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# Ecosystem Services – Examples of Their Valuation Methods in Czech Republic and Slovakia

**Abstract:** This literature review deals with the understanding of ecosystem services related to the question of their applicability and appropriate methods for their valuation. We distinguish between ecological valuation methods that aim to assess the significance of landscape characteristics, conventional economic, i.e. monetary valuation and non-monetizing valuation or assessment. Ecological evaluation methods derive values by following a cost of production approach which neglects consumer preferences. Economic valuation methods focus on the exchange value of ecosystem services, i.e. they are based on consumer preferences, but do not adequately take into account the complex internal structure of ecosystems. We conclude that – from the view of implementation of ecosystem services for policy support and consulting – successful valuation approaches should particularly consider the relationships between economic, ecological and social aspects of ecosystem services' provision.

**Keywords:** Ecosystem services; ecosystem processes; ecosystem functions; ecological, sociocultural and economic value of ecosystems; cost of production; exchange value; consumer preferences

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## 1 Introduction

Ecosystem services and the benefits that they provide for society are a specific research topic at the interface of social and natural systems [1-7]. Along with the recognition of their economic importance, there is an intensive debate on the economic valuation of ecosystem functions and the services that they provide [4].

The distinction between ecosystem processes, ecosystem functions and ecosystem services needs to be clarified. Ecosystem processes are seen as the complex interactions among biotic and abiotic elements of ecosystems, encompassing in broad terms material cycles and the flow of energy [8]. Although this definition is widely accepted, scientists interpret and classify processes in different ways [9]. In ecology, the term ecosystem function has traditionally been used to refer to the set of ecosystem processes operating within an ecological system [10], irrespective of whether or not such processes are useful for humans [11]. Ecosystem functions can be defined, according to [12], as the "capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly" [7]. Various definitions of ecosystem services can be found in the literature [5,7]. A commonly accepted definition of ecosystem services is the natural processes by which ecosystems, and the species that make them up, sustain and fulfil human life [2]. Another commonly accepted definition is the one used in the Millennium Ecosystem Assessment [13], which defines them simply as being the benefits that people obtain from ecosystems. The MA further classifies them into provisioning, regulating, supporting or cultural services.

The importance of ecosystems is roughly divided into three types: ecological, sociocultural and economic value [14]. The papers by [4, 15-17] discuss these three concepts of value in more detail. It is beyond the scope of this paper to address these issues further.

The existing scientific literature on environmental valuation is based on two distinct foundations. The ecological valuation methods derive values by following a

cost of production approach. Their common characteristic is the neglect of consumer preferences. The economic valuation methods focus on the exchange value of ecosystem services. Their common characteristic is that they are finally based on consumer preferences and do not adequately take into account the complex internal structure of ecosystems. A detailed historical overview can be found in various papers [11,18].

Over the past few years, there has been an explosion of interest in ecosystem services. The 2005 publication of the Millennium Ecosystem Assessment, which made ecosystem services its central focus, prompted a chain of efforts to address ecosystem services. The major recent studies include Valuing Ecosystem Services: Towards Better Environmental Decision-Making [19], Valuing the Protection of Ecological Systems and Services [20], The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature [21], Natural Capital: Theory and Practice of Mapping Ecosystem Services [22] and [23]. All of these efforts blend economics with ecology and other disciplines to measure the provision and value of ecosystem services and to think about policy levers to provide incentives for the sustainable provision of services [24].

Within the International Union for Conservation of Nature (IUCN), a thematic group on ecosystem services exists, with the aim of improving the knowledge base on ecosystem services and their values and stimulating the integration of this knowledge into planning and decision making for sustainable ecosystem management.

Furthermore, in the EU's new post-2010 biodiversity strategy, announced in May 2011, ESs are not only mentioned but also linked to specific targets [25]. The concept is increasingly being advocated in other policy fields, too, such as sustainable land and water use, climate change mitigation and ecosystem restoration [21]. For a detailed analysis, see [26].

In forestry, the Legally Binding Agreement on Forests recognizes in its text that forests and sustainable forest management contribute to climate change mitigation and adaptation, provide renewable raw material, energy supply, water and soil protection and other ecosystem services as well as protect society and societal infrastructures from natural hazards. Ensuring sustainable forest management in Europe and the long-term provision of a broad range of goods and forest ecosystem services is vital [27].

Ecosystem services are broadly used as a key word or concept for different studies dealing with the utilization, management, policy, ecological and external influences of ecological systems on human beings. It is therefore important to have an overview of selected valuation methods. The aim of this paper is to present various economic and ecological methods used for ecosystem services' valuation.

## 2 Material and methods

We used a literature review of papers published in scientific journals in the English language and grey literature dealing with ecosystem services' valuation in the Czech Republic and Slovakia.

The division of methods for the assessment and valuation options stems from the work of [28]. Ecosystem services are regarded not only as economic goods but also as an integral part of the national heritage and are an essential environmental component. This is recognized not only by the related legislation in various countries (forestry, land use) but also by environmental legislation regulating nature protection. The Vyskot method is not embedded in the Czech legislation; it is only used as methodological guidance for the evaluation of environmental harm.

In this paper, we distinguish between the terms "assessment", "valuation" and "evaluation". Assessment is understood in the broadest sense as the act of judging or deciding on the amount, value, quality or importance of ecosystem services for society as presented in the Millennium Ecosystem Assessment. The Millennium Ecosystem Assessment uses a new conceptual framework for documenting, analysing and understanding the effects of environmental change on ecosystems and human well-being. It views ecosystems through the lens of the services that they provide to society, how these services in turn benefit humanity and how human actions alter ecosystems and the services that they provide. The focus on ecosystem services has been adopted widely among the scientific and policy communities and has resulted in new approaches to research, conservation and development [29]. The term "valuation" is used for economic methods and "evaluation" for ecological methods for the assessment of ecosystem services.

## 3 Results and discussion

Based on Figure 1, two different approaches to ecosystem services' valuation can be named. Ecological valuation methods aim to assess the significance of landscape characteristics. The methods of economic valuation of ecosystem services are conventional economic valuation [19,30-32] and non-monetizing valuation or assessment [11,33-34].

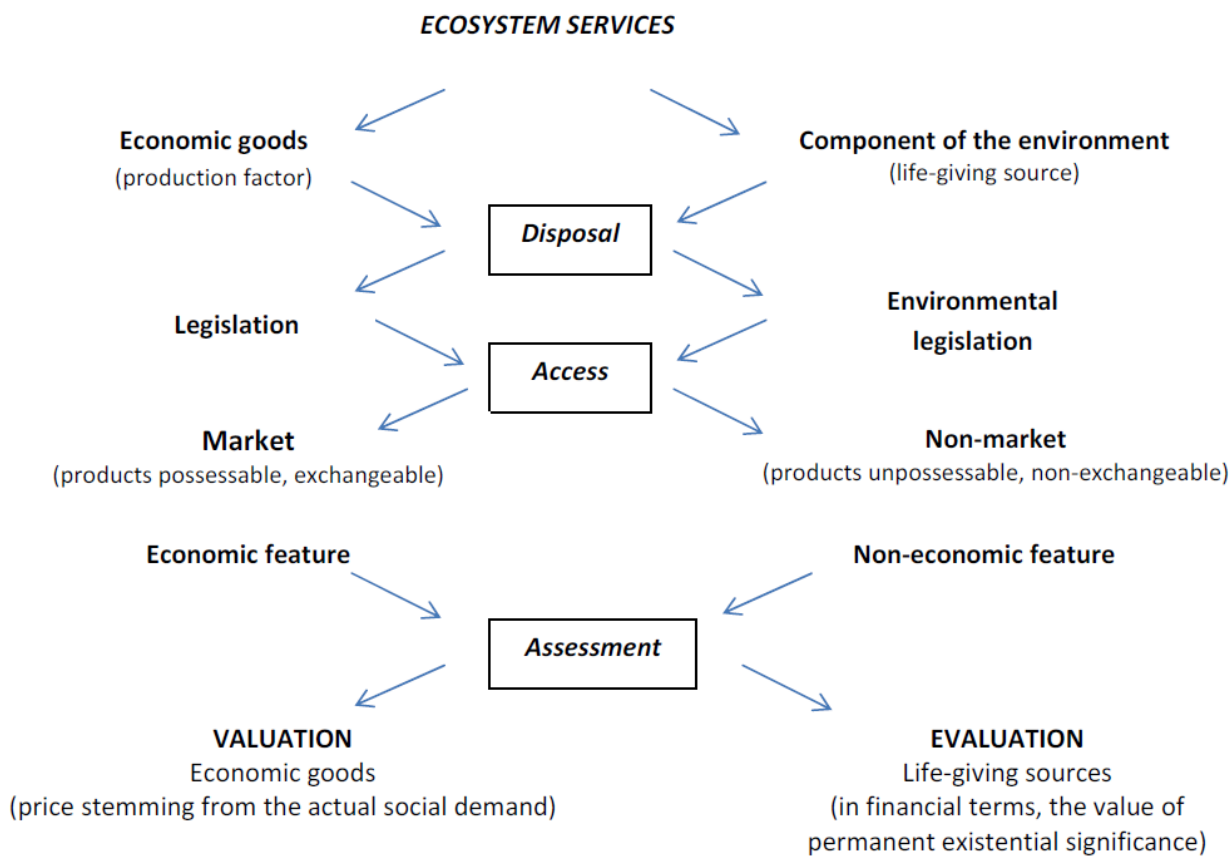


**Figure 1:** Framework for ecosystem services valuation and assessment (23, modified).

In the ecological, landscape and environmental economics literature, two main approaches have been developed. The first approach focuses on the benefits supplied by landscapes that were historically strongly influenced by mankind. This approach employs the valuation of the functions of ecosystems. It was mainly developed in countries that are characterized by such landscapes, including Germany [35-37] and the Netherlands [12,38]. In this approach, the functions are defined as the capacity to provide benefits to society, directly or indirectly [12]. The second approach focuses on the benefits supplied by natural and semi-natural ecosystems. This approach employs the valuation of the goods and services of ecosystems. It was mainly developed in the Anglo-Saxon world [39,40]. In this approach, ecosystem services are defined as the benefits provided by ecosystems to society [41]. Both approaches currently persist, although, in recent years, the Anglo-Saxon interpretation has probably become more dominant in international fora [1,13,42]. The new rise of the topic usage of evaluation methods succeeds through terms such as the green economy, compensation mechanisms or payments for ecosystem services (UNECE, FOREST EUROPE, IUCN).

A commonly used conceptual model for framing ecosystem services is the ecosystem service cascade model [14,21,43,44]. This framework links biodiversity and ecosystems stepwise to human well-being through the flow of ESs. Ecosystems provide the necessary structure and processes that underpin ecosystem functions, which are defined as the capacity or potential to deliver services. ES are derived from ecosystem functions and represent the realized flow of services in relation to the benefits and values of people [44].

In its report, TEEB proposes a set of steps for effectively appraising ecosystem services. TEEB does not use a cost–benefit approach to valuation. Instead, it recognizes valuation as a human institution, a way for society to give itself feedback. One can assign value with no use of economics whatsoever [21].

There are also market-based approaches to valuing ecosystem services, such as PES [45,46], an economic conservation tool that has recently gained much attention. It is believed to show a great deal of promise in managing natural resources by incentivizing stakeholders to agree on behavioural changes that are more sustainable. The environmental impacts of these behavioural changes are

quantified and the changes rewarded. It is an instrument through which buyers and sellers voluntarily agree on a payment for the provision of a specific ecosystem service (or for an activity that is believed to ensure such provision), which would otherwise not take place [47].

There are additional opportunities for valuing ecosystem services by "fixing" and "creating" markets. Attempts are made to "fix" markets by addressing externalities through certification, such as the Forest Stewardship Council (FSC) certification for timber markets and the Marine Stewardship Council (MSC) certification for fisheries markets. Similarly, in crop markets, polluters can be made to pay by incorporating a charge for pollution into the value of a good. "Creating markets" involves developing new markets, such as premium credits 3 under REDD+ and biodiversity banking [48].

Some initiatives focusing on modelling ESs are being established, such as the Natural Capital Project and the Ecosystem Services Partnership. Recently, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) was launched to guide the flow of scientific information related to biodiversity and ESs to governments and practitioners [44].

## 3.1 Ecological evaluation methods

Landscape ecological planning is an inseparable part of landscape ecology. It presents the application of the theoretical principles of landscape ecology for the solution of practical problems of ecologically optimum and sustainable development of mankind on Earth. The need for the development of landscape ecological planning is stressed by the growing problems arising from non-observance of natural rules and processes in the development of population and civilization processes.

Landscape ecology methods use territory valuation and reflect the importance of the ecosystem service foremost in certain grades or relative units. They are based on an analytical and synthetic approach to landscape evaluation and its structure or elements on the basis of various landscape elements' (or ecosystems, geobiocenoses) inventory and their evaluation based on site conditions and relations to ecological stability [49]. Analytical evaluation is difficult (though feasible using landscape ecology indexes) and focuses on visual evaluation with discrete territory classification (e.g. on a scale 0–0.5–1).

Various evaluation methods are used in landscape planning, such as diversity indices, the evaluation of the functional efficiency of non-forest vegetation, landscape complexes and LANDEP.

### 3.1.1 Diversity indices

A diversity index is a mathematical measure of the species diversity in a community. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundance of different species into account. The most commonly used are the Shannon–Wiener Index (H'), Simpson's Index (γ), Berger–Parker Index and similarity indices that measure the similarity between communities based on species composition.

The *Shannon–Wiener Diversity Index* (H') enables us to measure the diversity of the landscape. Its calculation takes into account the proportional representation of each type of land cover. The rate of the index increases when the number of various land cover types increases and/or if the proportional distribution of various land cover types is balanced.

*Simpson's Index* (γ) is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the quantity of each species. It measures the probability that two individuals randomly selected from a sample will belong to the same species.

The *Berger–Parker Diversity Index* is the proportion of the most common species in the community or sample. It is the simplest and most easily understood diversity index, since it only calculates the proportion of the commonest species in a sample.

*Similarity indices* measure the similarity between communities based on species composition and are useful in comparing communities under different forms of management.

### 3.1.2 Evaluation of the functional efficiency of non-forest vegetation

Non-forest vegetation is one of the significant components of the landscape structure that is important for humans' and other organisms' environment. It presents original, natural, semi-natural and synantrop or purposely human-created communities (habitats). In the agricultural and urbanized landscape, these habitats provide various ecosystem services and therefore positively influence the improvement of its ecological stability. This landscape ecology method for landscape planning based on the site conditions and relations to ecological stability has been used by various authors.

Múdry [50], using inventory data, evaluates the functional efficiency of landscape vegetation that serves for the classification of the guiding value and

environment stabilization efficiency of tree and shrub structure types. These serve to elaborate the surface typing of the present landscape to determine the degree of diversity of dominant land use and the value of stabilization of these types using vegetation forms of land use (pastures, meadows, arable land) and propose measures to stabilize areas for protection and vegetation creation.

Ulrychová [51] evaluates the significance of non-forest vegetation using the classic Zurich–Montpellier method in vegetation science from the operational, landscape ecology, park landscape and architectonic-aesthetic point of view.

Rózová [52] uses LANDEP, which deals with the ecologically optimal operational classification of agricultural land.

Sláviková [53-54] evaluates the functional efficiency of non-forest tree vegetation formation. Ecological functions (edaphic, hydric, climatic and biotic) are assessed by the relation of the non-forest tree vegetation formation efficiency in the present anthropic influences on landscape conditions. Based on their operational effectiveness, individual formations are classified into the I or II category.

#### 3.1.3 Land use complexes

Míchal [55-56] proposes ecosystem services' valuation of the landscape on two levels:

1. Typological classification (based on geoecological criteria) that focuses on the landscape as a set of ecosystems and how the history of ecosystems influenced by mankind is reflected in the landscape shape and arrangement.
2. Land use, which is ecological and aesthetic valuation of ecosystems in a specific sense (foremost according to the environmental values or from the landscape scenery). Aesthetic valuation criteria are in principal social and take into account the share of subjective processes in phenomena evaluation.

Typing the area leads to the calculation of the ecological stability coefficient (KES) for individual cadastrial areas (the share of relatively stable ecological areas – forests, meadows, water areas, etc. – and non-stable areas – built-up areas, arable land). In general, land use complexes with a low level of landscape values have a high need for new positive ecological and aesthetic values and thus greater ecosystem services.

#### 3.1.4 LANDEP

The conception of LANDEP – Landscape Ecological Planning [57] – brings to the fore the need for a multidisciplinary approach to landscape evaluation as an area in which the activities of man and society are developed on the bases of natural phenomena and processes. It is necessary to improve, overspread and systematically classify the knowledge and bases of ecological factors that have been utilized on different levels and in different ways in territorial planning, in land adjustment and in the projection and realization of landscape changes. LANDEP can move passive landscape protection to an active position of prevention when protection is realized in planning and landscape formation as part of the environment. LANDEP is a widely drafted synthesis of knowledge of potential possibilities of ecologically optimum landscape utilization from the viewpoint of purposeful formation of the conditions for the conservation and development of healthy populations of organisms and humans and for the development of human society. From the methodological viewpoint, LANDEP is based on the analysis, interpretation, synthesis and evaluation of ecological features. The result of LANDEP is a proposal for ecologically optimum landscape utilization aimed at the harmonization of social activities in the landscape with its ecological features in time and space.

### 3.2 Economic valuation methods

The economic valuation methods can be divided into two groups:

- valuation methods from the consumer's perspective,
- valuation methods from the producer's perspective.

The valuation methods from the consumer's perspective can be further divided into direct and indirect methods based on the valuation concept. The indirect methods value ecosystems based on the participants' behaviour in the influenced market. The direct methods value ecosystems using questionnaire methods and their evaluation.

The indirect methods use the linkage with market goods or services to assess the willingness to pay. The most used methods are the following:

- The *market price method* estimates the economic value of the ecosystem products or services that are bought and sold in commercial markets. The market price method can be used to value changes in either the quantity or the quality of a good or service. It

uses standard economic techniques to measure the economic benefits from marketed goods, based on the quantity that people purchase at different prices and the quantity supplied at different prices. The standard method for measuring the use value of resources traded in the marketplace is the estimation of consumer surplus and producer surplus using the market price and quantity data.

- *Production function-based approaches* (PFs) estimate the value of a non-marketed resource or ecological function in terms of changes in economic activity by modelling the physical contribution of the resource or function to the economic output [58].
- The *replacement cost method* estimates the costs incurred by replacing ecosystem services with artificial technologies [58].
- The *relocation cost* (RLC) method uses the costs of relocating threatened communities [59].
- The *mitigation* or *restoration cost method* refers to the cost of mitigating the effects caused by the loss of ecosystem services or the cost of restoring those services [59].
- The *travel costs method* (including applications using random utility models) use information about how much people implicitly or explicitly pay to visit locations with specific environmental attributes, including specific levels of ecosystem services, to infer how much they value changes in those attributes [60].
- The *opportunity costs method* uses the value of alternative environmental goods for ecosystem valuation. It assesses the value relinquished in order to protect, enhance or create an environmental asset (i.e. loss of revenue caused by protecting a forest from clearance for agricultural production).
- The *hedonic pricing method* uses information about how much people pay for houses or other directly purchased items with specific environmental attributes (e.g., visibility, proximity to amenities or disamenities) to infer how much they value changes in those attributes. It may also use information about the wages that people would be willing to accept for jobs with differing mortality or morbidity risk levels to infer how much they value changes in those risks.

The direct methods are based on questionnaires. The following methods are used:

- The *contingent valuation method* adopts a survey-style approach that constructs hypothetical markets via a questionnaire. A participant's response reveals his or her willingness to pay for a particular environmental change. In theory, this method can capture all the elements of the total economic value, but in practice it is hard to assess the complexities of various use and non-use values.
- *Choice modelling* is a survey-style approach that focuses on the individual attributes of a particular ecosystem. Participants are presented with combinations of attributes and asked to decide upon their preferred combination or rank the alternative combinations. Each combination of attributes has a price associated with it and therefore the respondents reveal their willingness to pay or willingness to accept each attribute. This method is able to ascertain all the elements of the total economic value.
- The *benefit transfer method* is used to estimate economic values for ecosystem services by transferring the available information from studies already completed in another location and/or context. For example, the values for recreational fishing in a particular state may be estimated by applying measures of recreational fishing values from a study conducted in another state.

The valuation methods from the producer's perspective are based on valuing the compensation requirements for the production of public goods, which are reflected in reduced revenues and increased costs. The most commonly used method is the *reduced revenues and increased costs method*.

Another classification of economic valuation methods is presented below and stems from the work of Liu et al. [18]. A spectrum of non-market valuation techniques has been developed to value ecosystem services, including both non-monetary valuation methods and environmental economic techniques based on a monetary metric. The use of a monetary metric assumes that individuals are willing to trade the ecosystem service being valued for other services represented by the metric. The purpose of monetary valuation is to allow the measurement of the costs or benefits associated with changes in the ecosystem services by calculating a shadow price. The principle distinction among monetary valuation methods is based on the data source, that is, whether it derives from observations of human behaviour in the real world (i.e., revealed-preference approaches) or from human responses to hypothetical questions (stated-preference approaches). Finally, non-monetary methods do not require valuation results expressed in a single monetary unit.

#### 3.2.1 Revealed-preference approaches

Revealed-preference techniques are based on the observation of individual choices in existing markets that are related to the ecosystem service that is the subject of valuation. In this case, it is said that economic agents "reveal" their preferences through their choices.

- *Travel cost*: Valuations of site-based amenities are implied by the costs that people incur to enjoy them (e.g., cleaner recreational lakes).
- *Market methods*: Valuations are directly obtained from what people must be willing to pay for the service or good (e.g., timber harvest).
- *Hedonic methods*: The value of a service is implied by what people will be willing to pay for the service through purchases in related markets, such as housing markets (e.g., open-space amenities).
- *Production approaches*: Service values are assigned from the impacts of those services on economic outputs (e.g., increased shrimp yields from increased areas of wetlands).

#### 3.2.2 Stated-preference approaches

Stated-preference approaches simulate a market and the demand for ecosystem services by means of surveys on hypothetical (policy-induced) changes in the provision of ecosystem services. Stated-preference methods can be used to estimate both use and non-use values of ecosystems and/or when no surrogate market exists from which the value of ecosystems can be deduced.

- *Contingent valuation*: People are directly asked their willingness to pay or accept compensation for a particular change in an ecological service (e.g., willingness to pay for cleaner air).
- *Conjoint analysis*: People are asked to choose or rank different service scenarios or ecological conditions that differ in the mix of those conditions (e.g., choosing between wetland scenarios with differing levels of flood protection and fishery yields).
- *Choice modelling* (CM): This attempts to model the decision process of an individual in a given context [61]. Individuals are faced with two or more alternatives with shared attributes of the services to be valued, but with different levels of attributes (one of the attributes being the money that people would have to pay for the service).
- *Group valuation*: This combines stated-preference techniques with elements of deliberative processes from political science [62] and is being increasingly used as a way to capture value types that may escape individual-based surveys, such as value pluralism, incommensurability, non-human values or social justice [63].

#### 3.2.3 Cost-based approaches

- *Replacement cost*: The loss of a natural system service is evaluated in terms of what it would cost to replace that service (e.g., tertiary treatment values of wetlands if the cost of replacement is less than the value that society places on tertiary treatment).
- *Avoidance cost*: A service is valued on the basis of costs avoided or the extent to which it allows the avoidance of costly averting behaviours, including mitigation (e.g., clean water reduces costly incidents of diarrhoea).

#### 3.2.4 Non-monetizing valuation or assessment

- *Individual index-based methods*, including rating or ranking choice models and expert opinion.
- *Group-based methods*, including voting mechanisms, focus groups, citizen juries [16, 64] and stakeholder analysis [65].
- *Measures of attitudes, preferences and intentions* are socio-psychological approaches to assessing the value of ecosystems and ecosystem services. They employ a number of methods to identify, characterize and measure the values that people hold, express and advocate with respect to changes in ecological states or their personal and social consequences. These methods elicit value-relevant perceptions and judgements, typically expressed as choices, rankings or ratings among presented sets of alternative ecosystem protection policies and may include comparisons with potentially competing social and economic goals [20].
- *Civic valuation* seeks to measure the values that people place on changes in ecosystems or ecosystem services when explicitly considering or acting in their role as citizens. These valuation methods often seek to value changes that would benefit or harm the community at large. They purposefully seek to assess the full value that groups attach to any increase in community well-being attributable to changes in the relevant ecosystems and services. Civic valuation methods are referenda, initiatives and citizen valuation juries [20].

- *Decision science approaches* derive information about people's values through a deliberative process that helps individuals to understand and assess trade-offs among multiple attributes. The ultimate goal is for an individual or group to assign scores to alternatives (e.g., different projects) that can then be used to choose among those alternatives, recognizing that those alternatives will differ along a number of relevant dimensions or attributes. Generally, one alternative will score higher along some dimensions but not others, suggesting that trade-offs must be made when choosing among alternatives [66,67].
- *Ecosystem benefit indicators* offer quantitative metrics that are generally correlated with ecological contributions to human well-being and hence can serve as indicators for these contributions in a specific setting. They use geo-spatial data to provide information related to the demand for, supply (or scarcity) of and complements to particular ecosystem services across a given landscape, based on social and biophysical features that influence – positively or negatively – the contributions of ecosystem services to human well-being [68].
- *Biophysical ranking methods* try to value ecosystem services' values based on the quantification of biophysical indicators. Possible indicators include measures of biodiversity, biomass production, carbon sequestration or energy and material use [69].

The above-mentioned valuation and evaluation methods are significant for many areas, such as landscape and urban planning, landscape valuation, participatory processes, the formulation of strategic policy documents, natural capital accounting, the value of the world's ecosystem services and natural capital and many more.

New approaches to ecosystem valuation attempt to integrate economic valuation methods, which are based on consumer preferences and the exchange value of services, with ecological valuation methods, which are based on the cost of production and social values. Production function approaches to valuation explicitly incorporate ecosystem processes into economic studies. These integrative approaches are more likely to capture the full value of ecosystems in providing services.

While research has produced a vast amount of knowledge about ecosystem services, in many cases this knowledge has not yet been put to use in decision making regarding ecosystem services. There is no simple or established way of integrating the ecosystem services concept into policies and decision-making processes. Hauck et al. [26] identify two specific challenges arising in the context of policy formulation and implementation, namely the valuing of ES across scales and the trade-offs that occur when one ES is preferred over another: it is generally not possible to valuate different ESs independently from each other. Ecosystems usually provide multiple (potential) services that are interlinked.

# 4 Conclusions

The existing research on ecosystem services has been extraordinarily productive up to this time. Various methods are used and implemented for the valuation of ecosystem services. The methods and their results are based on a basic theoretical background, purpose of valuation, socio-economic conditions and input data availability.

For the successful implementation of the methods provided by scientific research, effective policy tools are crucial. For ecosystem services' protection to be effective, the research in those areas must be driven by the needs and constraints of policy. Policy makers need information about the magnitude of natural service variation as well as how the service supply will vary in the face of human-induced environmental change.

Valuation represents not only a professional issue but also a political issue of enforcement of respective political interests. The question is whether it is possible to align the incentives for the sustainable provision of ESs. This is an implementation question that has to be decided by policy makers. Nevertheless, the valuation approaches and results should consider rational relationships between the economic, the ecological and the social aspects of ecosystem services' provision.

To conserve and enhance ecosystem services effectively, nature and social science must be expanded and integrated to identify, prioritize and target ecosystem services, which is the task of interdisciplinary research.

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