NATURAL RESOURCES, LIVELIHOODS, AND RESERVE MANAGEMENT: A CASE STUDY FROM SUNDARBANS MANGROVE FORESTS, BANGLADESH

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ABSTRACT

The Sundarbans Reserved Forest, and its surrounding buffer zone, is one of the most diverse and richest areas of natural resource in Bangladesh. It is a part of the largest mangrove forest in the world, with an area of about 10,000 km², of which 6,000 km² are in Bangladesh and about 4,000 km² are part of India: it has been recognized as an internationally important World Heritage and Ramsar site. The mangroves provide substantial ecosystem services supporting the livelihood of local communities. This paper describes the diverse uses of these natural resources and aims to evaluate the contribution of ecosystem services to the livelihood of residents. The results indicate that residents depend on ecosystem services in two ways. First, local households earn cash income by selling ecosystem products, such as fish, honey, and nipa palm, at local markets. Second, the use of natural resources provides substantial subsistence such as food, fresh water, and timber. However, residents' income may be significantly increased by improved resource management, including reducing local authority corruption and improvements in law enforcement. Our paper concludes with a range of recommendations for enhancing residents' standard of living while conserving natural resources.

Keywords: Ecosystem services, livelihood, park management, production function approach, protected areas.

1 INTRODUCTION AND BACKGROUND

Protected areas are often considered as cornerstones of conservation policies, providing multiple benefits for people and contributing to sustainability from the viewpoint of ecology, social, and economic development [1–4]. The Convention on Biological Diversity (CBD) acknowledges this sustainability perspective by stressing the need to conserve biodiversity in the context of benefit sharing [5].

In-situ conservation of biodiversity in well-managed protected areas may be especially significant in providing ecosystem services to local residents while sustaining the functioning and dynamics of natural systems. Ecosystem services, such as ecosystem products (e.g. food, timber), supply of purified water, water retention, and erosion control, can substantially contribute to the livelihood of the local communities, in particular in low-income countries. The manifold ecosystem services – the supporting, provisioning, regulating, and cultural functions of ecosystems [6] – not only provide livelihoods for local people but also often serve as the basis of human survival: for instance, ecosystem services buffer communities against extreme events, provide vital diversity of crops, or ensure a supply of drinking water [7, 8].

Conservation of biodiversity in protected areas provides subsistence and livelihood, and therefore contributes to sustainable development and poverty reduction, especially in poor countries [3, 9, 10]. A recent estimate indicates that about 1.1 billion people worldwide may depend on protected areas for substantially providing their livelihood ([6]; cf. also the recent overview by Coad *et al.* [11]). With respect to mangrove ecosystems, Sathirathai and Barbier [12] have made a strong economic argument that the monetary value of conserving the full range of ecosystem services provided to local households as well as to the national economy, substantially exceeds the benefits of commercial developments, such as shrimp farming [13].

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The provision of the full range of ecosystem services is also an important benefit of the conservation of the Sundarbans Reserved Forest and its surrounding buffer zone as one of the most diverse and richest areas of natural resource in Bangladesh [14] (for the location of Sundarbans, see Fig. 1). It is a part of the largest mangrove forest in the world, with an area of about 10,000 km², of which 6,000 km² is in Bangladesh and about 4,000 km² is part of India: it has been recognized as an internationally important World Heritage and Ramsar site. The mangroves provide substantial ecosystem services supporting the livelihood of local communities and are still a functioning ecosystem facing only a few manageable ecological threats [15–17]. Other studies referring to valuing ecosystem services contributing to livelihood in Bangladesh include, e.g. Mukul *et al.* [18]; Sohel *et al.* [19]. The Sundarbans Forest plays a significant role in the local, regional, and national economy, as well as in the biodiversity conservation of pristine mangrove ecosystems, since restoration of impaired mangroves is only partially successful [20]. Sundarbans provides direct ecosystem products, especially fish resources, which are also exported around the globe, and various non-timber forest products. Sundarbans resources are important even to the national economy of Bangladesh. In our study, we focus on ecosystem services important for local livelihood of households. We therefore omit ecosystem services provided by mangroves that may be nationally or globally important e.g. with respect to natural disasters (tsunamis) or global climate change [21].

The current paper describes the diverse uses of natural resources and aims to evaluate the contribution of ecosystem services to the livelihood of residents. The paper specifically aims to:

- assess the dependency of local communities on Sundarbans' natural resources;
- describe the socio-economics of the local residents and communities;
- explore and evaluate the contribution of ecosystem services to the livelihood of local communities in terms of cash income and subsistence; and
- provide recommendations for improvements to the management of the reserve, especially regarding unsustainable management, unequal distribution of resources, and corruption.

The results indicate that the residents depend on ecosystem services in two ways. First, local households earn cash income by selling ecosystem products such as fish, honey, and nipa palm, at local (and national) markets. Second, the use of natural resources provides substantial subsistence such as food, fresh water, and timber.

However, residents' income may be significantly increased by improved resource management, including reducing local authority corruption, and by improvements in law enforcement. Our paper concludes with a range of recommendations for enhancing the standard of living while also conserving natural resources.

The structure of the paper is as follows: Section 2 presents our methodology and provides an overview of the survey of local residents and households of the Sundarbans Forest. Section 3 presents the results of the survey for the different resource users (harvesters). Section 4 then discusses the results and summarizes and concludes with a range of recommendations for improving livelihoods as well as reserve management.

2 OVERVIEW OF THE CASE STUDY AREA AND THE SURVEY OF LOCAL HOUSEHOLDS

In order to evaluate the contribution of the Sundarbans Forest to the livelihood of local residents, a comprehensive field study was undertaken from January to March 2011. The field work consisted of a survey using standardized questionnaires, focus group interviews, expert and targeted stakeholder interviews, and secondary data collection, complemented by a review of the relevant literature.

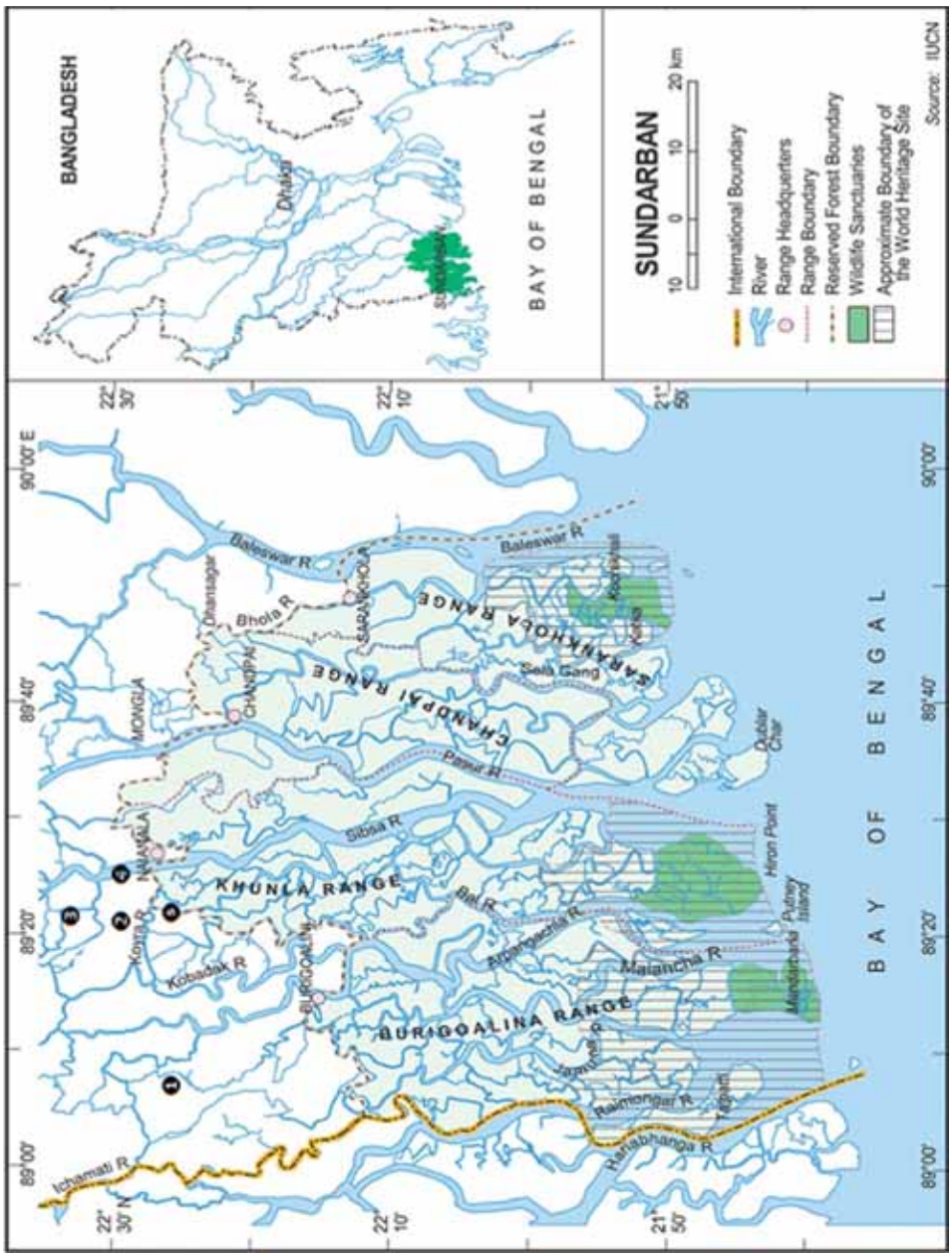

Figure 1: Location of Sundarbans mangrove forest reserve and of surveyed villages. Location of surveyed villages: Munshiganj ❶, Gobra ❷, Modinabad ❸, 4 no. Koyra ❹, Pathor khali ❺. *Source:* Own draft based on www.Banglapedia.org and IUCN (International Union for Conservation of Nature), 2011.

The household survey was undertaken in five villages in the central Sundarbans Forest region (the villages of Munshiganj ❶, Gobra ❷, Modinabad ❸, 4 no. Koyra ❹, Pathor khali ❺; cf. Fig. 1). The choice of the villages to be surveyed was based on prior knowledge about the villages and availability of data and access; as far as the socio-economics of respondents is concerned, the sample of households is representative for the total population and may also be considered to be representative for villages in and around the reserve. In these villages, 155 households were surveyed across all five villages (total number of households in the five villages: 1,260). Households were selected randomly. In each village, we conducted 31 interviews. The survey used a standardized questionnaire and concentrated on obtaining socio-economic data, such as age of respondent and household members, family size, education, land ownership and available land, amount of ecosystem products harvested and sold on markets, and own consumption of resources. In order to value the cash income earned by selling products on the market, total sales (revenues) were elicited, together with the production cost such as hired labor, interest, fees, and other costs, in order to achieve an estimate of the net income of households.

The representative survey was complemented by focus group interviews in all five villages, with five to ten selected stakeholders per village. Participants included fishermen, honey collectors, crab catchers, nipa palm collectors, and hired workers. The main focus of the focus group discussions was to investigate the range of forest products used in households, market prices of products, transport and delivery chains, and the seasonality of product availability. As Kaplowitz [22] has shown, focus group and in-depth interviews are an excellent methodological approach for exploring the viewpoints of local households regarding the significance of ecosystem services for their livelihood. Walters *et al.* [23] stress the importance of local (tacit) knowledge in assessing the specifics of an ecosystem that can be elicited by participatory approaches.

Targeted stakeholder and expert interviews basically aimed to explore the linkages between ecosystem services and livelihood, together with options for improving reserve management and the diverse problems of local communities such as natural disasters and problems of corruption, health, and education.

3 EMPIRICAL RESULTS

3.1 Social status and land ownership of local households at the Sundarbans Forest

Households in the Sundarbans Forest are able to pursue four types of occupations: fishing, catching crabs, collecting honey, and/or harvesting nipa palm. Usually, occupations are divided between households, and the average household engages in only one of these income-generating activities. In the sample of 155 households we surveyed, fishing was the most prominent occupation of 67% of households, crab catching was the main occupation of 14%, and 9% of households collected honey or harvested nipa palm as their primary source of income. While many households have primary sources of income, there are also households engaging in more than one activity. For instance, many honey collectors also earn income from fishing. With the exception of a few households, family heads were the only household member engaged in the income-generating activities meaning that, per household, there is a single occupation earning cash income from resource use for an average total household size of 4.8 family members.

More than half of respondents in the household survey had primary education (about 52–58%, depending on the occupation). About 23–30% of household heads did not have any formal education, while secondary education was achieved by about 14–23%. Interestingly, fishermen have the lowest secondary education rate, while crab catchers and nipa palm collectors have the highest rate

Table 1: Land ownership and average amount of land property.

Occupation of household	Landless (%)	Own land (%)	Average amount of land owned by household (ha)
Fishermen	36.19	63.81	0.10
Crab catcher	40.91	59.09	0.06
Honey collector	35.71	64.28	0.10
Nipa palm collector	14.28	85.71	0.18
Average	**31.77**	**68.22**	**0.11**

of secondary education. Sarkar and Bhattacharya [24] emphasize the importance of increasing education and awareness levels for sustainable management of mangrove forests.

Each household's own land for subsistence was very small and depended on the occupational group. About 32% of households do not own land, while 68% are land owners (see Table 1). However, plots of land available for subsistence and housing are very small. On average, each household owned land of about 0.11 hectares (ha); nipa palm collectors owned an average of about 0.18 ha of land, while crab catchers had the smallest amount of land at only 0.06 ha per household. Some households have small-scale forests and ponds on their property for wood fuel and drinking water.

3.2 Subsistence and livelihood of local residents

3.2.1 Cash income from non-timber products

Residents need permission from the forest department of the local authority in order to harvest and use natural resources and have to pay a corresponding fee. The forest department regulates the type of resources that can be harvested, e.g. fish, crabs, honey, and nipa palm. In forests that are not privately owned by residents, timber extraction or the use of other resources is prohibited. Extraction of resources is regulated by assigning specific areas to be used for harvesting, and the quantity of resources used is limited based on monthly and annual quantity thresholds for different user groups. Fishing and crab catching is allowed year-round, while honey and nipa palm can be collected for 3 and 5 months per year, respectively. Of course, it can be questioned to which extent government regulations are effective, i.e. whether households obey rules regarding the maximum amount of harvesting or there is substantial illegal harvesting. Compared with the quantities of harvested resources indicated by respondents in the survey, the authors feel that households would broadly follow harvesting rules. The usual means of harvesting and transport are small boats.

Fishing usually takes place in the channels and rivers in the mangrove forests but is also undertaken offshore in the marine fishing areas of Sundarbans. Crab catching is also performed both inshore and offshore.

Figure 2 presents an overview of resources harvested in the five villages we surveyed in the Sundarbans Forest. Based on averages of all households, the surveyed households each catch about 1.4 metric tons of fish and about 1.1 tons of crab every year; fish and crab caught for the household's own consumption amount to about 68 and 10 kg per year, respectively. This means that 1–4% of the total harvest is consumed while the rest is sold on local markets or to traders. Honey collectors harvest about 0.7 tons per year, of which they consume about 1%. The quantity of nipa palm harvested amounts to about 27.8 tons per year, of which the collectors consume about 4% of the total harvest.

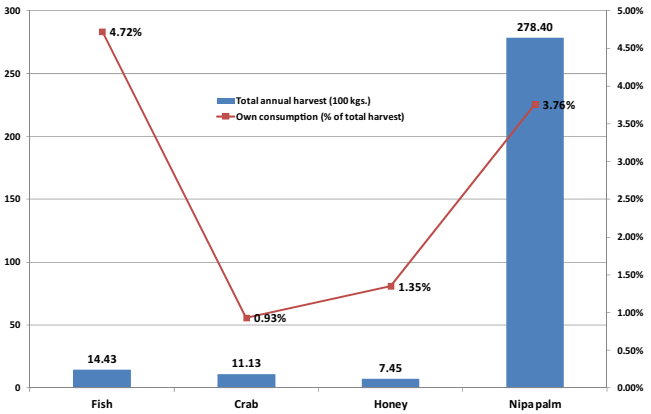

Figure 2: Harvest and households' own consumption of resources.

Table 2: Harvesting periods at Sundarbans Forest reserve.

Occupation	Permission period for harvesting (harvesting seasons)	Days allowed for harvesting per month	Total no. of days for harvesting per year	Mean selling price of ecosystem products (EUR per kg)[a]
Fishermen	January–December	14	168	1.02
Crab catcher	January–December	14	168	1.32
Honey collector	April–June	15	45	1.82
Nipa palm collector	November–March	20–26	100–130	0.07

[a]Average price of products households receive for selling these at markets or to traders; conversion from local currency (Bangladeshi Taka, BDT) based on exchange rates of February 2011.

While own consumption of honey and crab is low, fish – as an important source of protein – and nipa palm for construction purposes are important direct uses of natural resources for local households. Furthermore, crab consumption is not traditional in some households, while honey is more likely to be sold on the market due to the higher prices it fetches, thus contributing to the cash income of households. Table 2 presents the periods within which the forest department issues permits for harvesting resources. Many households that do not catch fish or collect crabs have only a limited time during the year to earn cash income by the harvesting and selling of ecosystem products; for instance, many honey collectors engage in fishing during the rest of the year in order to increase family income. The overview in Table 2 also includes the average price of ecosystem products harvested by local residents and sold at local markets or to traders.

Assessing the amount and pricing of resources sold on markets, we were able to calculate total revenue per occupation. Table 3 presents our findings on the net income of households. The annual revenues (total sales) of fishermen and crab collectors amount to approximately EUR 1,400 per year, which is about EUR 200 more than the income of a combination of honey collecting and fishing and about EUR 300 less than that earned by nipa palm collectors.

However, revenues must cover costs of production as well as taxes and fees, representing the net value of ecosystem services based on the production method (cf. with respect to mangrove ecosystems [25]).

Table 3: Calculation of cash income net of taxes and expenses according to occupation (harvesting of ecosystem products).

Occupation	Revenues (gross sales)	Taxes paid to forest department	Illegal fees to water hijackers	Illegal payments to forest department staff	Operating and maintenance costs (financed by loans)	Loan interest (5–10% of revenues)	Costs of hired labor	Total expenses	Net income
Fishermen	1402.2	88.4	240.0	48.0	200.0	70.1	168.0	814.6	587.7
Crab catcher	1455.8	76.1	264.0	51.0	190.0	145.6	162.0	888.7	567.2
Honey collector	653.9	20.5	18.3	15.8	200.0	65.4		320.0	333.9
Honey collector, fishing[a]	1273.9	63.1	138.3	39.8	300.0	96.4	84.0	721.6	552.3
Nypa palm collector	1795.1	35.6	165.0	13.5	500.0	179.5	200.0	1093.6	701.4

[a]As honey collecting is allowed only during 3 months, the rest of the year is on average used for fishing.

While the forest department charges only small 'official' fees, illegal payments to water hijackers – especially for fishermen and crab collectors – and to the forest department staff contribute to a large deduction from revenue, by approximately 10–20%. Operating and maintenance costs account for about 15–30% of revenue; most of these costs are financed through loans, due to a lack of liquidity at the beginning of the harvesting period. Loans are based on a share of revenue (usually 5–10% of revenue) rather than on an interest rate on the outstanding debt. For some occupations, costs also include hired labor. The total net cash income of households surveyed is on average around EUR 550–700 per year, amounting to approximately 40% of total gross revenue while total costs come up to about 60%.

In addition to the net income of households engaged in these four occupations, the field survey exhibited that for each household, on average, 1.5 persons earn cash income. Thus, there is additional income from other sources. Households included in the survey indicated that they earned EUR 71 per year as extra income, from other sources than the occupations described above. This means that the average income of all households (calculated for all occupations) is about EUR 670, of which around 10% originates from other sources, while the major share of household cash income (90%) directly relates to the harvesting and use of natural resources (ecosystem products).

While the importance of sustaining ecosystem services was apparent for earning cash income of households at Sundarbans Forest, the calculation of income also revealed the significance of several illegal activities hindering households in increasing their income. Illegal payments to water hijackers and forest department staff are substantial and point to weaknesses in the legal and regulatory framework and the need for strengthening the powers of institutions regulating property rights, such as access and use of natural resources.

3.2.2 Value of own consumption of non-timber products and timber

In addition to the harvesting and selling of non-timber ecosystem products, households are direct consumers of ecosystem services and products. While fish and nipa palm are the most important products used directly, households also collect timber (wood for fuel) from the Sundarbans Forest for their own consumption: collecting and harvesting timber for sale are forbidden.

Households each collect about 1,100 kg of wood fuel, primarily used for cooking, per year. In addition, households buy approximately 200 to 300 kg of wood fuel at local markets. Based on the amount of fuel wood collected and sold at local markets, household expenses increase by approximately EUR 50–60 per year. Thus, the value of wood fuel collected as an important ecosystem product for local residents can be estimated using these values. Similar relations between cash income and the value of ecosystem services can also be found in other mangrove forests [26].

Furthermore, households breed livestock, harvest vegetables and other food, and partially abstract drinking water, on their own land plots. Our survey omitted an assessment of other ecosystem services used by local residents. However, other studies [1] show that the value of directly used ecosystem services may easily be larger than the cash income earned by households. Based on this study, it is safe to assume that the value of household use of ecosystem services and products is at least EUR 500–600, in addition to the cash income earned in the various occupational fields.

3.3 Determinants of livelihood at Sundarbans Forest

As highlighted above, households face limited income and fully depend on natural resources for their subsistence and livelihood. However, there are numerous threats to income generation, both potential and actual. Figure 3 presents an overview of threats and risks to livelihood and income generation, based on the focus group discussions and expert interviews undertaken as part of our study.

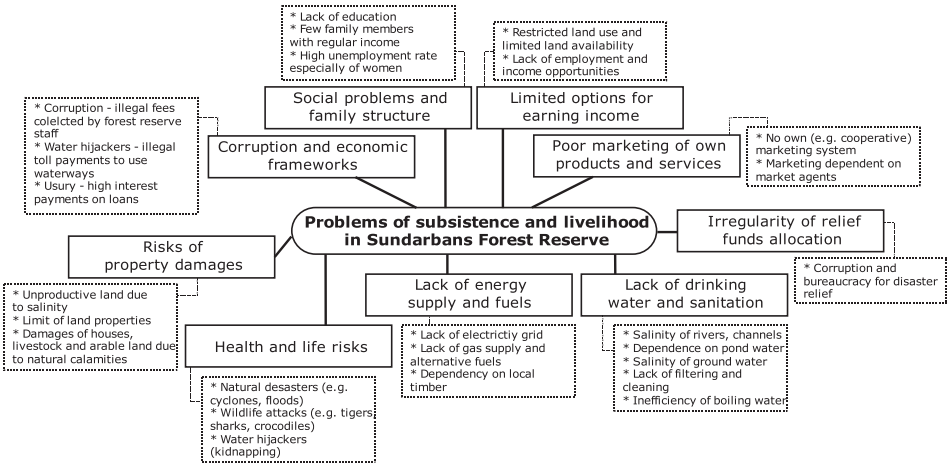

Figure 3: Problems of securing subsistence and livelihood in Sundarbans Forest reserve.

First, a wide range of risks arising from natural dynamics – natural disasters as well as human–wildlife conflicts, while wildlife conflicts may be 'natural' in a protected area such as the Sundarbans Forest, monitoring and several management policies might help to mitigate this problem [27], and the salinity of water – pose serious threats to livelihood, and quality of life in general. Due to the very specific location and nature of the mangrove forests (such as flooding, dependence on weather conditions, arbitrary policies pursued by reserve officials), local residents and communities are under permanent threat of losing their sources of subsistence and livelihood, especially in terms of availability and usability of natural resources. Some of these problems, however, cannot be addressed by changing the management regime of the forests because their origin, e.g. salinity of ground water, depends on agricultural practices upstream [28].

Second, there are socio-economic threats due to the lack of education, unemployment, and limited opportunities for other sources of income generation. Third, the economic, political, and institutional (legal) frameworks are weak in terms of property rights as well as in supporting basic security. While property rights appear well defined on paper with respect to using resources (with reference to wetlands, see Ref. [29]), the corruption of government and park officials, hijacking, and usury pose serious threats to consistent income generation. Especially in vulnerable ecosystems such as these, strong regulatory and institutional frameworks have proven to be of special importance [17], the lack of which leads to overuse of resources and poor management. Furthermore, disaster relief appears too slow to help residents after natural catastrophes. Finally, the market and the trading structure, especially regarding the dependency on middlemen for marketing and transporting local products to the markets, are significant problems.

4 DISCUSSION, SUMMARY, AND CONCLUSIONS

This paper has highlighted the importance of ecosystem services as the economic basis of households living in the Sundarbans mangrove forests in Bangladesh. While several occupations (fishing, crab catching, honey collecting, and nipa palm harvesting) provide cash income to local households living in the mangrove forests, it was estimated that their subsistence in terms of small-scale agriculture on their own land, harvesting wood for fuel, and abstracting drinking water, directly depend on the functioning of the ecosystem.

As the Sundarbans mangrove forests are protected under several regulatory frameworks, the conservation of the natural dynamics provides the basis for local residents' livelihoods and thus contributes to poverty reduction. This is of particular importance since the predominant share of households' cash income (on average about EUR 600 to 800 per year) depends directly on the harvest and sale of ecosystem products. Only about 10% of household income originates from other sources.

The importance of a strong regulatory and institutional regime, including participatory approaches and implementation of a sound property rights structure, is particularly highlighted with respect to income generation. While it is a commonplace in conservation studies that such a regime is a prerequisite for preventing overexploitation of resources, our study also provided evidence that unlawful practices, such as illegal fees to water hijackers, bribing forest staff department, and usury regarding loan interest, are major threats to raising income of local households.

Sound governance, strong law enforcement, and robust management systems are therefore important for ensuring real benefits from Sundarbans resources for residents. The current situation in Sundarbans Forest may be described as a management regime implemented as a protected area authority. Due to the lack of well-defined property rights for most of the area, the open access of resources (common-pool resources) and the lack of implementation of basic civil law (crime), solutions such as that proposed by Ostrom [30], may not be viable in our study area. This is particularly true for households in the Sundarbans Forest area since household livelihoods are extremely vulnerable [31], with reference to overexploitation of marine and coastal resources). Households are facing a broad range of challenges, such as natural calamities, tiger attacks, water hijackers, pressure from forest staff, and drinking water shortages. Priority governance and management tasks include combating illegal practices and crime (water hijacker, bribes) and support residents in freeing themselves from loan dependency. Regarding the potential overexploitation of natural resources, the survey including the numerous focus group debates indicated that at the moment there seems to be a sustainable use of resources. Threats to mangrove forests thus may rather be attributed to well-known causes such as urban development, aquaculture, and mining [21], which are not pursued by the local residents.

The following recommendations to improve the livelihoods of local communities, while sustaining the functioning of the mangrove ecosystem, may therefore be drawn from our study:

- Priority should be given to robust law enforcement to protect waterways and to combat corruption and crime (good governance).
- Loan dependence should be reduced. If illegal payments could be eliminated, households would gain enough free cash resources to finance operating and maintenance costs of their occupations.
- Local communities should be encouraged to cooperate in the marketing of their products in order to reduce dependence on traders and 'middlemen'.
- NGOs might have a particular role in supporting local communities in finding new sources of income generation.
- Empowerment of women and supporting their potential role in contributing to family income generation, e.g. establishment of small trade and handicrafts, might further increase income security.
- A potential opportunity lies in developing sustainable tourism alternatives based on community involvement, in close cooperation with park authorities.
- Education initiatives may additionally increase the scope for a more efficient use of resources.
- Disaster prevention and management should be substantially improved to provide adequate warning of natural calamities (e.g. cyclones, floods).

- Support in securing an adequate supply of drinking water, and waste water management, would help local communities.
- Energy sources (e.g. biogas) should be developed as an alternative to using wood harvested for fuel from the ecosystem.
- Local communities should be involved in developing and implementing an effective management regime.

In conclusion, we envision a broad range of potential policies will help secure the livelihood of residents of Sundarbans mangrove forests, as well as sustain the functioning of the whole ecosystem, which has an extremely important function, not only in terms of poverty reduction but also on a national and global scale by conserving a rich biodiversity.

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REFERENCES

[1] Akwetaireho, S. & Getzner, M., Ecosystem services and sustainable livelihood of local residents: a case study from Mabamba Bay wetlands (Lake Victoria, Uganda). *International Journal of Biodiversity Science, Ecosystem Services & Management*, **6**, pp. 1–13, 2010.

[2] Balmford, A. & Whitten T., Who should pay for tropical conservation, and how could the costs be met? *Oryx*, **37**, pp. 238–250, 2003. doi: http://dx.doi.org/10.1017/S0030605303000413

[3] Mulongoy, K.J. & Gidda, S.B., *The Value of Nature: Ecological, Economic, Cultural and Social Benefits of Protected Areas*, Secretariat of the Convention on Biological Diversity (CBD): Montreal, 2008.

[4] Dudley, N., Stolton, S., Belokurov, A., Krueger, L., Lopoukhine, N., MacKinnon, K., Sandwith, T. & Sekhran, N. (eds.), *Natural Solutions: Protected Areas Helping People Cope with Climate Change*, IUCN-WCPA, The Nature Conservancy, UNDP, Wildlife Conservation Society, The World Bank and WWF, Gland: Switzerland and Washington D.C, 2010.

[5] Secretariat of the CBD, *Handbook of the Convention on Biological Diversity Including its Cartagena Protocol on Biosafety*, 3rd edn., Secretariat of the Convention on Biological Diversity (CBD): Montreal, 2005.

[6] Millennium Ecosystem Assessment, *Ecosystems and Human Well-Being: Wetlands and Water*, World Resources Institute: Washington, DC, 2005.

[7] Dudley, N., Stolton, S. (eds.), *Running Pure: The Importance of Forest Protected Areas to Drinking Water,* WWF/World Bank Alliance for Forest Conservation and Sustainable Use: Gland, Switzerland, 2003.

[8] Stolton S., Dudley, N. & Randall, J., *Natural Security: Protected Areas and Hazard Mitigation*, WWF: Gland, Switzerland, 2008.

[9] Andam, K.S., Ferraro, P.J., Sims, K., Healy, A. & Holland, M., Protected areas reduced poverty in Costa Rica and Thailand. *Proceedings of the National Academy of Sciences (PNAS)*, **107**, pp. 9996–10001, 2010. doi: http://dx.doi.org/10.1073/pnas.0914177107

[10] Wells, M.P. & McShane, T.O., Integrating protected area management with local needs and aspirations. *Ambio*, **33**, pp. 513–519, 2004.

[11] Coad, L., Campbell, A., Miles, L. & Humphries, K., *The Costs and Benefits of Forest Protected Areas for Local Livelihoods: A Review of the Current Literature*, Working Paper, UNEP World Conservation Monitoring Centre: Cambridge, U.K., 2008.

[12] Sathirathai, S. & Barbier, E.B., Valuing mangrove conservation in Southern Thailand. *Contemporary Economic Policy*, **19**, pp. 109–122, 2001. doi: http://dx.doi.org/10.1111/j.1465-7287.2001.tb00054.x

[13] Swapan, S.H. & Gavin, M., A desert in the delta: participatory assessment of changing livelihoods induced by commercial shrimp farming in Southwest Bangladesh. *Ocean & Coastal Management*, **54**, pp. 45–54, 2011. doi: http://dx.doi.org/10.1016/j.ocecoaman.2010.10.011

[14] Nagelkerken, I., Blaber, S.J.M., Bouillon, S., Green, P., Haywood, M., Kirton, L.G., Meynecke, J.-O., Pawlik, J., Penrose, H.M., Sasekumar, A. & Somerfield, P.J., The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany*, **89**, pp. 155–185, 2008. doi: http://dx.doi.org/10.1016/j.aquabot.2007.12.007

[15] Biswas, S.R., Choudhury, J.K., Nishat, A. & Md., Matiur Rahman, Do invasive plants threaten the Sundarbans mangrove forest of Bangladesh? *Forest Ecology and Management*, **245**, pp. 1–9, 2007. doi: http://dx.doi.org/10.1016/j.foreco.2007.02.011

[16] Giri, C., Pengra, B., Zhu, Z., Singh, A. & Tieszen, L.L., Monitoring mangrove forest dynamics of the Sundarbans in Bangladesh and India using multi-temporal satellite data from 1973 to 2000. *Estuarine, Coastal and Shelf Science*, **73**, pp. 91–100, 2007. doi: http://dx.doi.org/10.1016/j.ecss.2006.12.019

[17] Shahadat Hossain, Md., Biological aspects of the coastal and marine environment of Bangladesh. *Ocean & Coastal Management*, **44**, pp. 261–282, 2001. doi: http://dx.doi.org/10.1016/S0964-5691(01)00049-7

[18] Mukul, S.A., Uddin, Md. B., Rashid, A.Z.M. & Fox, J., Integrating livelihoods and conservation in protected areas: understanding the role and stakeholder views on prospects for non-timber forest products, a Bangladesh case study. *International Journal of Sustainable Development & World Ecology*, **17**, pp. 180–188, 2010. doi: http://dx.doi.org/10.1080/13504500903549676

[19] Sohel, Md. S.I., Rana, Md. P., Karim, Md. F. & Akhter, S., Linking Co-Management, Livelihood and Forest Conservation in Protected Area: A Case Study of Wildlife Sanctuary. *International Journal of Ecological Economics & Statistics*, **16 (W10)**, pp. 86–95, 2010.

[20] Bosire, J.O., Dahdouh-Guebas, F., Walton, M., Crona, B.I., Lewis, R.R., III, Field, C., Kairo, J.G. & Koedam, N., Functionality of restored mangroves: a review. *Aquatic Botany*, **89**, pp. 251–259, 2008. doi: http://dx.doi.org/10.1016/j.aquabot.2008.03.010

[21] Alongi, D.M., Mangrove forests: resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science*, **76**, pp. 1–13, 2008. doi: http://dx.doi.org/10.1016/j.ecss.2007.08.024

[22] Kaplowitz, M., Assessing mangrove products and services at the local level: the use of focus groups and individual interviews. *Landscape and Urban Planning*, **56**, pp. 53–60, 2001. doi: http://dx.doi.org/10.1016/S0169-2046(01)00170-0

[23] Walters, B.B., Ronnback, P., Kovacs, J.M., Crona, B., Hussain, S.A., Badola, R., Primavera, J.H., Barbier, E. & Dahdouh-Guebas, F., Ethnobiology, socio-economics and management of mangrove forests: a review. *Aquatic Botany*, **89**, pp. 220–236, 2008. doi: http://dx.doi.org/10.1016/j.aquabot.2008.02.009

[24] Sarkar, S.K. & Bhattacharya, A.K., Conservation of biodiversity of the coastal resources of Sundarbans, Northeast India: an integrated approach through environmental education. *Marine Pollution Bulletin*, **47**, pp. 260–264, 2003. doi: http://dx.doi.org/10.1016/S0025-326X(02)00475-7

[25] Lal, P., Economic valuation of mangroves and decision-making in the Pacific. *Ocean & Coastal Management*, **46**, pp. 823–844, 2003. doi: http://dx.doi.org/10.1016/S0964-5691(03)00062-0

[26] Christensen, S.M., Tarp, P. & Hjortsø, C.N., Mangrove forest management planning in coastal buffer and conservation zones, Vietnam: a multimethodological approach incorporating multiple stakeholders. *Ocean & Coastal Management*, **51**, pp. 712–726, 2008. doi: http://dx.doi.org/10.1016/j.ocecoaman.2008.06.014

[27] Barlow, A.C.D., Ahmed, Md. I.U., Mizanur Rahman, Md., Howlader, A., Smith, A.C. & Smith, J.L.D., Linking monitoring and intervention for improved management of tigers in the Sundarbans of Bangladesh. *Biological Conservation*, **141**, pp. 2032–2040, 2008. doi: http://dx.doi.org/10.1016/j.biocon.2008.05.018

[28] Atapattu, S.S. & Kodituwakku, D.C., Agriculture in South Asia and its implications on downstream health and sustainability: a review. *Agricultural Water Management*, **96**, pp. 361–373, 2009. doi: http://dx.doi.org/10.1016/j.agwat.2008.09.028

[29] Adger, W.N. & Luttrell, C., Property rights and the utilization of wetlands. *Ecological Economics*, **35**, 75–89, 2000. doi: http://dx.doi.org/10.1016/S0921-8009(00)00169-5

[30] Ostrom, E., *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge University Press: Cambridge, 1990. doi: http://dx.doi.org/10.1017/CBO9780511807763

[31] Shahidul Islam. Md., Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh. *Ocean & Coastal Management*, **46**, pp. 763–796, 2003. doi: http://dx.doi.org/10.1016/S0964-5691(03)00064-4