The Economic Valuation of Mangrove Forest Ecosystem Services: Implications for Protected Area Conservation

Mahmoud Sarhan and Rady Tawfik

Introduction

Mangroves are forest ecosystems with high productivity and biological diversity, adapted to survive in harsh zones between the sea and the coast (ITTO 2012). The word "mangrove" refers to trees, families of the plant, and the ecosystem that has adapted to tidal zones (Tomlinson 1986). FAO (2007) defines mangroves as "salt-tolerant evergreen forests found at sheltered coastlines, shallow-water lagoons, estuaries, rivers or deltas." They primarily exist in intertidal areas around the globe in the subtropics (Woodroffe and Grindrod 1991), with 73 species (Spalding et al. 2010) covering an area of over 150,000km^2 in 123 countries, although over two-thirds of mangroves are found in just 12 countries, with Indonesia alone accounting for over 20% of the global mangrove area (ITTO 2012). Brazil has about 8% of the total area and the largest continuous mangrove forest (Spalding et al. 2010). Compared with other forms of forest, mangroves are rare, representing less than 1% of tropical forests and 0.4% of global forest areas (FAO 2007).

In tropical estuaries of Indonesia and Brazil, mangroves are typified by dense forests and canopies with heights of 30m or more; whereas in arid, very saline regions (e.g., along the Red Sea) they grow as narrow fringes of stunted trees and shrubs no more than 3m high (UNEP 2014).They have evolved mechanisms to allow them to survive in areas with high levels of salt concentrations and habitual immersion of their roots by tides. They also need freshwater influx, which provides silt essential for their support and for nutrients commencing upstream. Mangroves cannot flourish in stagnant water (Kathiresan and Bingham 2001).

The George Wright Forum, vol. 35, no. 3, pp. 341–349 (2018).

ISSN 0732-4715. Please direct all permissions requests to info@georgewright.org.

Mangrove ecosystems provide significant socioeconomic benefits, such as timber, fish, tourism opportunities, and environmental services (e.g., coastal protection, water regulation, carbon sequestration, and nursery habitat for a wide-ranging diversity of species). Global damage of mangroves has become substantial in recent years, even though some areas still have very rich mangrove forests (Alongi 2002). They are threatened by climate change, natural impacts such as hurricanes, and human impacts, such as deforestation, pollution, and alterations in freshwater management regimes. Approximately 35% of mangrove trees were lost during the last two decades of the 20th century (MEA 2005). Part of the problem is that mangroves are still considered by some as having little value (Dahdouh-Guebas et al. 2005).

The establishment of protected areas is a main policy tool to conserve mangrove forests and their services and benefits, and to prevent further mangrove loss. It is more economical to conserve than to restore mangroves (Webber et al. 2014). As of 2005, approximately 19% of mangroves were within protected areas (Chape et al. 2005).

Assessing the economic value of ecosystem services increasingly is considered essential for environmental decision-making (Vo et al. 2012). This paper addresses the economic value of ecosystem services provided by mangroves and the implications for protected areas, along with current research gaps and needs for future research.

For this paper, a standard systematic literature review and case study analysis methods were used, employing a manual search of academic journals, technical reports, case studies, and conference proceedings. Empirical studies about the economic and socioeconomic valuation of mangrove ecosystems were reviewed and analyzed. Mangrove valuation techniques were reviewed and results of case studies were presented and compared.

Mangrove ecosystem services and benefits

Ecosystem services are the benefits that humans derive for free from properly functioning natural systems. The notion of ecosystem services involves the creation, delivery, and safeguarding of nature-derived goods and services perceived by humans (Daily 1997). The Millennium Ecosystem Assessment put global ecosystem services into four categories: regulating, provisioning, cultural, and supporting services (MEA 2005). In a landmark study, Costanza et al. (1997) assessed the present economic value of 17 ecosystem services for 16 different habitats. They concluded that the value of the whole biosphere is approximately US$16–54 trillion per year. or US$33 trillion per year on average. Those figures are undoubtedly higher today.

As some of the most productive natural terrestrial ecosystems (FAO 1994), mangroves supply important ecosystem services in all four categories: provisioning services, e.g., timber, fuelwood, and charcoal (UNEP 2007: 25); regulating services, e.g., flood, storm, and erosion control, and prevention of saltwater intrusion; supporting services, e.g., breeding, spawning and nursery habitat for commercial fish species; and cultural services, e.g., recreation as well as aesthetic and other non-use values (TEEB 2010: 35).

Mangrove valuation studies

Numerous studies have been done on the economic values of mangrove ecosystem services.

Some of them capture the total economic value (i.e., the sum of direct, indirect, and non-use values), but most are narrower, focusing on what were considered to be the most important services that have market value, can be measured with available data, or are needed for decision-making. No one valuation method is suitable for assessing all ecosystem services; rather, a variety of methods has been used according to service type, available data, and the time-frame of the study. However, some methods are used frequently. For example, the production function approach is commonly used to assess the value mangroves provide to commercial fisheries (Barbier 2003). In some cases, where there are time and cost constraints, the benefit transfer method has been used. Table 1 summarizes results of some typical economic valuation studies of mangrove ecosystem services.

Implications for protected areas

Mangroves are under unprecedented threat. Coastal and urban development and alteration of coastal structures and processes, over-exploitation for timber and fuelwood, conversion to aquaculture and agriculture, and climate change and sea level rise are the primary threats pushing these valuable ecosystems toward crisis, with serious consequences for the provision of the benefits that sustain human communities. Since 1980, a higher percentage of mangroves has been destroyed worldwide than that of coral reefs or tropical rainforests (Valiela et al. 2001; FAO 2007). Approximately 120 million people live within 10km of significant mangrove areas (UNEP 2014), many of whom depend on mangroves for their daily sustenance and well-being.

Drastic measures are required if we are to prevent further widespread and irreversible loss of these ecosystems, and sustain their ability to support human societies. Current place-based mangrove conservation measures include:

- *International protected area conventions and programs.* The Ramsar Convention on internationally important wetlands protects mangroves at 278 sites in 68 countries, the World Heritage Convention includes 26 sites that protect mangroves, as do 88 biosphere reserves under the UNESCO (United Nations Educational, Scientific, and Cultural Organization) Man and the Biosphere Program (UNESCO n.d.).
- *Conservation through legislation that specifically protects mangroves,* such as Brazil's Federal Forestry Code and the Mangrove Trimming and Preservation Act in Florida, USA.
- *Conservation through management, education, and restoration projects,* such as the Mangrove Action Project, Mangroves for the Future, Western Indian Ocean Mangrove Network, the Mangrove Alliance, the International Society for Mangrove Ecosystems, IUCN's Pacific Mangrove Initiative, and Mangrove Watch.
- *Emerging place-based conservation payment strategies,* such as various payment for ecosystem services (PES) schemes, or the United Nations' Reduced Emissions from Deforestation and Forest Degradation (REDD+) program under the UN Framework Convention on Climate Change.

Table 1. Examples of economic valuation studies of mangrove ecosystem services.

Location	Ecosystem services delivered	Estimated value (US$)	Valuation methods used	Source
Fiji	Water quality, agriculture, fisheries, forestry	52–5,820/ha/yr	Alternative costs, market price, shadow price	Lal 1990
Bintuni Bay, Irian Jaya, Indonesia	Commercial fisheries and forestry, various noncommercial uses	37,833/household/yr total economic value (TEV)	Cost-benefit analysis, socioeconomic assessment	Ruitenbeek 1994
Terminos Lagoon, Campeche, Mexico	Timber, fisheries, water quality, threatened-species habitat	1–1,578/ha/yr	Net revenue, productivity, alternative cost, contingent valuation	Cabrera et al. 1998
Johor, Malaysia (a biodiversity hotspot)	Capture fisheries, tourism, shoreline protection	1,375/ha/yr (direct use values); 7,512/ha (non-use values)	Contingent valuation	Bann 1999 (author recommended protected area status for site)
Global	Capture fisheries	750–16,750/ha/yr	Market value	Ronnback 1999
Gulf of Thailand	Fisheries	33–110/ha/yr	Production function	Barbier 2000
Ras Mohammed National Park, Egypt	Socioeconomic (income, jobs, etc.)	91,000/ha/yr	Rapid assessment	Spurgeon 2002
Nabq Protected Area, Egypt	Socioeconomic (income, jobs, etc.)	24,000/ha/yr	Rapid assessment	Spurgeon 2002
Miani Hor, Pakistan	Fisheries	1,287/ha/yr	Market prices and close substitutes, effect on production	Baig and Iftikhar 2005
Southeast Asia	Fisheries, fuelwood, coastal protection	239–4,185/ha/yr	Benefit transfer	Brander et al. 2012
Can Gio, Vietnam	Fisheries, forest products, aesthetic and recreational values, climate change mitigation	358–503 million TEV	Market prices, value transfer	Kuenzer and Tuan 2013
Sundarbans Reserve Forest, Bangladesh / India	Timber, fuelwood, wild foods, cultural services	744,000/yr	Direct market valuation	Uddin et al. 2013

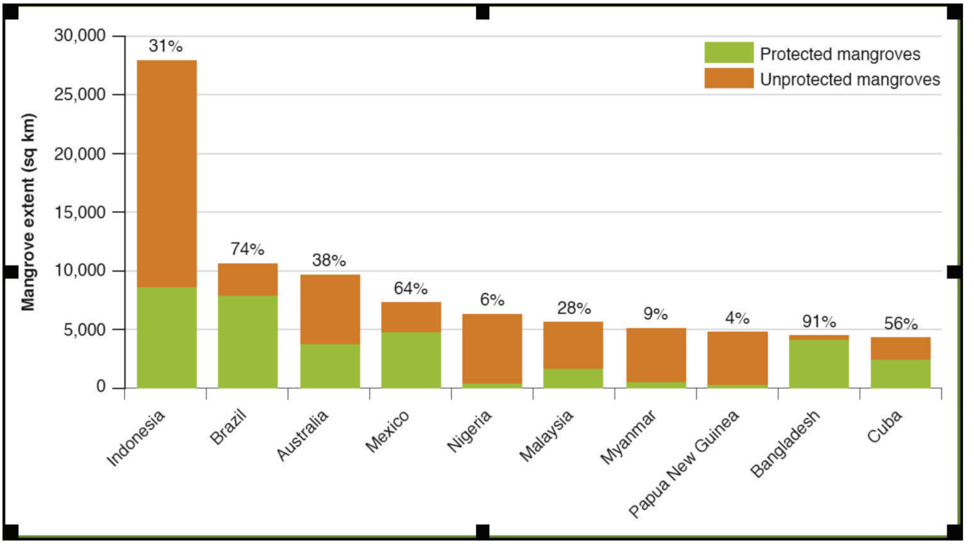
Establishing terrestrial and marine protected areas is often used as a management tool to conserve mangrove forests. Nonetheless, much remains to be done. As mentioned earlier, as of 2005 it was reported that only 19% of the world's mangroves was being conserved within protected areas (Chape et al. 2005). Even so, a more recent estimate from Giri et al. (2011) calculated the figure at just 6.9%. In terms of numbers of sites, UNEP reports that about 2,260 nationally and 285 internationally designated protected areas contain mangroves (UNEP 2014). The proportion of mangroves that lie outside of protected areas but which still have some measure of protection varies between nations. Australia, for instance, protects all mangroves by law, although just over a third fall within protected areas. Bangladesh appears to have stopped the intense degradation that had happened in previous years and now protects most of its mangrove areas through various means. In Brazil, more than 70% of its mangroves lie within protected areas, whereas many other mangrove-rich countries (e.g., Indonesia, Nigeria, Myanmar, Papua New Guinea) have a very low proportion protected (Figure 1).

Moreover, the effectiveness of protection is highly variable, with several protected areas failing to halt mangrove decline because they were poorly designed or lack enforcement. To achieve conservation goals, both coverage effectiveness (the number and extent of protected areas and how much and what biodiversity they include) and management effectiveness (whether and how protected areas being operated and managed effectively) must be considered (Chape et al. 2005).

Economic valuation of mangroves as a conservation tool

Given the dramatic losses of mangroves, there is a need to understand the implications of

Figure 1. Proportion of mangroves protected in the ten largest countries having mangroves. Source: USGS Global Distribution of Mangroves (2011), cited in UNEP (2014).



their further loss to biodiversity, and develop long-term strategies to save these natural treasures. Economic valuation can assist in this debate through addressing questions such as: If mangrove-based ecosystem services are valuable in an economic sense, why do we continue to use them in unsustainable ways? Why are they not being better managed? Is there a role for economic valuation to help protect and manage them?

Most mangrove ecosystem services are public goods. which means that we cannot exclude individuals from receiving their benefits, and that, for certain services (e.g., climate change mitigation, coastal protection), benefits going to one receiver do not decrease the amount going to others (Vo et al. 2012). Therefore, no markets exist for such services. Consequently, mangroves are regularly undervalued in private and public policy-making. The lack of awareness and understanding of the benefits of mangrove ecosystem services, and the fact that in most cases their monetary values have not been calculated, are the factors that have mostly directed contributed to their being overlooked in decision-making (Brander et al. 2012). Therefore, the availability of monetary values for mangrove ecosystem services is vital, especially when evaluating alternative investment opportunities. Cost–benefit analysis will support this process.

We suggest that the major reason for the underestimation of mangrove ecosystem values is that most studies fail to include all services, i.e., the total economic value (TEV). This is basically because most of studies focus on valuing services for which there are markets and ignore others because of the difficulties in measuring indirect use, non-use, and option values. The pioneering global ecosystem services' study by Costanza and colleagues stressed that "because the ecosystem services are not fully captured in commercial markets or adequately quantified in terms of comparability with economic services and manufactured capital, they are often given too little weight in policy decisions" (Costanza et al. 1997). According to Alongi, because all ecosystem services are outside the domain of markets, they likely become invisible in economic analyses of mangrove value. If they are included, mangroves' TEV is immense—some US$181 billion (Alongi 2002).

To precisely quantify the ecosystem services benefits of mangroves, more information is needed. There remains much work to be done on assessing these benefits. Further research needs to fill this knowledge gap and address the lack of valuation studies in many areas of the world.

Conclusion

Effective management of mangroves has never been more important. Yet the social, economic, and political settings in which protected areas operate, and the stressed condition of many environments they are charged with protecting, mean that the establishment of effective protected areas is challenging. Their success depends upon the science on which they are based, the range of mangrove habitats and species protected, the different community types, the connectivity between coastal ecosystems, the level of compliance with rules and laws, and the extent of impacts on mangroves and the people who depend on them. Implementing resource-protection strategies without sufficient knowledge of the resource value and the likely socioeconomic implications can hinder the ability of protected areas to achieve conservation and socioeconomic goals (Hampshire et al. 2004). Precise and consistent valuation of mangrove benefits has been labeled as a significant knowledge gap in the First Global Integrated Marine Assessment (UN 2016).

Evidence is rapidly accumulating to show that the incorporation of economic perspectives and ecosystem values into the management process may significantly contribute to the success of protected areas and maximize their effectiveness. Valuation of the costs and benefits of formal protection are increasingly recognized as central to protected area success (Hampshire et al. 2004). At the same time, the protection of specific areas positively affects the value of the ecosystems that exist there. For example, employing a meta-regression analysis Salem and Mercer (2012) found a significant and positive relation between mangrove values and their being designated as a Ramsar site. This may be expected because protection ensures higher productivity and increases the provisioning, supporting, and cultural services mangroves provide to human communities.

References

Alongi, D.M. 2002. Present state and future of the world's mangrove forests. *Environmental Conservation* 29: 331–349.

Baig, S., and U. Iftekhar. 2005. Are the Mangroves for the Future? Empirical Evidence of the Value of Miani Hor Mangrove Ecosystem as the Basis for Investments. Gland, Switzerland: IUCN.

Bann, C. 1999. A Contingent Valuation of the Mangroves of Benut, Johor State, Malaysia. Report to the Johor State Forestry Department, Malaysia.

Barbier, E. 2000. Valuing the environment as input: Review of applications to mangrove–fishery linkages. *Ecological Economics* 35: 47–61

Barbier, E.B. 2003. Habitat–fishery linkages and mangrove loss in Thailand. *Contemporary Economic Policy* 21: 59–77.

Barbier, E.B., S.D. Hacker, C. Kennedy, E.W. Koch, A.C. Stier, and B.R. Silliman. 2011. The value of estuarine and coastal ecosystem services. *Ecological Monographs* 81: 169–193.

Bennett, E.L., and C.J. Reynolds. 1993. The value of a mangrove area in Sarawak. *Biodiversity Conservation* 2,: 359–375.

Brander, L., A. Wagtendonk, S. Hussain , A. McVittie , P. Verburg, R. de Groot, and S. van der Ploeg. 2012. Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application. *Ecosystem Services* 1: 62–69

Cabrera, M.A., J.C. Seijo, J. Euan, and E. Perez. 1998. Economic values of ecological services from a mangrove ecosystem. *Intercoast Network* 32: 1–2.

Chape, S., J. Harrison, M. Spalding, and I. Lysenko. 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. *Philosophical Transactions of the Royal Society B: Biological Sciences* 360(1454): 443–455.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253–260.

Dahdouh-Guebas, F., S. Hettiarachchi, D. Lo Seen, O. Batelaan, S. Sooriyarachchi, L.P. Jayatissa, and N. Koedam. 2005. Transitions in ancient inland freshwater resource management in Sri Lanka affect biota and human populations in and around coastal lagoons. *Current Biology* 15: 579–586.

Daily, G.C. 1997. Introduction: What are ecosystem services? In *Nature's Services: Societal Dependence on Natural Ecosystems.* G.C. Daily, ed. Washington, DC: Island Press, 1–10.

FAO [Food and Agriculture Organization of the United Nations]. 1994. *Mangrove Forest Management Guidelines.* Forestry Paper no. 117. Rome: FAO.

———. 2007. *The World's Mangroves 1985–2005.* Forestry Paper no. 153. Rome: FAO.

Giri, C., E. Ochieng, L. Tieszen, Z. Zhu, A. Singh, T. Loveland, J. Masek, and N. Duke. 2011. Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography* 20: 154–159.

Hampshire, K., S. Bell, and G. Wallace. 2004. "Real" poachers and predators: Shades of meaning in local understanding of threats to fisheries. *Society and Natural Resources* 17: 305–318.

ITTO [International Tropical Timber Organization]. 2012. *Tropical Forest Update* 21(2).

Kathiresan, K., and B.L. Bingham. 2001.Biology of mangroves and mangrove ecosystems. *Advances in Marine Biology* 40: 81–251.

Kuenzer, C., and V. Tuan. 2013. Assessing the ecosystem services value of Can Gio Mangrove Biosphere Reserve: Combining earth-observation- and household-survey-based analyses. *Applied Geography* 45: 167–184.

Lal, P.N. 1990. *Conservation or Conversion of Mangroves in Fiji: An Ecological Economic Analysis.* Occasional Paper no. 11: Honolulu: East–West Environment and Policy Institute.

MEA [Millennium Ecosystem Assessment]. 2005. *Ecosystems and Human Well-being: Synthesis*. Washington, DC: Island Press.

Ronnback, P. 1999. The ecological basis for economic value of seafood production supported by mangrove ecosystems. *Ecological Economics* 29: 235–252.

Ruitenbeek, H.J. 1994. Modeling economy–ecology linkages in mangroves: Economic evidence for promoting conservation in Bintuni Bay, Indonesia. *Ecological Economics* 10: 233–247.

Salem, M., and D.E. Mercer. 2012. The economic value of mangroves: A meta-analysis. *Sustainability* 4: 359–383.

Spalding, M., M. Kainuma, and L. Collins, L. 2010. *World Atlas of Mangroves.* London: Earthscan.

Spurgeon, J. 2002. *Socio-economic Assessment and Economic Valuation of Egypt's Mangroves.* Cairo: FAO.

TEEB [The Economics of Ecosystems and Biodiversity team]. 2010. *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations.* P. Kumar, ed. London and Washington, DC: Earthscan.

Tomlinson, P.B. 1986. *The Botany of Mangroves.* Cambridge, UK: Cambridge University Press.

Uddin, M., E. Steveninck, M. Stuip, and M. Shah. 2013. Economic valuation of provisioning and cultural services of a protected mangrove ecosystem: A case study on Sundarbans Reserve Forest, Bangladesh. *Ecosystem Services* 5: 88–93.

UN [United Nations]. 2016. *The First Global Integrated Marine Assessment: World Ocean Assessment I.* Cambridge, UK: Cambridge University Press, 877–886. doi:10.1017/9781108186148.058.

UNEP [United nations Environment Program)] 2007. *Mangroves of Western and Central Africa.* Cambridge, UK: UNEP Regional Seas Program, UNEP/WCMC [World Conservation Monitoring Centre].

———. 2014. *The Importance of Mangroves to People: A Call to Action*. J. van Bochove, E. Sullivan, and T. Nakamura, eds. Cambridge, UK; UNEC/WCMC.

UNESCO [United Nations Educational, Scientific, and Cultural Organization]. N.d. Mangroves. http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/specific-ecosystems/mangroves/.

Valiela, I., J.L. Bowen, and J.K. York. 2001. Mangrove forests: One of the world's threatened major tropical environments. *BioScience* 51: 807–815.

Vo, Q.T., C. Kuenzer, Q.M. Vo, F. Moder, and N. Oppelt. 2012. Review of valuation methods for mangrove ecosystem services. *Ecological Indicators* 23: 431–446.

Webber, M., D. Webber, and C. Trench. 2014. Agroecology for sustainable coastal ecosystems: A case for mangrove forest restoration. In *Agroecology, Ecosystems and Sustainability.* N. Benkeblia, ed. Boca Raton: CRC Press.

Woodroffe, C., and J. Grindrod,. 1991. Mangrove biogeography: The role of quaternary environmental and sea-level change. *Journal of Biogeography* 18: 479–492.

Mahmoud Sarhan, Apartment 7, Building 16a, Street 103, Cairo, Egypt; mis73@cornell.edu

Rady Tawfik, Faculty of Agricultural and Food Science, King Faisal University, P.O. Box 420, Al-Ahsaa 31982; Saudi Arabia; rtawfik@kfu.edu.sa