Ocean and Coastal Management 161 (2018) 211–221

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

# Economic feasibility of mangrove restoration in the Southeastern Coast of Bangladesh

Mohammad Mahfuzur Rahman*, Md. Abdullah Mahmud

*Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong 4331, Bangladesh*

ARTICLE INFO

*Keywords:*
Benefit cost ratio
Economic feasibility
Mangroves
Sensitivity analysis
Silvofishery

ABSTRACT

Chakaria Sundarban (CSB), Maheshkhali, and Kutubdia are the major mangrove islands in the Southeastern Coast of Bangladesh. The mangroves of these islands have been replaced almost entirely with shrimp and salt farms. Shifting mangrove land to non-mangrove uses has left the coast with adverse environmental consequences. Local people are realizing that integrated silvofishery could be a way better option compared to the existing non-mangrove land use. This study was designed to evaluate the economic potentials of mangrove restoration in these islands through four silvofishery practices- Integrated Mangrove Shrimp (IMS), Integrated Nypa Shrimp (INS), Mangrove Bio-Filter (MBF), and Integrated Mangrove Crab (IMC). Benefit Cost Ratio (BCR) in IMS was the highest, 2.33 on a 35-year long time horizon for analysis followed by INS and MBF with BCRs 1.80 and 1.40, respectively. Only IMC had the BCR greater than 1.00 in all three phases of restoration. Overall, when environmental benefits of mangroves were considered, all the silvofishery practices ensured better returns for the society compared to what the existing land use is providing. However, the restoration efforts are expected to face enormous challenges from existing sociopolitical makeup of the islands. The success of proposed restoration program is contingent to community participation in the process and strong political commitment of the government and the leadership in the study area.

## 1. Introduction

In recent years, Bangladesh is facing an intense degradation of its bio-resource base for a wide variety of reasons. Both coastal and inland forests are being depleted through illicit felling, land encroachment, and conversion of forest land to non-forestry uses. An estimated 2000 hectares of forest land is depleted annually in Bangladesh (FAO, 2010). Presently, the country has a little over 9% forest cover as opposed to 14% in 1990 (Sunderland et al., 2011). This depletion is more pronounced for mangrove forests due to unplanned shrimp farming, salt panning, and agricultural activities. In the current world scenario, the economic value of natural products and ecosystem services generated by mangrove forests are by and large underestimated (Badola and Hussain, 2005; Barbier, 1994; Sathirathai, 2003; Vo et al., 2012). Nonetheless, economic analysis shows that the functions and services provided by mangroves and wetlands in general have positive economic values that are often ignored (Barbier, 1993; Farber, 1987; Ruitenbeek, 1994; Swallow, 1994).

With motivations for immediate and larger financial gains, local people with support from the government as well as international donor agencies, the entire 7490 ha of CSB has been transformed into shrimp farms in just two decades (Hossain et al., 2001a, 2001b; Rahman and Hossain, 2015; Samsuddoha and Chowdhury, 2009a, 2009b). Although the conversion of CSB began during the colonial British rule in this region by allowing people to settle in the forest, the destruction was acerbated due to the financial incentive for shrimp cultivation provided by World Bank (WB) and Asian Development Bank (ADB) money, USD 26.5 million, between 1985 and 1988 (Hossain et al., 2001b; Shamsuddoha and Chowdhury, 2009). By early 1990's, the entire mangrove forest of CSB was cleared off for shrimp and salt farming with minor human settlement (Pokrant and Reeves, 2005; Rahman and Hossain, 2015).

The mangroves of the adjacent islands, Maheshkhali and Kutubdia, are also in a similar state. During our fieldwork, we observed some sparse mangroves in both Maheshkhali and Kutubdia islands. The destruction of mangroves in the region could be attributed to a number of factors including, but are not limited to, (i) internal policy pressure of the government to earn foreign exchange through the export of shrimp, (ii) the power of the local landlords, urban businesses, and politics in favor of shrimp farming, and (iii) the prescription from international donor agencies such as the WB and ADB to shift towards a more open and export-oriented economy (Pokrant and Reeves, 2005). The

* Corresponding author.
*E-mail addresses:* mahfuzusa@yahoo.com (M.M. Rahman), pavelifescu29@gmail.com (Md. A. Mahmud).

https://doi.org/10.1016/j.ocecoaman.2018.05.009
Received 11 November 2017; Received in revised form 7 May 2018; Accepted 13 May 2018

government hardly paid any attention to the Forest Department's argument for the development of alternative rural livelihood strategies rooted in longstanding local practices (Pokrant and Reeves, 2005). Although shrimp cultivation created some employment opportunities for few local people at CSB, Maheshkhali, and Kutubdia, most of the benefits of these activities went to shrimp farm owners. The destruction of CSB badly affected the socioeconomic conditions of 90 percent of the local communities. The situation has worsened over time with entire CSB and most places of Maheshkhali and Kutubdia being under the illegal occupation of the local land grabbers (Siddique, 2012).

Failure to recognize the ecological and economic worth of mangroves is one of the major reasons for people to opt for putting mangrove land to other uses. However, the conversion of mangroves to other land uses did not yield better economic gains in the end, as are the cases for these islands (Gunawardena and Rowan, 2005; Lal, 2003; Sathirathai, 2003). Initially, the shrimp farmers saw better yield that gradually declined (Rahman and Hossain, 2015). Many shrimp ponds became unproductive or abandoned across the coast of Bangladesh (Hossain et al., 2004). Similar results were also observed in some parts of the world. Huitric et al. (2002) conducted a study in Thailand and reported that the replacement of mangroves with aquaculture, agriculture, and other forms of development has been proven to be a bad economic trade-off both in the short-term and long-term. Barbier (2006) conducted a similar study in Indonesia and reported that the alternative use of mangrove often yields unsustainable outcomes in the end. Gammage (1997) conducted a study to estimate the benefits of non-mangrove uses of mangrove ecosystems in part of the Gulf of Fonseca and El Salvador and reported that sustainable ecological benefits to be available from mangroves on a perpetual basis surpass all alternative non-forestry uses of mangroves.

The consequences of mangrove removal have resulted in reduced social welfare and equity. Such conversions have permanently deprived local people from many ecosystem services such as livelihood supports and environmental protection they once enjoyed from the forest. Biswas et al. (2009) identified a number of benefits derived from the presence of mangrove forest such as white fish, crabs, and protection from cyclones. More than 16,700 people died alone in the CSB settlement area in the devastating cyclone on April 29, 1991 (Banglapedia, 2012). This figure for Kutubdia was 8000 (Enz et al., 2009). Das (2009) and Das and Crepin (2013) showed that the presence of a thick mangrove can considerably reduce the casualties. Hossain (2013) and Hossain and Baten (2011) also claimed that mangrove provide an effective shield for the coastal communities against the cyclonic catastrophes.

Even though the mangroves of CSB, Maheshkhali, and Kutubdia have been studied extensively by botanists, ecologists and marine scientists (Barbier, 1993; Farber, 1987; Kathiresan and Bingham, 2001; Lacerda, 2002; Macnae, 1968; Ruitenbeek, 1994; Saenger et al., 1983; Swallow, 1994; Tomlinson, 1986), they focused mostly on ecological and biodiversity issues. However, the restoration potentials of these denuded islands have not been sufficiently addressed with a major focus on the economic feasibility of such restoration.

This study is a pioneering effort to evaluate the socio-economic feasibility of restoring the depleted mangroves in these islands. The study has suggested possible strategies to implement the restoration alternatives that might help effective policy formulation for a successful restoration process in the region.

## 2. Methods

### 2.1. Description of the study sites

The study areas are located at CSB (21°41′09.1″N and 92°01′25.1″E), Maheshkhali (21°35′31.1″N and 91°54′58.1″E), and Kutubdia islands (21°35′31.1″N and 91°54′58.1″E) in the Southeastern Coast of Bangladesh (Fig. 1). Mangroves of these islands are situated at, on the Matamuhury and Baghkhali Deltas of the Cox's Bazar District that are criss-crossed by many tributaries and micro-channels of the Matamuhuri and the Baghkhali rivers (Hossain et al., 2015). The total areas of CSB, Maheshkhali upazila and Kutubdia upazila are 7490 ha, 36218 ha, and 21580 ha, respectively (Banglapedia, 2012). Presently, the area is severely depleted of mangroves; most of the forest land has been converted to rapidly expanding shrimp farms and salt pans. Initially, about 1600 ha of CSB land was leased to landless families for their settlement in 1926 during the colonial British period. Later, shrimp farming replaced the mangroves of 2251 ha and 694 ha CSB land in 1977 and 1982, respectively.

### 2.2. Current scenario

The existing land use condition has been defined as the current scenario (without-restoration efforts) for the analysis. As explained already, at CSB area there was no natural forest or afforestation program. The land was being used mainly for shrimp culture and salt farming with some sporadic agricultural activities. The present land use activities have been captured through a semi-structured questionnaire survey in the field. Maheshkhali and Kutubdia had all these activities plus some mangroves species. Thus, the situations in Maheshkhali and Kutubdia were a little better than that in CSB. However, the existing land use activities have been used to define site-specific current scenario.

### 2.3. With-restoration scenario

Based on the ecological feasibility of mangrove restoration as studied by Hossain et al. (2015), we identified three phases of development with-restoration scenarios and these were: (1) Establishment Phase (EP), which would span over the first three years from the inception of the potential restoration activities, (2) Increasing Yield Phase (IP), which would span from 4th through 10th year of existing shrimp production, and Stable Phase (SP) would continue for the rest of the life of the restoration effort beyond its 10th year of production. It was assumed that the government would provide financial, technical, and monitoring supports to the participants in the establishment phase. This phase would be more of an investment phase with little benefits to come in. The subsequent phases might be expected to yield both mangrove and fishery benefits in addition to non-market ecosystem services. However, in the subsequent phases, only monitoring and technical supports would be provided to the local community to help sustain the potential ecological and economic gains through restoration efforts.

#### 2.3.1. Silvofishery systems

The mode of restoration would be silvofishery - a system of aquaculture integrated with mangrove forest management systems (Hossain et al., 2015). The silvofishery system demands relatively few man-made inputs to generate multiple products, including both aquatic species (fish, mollusks, shrimps and other crustaceans) and mangroves forest cover. In this system, growth and yield of both mangrove and fishery gain synergy (Fitzgerald, 2002). A number of countries including Indonesia, China, Vietnam, Philippines, Thailand, Malaysia, Kenya, Tanzania, and Jamaica are practicing silvofishery. While silvofishery system is a sustainable concept (Fitzgerald, 2002), semi and intensive shrimp farmings have had limited lifetime due to their adverse susceptibility to environmental impacts (Kautsky et al., 2000).

However, four different silvofishery systems (Table 1), as suggested by Hossain et al. (2015), were used in this study as outlined below:

*2.3.1.1. Integrated mangrove-shrimp system – IMS.* Boroghop, Badarkhali, Rampura, South Nolbila, Bahaltali, Varuakhali, and Khuruskul were suitable locations for the IMS system. The major mangrove species recommended for restoration were *Sonneratia apetala, Avicennia officinalis, and Rhizophora gymnorrhiza*. In the IMS