Ecological limits to socio-economic developments

Rudy Vannevel (a, b)

(a) Flemish Environment Agency, A. Van de Maelestraat 96, 9320 Erembodegem, Belgium

(b) Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, J. Plateaustraat 22, 9000 Ghent, Belgium

r.vannevel@vmm.be

ABSTRACT

The principle of sustainable development supports the idea of obtaining a long-term equilibrium between the economic, social and natural capitals. This requires the valuation of ecosystems and the economy and of the ecosystem goods and services (ES G&Ss) that relates them. A flow-chart must be drawn to relate the fundamental elements and processes of the environment and the economy in order to evaluate their mutual impacts. Analysis reveals that ES G&Ss - in particular the biotic value - are not fully reflected in economic pricing. The existing gaps in the current approach will be indicated as well as the economic limitations resulting from limited natural resources.

KEY WORDS: *Ecosystem value, ecological equilibrium, carrying capacity, green growth.*

INTRODUCTION

Any environmental change relates to an environmental impact, and most significant impacts result from socio-economic activities or developments. Understanding the nature of an impact is a prerequisite for understanding the societal shifts and for policy-making. As natural resources become scarce and ecosystems seem to degrade despite of all improvement measures, continuous resources abstraction has become subject of a broad public debate. In

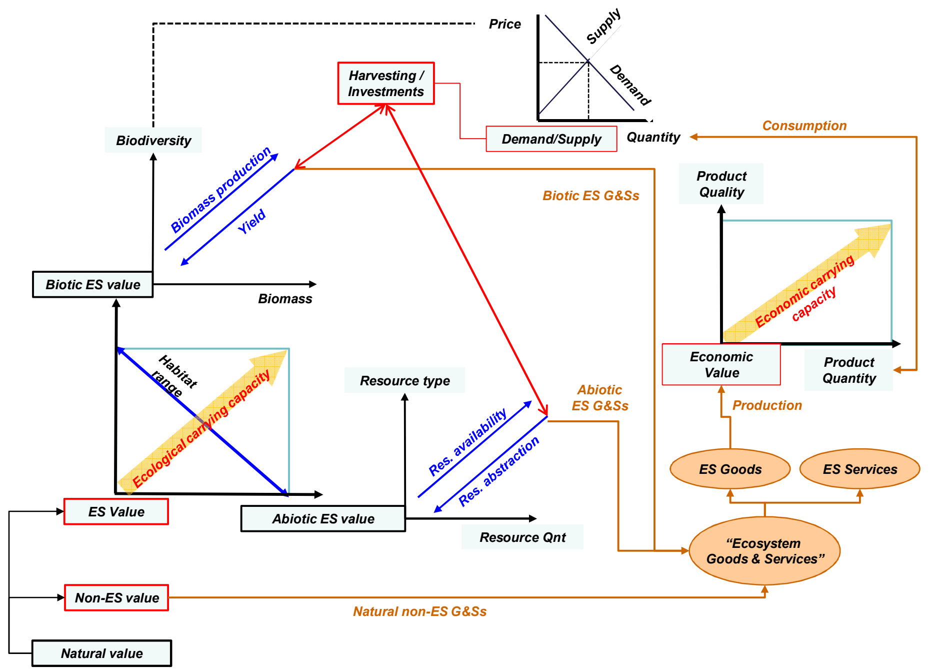

Figure 1. Basic valuation scheme. Natural and economic values are related and flows of environmental goods are depicted. Demand and supply of products determine the amount of ecosystem goods to be abstracted. The limiting factor is the availability of ecosystem (abiotic and biotic) and non-ecosystem resources. Pricing is the economic quality factor, but it does not reflect the ecosystem's quality, such as biodiversity (dotted line).

Ecosystem (ES) valuation mostly focuses on valuing ecosystem goods and services, suitable for developing a policy tool. However, the ultimate goal is to meet and balance the ecological and economic equilibrium. To achieve this, the process of interaction between the environmental and economic capitals must be drawn, linking the ecological and economic carrying capacity and equilibrium and the role of ecosystem goods and services.

ECOSYSTEM AND ECONOMIC VALUATION

In the basic valuation schema (Figure 1), the notion ‘natural value’ is the cornerstone for understanding the linkage between environmental and economic valuation. The natural value includes both ES value and non-ES value. Non-ES value (such as fossil fuels or rare earths) is part of the (non-human) environment, but does normally not contribute to ES functioning. However, because these resources are environmental substances, they are mostly indicated as ‘ecosystem goods’. Any other environmental resource is considered as having real ES value, either of abiotic or biotic nature. Abiotic ES value includes a number of non-living resource types (water, minerals, nutrients) that support ecosystems and occur in nature in different quantities. Biotic ES value is the degree biomass is created and distributed over a number of species (biodiversity). The amount and kind of biotic and abiotic resources created determines the use of them. The extent of harvesting biotic value (yield) and abstraction of abiotic value determines the socio-economic production and consumption process, ultimately ruled by human demand & supply. From this, it must be concluded that ES G&Ss also include non-ecosystem goods and that the economic process is mainly quantity-driven by harvesting and resource abstraction.

There is a natural balance between the amount of life that can be generated within the limits of the abiotic ES value (ecological carrying capacity) and the extent to which species make use of resources within a spatial limits (habitat range). But a continuous economic pressure (by harvesting or abstracting resources) on ecosystems is noted, risking species to extinct. Whereas ES resources and product quantity are depending on each other, pricing and biotic value are not. On the contrary, species and habitats becoming rare are considered as a loss of natural value, but are at the same time of higher economic value. The result is that the ecosystem-economic process is cyclic but not self-regulating.

Part of the abiotic ES quantities can be exploited within the limits determined by environmental quality standards (EQSs), providing in abiotic ES G&Ss (Figure 2). The same applies to the biotic ES value, consisting of a number of species (reflecting biodiversity) occurring in a number of individuals (reflecting biomass). Some species serve as biotic ES G&Ss since they are harvested. Agriculture, fishery and animal husbandry are intensified ways of using biotic ES G&Ss. The ecological (or ecosystem) carrying capacity (ECC) relates the abiotic and biotic value, but available resources limit the biomass production which is divided over a number of species (biodiversity) by the trophic levels. The trophic structure determines the total habitat range of a set of species. Increase of ECC can relate to either increase of biomass (with biodiversity loss) or to biodiversity increase (with resource loss). It is noticed that ecosystem and non-ecosystem goods sustain the economy, whereas ecosystem services, such as recreation or the natural breakdown of pollutants in the water system, hardly influence economic pricing.

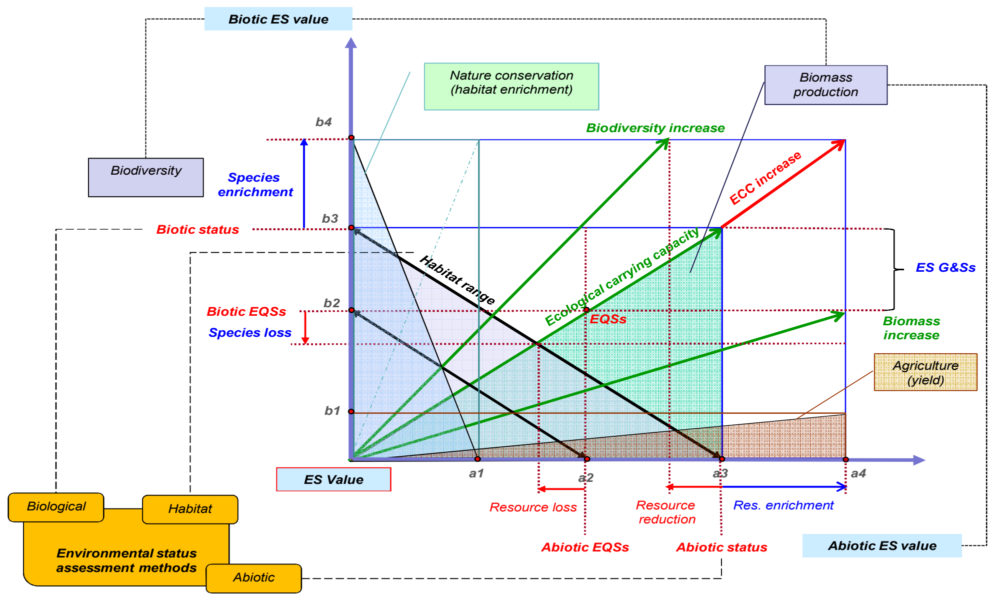

Figure 2. Changes in habitat range and value. Nature conservation and agriculture are extreme forms of carrying capacity, focusing on habitat enrichment and biomass production respectively. EQSs define the minimum environmental status and maximum ES G&Ss. This combined approach may require new or adapted assessment methods, integrating abiotic, biological and habitat assessments.

'ES G&Ss' are the total of non-ES G&Ss and abiotic and biotic ES G&Ss and indicate the amount of environmental value abstracted from the non-human environment to serve human needs, creating economic value. Abstraction of abiotic resources practically includes the exploitation of e.g. water resources. In particular non-renewable resources are continuously decreasing, causing adverse biological side-effects. The extent of harvesting biotic value (yield) relates to biological factors and is depending on the species' population dynamics and the community's trophic structure. Sustainable harvesting should include the regeneration of biomass without biodiversity loss. Both abiotic and biotic resource use depends on economic factors such as demand & supply, determining the economic equilibrium. On the other hand, any resource use will affect the ecological equilibrium and hence impacts the abiotic and biotic value to a lesser or greater extent. Sustainable development aims at limiting the amount of ES G&Ss use to the degree they meet both the economic and ecological equilibrium. From this we must conclude that, in general, the value of biotic ecosystem quality, such as habitat quality or biodiversity, is not directly related to the socio-economic capital and its pricing.

RESILIENCE AND SUSTAINABILITY

Ecosystem resilience and ES G&Ss relate to different ambitions (Figure 3). Ecosystem resilience indicates the extent to which ecosystems can be used and must be protected in order to avoid loss of biodiversity. ES G&Ss indicate the possibility ecosystems can be used to serve human needs. Population increase and changing consumption pattern result in many cases and places in over-abstraction of natural resources, exceeding EQSs limits. Beside the direct exploitation of abiotic and biotic resources resulting in loss of biotic value, also the disappearance of habitats is crucial in sustainable ecosystem development.

In this study, economic value includes the physical production of goods of a certain quantity and quality. Consequently, the extent to which economic value can be created using natural resources, called economic carrying capacity, depends on the extent ES G&Ss can be provided. On its turn, the provision of ES G&Ss depends on the ecological carrying capacity. EQSs determine those limits. In the future, EQSs should not only be used for environmental status assessment, but also to indicate limits of ecosystems variability and dynamism and consequently the exploitation of natural resources. In the case ES variability reflects also ES resilience, EQS relate to both ES stability and the provision of ES G&Ss, besides their role in environmental status analyses.

Despite the fact countries have hardly established environmental flows (E-flows), the on-going discourse on water scarcity and drought indicate the need of environmental water quantity standards. Drought is an effect of natural phenomena, indicating water availability is lower than the minimum EQS level. The limit point of ES damage also indicates the limit to which 'scarcity' applies. The degree of water abstraction depends on the societal demand and use. Sustainable abstraction may not affect E-flows, which requires abstraction is not exceeding availability.

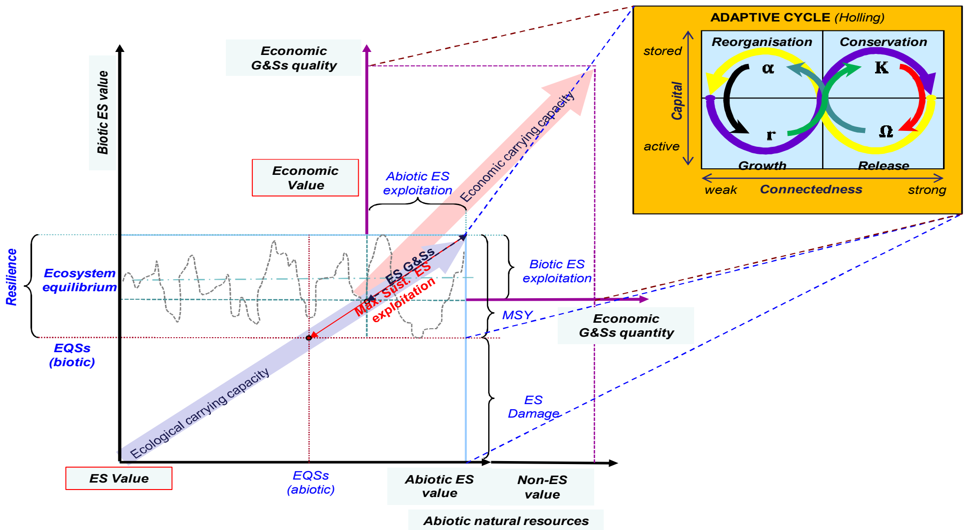

Figure 3. Ecological and economic carrying capacity. ES G&Ss depend on the resilience of ecosystems, the bottom value being determined by the EQSs. Significant impacts are then causing ecosystem damage. Above these limits, the ecosystem is considered as being sustainably manageable and exploitation being within the resilience range. Within the resilience range, the ECC limits the ES goods that can be used, also known as maximum sustainable yield (MSY). Holling's Adaptive Cycle enables to understand the dynamics of both ecosystems and the economy. In this respect, ecosystem resilience can be explained by the degree substances are released and used by organisms through the adaptive cycle. (Adaptive Cycle: redrawn after Peterson, 2000: 326).

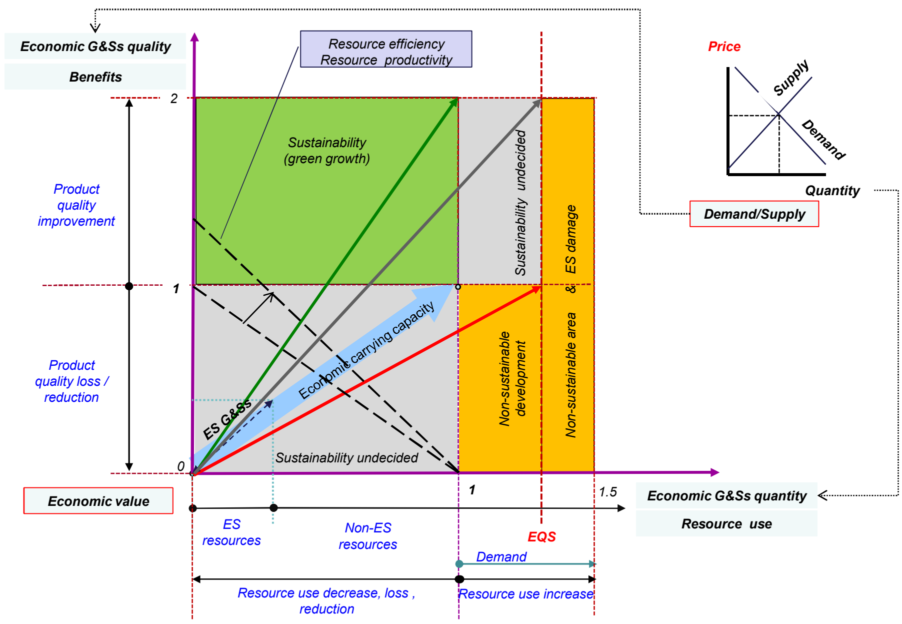

Figure 4. Green growth providing in sustainability. Any additional use of resources when the environmental status is low includes unsustainability or even ES damage. Resource productivity and efficiency can be improved by minimising resource losses and product quality improvement.

Overabstraction equals ecosystem damage. Water scarcity implies additional measures must be taken to reduce abstractions: reducing demand, water recycling, water re-use, etc. If drought already occurs, ES damage will include the effects of both drought and overabstraction. These effects will be enhanced in the case of unexploitable resources (e.g. as a result of pollution), lowering the available water volumes. This means that improving water quality (e.g. by waste water treatment) may provide in additional water resource volumes.

SUSTAINABLE DEVELOPMENT

Sustainable development combines the social (S), economic (E) and natural (N) capitals. Related to water, economic growth and social well-being may improve as long as limits of sustainable use of water resources are not met. Resource efficiency (water savings or spills) may retard or fasten this process. Additional use of water resources exceeding EQS levels may positively influence economic welfare, but also lead to reduced well-being by making natural (water) resources unavailable or reducing amenities. Decoupling refers to the nexus of resource use, economic growth and environmental impacts[1] and is about less water use, but still resulting in economic growth. Current production and consumption patterns include the unlimited use of water and other resources. Green economy implies setting EQSs to limit resource availability and to increase resource use efficiency by decoupling. This means that 'green economy' can only be applied if, for instance, less water volumes are used to produce the same amount of products. This illustrates that, in general, all ecosystem resources are provided as goods available in different forms and socio-economic demand will result in the use of these goods. However, ecosystem quality is not directly included in the economic demand and supply curves.

Considering the interactions between the natural and economic capitals should provide in solutions to regulate or adapt the economic instruments to improve the economic value. Current economic practices focus on product quantities and the resources used. Product pricing benefits product quantity turn-over (overconsumption) and affects resource quantities. However, pricing does not fully reflect ES quality aspects that relate both the resource quality and to ecosystem damage. Figure 4 shows the possibilities and limitations of sustainable growth, taking into account the environmental conditions. In the case of water, when drought or shortage of water occurs, any additional abstraction of water volumes is non-sustainable.

The combined effect of both using less resources quantities (e.g. water saving) and improving product quality (e.g. waste water treatment) offers most opportunities for sustainability.

CONCLUSIONS

Understanding the interactions between economy and ecosystems is a prerequisite for detecting possibilities and limitations of sustainable development and green growth. This requires a thorough understanding of ecosystem valuation and ecological processes. Limiting natural resources quantities only may seem insufficient and

[1] UNEP (2012: 23): "*resource decoupling in general means reducing resource use per unit of economic activity*".

improving product quality should gain more attention. Another shortcoming is the economic pricing, not fully reflecting or including the environmental quality, the ecosystem damage and the ecosystem services. From this, it can be stated that higher tension can be expected between minimal environmental protection requirements to maintain biodiversity and the increasing resource use to meet the societal demands. With limited resources, economic possibilities are increasingly dependent on the environmental limits and requirements as defined by environmental quality standards (EQSs). It can be concluded that, beside resource use reduction, environmental quality should be fully included in economic pricing.

REFERENCES

Peterson, G., 2000. Political ecology and ecological resilience: An integration of human and ecological dynamics. *Ecological Economics* 35 (2000): 323-336.

UNEP, 2012. Measuring Water use in a Green Economy. A report of the Working Group on Water Efficiency to the International Resource Panel. United Nations Environment Programme. 72 p.