urban land uptake by waste dump sites

LCF37 Construction: Extension over non-urban land of areas under construction during the period (note: covers mainly construction of economic sites and infrastructures)

LCF38 Sprawl of sport and leisure facilities: Conversion from developed as well as non-urban land to sport and leisure facilities

LCF4 Agriculture internal conversions: Conversion between farming types. Rotation between annual crops is not monitored by CLC

LCF41 Extension of set aside fallow land and pasture: Conversion from crop land to grassland as an agricultural rotation or for cattle husbandry

LCF411 Uniform extension of set aside fallow land and pasture: Large parcels conversion from crop land to grassland

LCF412 Diffuse extension of set aside fallow land and pasture: Conversion from crop land to complex cultivation patterns (with grassland) and from mixed agriculture to large pasture parcels

LCF42 Internal conversions between annual crops: Conversions between irrigated and non-irrigated agriculture

LCF421 Conversion from arable land to permanent irrigation perimeters: Extension of permanent irrigation (incl. rice fields) over arable land

LCF422 Other internal conversions of arable land: Other conversions between arable land and irrigated perimeters, incl. rice fields

LCF43 Internal conversions between permanent crops: Conversions between vineyards, orchards and/or olive groves

LCF431 Conversion from olives groves to vineyards and orchards: Conversion from olives groves to vineyards and orchards

LCF432 Conversion from vineyards and orchards to olive groves: Conversion from vineyards and orchards to olive groves4

LCF433 Other conversions between vineyards and orchards: Other conversions between vineyards and orchards

LCF44 Conversion from permanent crops to arable land: Conversion from vineyards, orchards and olive groves to irrigated and/or non-irrigated arable land

LCF441 Conversion from permanent crops to permanent irrigation perimeters: Conversion from permanent crops (incl. when associated with arable land — CLC241) to permanent (large) irrigation perimeters and rice fields

LCF442 Conversion from vineyards and orchards to non-irrigated arable land: Conversion from vineyards and orchards to non-irrigated arable land and from associations of annual and permanent crops to uniform arable land

LCF443 Conversion from olive groves to non-irrigated arable land: Conversion from olive groves to non-irrigated arable land, incl. conversions to associations of annual and permanent crops (CLC241) and of crops and pasture (CLC242)

LCF444 Diffuse conversion from permanent crops to arable land: Conversion from vineyards and orchards to associations of annual and permanent crops (CLC241) and of crops and pasture (CLC242: complex cultivation patterns)

LCF45 Conversion from arable land to permanent crops: Plantation of vineyards, orchards and olive groves on arable land

LCF451 Conversion from arable land to vineyards and orchards: Plantation of vineyards, orchards on arable land

LCF452 Conversion from arable land to olive groves: Plantation of olive groves on arable land

LCF453 Diffuse conversion from arable land to permanent crops: Conversion from uniform arable land to associations of permanent crops and annual crops (CLC241)

LCF46 Conversion from pasture to arable and permanent crops: Conversion from pasture to arable and permanent crops

LCF461 Conversion from pasture to permanent irrigation perimeters: Conversion of uniform pasture areas to permanent irrigation perimeters

LCF462 Intensive conversion from pasture to non-irrigated arable land and permanent crops: Conversion of uniform pasture areas to non-irrigated annual and permanent crops

LCF463 Diffuse conversion from pasture to arable and permanent crops: Conversion from complex cultivation patterns including pasture (CLC242) to uniform arable land and permanent crops as well as to associations of the last two (CLC241) and conversion of uniform pasture (CLC231) to complex cultivation patterns

LCF47 Extension of agro-forestry: Conversion of cultivated land and open pasture to agro-forestry systems such as dehesas and montados (note: conversion from 243 to 244, where natural vegetation is important, is recorded under LCF522)

LCF48 Other conversions from agriculture mosaics to arable land and permanent crops: This land cover class is used only when changes are detected from a Corine land cover matrix combing classification of level2 for the initial year and level 3 for the final year. Agriculture mosaic classes being grouped in CLC24 only, it is not possible to differentiate the processes according to the type of land consumed. It includes in particular the sub-class LCF523, conversions from agriculture-nature mosaics to continuous agriculture, not isolated in this case

LCF481 Other conversions from agriculture mosaics to permanent crops: Used for CLC level 2 x level 3 only. It includes conversion of agriculture-nature mosaics to arable land (see LCF48)

LCF482 Other conversions from agriculture mosaics to arable land (including conversion of agriculture-nature mosaics to permanent crops). Used for CLC level 2 x level 3 only. It includes conversion of agriculture-nature mosaics to arable land (see LCF48)

LCF5 Conversion from forested and natural land to agriculture: Extension of agriculture land use

LCF51 Conversion from forest to agriculture: Deforestation for agriculture purpose, including agricultural conversion of transitional woodland shrub

LCF511 Intensive conversion from forest to agriculture: Deforestation, including agricultural conversion of transitional woodland shrub, for cultivation of annual and permanent crops (incl. in association, CLC241)

LCF512 Diffuse conversion from forest to agriculture: Conversion from uniform forest to complex cultivation patterns, mosaic agricultural landscape and agro-forestry. Due to possible uncertainties in monitoring extension of pasture vs. recent felling, conversion from forests to pasture land (CLC231) is recorded here

LCF52 Conversion from semi-natural land to agriculture: Conversion from dry semi-natural land (except CLC324, grouped with forests) to agriculture

LCF521 Intensive conversion from semi-natural land to agriculture: Conversion from dry semi-natural land (except CLC324, grouped with forests) to annual crops, permanent crops and their association

LCF522 Diffuse conversion from semi-natural land to agriculture: Conversion from dry semi-natural land (except CLC324, grouped with forests) to pasture and mixed agriculture with pasture

LCF523 Conversions from agriculture-nature mosaics to continuous agriculture: Conversion from CLC243, where natural areas are distinctive feature of the land systems to continuous agriculture. This is an over-estimation from an agriculture perspective but is justified in terms of analysis of ecological potentials of complex land systems

LCF53 Conversion from wetlands to agriculture: Conversion of wetlands to any type of farmland (CLC2)

LCF54 Conversion from developed areas to agriculture: Conversion of urban land to any type of farmland (CLC2)

LCF6 Withdrawal of farming: Farmland abandonment and other conversions from agriculture activity in favour of forests or natural land

LCF61 Withdrawal of farming with woodland creation: Forest and woodland creation (incl. transitional woodland shrub) from all CLC agriculture types. Withdrawal of farming with woodland creation is a broader concept than farmland abandonment with woodland creation, which results more from decline of agriculture than afforestation programmes. Additional information is necessary to identify an abandonment process (type of agriculture, landscape type, socio-economic statistics...)

LCF62 Withdrawal of farming without significant woodland creation: Farmland abandonment in favour of natural or semi-natural landscape (except forests and transitional woodland shrub), as long as they are a possible transition. Some odd cases are provisionally recorded as

LCF99 Other changes and unknown

LCF7 Forests creation and management: Creation of forests and management of the forest territory by felling and replanting. Due to the CLC cycle of 10 years, only one part of the shrubs are tall enough to be identified as trees. In order to taking stock of all recent plantations, conversions of semi-natural land to CLC324 are conventionally recorded as afforestation (although some natural colonisation may take place). In the case of conversion from farmland, see LCF61

LCF71 Conversion from transitional woodland to forest: Conversion from transitional woodland to broadleaved, coniferous or mixed forest, taking place when shrubs can be detected as trees

LCF72 Forest creation, afforestation: Forest creation and afforestation take place on all previously non-agricultural landscapes where new forests can be identified. Extension of transitional woodland shrub over non-agricultural land is recorded as afforestation. Conversion from transitional woodland to broadleaved, coniferous or mixed forest are not a creation of forest territory and are therefore registered separately (LCF71)

LCF73 Forests internal conversions: Conversions between broadleaved, coniferous and/or mixed forest (CLC311, 312 and 313)

LCF74 Recent felling and transition: Conversion from broadleaved, coniferous and/or mixed forest to open semi-natural and natural dry land resulting more likely from felling. The main transition is towards CLC324 Transitional woodland shrub, although some other types can be detected. Due to uncertainties, all are provisionally considered as transitional states of forests

LCF8 Water bodies creation and management: Creation of dams and reservoirs and possible consequences of the management of the water resource on the water surface area

LCF81 Water bodies creation: Extension of water surfaces resulting from the creation of dams and reservoirs

LCF82 Water bodies management: Consequences of the management of the water resource on the water surface area of reservoirs

LCF9 Changes of land cover due to natural and multiple causes: Changes in land cover resulting from natural phenomena with or without any human influence

LCF91 Semi-natural creation and rotation: Changes in natural and semi-natural land cover due to natural factors

LCF911 Semi-natural creation: Natural colonisation of land previously used by human activities. Note that extension of CLC324 is considered as the result of farmland abandonment or direct afforestation

LCF912 Semi-natural rotation: Rotation between the dry semi-natural and natural land cover types of CLC (except forest and transitional woodland shrub)

LCF913 Extension of water courses: Results from natural erosion and artificial works. Due to the very incomplete detection of rivers with CLC, the LCF913 flow item has to be used very carefully

LCF92 Forests and shrubs fires: Due to the short cycle of recovery of vegetation from fire, burnt areas (which are well identified on satellite images) cannot be compared in a ten-year interval, except for very aggregated statistics

LCF93 Coastal erosion: Conversion of all land cover types to intertidal flats, estuaries or sea and ocean. The tide level when the satellite image is shot being unknown of the photointerpretors, the coastal erosion flow has to be used very carefully

LCF94 Decrease in permanent snow and glaciers cover: Decrease of permanent snow and glaciers due to climate change to semi-natural and natural land covers, mainly to bare rock, sparsely vegetated areas and water systems

LCF99 Other changes and unknown: In this category are recorded land cover changes that are rare or more likely improbable

ANNEX VII: Main needs identified for PEGASO T4.2 at the start of the project

Task 4.2 Coastal land and marine ecosystem accounting

- Need to extend the Land account to the sea
  - Data need for the 3 dimensions of the sea
    - Bathymetric charts,
    - local maps of benthic communities (ex. Poseidon for part of the Mediterranean),
    - Sediment and nutrients fluxes from the rivers and into the sea
    - fuzzy maps of sea bottom (IFREMER) where a number of parameters are taken into account and then most probable community are mapped
    - Data reported for article 17 HD,
    - IUCN atlases on BD
    - IUCN Red list
    - Maps of coastal and Marine Protected areas
    - Ocean colour maps (ESA, MODIS_NASA, GMES MARCOAST)
    - Pollution data at local/Regional level (UNEP GRID)
    - Species data from birdlife international
    - Data base on alien species
    - Fishery and aquaculture (Eurostat and FAO statistics+ national)
    - Map of the use of the sea (ship routes and volume transported, accidents and oil spills, oleoducts, deep sea cables, platform for gas, oil and wind farms, tidal and wave energy, etc), recreation facilities, metal nodes, mining, dredging, waste disposals, etc
  - Data availability
    - We expect to have lots of data at local and sub regional level in some places but we can have difficulties to get them. We will begin to work in places where data are available through our partners.
    - We can find that for some issues no data exist, or exist partially, at some time and place. So different strategies will be develop for the different issues (ex. The number of monitoring station on water quality is generally localised in some coastal parts, but as we need information on these data for the whole basin, we will have to use remote sensing data as a proxi for example testing ocean colour results and comparability with monitoring stations data, etc to bridge the gap).
    - For issues such as introduced species, expert knowledge, observations from fishermen, etc, can be of high value to get information.

  - Methodology to be developed
    - For all partners, write a conceptual framework on LEAC for land to inform them and have same departure point
    - Make a number of tutorial to build a share knowledge with partners and end users on indicators, spatial indicators, accounts, scenarios and socio-economic valuation, and participative work for valuation.
    - Need ontological framework (Mindjet method to structure all sources of knowledge in a systematic way ; ETC-BD)

- Identify the most important issues to be taken into account by LEAC, from different possible inputs and methods.
- Work on stock and flows, comparing land processes with sea bottom processes, processes on the water column and at the
- Identification of stock behaviour and flows at sea, linked with wave and tides, meteorology, etc.
- For time series , stocks and flows at sea can pass by different cycles than on land
- So a standardized framework need to be constructed taking into account listed issues (and probably more).
- A conceptual model is needed to start gathering and developing ideas on how to integrate terrestrial, coastal and marine issues into the same accounting system, incl. 2-dimensional and 3-dimensional issues, following mass-balance, different transitional status, seasonal variability in species, migrations, etc

- From concept to multi-scale implementation
    - We will begin with available data at basin scale and will present general picture on the main issues on the basin (eg. Water quality, community distribution, biodiversity, etc). Results will be first updated by southern and eastern partners, before to be tested on CASES and, therefore, their global/local relevance will be evaluated.
    - When concepts are well understood at local level, then we will work using LEAC for some key activities (e.g. aquaculture, energy…), and on specific issues (eg. water quality, biodiversity, invasive species, etc.
    - At this stage we will develop pilot accounts for Marine Protected Areas and for some islands (focusing towards island metabolism)
    - During 2011 the work on CASE will designed using the inputs of these first results.

- Middle step (mid project):
    - Need to bridge what is done at sea with what is done on land to better integrate the whole system (including rivers, land , water and air)
    - Propose LEAC land-sea for some relevant situations.

- End of project
    - Review the different tools (indicators, LEAC , scenario and economic/social valuation, etc) to see how they can work in complementarities (Review work done by other EU project such as SENSOR)