

## Chapter 9

# Livelihood Strategies and Resource Dependency Nexus in the Sundarbans

Md. Nasif Ahsan, Karina Vink, and Kuniyoshi Takeuchi

**Abstract** The short- and long-term impacts from natural hazards, which are thought to be the consequences of climate change, interrupt the functions of the social-ecological system of the Sundarbans Mangrove Forest (SMF) in Bangladesh, which in turn affect the livelihood of people at risk. In the absence of sustainable livelihood options, over time these people have become more dependent on the resources of the Sundarbans. This study investigates how their livelihood strategies affect the dependency pattern on the common resources of this mangrove forest during economic depressions that resulted from disasters caused by extreme climatic events. The focus of this investigation is on a sub-district known as *Koyra*, located in southwestern coastal Bangladesh, which has the longest border with the Sundarbans. Relevant parameters such as climatic trends and extreme events, financial-physical-structural damage patterns, socioeconomic peculiarities, changes in consumption expenditure, asset portfolio, and occupation patterns are considered. Data are collected from 420 households through face-to-face questionnaires and seven focus group discussions (FGDs). The empirical results suggest that the higher intensity and frequency of natural hazards have led to substantially higher damages of asset and capital goods. Over the last two decades, around 8 % of the sampled households have become landless; more than 25 % have switched from crops to other nonagricultural occupations; and more than 26 % have started depending on forest resources for their consumption smoothing. In addition, each household has incurred annual disaster damages of on average US\$ 177. Combined with the absence of well-defined property rights, the people at risk have become more dependent on resources from the SMF for their livelihoods as well as consumption smoothing, which eventually is likely to jeopardize the stock of

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M.N. Ahsan (✉)

International Centre for Water Hazard and Risk Management (UNESCO-ICHARM), Tsukuba, Japan

National Graduate Institute for Policy Studies (GRIPS), Tokyo, Japan

Economics Discipline, Khulna University, Khulna, Bangladesh

e-mail: [nasif.ahsan@yahoo.com](mailto:nasif.ahsan@yahoo.com)

K. Vink • K. Takeuchi

International Centre for Water Hazard and Risk Management (UNESCO-ICHARM), Tsukuba, Japan

renewable resources of this forest. We recommend redefining property rights to ensure a win-win platform for all the stakeholders.

**Keywords** Extreme climatic events • Coastal households • Consumption • Sundarbans • Forest resources

## 9.1 Introduction

Despite the increasing anthropogenic pressure from the surrounding communities resulting in gradual resource depletion, the Sundarbans Mangrove Forest (SMF) contributes to around 3 % of the country's gross domestic product (GDP) and over 5 % to the whole forestry sector in Bangladesh (GoB 2011; Kabir and Hossain 2008). In situ conservation of biodiversity in well-managed protected areas is likely to not only provide essential ecosystem services to the surrounding communities but also ensure the sustainable functioning of socio-ecological dynamics (Randall and Dolcemascolo 2010). As suggested by Sathirathai and Barbier (2001), the monetary value of conserving all available ecosystem services in mangrove forests substantially outweighs the benefits obtained from commercial activities.

Over the past decades, this mangrove forest has played a potent role as a protective shield for its surrounding settlers during high-speed wind-related hazards (i.e., tropical cyclones) by obstructing the wind speed (Ostling et al. 2009). Recently the southwestern coastal zone including the SMF suffered colossal losses due to two consecutive powerful tropical cyclones, *Sidr* and *Aila*, in 2007 and 2009, respectively. The short- and long-term adverse impacts of these disasters exacerbated income shocks for the coastal households who struggled to secure their minimum consumption level (Ahsan 2010). Hence, these hazard-affected households were impelled to depend more on the common resources from the surrounding areas over time (Ahsan 2014; Getzner and Islam 2013; Roy 2014). Furthermore, these coastal communities are physically isolated, rendering them highly dependent on natural resources, which appears to squeeze their access to alternative livelihood opportunities. This dependence leaves them being vulnerable to shocks, especially to natural hazards, and thereby they suffer from uneven social and economic powers, weak involvement in decision-making, limited or nil asset possession, and poorly implemented laws and regulations that invoke the imbalance between entitlement and endowment of resource access (Koli 2013; Pomeroy et al. 2006).

Empirical findings of a number of studies suggest that over the past few decades, the scope of historically dominant livelihood opportunities is gradually being squeezed due to a high degree of natural resource exploitation in the southwestern coastal area, including the SMF in Bangladesh (Ahsan 2014; Getzner and Islam 2013; Iftekhar and Islam 2004; Miah et al. 2010; Roy et al. 2013a; Vivekananda et al. 2014). In addition, the poor and marginalized households in coastal communities usually suffer income shocks in ex post hazard (e.g., cyclone) due to a narrower scope for livelihood earnings (Ahsan and Warner 2014), which is further

exacerbated by the damaged socioeconomic infrastructure (Mallick et al. 2011). Such an unfavorable situation resembles human insecurity from the perspective of narrower access to natural resources required for sustaining livelihoods (Barnett and Adger 2007). Studies carried out in the southwestern coastal belt have addressed health issues of coastal households (Ray-Bennett et al. 2010), physical injuries (Paul 2010), factors affecting household behavior during tropical cyclones (Paul and Dutt 2010), community-level coping mechanisms (Parvin et al. 2008), social vulnerability in connection with forest management (Koli 2013), property right regimes of the SMF resources (Roy and Alam 2012, 2013b), and forest resource conservation (Rahman et al. 2010). However, none of these studies investigated the nexus between the changing pattern of livelihood strategies and the forest resource dependency patterns of the coastal communities. This study investigates this nexus, considering the impacts of natural hazards, by applying a household-level case study approach. The term nexus in this study indicates the mutual link between the people at risk's livelihood options and resource extraction frequency from the SMF and is discussed more elaborately in Sects. 9.5 and 9.6. This study examines two specific questions: (1) whether the degree of dependency, for managing the livelihoods of the households in the study location, on forest resources is escalating and (2) whether household consumption is affected by their access frequency to the SMF along with other socioeconomic determinants.

## 9.2 Theoretical Framework

Consumption smoothing occurs as households cope with income shocks by adjusting their consumption (Dercon et al. 2012). Adger and Kelly (1999) presented such coping mechanisms by introducing the “entitlement” approach and linking this to relevant materialistic well-being parameters (e.g., income and health) to focus on household resilience. Considering that spatial heterogeneity triggered differences in the degrees of resilience (Nyström and Folke 2001), covariant shocks such as devastation by tropical cyclones are likely to affect the socio-ecological system and eventually lead to uncontrolled resource exploitation by at-risk households resulting from their alternative income-generating activities to secure livelihoods (Adger et al. 2005).

The ex post hazard shocks usually exacerbate existing economic depressions, which not only diminishes the prospect of new job opportunities but also squeezes the incomes of affected households with jobs (Skoufias 2003). As suggested by Kazianga and Udry (2006), households in ex post catastrophes opt for utilizing their buffer stock (e.g., livestock) to cope with covariant shocks, although very few empirical evidences are found for buffer stock playing effective roles in risk coping. In such situation, the affected households utilize both their buffer stock of livestock they own and informal social networks for smoothing concerned consumption (Brown et al. 2014; Petrikova and Chadha 2013). Over time the buffer stock and assistance from social networks decline, which eventually motivate affected

households to look for common pool resources (CPRs) (Ahsan 2014). Costly exclusion and rivalry in usage are two main characteristics of CPRs, implying a resource is common to all who wish to use it but it is produced by private initiatives (Ostrom et al. 1999). Such embedded property rights for CPRs are commonly found in many countries and have been considered as effective tools for institutional arrangements (Chhatre and Agrawal 2009).

Sen (1981, 1986) argues that the scarcity of a resource does not necessarily indicate the absence of that particular resource; rather it implies people's least degree of access to it. Sen (1986) emphasizes the "entitlement" rather than "endowment" of resources, where the former refers to rights people *can* have, while the latter refers to rights people *should* have. Thus, entitlement of resources refers to a legitimate and effective command over an alternative commodity bundle (Chomba et al. 2014; Clark 2005), which eventually enhances people's capabilities and freedom to choose optimal paths to carry out activities ensuring their sustainable livelihoods. However, poorly defined entitlement (i.e., property rights) often leads the hazard-affected households to exhaust available CPRs by over-exploiting and under-investing (Dietz et al. 2003; Koli 2013; Laerhoven and Ostrom 2007; Ostrom 1999). In other words, in the absence of well-defined institutional arrangements (i.e., property rights), along with weakly implemented regulations, hazard-affected households are likely to use up existing CPRs for their consumption smoothing (Getzner and Islam 2013). This appears to create a substantial nexus between the livelihood strategies of forest-dependent households and the CPR stocks (Padli et al. 2010).

### 9.3 Study Location

*Koyra* Upazila (subdistrict) in the Khulna District in southwestern coastal Bangladesh (Fig. 9.1) was selected to investigate the nexus between livelihood strategies of coastal households and their dependency on the SMF resources. This area is situated within the exposed coastal zone and is well recognized as a severely hazard-prone area.

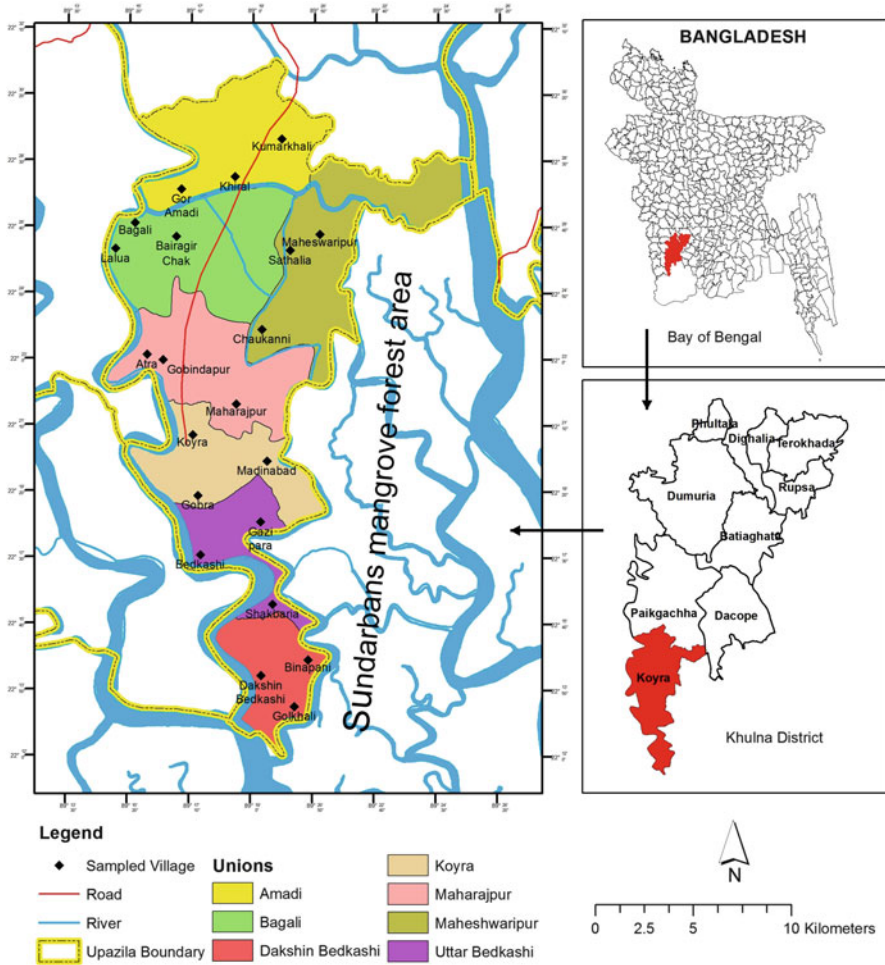
The total land area of *Koyra* is about 1800 sq. km. This Upazila consists of seven union parishads,<sup>1</sup> 72 mouzas,<sup>2</sup> and 131 villages (GoB 2013). The total population of *Koyra* is about 194,000, with an average household size of 4.24, a population density of 109 people per sq. km., and a male-female ratio of 0.97. The average literacy rate is 50.4 %, with a distribution of male and female of 56.33 % and 38.05 %, respectively. The occupational distribution consists mainly of cropping, fishing, small-scale trading, self-employment, and forest resource<sup>3</sup> collection (GoB

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<sup>1</sup>Lowest tier of the local government in Bangladesh.

<sup>2</sup>Clusters.

<sup>3</sup>Goods such as honey, wax, wood logs, and *nipa palm* are collected and sold.



**Fig. 9.1** Map of Koyra (Source: Prepared based on data provided by the GIS unit of the Local Government and Engineering Department (LGED) of the Government of Peoples Republic of Bangladesh 2010)

2013). The current market price of the top-grade agricultural land is valued at about Bangladeshi Taka (BDT) 6100 (≈ US\$ 78.34) per 0.01 hectare. Reports of the Bangladesh Bureau of Statistics (BBS) suggest that nearly 90 % of the households live in weak settlements made of mud, bamboo, and straw (GoB 2013). These economically poor and socially marginalized households are likely to live in the exposed areas of Koyra and often suffer colossal damages by natural hazards, such as tropical cyclones, storm surges, flash floods, heavy rainfall, river erosion, soil salinity, and waterlogging. Embankment breaches are a common event and occur after almost every strong tropical cyclone in many areas due to poor and irregular maintenance of existing embankments, which invokes waterlogging. The calendar

**Table 9.1** Hazard calendar of *Koyra*

Hazards	Months											
	Jan-Feb (Magh)*	Feb-Mar (Falgun)*	Mar-Apr (Chaitra)*	Apr-May (Boishakh)*	May-Jun (Joistho)*	Jun-Jul (Ashar)*	Jul-Aug (Shrabon)*	Aug-Sep (Bhadro)*	Sep-Oct (Ashwin)*	Oct-Nov (Kartik)*	Nov-Dec (Ogrohayon)*	Dec-Jan (Poush)*
Cyclone and tidal surge				a	a					a	a	a
Flood						a	a	a				
Water logging	b	b	b	b	b	b	b	b	b	b	b	b
Heavy rainfall						a	a					

\* Name of the Bengali months  
 a Hazard Prone period  
 b Can take place anytime

Source: Field survey (2010)

in Table 9.1, prepared on the basis of opinions of FGD participants living in the study location during the last 20 years, provides an idea of the hazards occurring throughout the year.

The geomorphological characteristics of *Koyra* indicate that it is about 2 m above the mean sea level at its northern side and 1 m at its southern side (Banglapedia 2006). *Koyra* is enclosed by the Sundarbans and the Bay of Bengal from the southeast and south directions. The river *Koyra* is the major water flow. Other rivers have a substantial effect on both surface and groundwater quality due to the natural tidal action. This study was carried out in all seven unions of *Koyra*, namely- *Amadi, Bagali, Koyra, Maharajpur, Maheswarpur, Uttar Bedkashi,* and *Dakshin Bedkashi* (shown in Fig. 9.1).

## 9.4 Methods of the Study

### 9.4.1 Data Collection

This study is based on primary data collected by a household-level questionnaire survey and focus group discussions (FGDs). Figure 9.2 shows the different stages of data collection, including the relevant data types, research methods, and operations. One FGD was carried out in each union of *Koyra*, where participants were invited from diverse societal groups (agriculturists, laborers, self-employed people, social elites,<sup>4</sup> and officials from GO and NGOs). More than 90 % of the FGD participants had been victims of tropical cyclone *Aila*. Livelihood options, household welfare indicators, and the impact of natural hazards were discussed to determine important

<sup>4</sup>Social elites are mainly comprised of community people with political power (e.g., village chairman and political leaders).

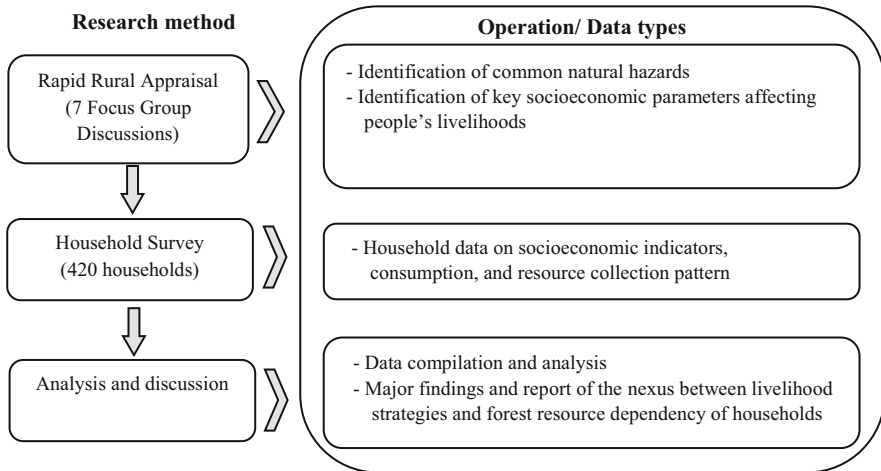


Fig. 9.2 Stages of data collection, data type, research methods, and operations

factors affecting local peoples’ livelihoods. A panel of five members (local government, representative of local NGOs, local public university, regional UNDP office, and one of the authors) took part in facilitating the discussions. All FGDs were completed before conducting the household questionnaire surveys. All possible precautions (e.g., selecting local participants who were not beneficiaries of same NGO-operated program) were maintained to avoid bias while finalizing FGD outcomes.

The guidelines of the United Nations Statistical Division (UN 2008) were followed for conducting the household questionnaire surveys. The questionnaire was designed following an iterative process where the first draft was prepared after seven FGDs, followed by discussion with local experts (such as the local government officials, NGO workers, priests, and teachers from schools and colleges). The final version of the questionnaire focused on basic socioeconomic information of the household (income, consumption, asset portfolio, settlement condition, utilities, and sanitation) in the general section and on a set of recall-type questions on disaster experiences, including the dependency trend on the common resources in the SMF in the specific section. Three villages from each union were randomly selected, and from each village, 20 households were also randomly chosen. Thus, from 21 villages (in seven unions) a total of 420 households were selected as samples for the questionnaire survey. The locations of the sample villages are shown in Fig. 9.1. Due to the incidence of two consecutive cyclones within less than 2 years (tropical cyclone *Sidr* in 2007 and *Aila* in 2009), there was a high rate of in- and out-migration in the study location, and hence, the Local Government Office could not provide us an updated list of households. Under the circumstances, the “random walk” method, developed by the World Health Organization (WHO 2011), was applied for selecting the road direction from the central marketplace

(commonly known as *Hut* in Bengali) in concerned localities, where every 20th household along the randomly chosen road was approached for a face-to-face survey.

### 9.4.2 Analytical Framework

The analysis was divided into three stages. First, the extreme events and important climatic parameters' trends were assessed by utilizing time series data and ranking of the common natural hazards assigned by the FGD participants. Second, the damage pattern incurred by households from those extreme events over time was assessed. Finally, the extent to which these disaster impacts indulged the households to depend on SMF resources was examined. Relevant parametric and non-parametric test statistics (z-test, chi-squared test, and correlation) were used in this study. Furthermore, a deterministic model (Eq. 9.1) was estimated to investigate the nexus between household's consumption expenditure and socioeconomic parameters including households' degree of access into the SMF. Consumption was chosen over income since income of the sampled households was very volatile in ex post cyclone Aila. Moreover, theoretically consumption is a function of income (Keynes 1936), and, thus, the consumption pattern of households necessarily reflects their income levels. The socioeconomic variables were selected on the basis of the opinions of the FGD participants. In line with the study by Adhikari et al. (2004), Eq. 9.1 was used to investigate the nexus between household's consumption and socioeconomic variables. The structural form of the equation is:

$$CBN_i = b_0 + \sum_{j=1}^{11} b_j x_j + \varepsilon \dots \dots \dots \quad (9.1)$$

where CBN indicates the cost of basic needs (i.e., food and nonfood consumption expenditures),  $x$  denotes independent variables, and  $b_0$  and  $b_j$  are the coefficients to be estimated.  $\varepsilon$  is the error term. The devastating tropical cyclone *Aila* in 2009 was considered as a cutout point to assess the nexus between consumption and socioeconomic parameters. We ran two regression models (as of Eq. 9.1), where the dependent variables were considered as households' consumption expenditures ( $CBN_i$ ) in the years 2008 and 2009 (i.e., before and after cyclone *Aila*), while the same set of socioeconomic variables ( $x_j$ ) was considered as independent variables measured in the year 2009. A detailed description of the variables used in Eq. 9.1 is given in Table 9.2.



**Table 9.2** Details of the variables used in the regression model

Variable	Description	Measuring unit	Adapted source	Assumed relationship with CBN
CBN	Cost of basic need (= consumption/capita/year)	US\$ in 2008, 2009 (adjusted for 2010)	Brouwer et al. (2007)	–
$x_1$	Household size	Number	Adhikari et al. (2004)	Negative
$x_2$	Dependency ratio	–	Mallick et al. (2011)	Negative
$x_3$	Age of the household head	Years	Davidar et al. (2008)	Positive
$x_4$	Standard deviation of schooling years from sample mean for household members	Years	Démurger and Fournier (2011) and Rockoff (2004)	Negative
$x_5$	Social capital (living duration with the same community)	Years	Ahsan and Warner (2014)	Positive
$x_7$	Household incurred loss of land in last 5 years	1/0 <sup>b</sup>	Wang et al. (2014)	Negative
$x_6$	Member of any NGO	1/0 <sup>b</sup>	Anderson et al. (2002)	Positive
$x_8$	Access 1: Very rare access to the SMF <sup>c</sup> (1–2 days/month) <sup>a</sup>	1/0 <sup>b</sup>	Ahsan (2010)	Positive
$x_9$	Access 2: Rare access to the SMF <sup>c</sup> (3 days/month) <sup>a</sup>	1/0 <sup>b</sup>		
$x_{10}$	Access 3: Frequent access to the SMF <sup>c</sup> (4–5 days/month) <sup>a</sup>	1/0 <sup>b</sup>		
$x_{11}$	Access 4: Very frequent access to the SMF <sup>c</sup> (6 or more days/month) <sup>a</sup>	1/0 <sup>b</sup>		

<sup>a</sup>The baseline level is for the group who never accesses into the SMF

<sup>b</sup>1=yes; 0=otherwise

<sup>c</sup>In this study access is comprised of both authorized and unauthorized access, where the former refers to accessing into the forest with permission from the Forest Department (FD) and the latter refers to accessing without permission of the said department

## 9.5 Major Findings

### 9.5.1 Socioeconomic Characteristics of Respondent Households

The descriptive statistics indicate about 83 % of the sampled respondents in the survey were male. The average size of these households was 4.85 which is slightly higher than that of the census average (see Sect. 9.3). A similar trend was obtained

**Table 9.3** Ranking of most common extreme events in the study location

Extreme events	Rank	Average percentage of participants of FGDs who indicated the event occurred
Tropical cyclone and storm surge	1	83
Flash flood	2	74
Temperature rising	3	71
Change in rainfall pattern	4	68
Waterlogging	5	61
Salinity intrusion	6	56
Erosion	7	41
Drought	8	12

Source: Authors' compilation based on FGDs conducted in (2010)

for the male-female ratio (sample ratio 0.99). Nearly 10 % of the sampled households reported not to have any paid job (i.e., unemployed), and nearly 73 % of them depended on various natural resources for their livelihood. The mean schooling years for these households was 4.53 ( $\pm$  3.21) years. Nearly 72 % of households were living under the poverty threshold,<sup>5</sup> which is consistent with results from the poverty map jointly prepared by the World Bank, Bangladesh Bureau of Statistics, and World Food Programme (GoB 2009).

### 9.5.2 Trends of Extreme Events and Climatic Parameters

Over the past several decades, the Bay of Bengal has become a hot spot for category 3–5 tropical cyclones, and most of these cyclones have made landfall on the coast of Bangladesh (Dastagir 2015; Hoarau et al. 2012). This situation is consistent with a remark of the fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), which suggests that the frequency of climatic extreme events will either decline or remain unchanged in the remainder of the current century; however, the degree of intensity of these events is likely to be higher (IPCC 2014, p. 8). In this study we constructed a “ranking of climatic extremes” based on the FGD results from all the unions of *Koyra*. Participants were asked to rank the most frequent climatic extreme events (i.e., natural hazards) in their areas over their lifetime. Table 9.3 presents the overall ranking of the most common extreme events in *Koyra*.

<sup>5</sup>The poverty line was calculated in 2005 (accordingly adjusted for 2008–2009) by applying the cost of basic need (CBN) consumption as a poverty threshold value, which was US\$ 202/capita/year in 2008–2009 (BBS 2005, 2010, 2011). The CBN consumption consists of both food and nonfood items required for maintaining a minimum living standard.

The ranking presented in Table 9.3 was prepared by considering the average percentages of participants who assigned specific rankings with specific extreme events within and among the FGDs. More than 80 % of the FGD participants opined that during their lifetime they experienced tropical cyclones and storm surges, followed by flash flood most often. From Table 9.3 a close association between the top two extreme events in *Koyra* can be apprehended since the former one is likely to propagate the latter. While different parts of *Koyra* suffer frequently from inundations due to cyclones and associated hazards, drought was mentioned as a past climatic extreme event. A group of 12 % of the respondents with an average age of over 78 years mentioned drought. It was verified by the International Disaster Database (EM-DAT 2014) that droughts occurred in this area during the early 1940s.

A list of tropical cyclones that made landfall in coastal Bangladesh over the last 50 years (1960–2010) is presented in Table 9.4. The trend shows an increasing intensity of cyclones (in terms of wind speed) over time implying that Bangladesh may experience stronger tropical cyclones in the remaining years of the current century. In addition, the average return period of cyclones with a wind speed of more than 168 km/h<sup>6</sup> has gradually decreased since the 1960s as shown in Table 9.4. Such a time frame implies changes in the climatic characteristics in form of regular strong climatic extreme events causing huge damage in coastal Bangladesh, not only through tropical cyclones but also due to storm surges, floods, and waterlogging.

Additionally we considered the trends of three important climatic parameters, namely: temperature, rainfall, and mean sea level. Over the last 18 years (1992–2009), these parameters showed increasing trends (Fig. 9.3) where only the trend of the mean sea level has changed substantially compared to the other parameters. Concerned data for the mean sea level (MSL) was available from 1992 to 2009 showing a yearly average change of 0.1 mm for the Bay of Bengal (University of Colorado 2015). However, considering the trends of temperature and rainfall which were available for a longer span (1948–2009), the average yearly deviations in temperature and rainfall were found as 0.65 °C and 0.02 mm, respectively (Dastagir 2015; Shahid 2011; World Bank 2015).

The triangulation of trends of extreme events, climatic parameters, and the hazard ranking suggests that the occurrence of climatic extreme events has increased over the last several decades, and return period of powerful tropical cyclones has decreased (see Table 9.4). In addition, important climatic parameters showed an anomalous trend over time in Bangladesh. Aligning the empirical trends of climatic extremes and parameters and the regional remarks from the IPCC's AR5 on temperature, rainfall, and extreme events, together with observations made by the older adults of the study location, it can be suggested that the southwestern

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<sup>6</sup>The Regional Specialized Meteorological Centre for South Asia defines very severe cyclonic storms as having wind speeds of over 168 km/h (RSMC 2013). Storms with this wind speed are considered as category 3 storms according to the Saffir-Simpson scale used by US-based RSMCs.

**Table 9.4** Time series profile of cyclones with storm surges in Bangladesh

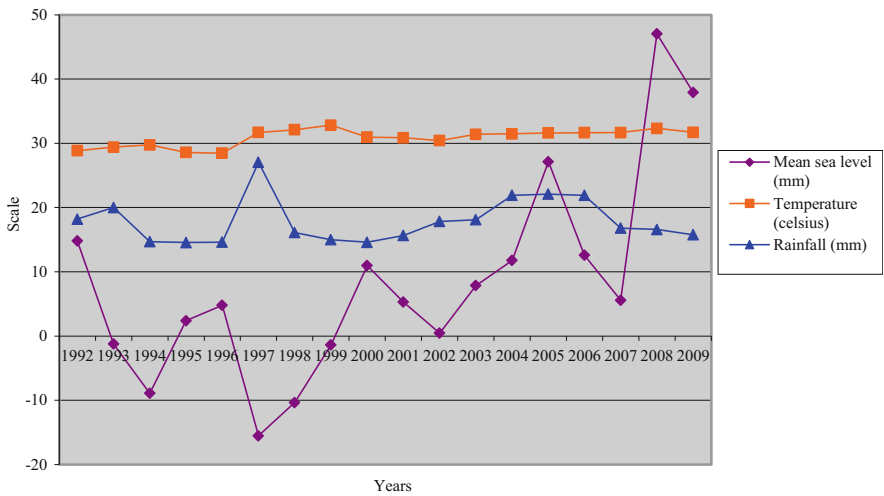
Sl.	Date	Location	Max wind speed (km/h)	Max surge height (m)	Death toll (people)
1	25 May 2009	<i>Bagerhat, Khulna, Satkhira</i>	120	2–3	210
2	15 Nov 2007	<i>Barguna, Patuakhali, Bagerhat</i>	250	6	3406
3	19–22 Nov 1998	<i>Khulna, Barisal, Patuakhali</i>	90	1.22–2.44	N/A
4	16–20 May 1998	<i>Chittagong, Cox's Bazar, Noakhali</i>	165	1.83–2.44	12
5	26 Sep 1997	<i>Chittagong, Cox's Bazar, Noakhali, Bhola</i>	150	1.83–3.04	155
6	19 May 1997	<i>Chittagong, Cox's Bazar, Feni, Noakhali, Bhola</i>	225	3.05	126
7	21–25 Nov 1995	<i>Cox's Bazar</i>	210	N/A	210
8	29 Apr–3 May 1994	<i>Cox's Bazar</i>	210	N/A	400
9	31 May–2 Jun 1991	<i>Patuakhali, Barisal, Noakhali, Chittagong</i>	110	1.9	N/A
10	29 Apr 1991	<i>Sandwip, Kalapara, Chittagong, Kutubdia, Cox's Bazar, Bhola</i>	225	6.1	138,000
11	24–30 Nov 1988	<i>Jessore, Kushtia, Faridpur, Khulna, Barisal</i>	162	4.5	5708
12	8–9 Nov 1986	<i>Chittagong, Barisal, Patuakhali, Noakhali, Khulna</i>	110	N/A	14
13	24–25 May 1985	<i>Chittagong, Cox's Bazar, Noakhali and coastal areas</i>	154	3.0–4.6	11,069
14	5–6 Nov 1983	<i>Chittagong, Cox's Bazar, offshore islands, Barisal, Patuakhali, Noakhali</i>	136	1.52	300
15	14–15 Oct 1983	<i>Chittagong, Noakhali, offshore islands</i>	122	N/A	43
16	9–12 May 1977	<i>Khulna, Noakhali, Barisal, Patuakhali, Chittagong, offshore islands</i>	112.63	N/A	N/A
17	9–12 May 1975	<i>Bhola, Cox's Bazar, Khulna</i>	112.6	N/A	5
18	18–24 Nov 1974	<i>Cox's Bazar, Chittagong</i>	161	2.8–5.2	200
19	13–15 Aug 1974	<i>Khulna</i>	80.5	N/A	600
20	28–30 Nov 1971	<i>The Sundarbans</i>	113	1	N/A
21	13 Nov 1970	<i>Bhola, Chittagong, Barguna, Patuakhali, offshore islands</i>	222	10.6	500,000

(continued)

**Table 9.4** (continued)

Sl.	Date	Location	Max wind speed (km/h)	Max surge height (m)	Death toll (people)
22	1 Oct 1966	<i>Sandwip, Bakerganj, Khulna, Chittagong, Noakhali, Comilla</i>	146	4.7–9.1	850
23	14–15 Dec 1965	<i>Cox’s Bazar and Patuakhali</i>	210	4.7–6.1	873
24	11–12 May 1965	<i>Barisal and Bakerganj</i>	162	3,7	19,279
25	28–29 May 1963	<i>Chittagong, Noakhali, offshore islands</i>	203	4.3–5.2	11,520
26	26–30 Oct 1962	<i>Feni</i>	161	2.5–3	1000
27	9 May 1960	<i>Bagerhat, Khulna</i>	161	2.44–3.05	11,468
28	30–31 Oct 1960	<i>Chittagong, Barisal, Noakhali, Patuakhali, Faridpur</i>	210	4.5–6.1	10,000
29	9–10 Oct 1960	<i>Rangamati, Hatiya, Noakhali</i>	201	3.05	3000

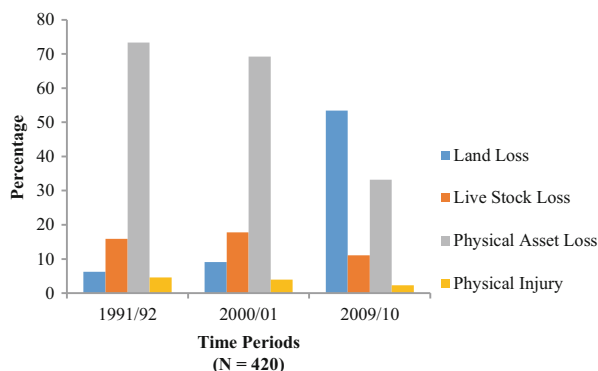
Source: Adopted from Mallick and Vogt (2011)



**Fig. 9.3** Trends of different climate parameters during 1992–2009 (Source: BMD 2013; University of Colorado 2015)

coastal Bangladesh area is very likely to have been experiencing the adverse effects of climate change over the past decades, which might escalate in remaining years of the current century.

**Fig. 9.4** Different losses incurred by households over the last two decades (Source: Field survey 2010)

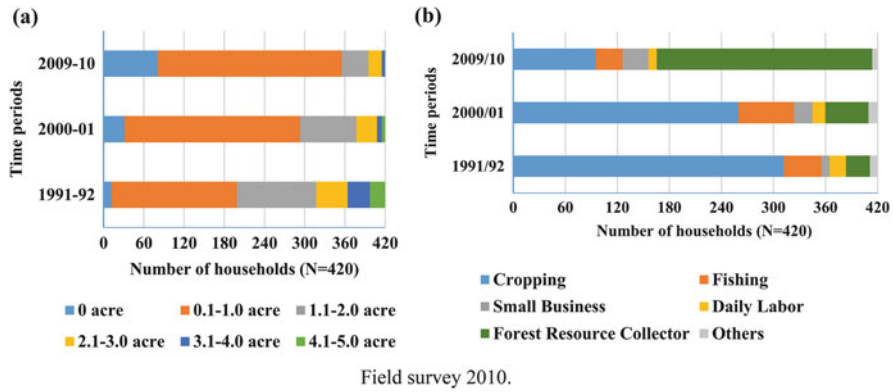


### 9.5.3 Damage Patterns Suffered by the Households

Due to impacts from the increasing trend of extreme events and anomalies in major climatic parameters, the households in *Koyra* have been suffering a number of damages over the years. We considered four types of natural hazard-led damages: land loss,<sup>7</sup> livestock loss, physical asset loss (i.e., fishing gear, boats, and bicycles), and physical injury. The results suggest that during the last two decades, households had suffered relatively more physical asset losses over the other above-mentioned losses. In addition, slightly over 53 % of the sampled households incurred land loss during the last decade due to natural hazards that triggered river erosion. Even during tropical cyclone *Aila*, the percentage of households which suffered land loss (especially for income-generating activities) significantly and systematically differed with those who did not incur any land loss ( $\chi^2(1)=16.33$ ,  $p<0.001$ , effect size<sup>8</sup>=0.42). A comparison among different hazard-led losses incurred by sampled households is presented by Fig. 9.4, which shows a trend of higher land loss and physical asset losses over the past two decades. The average annual economic damage due to natural hazards incurred by a household was estimated at US\$ 177 ( $\pm 33.5$ ). Economic damage also significantly and systematically differed between the sampled households who suffered at least two of the mentioned hazard-led damages ( $z=5.81$ ,  $p<0.000$ , effect size=0.39).

<sup>7</sup>Excluding transfer of the landownership to cope with ex post hazard shocks.

<sup>8</sup>This implies the power of a repetitive measure design. We divided the entire sample into two groups (poor and non-poor) where “systematically” refers to the effect size (i.e., power) of the repetitive measure, which is shown by point-biserial ( $r$ ) where 0.2, 0.5, and 0.8 refer to small, but not trivial, medium, and high effect size, respectively. For a detailed explanation, see Field (2005).



**Fig. 9.5** Changes in (a) landownership and (b) occupation pattern over the last two decades (Source: Field survey 2010)

### 9.5.4 Trends in Landownership Patterns

Results from the survey suggest that the direct and indirect effects of extreme events appeared to affect the households' landownership. A comparison of landownership patterns during 1991/1992, 2000/2001, and 2009/2010 clearly indicates the gradual increase of landless households (i.e., 0-acre group) over the last two decades (Fig. 9.5a) when percentage of such households had been increased on average by 8.21 ( $\pm 3.22$ ). The number of very small holdings (0.1–1.0 acre) had also been increased by on average 10.35 ( $\pm 2.03$ ) %. Interestingly, this group (i.e., 0.1–1.0 acre) of landowners were found more in contrast with the other groups, although since 2000 this group had increased acutely. The other groups of landowners (up to 2, 3, 4, and 5 acres), as shown by Fig. 9.5a, also persisted during the last two decades; however, these groups were decreased in percentages on average by 9.29 ( $\pm 1.08$ ), 3.21 ( $\pm 0.65$ ), 3.33 ( $\pm 0.21$ ), and 2.74 ( $\pm 0.38$ ), respectively. The households experienced severe unevenness in their ownership patterns since the latter part of 2007 when two consecutive tropical cyclones in 2007 and 2009 caused colossal damage to local socioeconomic infrastructure. Both the FGD participants and interviewed households mentioned that the immediate effects and short- and long-term impacts of tropical cyclones, storm surges, and floods contributed substantial damage due to riverbank erosion that eventually forced the relatively small landholders to sell their remaining lands to cope with the diversified hazard shocks. This phenomenon seemed to make the landownership patterns more unequal over time.

### 9.5.5 Trend in Occupational Pattern

We identified six major occupations of sampled households over the last two decades as shown in Fig. 9.5b. The adverse impacts of different catastrophes forced

the households to change their occupations. Results indicated that cropping-related occupations started declining by slightly over 12 % at the end of the 1990s and continued until 2010 when it finally reached a point just below 40 %. Fishing had been very common for the households, and findings showed that an increase of slightly over 49 % took place over the 1990s. However, during the period of 2000–2010, it decreased by more than 50 %. For small business related occupations, a robust growth was found during the 1990s, but this trend fell down to less than 40 % during 2000–2010 period. The number of daily laborers involved in cropping or fishing decreased on average by around 29 % over the last two decades. The most notable change in occupational patterns took place with forest resource collection-oriented occupations, which implies an increase of about 81 % during the 1990s, and during 2000–2010 this rate became nearly 400 %. Such a dramatic increase appears to have been caused by a higher degree of dependence on resources extracted from the SMF. As examples of forest resources, small wood logs, honey, wax, and nipa palm (*Nypa fruticans*) were considered in this study. A rise in small business occupations was also found in the study location which appeared to be a forward linkage activity of the forest resource collection-oriented occupations.

### 9.5.6 Consumption Dependency

Over years the impacts on livelihoods have been exacerbated by diverse climatic extreme events (i.e., natural hazards). As a result, people's livelihood opportunities were reported to be squeezed over the last two decades, which seemed to affect both their income and consumption. We assessed the relationship between households' consumption and different socioeconomic parameters including the degree of access into the SMF by estimating regression models. The model results suggest a significant inverse relationship between households' dependency ratio and consumption. We found that one additional year deviation in households' schooling (i.e., education) above the average significantly lessened their average consumption. Loss of land was also likely to decrease the households' average consumption.

The average consumption significantly and systematically differed for households living near (within 4 km.) as opposed to away (more than 4 km.) of the forest before and after cyclone *Aila* occurred (for 2008:  $z = 5.71$ ,  $p < 0.000$ , effect size = 0.3; for 2009:  $z = 5.68$ ,  $p < 0.000$ , effect size = 0.29). With regard to access frequency inside the SMF, regression models imply a significant positive association between the households' average consumption and their access frequency in the SMF. Especially after cyclone *Aila*, households accessing into the SMF 3 days, 4–5 days, and more than 6 days a month escalated their consumption significantly by 0.98 %, 1.08 %, and 1.13 %, <sup>9</sup> respectively (Table 9.5). In contrast, before the

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<sup>9</sup>In explaining the log-linear coefficients from Table 9.5, “ $(e^{\beta} - 1) \times 100$ ” is applied where  $\beta$  refers to the concerned regression coefficient.



**Table 9.5** Regression results

Variables	CBN2008 <sup>a</sup> (in log)	CBN2009 <sup>a</sup> (in log)
Household size	-0.0156 (0.0135)	-0.0165 (0.0134)
Dependency ratio in household	- 0.0938*** (0.0320)	- 0.0919*** (0.0315)
Age of the household head	- 0.00199 (0.00313)	- 0.00157 (0.00310)
Standard deviation of schooling years for household members	- 0.135*** (0.00805)	- 0.136*** (0.00785)
Social capital	0.00326 (0.00278)	0.00313 (0.00275)
Land loss (1=yes; 0=otherwise)	- 0.0107*** (0.0015)	- 0.0108*** (0.00187)
Member of NGO (1 = yes; 0 = otherwise)	0.000251 (0.0460)	- 0.00565 (0.0454)
Access 1 (very rare) <sup>b</sup>	0.00977 (0.00658)	0.00984 (0.10589)
Access 2 (rare) <sup>b</sup>	0.00976 (0.00656)	0.00985* (0.00588)
Access 3 (frequent) <sup>b</sup>	0.0106*** (0.00163)	0.0107* (0.00587)
Access 4 (very frequent) <sup>b</sup>	0.0111* (0.00655)	0.0112** (0.00587)
Constant	5.398*** (0.101)	5.402*** (0.0992)
Observations	417	417
R-squared	0.488	0.501

<sup>a</sup>Three observations of schooling years containing outlier values were eliminated from data

<sup>b</sup>The baseline level is for the group who never accesses into the SMF

Standard errors in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

cyclone, households with very frequent access (i.e., more than 6 days a month) escalated their average consumption significantly by 1.12 %. No significant difference was obtained for social capital, NGO membership, age of the household head, and household size in relation with consumption.

## 9.6 Discussion on Major Findings

The empirical findings indicate that after cyclone *Aila*, the percentage of poor households was increased from 70 to 79 ( $\chi^2(1) = 160.49$ ,  $p < 0.000$ , effect size = 0.12). At the same time, the adverse impacts of the said catastrophe resulted in narrower livelihood-earning opportunities, which finally led to an acute income shock to affected households. Different damages, namely- land loss, livestock, and physical assets and physical injuries, were found to be the key contributors in reducing income opportunities. These damages had been incurred over the last

two decades and mostly originated from the increasing frequency of climatic extreme events as reported by the sampled households. In addition, severe damages by cyclones and their impacts to important socioeconomic infrastructure such as road networks, culverts, embankments, academic institutions, and local health complexes affected the essential lifelines of the local people. As a consequence, the affected people were likely to suffer mid-term and/or long-term economic depression with a very small scope of coping with the shocks.

In the situation of natural hazard-triggered economic recession, households reported to cope with income shocks by adjusting their consumption, which eventually forced them to look for an alternative source(s) of livelihood. Slightly over 59 % of the households mentioned that until 2 months after cyclone *Aila*, they could manage their consumption by utilizing the post-hazard reliefs (e.g., food and cash). However, as the recession lingered, these households opted to sell part of their livestock (i.e., mostly cattle and poultry). Simultaneously, they kept availing the possible source(s) to smoothen their consumption even at a lower level. However, as the shock persisted for more than 4 months, they failed to avail anything from the existing possible sources to maintain their critical minimum level of consumption and eventually started looking for common resources in their immediate vicinity. Given this background, these households preferred accessing the SMF to collect resources and sell those to the local market and thereby smoothen their consumption expenditure. Considering this scenario, an important message can be obtained from Fig. 9.5b implying that over the last two decades, households in the study location gradually became resource collectors in the SMF. We identified several driving forces behind such forest resource dependency of households. First, the households depending on cropping and fishing suffered a series of hazards such as flash floods, storm surges, and soil salinity intrusion over the last decades, and next they had lost their livelihoods which forced them to switch over to nonagricultural activities, and eventually they became involved in forest resource collection. Second, more than 90 % of the sampled households depended on own land for their main income and had lost land either partially or completely over the last two decades which prompted them in resource collection from the adjacent SMF. Lastly, households incurred either a complete or partial loss of their livestock, together with damage of their physical assets (e.g., fishing gear) due to the catastrophes, and became asset poor which ultimately forced them to depend on common pool forest resources of the Sundarbans. Results from the regression outputs in Table 9.5 (Accesses 2, 3, and 4) are consistent with the aforementioned scenario implying that during ex post *Aila*, affected households opted for more frequent access into the SMF to smoothen their consumption.

The concerned results from Fig. 9.5b and Table 9.5 suggest that the coastal people affected by extreme events appeared to depend on resources of the SMF. Findings from the survey indicated that during the 2009/2010 period, slightly over 59 % of the sampled households depended solely on the Sundarbans for their livelihoods, whereas the concerned percentages were around 12 and 6.5 during the 2000/2001 and 1991/1992 periods, respectively. Dividing the 1991–2010 time period into two segments, our results show that during the former segment

(1991–2000), an additional 5 % of the households became involved in resource collection from the SMF, while in the latter segment (2001–2010), an additional 47 % sampled households started depending only on forest resources for their livelihoods.

The concerned Forest Department (FD) reserves the rights over the resources of the SMF either to extract or utilize those resources on the basis of previously given property rights and regulations. In addition, part of the forest that shares a border with our study location was declared as a protected area (PA). However, our empirical results show that irrespective of the damage incurred by hazard-affected households, the frequency of their access into the SMF did not differ significantly and systematically ( $z = 0.653$ ,  $p < 0.514$ , effect size = 0.093), and they kept depending on this forest at an alarming rate over the last two decades. Furthermore, households that accessed into SMF frequently (i.e., more than 3 days a month) were more likely to be acquainted with the local social elites ( $\chi^2(1) = 2.05$ ,  $p < 0.041$ , effect size = 0.61). These social elites were reported to have substantial influence on the routine functions of local FDs, especially on their monitoring over peoples' access to the SMF. Again, the poor households were more likely to access the SMF more frequently ( $\chi^2(4) = 61.7$ ,  $p < 0.030$ , effect size = 0.36).

## 9.7 Concluding Remarks and Policy Recommendation

Regarding the two key questions of the households' dependency on resources of the SMF for their livelihoods, and the relationship between their consumption and degree of access into SMF, we conclude that the adverse impacts of climatic extreme events in the form of natural hazards reduced the available livelihood opportunities in *Koyra*, which invoked long-term income shocks. This situation seemed to force the households depending on resources from the SMF to cope with the shock through consumption smoothening. Our empirical findings imply that sampled households had been accessing the SMF frequently over the last two decades; however, after tropical cyclone *Aila*, their access frequency escalated at an alarming rate, which indicates the degree of nexus between peoples' livelihood strategies and their resource dependency pattern from the SMF.

Such an increasing rate of access frequency puts a big question on the existing property rights and government regulations for forest resources, which is supposed to be taken care of by the concerned FDs. Over the past decades, the property rights of the SMF have led to an ambiguous situation in that forest-dependent communities are recognized as important stakeholders for resource conservation and they have continued their livelihoods in various levels of dependency on the SMF, while the state has remained the main holder of property rights, but does not enforce these rights (Roy 2014). Households reported to be significantly unaware of either property rights or the regulations of the government when using forest resources. Instead, they maintained a good relationship with the social elites, who appeared to manage the local FDs by exercising their political or local influence, for securing

access into the SMF. Based on the empirical findings on forest access frequency of households considering property right regimes and government regulations, the current resource stock of the SMF is very likely to be at stake due to its continuous extraction which could eventually jeopardize the ecosystem and biodiversity of this forest. Most resources of SMF are renewable, but over-extraction of resources through higher degrees of access into it seems to propagate the crossing of a critical minimal level for the regeneration of the SMF's resources. Thus, a good number of SMF's species are likely to become extinct in the near future. This scenario is consistent with study findings by Iftekhar and Islam (2004), Getzner and Islam (2013), and Islam (2014). Due to the existing scenario, not only is the government losing a substantial amount of revenue, but also the sustainability of this forest is very likely at risk.

In order to ensure the sustainability of both the ecosystem and the biodiversity of the SMF, we propose the following policy recommendations on the basis of the empirical findings, FGD participants' opinions, and discussion with local experts. First, the existing property right regime and its associated legal framework need to be revised and incorporated in the current forest act of the SMF. Second, the capacities of the concerned FD offices along the border of the SMF have to be enriched by providing the required manpower, communication equipment, discretionary power for decision-making up to a certain degree to overcome influence of the local elites, and other required logistics so that they can monitor and control the access of people into the forest. Third, a scheme of comanagement can be offered by the local FD offices to the adjacent communities where benefits obtained from the forest can be shared between the parties, which will at least ensure optimal extraction of forest resources and its sustainability in the long run. Finally, safety-net programs should be offered to poor and marginalized coastal households in the proximity of the SMF so that they gradually reduce their dependency on the forest resources for their livelihoods. Proper implementation of the aforementioned policy recommendations would ensure a "win-win" situation for all the stakeholders in the SMF through households' compliance with the existing property right regime and guaranteed livelihood support, a rise in revenue collection for the government, and environmental sustainability for this mangrove forest.

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