

Coastal ecosystems services in the Bay of Bengal and efforts to improve their management

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The present study provides a comprehensive synthesis of secondary data from available web-based published articles. Some stakeholders including community members, environmental and community NGOs, universities, research institutions, development agencies, donors are involved in the utilization of coastal services. The ecosystem services of the Bay of Bengal (BoB) are in danger due to overfishing, destructive fishing methods, sedimentation, and pollution. Hence, it is essential to utilize the resources sustainably for the betterment of coastal community livelihoods to receive continuous ecosystem services.

[Keywords: Ecosystem services, Bay of Bengal, Mangroves, Policy, Fisheries]

Introduction

An ecosystem is a complex dynamic functional interacting unit of the plant, animal and microorganisms, and non-living environment. These have been called by different names throughout the human history but are presently gaining global attention as 'ecosystem services'¹. Daily (1997) defines ecosystem services as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life"². However, The Millennium Ecosystem Assessment (2005) assumes that people are an integral part of ecosystems and ecosystem services are the benefits that people obtain from ecosystem³. Costanza et al., (1997) have estimated the value of the world ecosystem services, which contribute to human welfare, both directly and indirectly. The cost is estimated to be in the range of US\$ 16-54 trillion per year, with an average of US\$ 33 trillion per year⁴.

Coastal ecosystems provide a wide array of goods and services such as being a host of the world's first ports of commerce; the primary producers of fish, shellfish, and seaweed for human and animal consumption; an important source of fertilizer, pharmaceuticals, cosmetics, household products, and construction materials⁵. Coastal ecosystem encompasses a broad range of habitat types and harboring a wealth of species and genetic diversity. More than a billion people including developing

countries rely on fish as their primary source of animal protein⁶. Aquarium trade (ornamental fish), building materials (boat and house construction) and bioprospecting (new biological resources, for example- pharmaceuticals) are the essential services from these ecosystems. Coastal tourism is one of the fastest growing sectors of global tourism and playing an essential role in the economy of many small islands of developing states. The BoB is one of the most poorly studied areas in the world, no recent and comprehensive knowledge is available on different biological and ecological aspects of the coastal and marine fisheries, tourism and so on which to some extent, limit the utilization and management of the resources. This research described the present situation of the BoB surrounding countries coastal ecosystem services, their contribution and will find out the efforts to improve their management.

Materials and Methods

This study was based on using secondary data collected from scientific research and gray literature published in different forms, either in peer-reviewed journals or periodicals and government gazettes either as paper or made use of the internet as a source of information to complete the research. The BoB is one of the world's sixty-six Large Marine Ecosystems (LMEs)⁷. BoB is the arm of the Indian Ocean. It is 2,090 km long and 1,600 km wide with an average

depth of more than 2,600 m and occupying an area of about 2,172,000 sq. km⁸.

Bay of Bengal Programme (BOBP) points out: 'It encompasses the continental shelf of the Maldives, Sri Lanka, and Indonesia, where tuna are abundant; the nutrient-rich upland riverine basins and the unique Sunderban mangrove eco-systems of India and Bangladesh that support a host of fin and shell fish species of commercial significance; and the valuable coral reefs of Malaysia, Thailand and Myanmar⁹ (Fig. 1). Mangroves are the dominant coastal ecosystem regarding geographic spread, and a range of other coastal ecosystems occurs in the BoB¹⁰. The only exception is the Maldives where the dominant coral reefs ecosystem has associated seagrass beds and sandy beaches. Fisheries are of vital socio-economic importance to all countries bordering the Bay, as the industry provides direct employment to over two million fishers¹¹.

Results and Discussion

Seven countries border the BoB (Table 1). The coastal area of Bangladesh is an active delta, rich in water and land resources and runs parallel to the BoB. Furthermore, it covers 47,201 km² of land area, which is 32% of the total landmass of the country¹². The southern part of Bangladesh is one of the most productive ecosystems of the world as they receive the high discharge of many rivers¹³.

The Indian states situated along the BoB (West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Pondicherry, and Andaman & Nicobar Islands) have a continental shelf area of 153,000 km² and a population of over 225 million. The Andaman and Nicobar group of Islands located in the southeast BoB and covers about one-fourth of the total coastline of India. They consisted of 540 islands, the total land area is 8249 km², and the total coastline is 1,962 km. The marine ecosystem of the Andaman and Nicobar

Islands is unique in having a very high degree of coral diversity with endemism in flora and fauna¹⁴.

Sri Lanka also covers an area of 27,800 km² in the BoB region. Sri Lanka's coastal habitats include estuaries and lagoons (126,989 ha), mangroves (6,083 ha), seagrass beds, salt marshes (23,797 ha), coral reefs and large extents of beaches including barrier beaches, spits (5,621 ha) and dunes (15,546 ha). Many coastal and inshore resources associated with the coastal habitats support a thriving export industry based on the export of shrimp, lobster, chank, Beche de mer, ornamental fish, etc¹⁵.

Myanmar shares common maritime boundaries with Bangladesh in the north-east of the BoB and with Thailand and India in the Andaman Sea, which is a part of the BoB¹⁶. The Myanmar coast divides into three coastal regions: the Rakhine (from the mouth of



Fig. 1 — Location of the Bay of Bengal

Table 1 — Transboundary diagnostic analyses of the coastal area of the BoB⁶

Country	Total Land Area (km ²)	Total Population (million)	Coast line (km)	% of population within 100 km of the coast	EEZ (km ²)	Coastal Districts/ States/Province
Bangladesh	144,054	138	710	28	39,868	19
India	3,287,263	1400	4,645*	26	615,500*	5*
Sri Lanka	65,610	17	1,770	34	517,000	6*
Myanmar	676,577	42.9	3,000	49	486,000	3*
Thailand	514,000	62.3	2,624	39	116,280	5
Indonesia	1,900,000	210	490	-	2,914,978	4
Maldives	90,000	0.359	2,002	81	1000000	-

*In the Bay of Bengal area only

the Naaf River to Mawtin Point, about 740 km in length), the Ayeyarwaddy Delta and the Gulf of Moattama (Martaban) is about 460 km in length (from the Mawtin Point to the Gulf of Moattama) and the Thanintharyi (from the Gulf of Moattama to the mouth of the Pakchan River, about 1,200 km in length)¹⁷.

The Andaman Sea, a part of the BoB which is located on the west coast of Thailand with a total length of the coastline of about 740 km extending southwards from the Myanmar border to the Malaysian border. It is one of the world's large marine ecosystems. The most critical components of the ecosystem are mangrove forests, seagrass beds, coral reefs, and fishery resources and provide livelihoods for the coastal people¹⁸.

Indonesia is the world's largest archipelago with 17,805 islands and the second longest coastline (81,000 km) in the world. The Northern part of Sumatra Island, which consists of four provinces: Nanggroe Ace Darussalam (NAD), North Sumatra, West Sumatra, and Riau is the Indonesian portions, which directly related to the BoB (490,000 km²). Vast majorities of people living along the coast and facing numerous coastal and marine challenges as well as great opportunities that relate with coastal issues^{19, 20}.

The Maldives is one of the smallest countries in Asia and the Pacific by population and land area. Furthermore, its people are scattered across 194 islands. The Maldives comprises an archipelago of about 1,190 low-lying coral reef islands. Marine resources such as fisheries, coral reefs, seagrass, and tourism are the country's initial natural endowment with economic activities²¹.

Fisheries & coral reef services in the BoB

Bangladesh-Fisheries resources play a vital role in the economy of Bangladesh (6.22% of GDP). It is also a source of animal protein (63%), employment (9%) to its population and the second largest source of foreign exchange earnings (5%)²². Besides, the marine and coastal capture fisheries sector of Bangladesh is the only primary source of income and nutrition for over 484,000 households and 2.7 million family members in the coastal region of Bangladesh. St. Martin (9.8 km) is the only coral island of the country located in the BoB and the economy of the island is mainly based on fishing. About 1,650 metric tons of fishes are caught annually²².

India-Major fish producing countries in the world contributing over 3% of both marine and freshwater

fishes to the world production with the third position in capture fisheries. Fisheries and aquaculture play a vital role regarding food supply, food security and employment opportunities in India. In the year 2016, the total fish production was 10.07 million metric tons (65% from the inland sector), contributes to 1.1% of the GDP and 5.15% of the agricultural GDP²³.

Sri Lanka-In 2014, fisheries sector in Sri Lanka account for 1.8 percent of GDP. Total fish production in 2014 amounted to 535,050 metric tons, and its value addition was US\$ 1,350 Million. Around 272,140 active fishermen have engaged in both marine and inland fisheries, and 1,023,780 members of their household depend on the income gained through fishing and related activities²⁴. An estimated 2% of the 1,585km coastline has fringing reefs, with larger reef areas offshore in the Gulf of Mannar to the northwest and along the east coast. Reefs are important for fisheries, coastal tourism, and preventing coastal erosion. However, the coral reefs of Sri Lanka are being degraded rapidly by increasing human activities, particularly over-fishing, coral mining and the effects of sediment and nutrient pollution²¹.

Myanmar-The fisheries resources industries create a direct benefit to over 2.0 million people. Fisheries are the fourth most important source of exports earnings. Myanmar was the world's 10th highest producer of marine capture fisheries in 2012. In 2013, Myanmar exported a total of 345,000 metric tons of fish and fishery products to 32 countries with the value of US\$ 536.27 million²⁵. In the year 2015, the livestock and fisheries sectors account for more than 7% of the national GDP²⁶.

The coral reefs of Myanmar are the least studied and documented reefs in the world, with fewer than eight reports available on coral reef status. The Myeik Archipelago (also known as the Mergui Archipelago) contains 12,500 km² of land and 1,700 km² of coral reefs, including fringing reefs, submerged pinnacles, and seamounts, limestone caves, sheer and sloping rock. However, destructive fishing (including trawling and longline fishing as well as blast fishing) threatens this precious ecosystems³³.

Thailand-Fish are vital to the food security and self-sufficiency of Thailand. Thailand has become one of the top ten producers and exporters of fisheries products in the world since 1992. In the year 2006, fisheries contributed 1.27% of the total GDP, and more than 220,000 people were employed in the

fishing industry 27, 28. There are 153 km² of coral reefs along the entire coastline of 2,614 km and around 300 islands. Vast areas of the reefs have been damaged by natural and mainly by economic activities, such as fishing, tin mining and tourism²⁹.

Indonesia-Indonesia is the largest in the Western Pacific region when it comes to marine resources. Shrimp, tuna, crab, squid, and octopus are among the most valuable exported species, accounting for more than USD 3B in exported value in 2011. Blue Swimming Crab accounted for US\$ 329 million in exports in 2012, making it Indonesia's third most valuable seafood product after shrimp and tuna³⁰. The fishing industry provides nearly two-thirds of the supply of animal protein. In Indonesia, the coral reef area is 85,707 km², which represents about 14% of the world's corals. The more exotic and colorful species of Tubiporamusica, Acroporasp., Pocilloporasp., and Montiporasp., are used as decorations for aquariums, gardens, and walls. Many species of corals are also cleaned, bleached and dried for selling to the tourists and people manage their livelihoods³¹.

Maldives- the fish, provides the principal source of animal protein for the population, and half of the catch is consumed locally. About 22,000 individuals are involved in full-time and 5,000 as part-time fishers. The contribution of the fisheries sector to the overall economic growth has diminished significantly over the past years and accounted for a mere 1.2% of GDP during 2016. Despite this, the fishing industry remains vital to Maldivians, as it provides the livelihood of many livings in the rural areas of the country 32. Furthermore, Maldives is an archipelago of 1,192 coral islands grouped into 26 coral atolls (200 inhabited islands, plus 80 islands with tourist resorts). Red and black coral has been used as decoration for buildings, but it is harvested for export markets. However, over the last two decades, large quantities are removed, to make jewelry and other souvenirs for tourists²¹.

Mangroves as a coastal ecosystem service

Bangladesh-The Sundarbans is one of the most extensive mangrove forests in the world. The existence of Sundarbans, forming an ideal mangrove ecosystem, supports large groups of fish, shrimp, edible crab and supplies food and cash to the coastal communities. With over 3.5 million people from the surrounding areas depend directly or indirectly on the Sundarbans for their livelihood³⁴. Also, the

mangrove alone generates more than 50% of the revenue from the forestry sector in Bangladesh³⁵.

India- The mangrove forest that extends from Bangladesh into the Indian coastal belt is one of the world's three large mangrove systems. Approximately, a population of 3.2 million inhabits this vast saline tract. They depend on traditional skills to earn their livelihood and depend mostly on forest resources like firewood, timber wood, honey, bee wax and Golpata (Nypasp.) as alternative employment. They collect tiger shrimp seeds in large numbers thereby causing damaged to juvenile fish stock and mangroves³⁶.

Sri Lanka-In Sri Lanka many estuaries and lagoons are fringed with vastly diverse mangrove forests. The total mangrove cover is little as 0.1 to 0.2 percent of the total land area. The distribution of fauna and flora varies along with wet and dry zone in the country. Around 25 species of flora are exclusive to mangroves, and more than 25 species can be identified as associated mangroves. They provide a range of essential environmental services, including flood protection and nursery areas for some species of commercial importance, particularly shrimp. They are also used as sources for building poles, firewood and twigs, and branches for brush parks and a diverse range of other products. However, colossal utilization and reforestation for shrimp farms and building construction work severely effect on this ecosystem³⁷.

Myanmar-Artisanal fisheries along Myanmar coasts are largely mangrove dependent. Firewood and charcoal are the main products extract from the mangrove forest ecosystem in Myanmar leading to the depletion of mangrove areas. Mangrove can serve as an effective natural barrier to protect Myanmar's coastline against high winds, tidal bores and waves. It is a critical buffer zone, acted as a link between marine and terrestrial ecosystems and acted as protection of coastal biodiversity³⁸.

Thailand- The coastal area of the Andaman Sea is one of the wealthiest mangrove forest area (132,904 ha). The shoreline protection services of mangrove and coral ecosystems are particularly valuable during extreme weather events, such as cyclones, typhoons, and storms. The protective economic value of mangroves in Thailand regarding coastal protection and stabilization is assessed to be at around 12,400 Baht (US\$ 480) per 75m-wide range of mangrove per year³⁹.

Indonesia-Mangrove areas in Indonesia is estimated to be around 3.80 to 4.25 million ha (0.38

million ha are located along the East Coast of Sumatra). The mangroves, act as a natural resource and as a protector of the environment from extreme weather and storms thereby protecting localities found on the shores. Ruitenbeek (1992) assesses the shoreline protective values of mangrove ecosystems in Indonesia to be Rp.1.9 million per Household⁴⁰.

Maldives-The types of mangrove ecosystems in the country differ in size and composition and exhibit a strong geographical correlation. Fourteen mangrove species are found in the Maldives. The use of mangrove wood for boat building, for 'pushing' sticks on vessels and for hauling the baitfish nets is noteworthy. Although the uniqueness of the real value of the scattered mangroves in the Maldives is not well understood, the mangroves of the Maldives are unique as they are highly adapted to the marine conditions⁴¹.

Estuaries/Lagoons: Estuaries are found all the countries surrounded by BoB and the function of the estuaries are same. However, data relates to estuaries services are not available. Due to their high nutrient loading and water circulation patterns, estuaries support many commercially essential organisms, often in the critical early stages in their lifecycle. In Bangladesh, the estuarine system is comprised mainly of the Brahmaputra-Meghna (Gangetic delta), Karnaphuly, Matamuhuri, Bakkhali, and Naf rivers⁴². Besides, the estuarine resources of this country significantly contribute to the national economy as well as promote the socio-economic well-being of the coastal and often poor communities⁴².

Seagrass beds- There is not much information on the status of seagrass resources in the BoB adjoining countries. However, people in Myanmar call the seagrass as " Leik-Sar-Phat-Myet ", which means the food of marine turtles. It also provides shelter, feeding, spawning and nursery grounds for economically important species of marine invertebrates, coral reef fishes, and the sea cow Dugong dugon⁴³. Furthermore, seagrass beds in the Andaman Sea are more abundant than in the Gulf of Thailand regarding plant density and area. Therefore, in collaboration with the public sector and NGOs, the local small-scale fishers in many communities have engaged in a seagrass plantation program. At present, many seagrass beds in Phangnga and Trang provinces have increased annually, and the fishers can catch more fish from these areas⁴⁴.

Ornamental Fishery-Marine ornamental fish culture and its export potential in Bangladesh have so far remained unexploited. In the year 2012, the export

percentage of ornamental fish (Worldwide) from the Bay of Bengal regional countries were as follows: Indonesia (8%), Thailand (7.5%), India (0.3%), Maldives (0.2%) and Sri Lanka (3%)⁴⁵.

Coastal Tourism

Coastal tourism employs hundreds of millions of people worldwide in recreation, fishing, snorkeling, scuba diving, and other aquatic activities. At the national level, tourism industry serves the nation with economic development and in local level; it helps to strengthen the local economy, culture, and heritage⁴⁶. Bangladesh has the world's longest 125 km unbroken sandy sea beach sloping here down to the blue water of the Bay of Bengal in Cox's Bazar and Kuakata. A major part of this coastline is the marshy jungle, the Sundarbans, the largest mangrove forest in the world and home to diverse flora and fauna, including the Royal Bengal Tiger. In addition to that, there are other beaches like St. Martin Island, and Patenga beach which are also attractive to foreign as well as local tourists⁴⁷. In the year 2015, earnings from tourism (US, million) is as follows: Bangladesh (148,40), India (21,472,00), Maldives (2,664,00), SriLanka (3,978,00), Thailand (48,527,00) and Indonesia (12,054,00)⁴⁸.

Policies and Governances in the BoB

Coastal ecosystem services are the primary sources of income or employment for those who live in the coastal areas. On the other hand, good governance is recognized around the world as the core of efficient and sustainable coastal management practice⁴⁹.

Bangladesh- The government has much policy for coastal development, but in most cases do not have specific sections on coastal areas and often fail to capture the unique combinations of vulnerabilities and opportunities that characterize the coast. These policies include National Environment Policy 1992, National Tourism Policy 1992, National Forest Policy 1994, National Fisheries Policy 1998 and it is the most accurate in dealing with coastal issues and has profound importance for coastal livelihoods, NAP 1999, Industrial Policy 1999, etc⁴. The Project Development Office (PDO) for Integrated Coastal Zone Management (ICZM) is established in 2000 and steered by a Ministerial level Steering Committee and an Inter-departmental Technical Committee. These technical committees monitor the performance of the PDO, guide the PDO work, and assist the Steering Committee in the overall coordination of ICZM plan⁵⁰.

India- In 1991, the Indian government frames Coastal Regulation Zone rules to regulate various coastal zone activities under the Environment Protection Act; 1986. It is estimated that a total marine fish production of 3.26 million tons from the marine sector could be achieved at the end of the Tenth Plan⁵¹. The governance body relates to coastal zone are Department of Animal Husbandry & Dairy, Ministry of Fisheries, Ministry of Commerce. In the case of Tourism, The Ministry of Tourism is the nodal agency for the formulation of national policies and programs related to tourism⁵².

Sri Lanka-Sri Lanka is the first tropical country that centrally manages ICZM, as several coastal zone management policies are adopted in Sri Lanka from 1963. Sri Lanka's first Coastal Conservation Act was passed by parliament in 1981, and the Coastal Zone Management Plan (CZMP) is developed and accepted in 1990. In 1996, Fisheries and Aquatic Act (No.2) were designed to manage, regulate, preserve and improve fisheries and aquatic resources and has application to resources in the coastal zone. Ministry of Local Government, Urban Development Authority, Department of Fisheries and Aquatic Resource Development, DOF, Ministry of Forestry and Environment, NARA (National Aquatic Resources Agency), MPPA (Marine Pollution Prevention Authority) play the key rule in the governance of Sri-Lankan's coastal zone⁵³.

Myanmar-The Government of Myanmar has given high priority to coastal aquaculture development. The Law relating to aquaculture is enacted in 1989 to promote aquaculture sustainably. The DoF of the Ministry of Livestock and Fisheries is the primary government institute responsible for management of coastal aquaculture development. The prominent acts in coastal policy in Myanmar are as follows-The Factories Act 1951, The Forest Law 1992, The Pesticide Law 1990, The Waterpower Act 1927, The Law Relating to Aquaculture 1989, The Law Relating to the Fishing Rights of Foreign Fishing Vessels 1989, The Myanmar Marine Fisheries Law 1990⁵⁴.

Thailand-The Department of Fisheries is the leading national agency in policy development for fisheries in Thailand. The Department of Fisheries outlines the following National Fisheries Development Policies: Policy on Development of Fisheries and Involved Organization, Management of Fisheries Resources and Environment, Policy on Aquaculture Development, Over Sea Fisheries Development and Policy²⁸.

Indonesia-There are at least 20 administrative laws and 100s of regulations and ministerial decrees related to the management of coastal resources of Indonesia. It includes 14 laws on natural resources management and ocean activities and two rules for the ratification of international conventions. National legal frameworks for coastal resources management are laws of the sea, and maritime jurisdiction claims 1996, laws on ocean activities management 1992, regulations on physical spatial and other general planning activities 1992, laws of coastal and marine resources management 2004, the laws of decentralization authorities 2004, etc. The Department of Forestry and the local governments are responsible for implementing the policies and strategies, regarding conservation and management of the mangrove systems. Out of those institutions, NGOs and private sectors have vital roles preserving the coastal ecosystem of Indonesia⁵⁵.

Maldives-The Sixth Development Plan, from 2000 to 2006 includes the following policy- diversified the fisheries sector to reduce the economy's vulnerability to external shocks, increasing participation of the private sector in the fisheries industry. Furthermore, development and management of the marine resources of the country in a sustainable manner, ensure the sustainable socio-economic development of rural fishing communities through greater devolution of resource management authority. Many sectors of the government of the Maldives are involved in coral reef management. Regulation of coral mining is seen as a critical issue in 1992, and specific laws are enacted than to prevent coastal erosion. In June 1995, the Government of Maldives banned the export of some reef fish varieties that are ecologically important for the functioning of the reef system⁵⁶.

Joint efforts to manage the BoB

There are some joint efforts to manage the BoB by several countries. Among them BOBP, Bay of Bengal Large Marine Ecosystem (BOBLME) and The Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) are prominent.

BOBP-It is established during 2003 by Bangladesh, India, SriLanka and Maldives. The Programme has evolved from the recent BoBProgramme of the Food and Agriculture Organization of the United Nations. The program is contributing to promote, facilitate and secure the long-term development and utilization of coastal fisheries resources of the BoB based on

responsible fishing practices and environmentally sound management programs⁵⁷.

BOBLME-Regional cooperation between the countries (Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka, and Thailand) bordering the BoB is being established within the BOBLME. The theme of the program is the need for integrated and coordinated management of their coastal and near-shore living marine resources. Furthermore, it comprises various research and development projects focusing on improving the lives of about 2 million poor fishers and their families that live in the region's coastal areas. The most important part of the programs focuses on the conservation and the reconstruction of the ecosystems most productive for fish, mainly mangrove areas and coral reefs. The World Bank supports the program whereas the Swedish International Development Agency (SIDA) provides the planning support⁵⁸.

BIMSTEC-It is an international organization involving a group of countries in South Asia and South East Asia. The organization is formed in June 1997 in Thailand. The member nations of this cluster are Bangladesh, India, Myanmar, Sri Lanka, Thailand, Bhutan, and Nepal. They are playing an essential role in the ecosystem-based fishery management in the BoB⁵⁹.

Conclusion

Coastal ecosystem services are essential for the environment as well as the dependents. However, the services are in danger worldwide, and the BoB region is not an exception. The causes are lack of awareness of mangrove forest conservation, lack of efficient law enforcement, overfishing, destructive fishing methods, sedimentation as a consequence of poor land-use practices, beach sand and coral mining (especially in Maldives), pollution from fertilizers, biocides, toxic wastes, solid wastes and petroleum; collecting methods involving the use of cyanide and other poisons, coastal reclamation and inappropriate construction, including channel dredging and blasting, coastal and marine development projects undertaken with inadequate environmental impact assessment, and other tourism-related activities. Others may include physical degradation, sewage discharge, and construction-related activities. Coastal ecosystems services are providing the livelihoods of the millions of people in the BoB, and the national economies of the dependent countries rely on it in large quantities. Hence, it is essential to utilize the resources sustainably. Different authors in different

reports give several recommendations about the coastal ecosystem services. In our points of view, the following initiatives and management issues may play a significant hand in the sustainability of the coastal ecosystem resources in the BoB.

There is a need for improved coordination of programs at the national and regional level as well as harmonization of methodologies being used in projects. As an example, cooperation and sharing experience from the Indian part of Sunderbans for the management of mangrove resources in the Bangladesh part of Sunderbans can be done. Establishment of a network that can oversee and monitor these national and regional projects including the ecosystem services. Issues relevant to social equity, poverty, access, and rational resource utilization can be given priority.

Establishment and development of multi-stakeholder partnerships involving the public and private sectors, NGOs, the scientific community and local communities. Development of sustainable financing strategies and mechanisms for the projects to be done. Improved fisheries management together with improved management of coastal and marine protected areas. More efficient management through the adoption of integrated coastal management appropriate to the region, which incorporates cultural, social and economic considerations. For example, Integrated Coastal Zone Management. Research that can be applied to the management, conservation and sustainable use of coastal ecosystem services. Exchange of experts among the countries can be done in this regard. Improved legislative frameworks and enforcement capacity. Besides, Development and implementation of effective policies and legislation. Strict implementation of the rules to control over-exploitation of the coastal resources. To undertake a regular survey for assessment of the coastal resources together with updating the existing monitoring system and continuing the process and Development and implementation of the community-based coastal zone management plan.

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References

- 1 Costanza, Robert, et al. "The Value of the World's Ecosystem Services and Natural Capital (1997)." *The Globalization and Environment Reader* (2016): 117.

- 2 Daily, Gretchen. *Nature's services: societal dependence on natural ecosystems*. Island Press, 1997.
- 3 Hassan, Rashid, Robert Scholes, and Neville Ash. Ecosystems and human well-being: current state and trends: findings of the Condition and Trends Working Group. eds. No. 333.9 ECO V. 1. CIMMYT.2005.
- 4 Costanza, Robert, et al. "The value of the world's ecosystem services and natural capital." *Ecological economics* 25.1 (1998): 3-16.
- 5 World Resources Institute. Making Big Ideas Happen. N.p., n.d. Web. 26 Apr. 2017. <<http://www.wri.org/>>.
- 6 The Bay of Bengal Large Marine Ecosystem Project - Home. N.p., n.d. Web. 26 Apr. 2017. <<http://www.fao.org/fi/BoBlme/website/prospectus.htm>>.
- 7 Introduction to Large Marine Ecosystems. One shared ocean. N.p., n.d. Web. 26 Apr. 2017. <<http://onesharedocean.org/lmes/introduction>>.
- 8 Bay of Bengal. N.p., n.d. Web. 26 Apr. 2017. <<http://omp.gso.uri.edu/ompweb/doec/science/descript/bengal1.htm>>.
- 9 Suryanarayan, V. "Prospects for a Bay of Bengal community." *SEMINAR-NEW DELHI*. MALYIKA SINGH, 2000.
- 10 Souter, David, D. Obura, and O. Linden. "Coral reef degradation in the Indian Ocean." *Status report* (2000).
- 11 Samarakoon, Jayampathy. "Issues of livelihood, sustainable development, and governance: Bay of Bengal." *AMBIO: A Journal of the Human Environment* 33.1 (2004): 34-44.
- 12 Islam, M. Rafiqul. "Where land meets the sea: A profile of coastal zone of Bangladesh." (2004).
- 13 Islam, M. Shahidul. *Sea-level changes in Bangladesh: the last ten thousand years*. Asiatic Society of Bangladesh, 2001.
- 14 Venkataraman, K., and M. Wafar. "Coastal and marine biodiversity of India." (2005): 57-75.
- 15 Rajasuriya, Arjan. "Coral Reefs of Sri Lanka: Current status and resource management." *Regional Workshop on the Conservation and Sustainable Management of Coral Reefs*. 1997.
- 16 Bissinger, Jared. "The maritime boundary dispute between Bangladesh and Myanmar: Motivations, potential solutions, and implications." *asia policy* 10.1 (2010): 103-142.
- 17 De Young, Cassandra, ed. *Review of the state of world marine capture fisheries management: Indian Ocean*. No. 488. Food & Agriculture Org., 2006.
- 18 Nootmorn, Praulai, Rangsarn Chayakun, and Somsak Chullasorn. "The Andaman Sea Marine Ecosystem in Thailand." *Sustainable Management of the Bay of Bengal Large Marine Ecosystem. Report of the first Regional Workshop, 17-21 February, 2003, Pattaya, Thailand*. Vol. 2. 2003.
- 19 Cribb, Robert, and Michele Ford. "Indonesia as an archipelago: managing islands, managing the seas." (2009).
- 20 Christie, Patrick, and L. Katrina Ole-Moiyoi. "Status of marine protected areas and fish refugia in the Bay of Bengal Large Marine Ecosystem." (2011).
- 21 Rajasuriya, Arjan, et al. "Status of coral reefs in South Asia: Bangladesh, India, Maldives, Sri Lanka." *Proceedings of the Ninth International Coral Reef Symposium, Bali, 23-27 October 2000*, Vol. 2. 2002.
- 22 Hussain, M. G., and M. EnamulHoq, eds. *Sustainable Management of Fisheries Resources of the Bay of Bengal*. Support to Sustainable Management of the BOBLME Project, Bangladesh Fisheries Research Institute, 2010.
- 23 Zacharia, P. U., et al. "Climate change impact on coastal fisheries and aquaculture in the SAARC region: Country paper-India." (2016): 1-25.
- 24 MINISTRY OF FISHERIES AND AQUATIC RESOURCES DEVELOPMENT. N.p., n.d. Web. 26 Apr. 2017. <<http://www.fisheries.gov.lk/content.php?cnid=ststc>>.
- 25 Value chain analysis and competitiveness strategy: marine capture fisheries: Myeik and Yangon, Myanmar / International Labour Organization, ILO Liaison Officer for Myanmar. - Yangon: ILO, 2015
- 26 "FAO.org." *Myanmar at a glance* N.p., n.d. Web. 25 Apr. 2017. <http://www.fao.org/myanmar/fao-in-myanmar/myanmar/en/>
- 27 Ebarvia, Maria Corazon M. "Economic Assessment of Oceans for Sustainable Blue Economy Development." *Journal of Ocean and Coastal Economics* 2.2 (2016): 7.
- 28 Jarayabhand, Srisuda, et al. "Contribution of the marine sector to Thailand's national economy." *tropical coasts* (2009): 22.
- 29 Sudara, S., and T. Yeemin. "Status of Coral Reefs in Thailand." *Status of coral reefs in the Pacific. Sea Grant College Program, School of Ocean and Earth Science and Technology, University of Hawaii, CP-98-01* (1997): 135-144.
- 30 "Indonesia Fisheries: 2015 Review." *The David and Lucile Packard Foundation*. N.p., n.d. Web. 26 Apr. 2017. <<https://www.packard.org/wp-content/uploads/2016/09/Indonesia-Fisheries-2015-Review>>.
- 31 Cesar, Herman, et al. "Indonesian coral reefs-An economic analysis of a precious but threatened resource." *Ambio (Sweden)* (1997).
- 32 Maldives, Corporate. "THE MALDIVIAN ECONOMY IN 2016: FISHERIES SECTOR." *Corporate Maldives*. N.p., 23 Mar. 2017. Web. 26 Apr. 2017. <<http://corporatemaldives.com/2017/03/23/the-maldivian-economy-in-2016-fisheries-sector/>>.
- 33 Tun, Karenne, and Ming Chou. "Status of coral reefs, coral reef monitoring and management in Southeast Asia, 2004."
- 34 Shah, M. S., K. A. Huq, and S. M. B. Rahman. "Study on the conservation and management of fisheries resources of the Sundarbans." *Integrated Protected Area Co-Management (IPAC), Bangladesh* (2010).
- 35 Hossain, Md Shahadat, and C. Kwei Lin. "Land use zoning for integrated coastal zone management." *ITCZM monograph* 3 (2001): 24.
- 36 Vyas, P. "Sundarbans Biosphere Reserve'Workshop on Sundarbans Day, 3rd June." *Calcutta, Observed by Sundarbans Biosphere Reserve & Zilla Parishad-24 Parganas* (2001).
- 37 Karunathilake, K. M. B. C. "Status of mangroves in Sri Lanka." *Journal of coastal development* 7.1 (2010): 5-9.
- 38 Oo, Nay. "Present state and problems of mangrove management in Myanmar." *Trees-Structure and Function* 16.2 (2002): 218-223.
- 39 Sathirathai, Suthawan. *Economic valuation of mangroves and the roles of local communities in the conservation of natural resources: case study of Surat Thani, South of Thailand*. South Bridge: Economy and Environment Program for Southeast Asia, 1998.
- 40 Ruitenbeek, H. Jack. "Modelling economy-ecology linkages in mangroves: economic evidence for promoting conservation in

- Bintuni Bay, Indonesia." *Ecological economics* 10.3 (1994): 233-247.
- 41 Shazra, A., S. Rasheed, and A. A. Ansari. "Study on the mangrove ecosystem in Maldives." *Global J. Environ. Res* 2.2 (2008): 84-86.
 - 42 Kamal, Abu Hena M. "Coastal and estuarine resources of Bangladesh: management and conservation issues." (2009).
 - 43 Soe-Htun, U., et al. "Notes on seagrasses along Myanmar coastal regions." (2002).
 - 44 Poovachiranon, Sombat, and HansaChansang. "Community structure and biomass of seagrass beds in the Andaman Sea.I. Mangrove-associated seagrass beds." *Phuket Marine Biological Center Research Bulletin* 59 (1994): 53-64.
 - 45 "Statistics." *Ornamental Fish Exporters*.N.p., n.d. Web. 27 Apr. 2017. <<http://www.ornamentalfishexporters.com/industry-news/statistics/>>.
 - 46 Orams, Mark. *Marine tourism: development, impacts and management*. Psychology Press, 1999.
 - 47 Roy, Sanjay Chandra, and Mallika Roy. "Tourism in Bangladesh: Present status and future prospects." *International Journal of Management Science and Business Administration* 1.8 (2015): 53-61.
 - 48 "International tourism, receipts (current US\$)." *International tourism, receipts (current US\$) | Data*.N.p., n.d. Web. 27 Apr. 2017. <<http://data.worldbank.org/indicator/ST.INT.RCPT.CD>>.
 - 49 "Natural Resources Management and Development Portal." *Governance — USAID Natural Resource Management and Development Portal*.N.p., n.d. Web. 27 Apr. 2017. <<http://rmportal.net/tools/coastal-management-tools/governance>>.
 - 50 Chadwick, Matthew Thomas. *The 1998 flood: coping with flood events in Bangladesh*. 2004.
 - 51 Ramachandran, A., B. Enserink, and A. N. Balchand. "Coastal regulation zone rules in coastal panchayats (villages) of Kerala, India vis-à-vis socio-economic impacts from the recently introduced peoples' participatory program for local self-governance and sustainable development." *Ocean & coastal management* 48.7 (2005): 632-653.
 - 52 Department of Animal Husbandry, Dairying & Fisheries | Government of India. N.p., n.d. Web. 27 Apr. 2017. <<http://dahd.nic.in/>>.
 - 53 Powell, Robert B., Ariel Cuschnir, and Prakash Peiris. "Overcoming governance and institutional barriers to integrated coastal zone, marine protected area, and tourism management in Sri Lanka." *Coastal Management* 37.6 (2009): 633-655.
 - 54 The Bay of Bengal Large Marine Ecosystem Project - PROJECT OVERVIEW. N.p., n.d. Web. 27 Apr. 2017. <http://www.boblme.org/project_overview.html>.
 - 55 Dirhamsyah, D. "Indonesian legislative framework for coastal resources management: A critical review and recommendation." *Ocean & coastal management* 49.1 (2006): 68-92.
 - 56 Naseer, Abdulla. "Profile and status of coral reefs in Maldives and approaches to its management." *Regional Workshop on the Conservation and Sustainable Management of Coral Reefs*. 1997.
 - 57 Mslabs. *Bay of Bengal Programme - About BOBP*. N.p., n.d. Web. 27 Apr. 2017. <<http://bobpigo.org/aboutus.html>>.
 - 58 "THE BAY OF BENGAL LARGE MARINE ECOSYSTEM PROJECT." *The Bay of Bengal Large Marine Ecosystem Project - Home*.N.p., n.d. Web. 27 Apr. 2017. <<http://www.boblme.org/>>.
 - 59 *Home - Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation*. N.p., n.d. Web. 27 Apr. 2017. <<http://www.bimstec.org/>>.