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Review

Review of valuation methods for mangrove ecosystem services

Quoc Tuan Vo[a,*], C. Kuenzer[b], Quang Minh Vo[c], F. Moder[d], N. Oppelt[e]

[a] German Remote Sensing Data Centre, DFD, of the German Aerospace Centre, DLR, Oberpfaffenhofen, D-82234 Wessling, Germany
[b] German Remote Sensing Data Centre, DFD, of the German Aerospace Centre, DLR, Muenchner Str. 20, Oberpfaffenhofen, 82234 Wessling, Germany
[c] Department of Land Resource, College of Environment and Natural Resource Can Tho University, Viet Nam
[d] Ministry of Science and Technology, Southern Representative Office, Ho Chi Minh City, Viet Nam
[e] Kiel University, Department for Geography, Ludewig-Meyn-Str 14, 24098 Kiel, Germany

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ABSTRACT

The goods and services provided by natural ecosystems contribute to human well being, both directly and indirectly. The ability to calculate the economic value of the ecosystem goods and services is increasingly recognized as a necessary condition for integrated environmental decision-making, sustainable business practice, and land-use planning at multiple geographic scales and socio-political levels. We present a comprehensive overview and summary of studies undertaken to investigate the ecosystem services of mangrove forests. We address the variety of different methods applied for different ecosystem services evaluation of mangrove forests, as well as the methods and techniques employed for data analyses, and further to discuss their potential and limitations.

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1. Introduction

The term "ecosystem service" (ES) comprises all goods and services provided by natural and modified ecosystems that benefit, sustain and support human well-being. This includes benefits of the ecosystem based on the food production, building materials, medicines, regulation of microclimate, disease prevention, provision of productive soils and clean water resources, as well as landscape opportunities for recreational and spiritual benefits (Daily, 1997; Costanza and Folke, 1997; Millennium Ecosystem Assessment-MA, 2005; Banzhaf, 2007; Wallace, 2007). Such services are provided by ecosystems which consist of a combination of soil, animals, plants, water,air and other services such as the service that maintaining biodiversity or contribute to climate stability. If these elements are depleted, the ability or capacity of ecosystems to provide services is diminished. ES support our well-being, including

* Corresponding author. Tel.: +49 08153 28 1747.
E-mail address: tuan.voquoc@dlr.de (Q.T. Vo).

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the production of most of our living needs, and thus are of significant value. However, the services from the ecosystems are greatly undervalued by society. Most of them are not traded in the formal market, and its value is not easy to be estimated (Daily et al., 1997). ES are often neglected or even ignored by the economy, industry, and local habitants; even though most of them strongly depend on the flow of ES.

Knowing the economic value of an ecosystem and its services is an important asset, because a major demand is the support of human well being, sustainablility, and distributional fairness (Costanza and Farber, 2002). From the human perspective, natural ecosystems not only provide life supporting services, but also services beyond basic life support (e.g. recreational and aesthetic enjoyment) (Daily, 1997; Costanza and Farber, 2002). Over the past two decades, humans changed ecosystems more rapidly and comprehensively than in any comparable period before. This was mainly due to the rapidly growing demands for food, fresh water, timber, fiber, and fuel. This transformation of the planet has contributed to substantial net gains in human well-being and economic development (MA, 2005).

This review paper gives a comprehensive overview of studies on the concept of ecosystem functions and services, and synthesizes the methodologies for assessing the value of mangrove ecosystem services. ES concepts and valuations itself, which have been developed so far, are introduced briefly. The paper highlights key issues and trends in the application of economic valuation techniques on natural ecosystems. It reviews different valuation techniques and illustrates applications with examples drawn from empirical literature studies. The paper also includes a brief discussion of how results of previous valuation studies might be used for future evaluation methods of natural ecosystem services.

The paper summarizes and discusses studies on ES and functions in the context of environmental protection as well as climate change mitigation, published over the last two decades. The focus is set on ES in coastal areas, where mangrove wetlands are prevailing, which are an important asset for coastal protection, and provide numerous additional services for the coastal communities.

The next section describes the importance of ES research and the increasing focus on ecosystem studies. In Section 2, the general concept of ecosystem functions and services in the context of coastal environmental protection is discussed.

Section 3 reviews research papers on the valuation of mangrove ecosystem services based on different approaches. In Section 4, the different approaches to assess ecosystem functions and ecosystem evaluations are discussed. This section also discusses the difficulties of ES assessment especially concerning the definitions of economic values of ecosystem services.

1.1. Definition of ecosystem services

The concept of ES and their valuation was first introduced in the 1960s by King (1966) and Helliwell (1969) who refered the nature's functions in serving human societies. Afterwards, ecosystem services has been the focus of many publications (e.g. Pearce, 1993; Pearce and Moran, 1994; Daily, 1997; Costanza and Folke, 1997; De Groot et al., 2002; MA, 2005; Banzhaf, 2007; Wallace, 2007). The widely accepted definition of ES is: "Ecosystem services are the benefits provided by ecosystems to humans, which contribute to making human life both possible and worth living". (Díaz et al., 2006; MA, 2005a, b; Layke et al., 2012; van Oudenhoven et al., 2012). This includes goods such as food-crops, seafood, forage, timber, biomass fuels, natural fiber, pharmaceuticals, geologic resources, and industrial products, services such as the maintenance of biodiversity and life-support functions, including waste assimilation, cleansing, recycling and renewal (Table 1) (Costanza and Folke, 1997; Costanza et al., 1998; Daily, 1997; Norberg, 1999, Eisfelder et al., 2011; Busch et al., 2011), and intangible aesthetic and cultural benefits (Bengtsson, 1997; King et al., 2000; De Groot et al., 2002). According to the MA (2005a), ES are indispensable for both the natural environment and human beings. Four major categories of ES were identified by the MA, which are (i) provisioning services, (ii) regulating services, (iii) cultural services, and (iv) supporting services (MA, 2005a) (Fig. 1).

In ecological literature, the term "ecosystem services" has been subject to various and sometimes contradictory interpretations. Some authors use the term to describe the internal function such as nutrient cycling or energy maintenance (Daily, 1997; Wallace, 2007; Fisher et al., 2009); others relate ES to the benefit for humans, which can be derived from the processes of the ecosystem (e.g. food production, recreation) (De Groot et al., 2002; Brown et al., 2007; Luck et al., 2009). According to Jewitt (2002), ecosystem services are generated by a complex interplay of natural cycles, powered by solar energy, and operating across a wide range of space and time scales, incorporating both biotic and abiotic components.

Banzhaf (2007) integrated economic principles in their definition "Ecosystem services are components of nature, directly enjoyed, consumed, or used to yield human well-being". The important aspect of their work is that they distinguished between "end-products" and "intermediate products" to account welfare. "End products" are consumed directly by a household such as clean drinking water, but clean drinking water is depending on ecological processes, which are described as "intermediate products". They argue that if intermediate and final goods are not distinguished, the value of intermediate goods are double counted because the value of intermediate goods is embodied in the value of final goods (e.g. the value of steel used in for the production of cars is already part of the car's total value) (Banzhaf, 2007).

In general, definitions of ES are as diverse as the number of studies published in this context. All studies, however, acknowledge the strong relation between ecosystem function and human well-being. In other words, ecosystem services consist of flows of materials, energy, and information from natural capital stocks, which can be combined with manufactured and human capital services to produce human welfare.

The publication of the MA reports and their definition of ES also lead to intense discussions criticising the concept and several modified classification approaches were published (De Groot et al., 2002; Wallace, 2007; TEEB, 2008; Haines-Young and Poschkin, 2010). The main critics regarding the MEA definition of ES complain the simplified an very generic framework as well as an imprecise differentiation between services themselves, ecosystem processes and benefits (Wallace, 2007; Banzhaf, 2007; Fisher et al., 2008). Banzhaf (2007) tried to solve the mixing problem with an economical principle that should also standardize the concept of ES. Wallace (2007) also favours a standardized framework that only counts endpoints (final services) as ES and fits to all applications to facilitate the concept for landscape planners. However, each of them considers the need of multiple and context-based classification systems to fit the complexity of the human-ecosystem interface and find valuable benefits. Most authors suggest frameworks that separate the MA supporting services (e.g. nutrient or water cycling) in ecosystem functions and processes. Recently, multinational gatherings, including the "Convention on Biological Diversity", the "Ramsar Convention on Wetlands and Migratory Species", and the "Convention to Combat Desertification", have incorporated the ES concept into their discussion and convening. Also major Non-Governmental Organizations (NGO) including The Nature Conservancy, the World Wildlife Fund (WWF), the International Union for the conservation of Nature (IUCN), and the World Resource Institute (WRI) have begun to pilote ES programs, as have major intergovernmental agencies including the United Nations Development Program (UNDP), and the World Bank