Efficient and Equitable Utilization of Ecosystem Services

Giani Gradinaru

Abstract—**This paper proposes methods for efficient and equitable ecosystem services. First, develop adaptive model for trading the ecosystem services aiming to establish assumptions, studying the variability and uncertainty in the economy - ecosystem services connection, developing a set of alternative trading ecosystem services. Secondly, solutions are proposed for efficient and equitable utilization of ecosystem services.**

Index Terms—**Ecosystem services, adaptive model, economic context.**

I. Introduction

Trading of ecosystem services is a new field in the scientific research, based on the success of MEA (Millennium Ecosystem Assessment) which highlights the importance of ecosystem services for. The scientific approach was based on concepts and methodologies between economics, social, environment, mathematics, ecology and technology.

The loss of biodiversity is one of the biggest environmental problems. Decreasing of biodiversity means reduced capacity of ecosystems to provide essential services to the survival and welfare of the people. Nature conservation is an area of environmental science. The research has transferred the role that ecological processes play in the company of the inestimable value in the field of concrete values, estimated on the basis of objective scientific considerations. This approach has propelled the concept of ecosystem services in the operational area founded on the concept of utility. The harmonization premises between economic and ecological principles consisted in identifying areas of interference that allowed integration of the environment into the economic system, respectively its transformation into a factor of influence to manifest either the supply or the demand in accordance with the objective needs of the people and nature.

II. Developing Adaptive Model for Trading the Ecosystem Services

A. Assumptions

Developing adaptive model for trading of ecosystem services is based on an analysis - fundamental to observe the manifestation of ecosystem services. It creates a benchmark by an exact delimitation of the provided ecosystem services, as a starting point in identifying direct and indirect determinants of changes in ecosystems. Perform the support of correlation between ecosystem services and their functions and come off the manifest trend of different categories of ecosystem services.

The economic perspective removes viability of considering ecosystem services in an analysis of economic efficiency. But degradation of ecosystems and the services provided by these affect negatively the value of a business and the opportunities for further development. The model follows the justification of co-viability, in actual efficiency and intergeneration equity terms, in economy - ecosystem services connection. The settlement of ecosystem services in an economic context requires their monetization. The methods and quantification techniques based both on market mechanisms and on non-economic mechanisms are used. The result is a contingent quantification techniques appropriate to different types of ecosystem services.

B. Variability and Uncertainty in the Economy - Ecosystem Services Connection

With the help of a set of symbols, dependency relationships between economic and environmental phenomena, equations or systems of equations, allowing the understanding, explanation and obtaining new information on the expression of ecosystem services, are built different types of analysis models allowing the study of variability and uncertainty reduction.

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Changes in land use are previewed on past trends and on factors considered to have influence on the conversion of land from one category to another. The main result of these models is to explain the past and present use and future projection use. The types of models used are:

- *Gravitational* models or logistic functions: estimated land conversion depending on demographic evolution;
- *System* models: represents stocks and flows of information, materials and energy assets of differential equations connected by functions and intermediate data. Solving equations allow representation of retroactions;
- Models made by *statistical* methods based on empirical observations: econometric models that use statistical methods to test hypotheses about the consequences of road infrastructure. [1] believes that these models may underestimate the role of human and institutional choice;
- *Expert* models expresses qualitative knowledge in a quantitative way to determine the location of certain types use of land. Some methods combine expert

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judgment with Bayesian probability;

- *Computer* models inspired from evolutionary biology. The best known are models based on artificial neural networks and those applying the Darwinian theory of evolution (genetic programming);
- *Cell modeling* methods that use models to lead the way for operations on a set of congruent cells (grids);
- *Agent-based* models: collections of agents or software programs representing adaptive autonomous entities that extract information from the environment and applies to behaviors such as perception, planning and learning. These models are especially use locally.

Modeling changes in land utilization evolving from relatively simple models based on equations to complicated models depending by computer processing. There is a trend of increasing integration and hybridization approaches in order to compensate the disadvantages of individual methods and to address issues that not succeed to be explained by individual models.

Changes in food supply and demand have been shaped by many quantitative and qualitative projections. Global simulation models of interdependencies between population growth, food demand, the degradation of natural resources and food supply are another class of models, being used to underlain the first reports made by the Club of Rome (Meadows, Mesarovic and Pestel models).

Early food models (e.g., Malthusian model) compared the limited resources of agricultural land with the population increase. Then there followed models that considered nutritional requirements and models with regard to evolution of food production. The major variations in food prices that occurred in the 1970's were unsuitable models based on the difference between supply and demand, these being replaced by global price equilibrium models that are more sophisticated, more extensive and costly.

Changes in biodiversity and extinction although important for the development of plausible scenarios are difficult to predict due to difficulties in quantitative approach. So far, these have been prefigured using qualitative approach, the correlation with environmental variables, the relationship between species and areas, threat analysis and population viability analysis [2].

In the qualitative approach, ecosphere has been divided into 11 biomes and two types of freshwater ecosystems. In first phase, there were identified factors that may influence biodiversity change, respectively: land use, climate, nitrogen fixation, biotic changes (deliberate or accidental introduction of exotic species) and the atmospheric concentration of carbon dioxide. In second phase, the analysis was divided in two parts: factors evaluation and the characterization of biomes sensitivity to factors. The exercise handled to formulate three scenarios: no interaction between factors, with synergistic interaction and with antagonistic interaction.

In correlation with environmental variables, the climate has been identified as being most strongly correlated with species diversity. In conjunction with the change of topography, climate change was called down as the main explanation for hominid, trees, insects and birds' speciation and extinction.

The relationship between species and habitat area (area of distribution of the species) is the most commonly used approach for predicting species loss. According this, relationship between surface area and number of species is exponential, following the formula: $S = cA^z$ where:

S: the number of species;
A: habitat area;
z: constant depending by the type surface analysis;
c: constant depending by region and type of species.

The relationship implies that the number of species remaining after native habitat loss evolve by specie curve - habitat area, where A is the remaining habitat area.

Threat analysis is particularly useful for aquatic ecosystems, where the importance of habitat area is smaller. There are connections between wastewater discharge and diversity of fish populations. Because in marine ecosystems the extinctions are difficult to observe, the impact is measured by biomass variation from different trophic levels.

Population viability analysis is achieved by approximations of populations' diffusion and by stochastic matrix models. Extinction is a function of population size, environmental variability and population growth rate. Theoretically, population viability models can be summed to generate predictions about the aggregate risk of extinction.

Changes in populations and fish catches represent the interest about the consequences of fishing and other interventions. There are two approaches:

- Short-term analysis to specify the exploitable stock size in the following fishing season and
- Medium and long term analysis used to develop policies that evaluate the consequences of different management options. These are not intended for predicting the future but to represent a set of scenarios that are possible taking into account the past experience.

Methodologies can use data on one or more species and includes three components: a mathematical model used to describe the dynamic system influenced by fishing, an approach used to condition the model on available information and numerical tools used to implement predictions in different regimes of management.

The mathematical models used diversify greatly in complexity. The simplest models are those based on aggregate biomass of stocks and production that point out the production as a biomass aggregate stocks of a simple nonlinear function. The overflow production is zero when the stock is at the capacity support level and increases to a maximum at an intermediate level of the stock. To make the results more realistic are used the delay models of the difference that highlights the separate contribution of growth and reproduction at stock production. The complex models show the stock structure by age and size classes, and the most advanced add the spatial structure. The projections made by these models include stochasticity in at least one of the key processes.

Fishing models are conditioned using formal statistical methods based on maximum plausibility and Bayesian techniques. These techniques are used to derive the cumulative probability of posterior distributions for the model parameters (and their functions) conditional on all observations and prior information.

As numerical tools are used Monte Carlo techniques to simulate future trajectories of stocks incorporating different sources of uncertainty.

C. Alternatives for Trading Ecosystem Services

Due to the high level of uncertainty, information must be gathered and integrated continuously to learn and to adapt decisions. An important condition for this is assessing the impact of existing trading mechanisms and projection of new systems as experiments in which performance can be measured and can be learned. The adaptive model for trading the ecosystem services is shown in Fig. 1. The approach reduces the uncertainty related to ecosystem services in economic context.

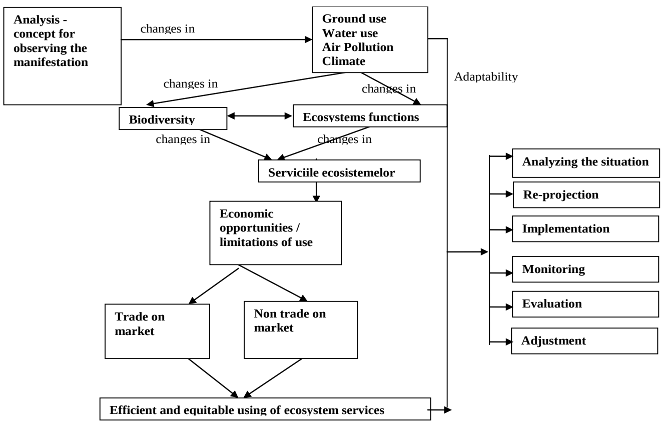

Fig. 1. The adaptive model for trading the ecosystem services.

III. Efficient and Equitable Utilization of Ecosystem Services

A. Realistic Expectations regarding the Utilization of Ecosystem Services

Implementation of policies for nature conservation and especially the rise of the economic approach for this effort are expected to contribute to an efficient and equitable utilization of ecosystem services. Programs that materialize this effort are developed based on several new concepts, such as: payments for ecosystem services, investments in green infrastructure, and investments in protected areas, credits or compensation biodiversity.

Payments for ecosystem services (PES) are implemented at the national level, but there exist a global project, born from two fronts conjugation environmental interests - climate change and biodiversity, the project Reducing Emissions from Deforestation and Degradation (REDD). Depending by the type of ecosystem services, PES can be implemented for a service or multiple services (service packs). The most common schemes aim water quality, carbon sequestration, removing invasive species and protecting biodiversity.

Investments in green infrastructure can be justified on the basis of a single ecosystem service, but becomes more attractive when consider the full range of services that can be provided by an ecosystem. This observation highlights the importance of an integrated approach to assessment. Investment analysis from the perspective of one sector can lead to loss calculation of additional benefits. The same arguments support the need to address these investments at spatial scale that exceed local ecosystems and should be able to get wise to the connections established on the ecosystems network. For example, the investment decisions from a water catchment area require a vision of the entire basin, showing the effects on ecosystems both upstream and downstream. In other words, the actions that need to be beneficial to people from the secondary stream have to be applied upstream towards this area [3].

The fact that ecological limits do not correspond to the political and administrative limits turns, the investments in green infrastructure, in the subject of negotiation between communities and states and highlights the importance of spatial area planning.

Investments in green infrastructure will manage, among other things, to create jobs and achieve to other social goals. Natural capital is an intensive investment in work force, number of jobs created as being higher than other eco-industries (renewable energy, waste management, water treatment). If job categories dependent on natural capital take into account the economic multiplier effect, result that in Europe over 16% of jobs depend directly or indirectly, to the environment. This connection is even stronger in most of developing countries [4].

Investments in protected areas will increase because the cost of extending the protected areas until the limits considered necessary - 15% of the land area and 30% of the marine area - is estimated at 45 billion USD / year [5]. Even if these estimations are only approximations rather inaccurate, based on numerous assumptions and generalizations, these can be considered a good indicator to assess the level of under-financing of protected areas, so far and in the perspective of expanding the network of protected areas. Regarding the social impact of investments in protected areas a realistic picture can be made based on number of jobs that these can be create. Under the new paradigm of nature conservation, which puts more emphasis on the social aspect, the relationship between protected areas and economic activities is not one of exclusion, but one complementary.

Biodiversity credits, known as compensation for biodiversity, are a way to generate funds for the protection of ecosystems on the assumption that the net loss of biodiversity should be avoided. Thus, an investor that through development, construction or other activities damages an ecosystem is required to invest an amount determined by a set of criteria that reflect the ecological importance of the ecosystem to protect another ecosystem. The credits system will only work while the legislation will provide this obligation for developers.

IV. Specific Solutions of Economic Sectors

Economic sectors depend on ecosystem services. One can appreciate the importance of biodiversity and healthy ecosystems for primary production in agriculture, forestry and fisheries. However, natural capital has an important contribution, also in the secondary and tertiary sector. Biodiversity protects against natural hazards and affects the risks on food security and health. Table I shows examples of market sectors dependent on genetic resources, one of the components of biodiversity. But, the community doesn't yet know the full range of ecosystem services that can be useful.

TABLE I: ECONOMIC SECTORS DEPENDENT ON GENETIC RESOURCES

Sector	Market size (billion USD)	Observations
Drugs	64 0	25-50% derived from genetic resources
Biotechnologie s	70	Only public companies Products are enzymes, microorganisms
Agriculture	30	Seeds
Food industry, including: Supplements Care Food	65 22 12 31	Some products derived from genetic resources. Represents the "natural" market component

The main elements that blocked management of natural capital in accordance with the requirements of sustainable use are: decision making based on economic indicators, poor awareness of the ecosystem services value, the poorly developed and implemented legislative frame, private benefits do not match or are contrary to the needs of the community, bad governance.

Recent views converge in identifying the economics of biodiversity as the main area where solutions should be sought. These may be:

- rethink today's subsidies to reflect the priorities of the future;

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- reward of unrecognized benefits and avoided penalty costs;
- participation in conservation benefits;
- measuring components managed (ecosystems, biodiversity).

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