Managing the Sundarbans region: opportunities for mutual gain by India and Bangladesh

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Abstract: The Sundarbans is managed separately by India and Bangladesh, but from ecological and socioeconomic perspectives the region is a single unit. Results from household surveys in each of the countries as well as the literature demonstrate the region's unity. Mutual advantages could flow from closer binational cooperation in managing the Sundarbans in several areas, such as disaster management systems, forest management to improve relationships with forest-dependent communities, and conservation of the Bengal tiger. Such collaboration has started, but government-to-government progress has been slow. Fruitful results have been obtained recently by civil society organisations with support from international aid organisations.

Keywords: South Asia; Bangladesh; India; Bengal; Sundarbans; household surveys; sea level rise; environmental management; disaster management systems; forest management; international cooperation.

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1 Introduction

The Sundarbans, which lies in India (about 40% by area) and Bangladesh, was a single entity until the partition of India in 1947; Bangladesh emerged as a nation state in 1971. The Sundarbans in India together with the Sundarbans Impact Zone (SIZ) in Bangladesh is home to about 6.5 million people. About 4 million of them live in India. The area lies within the State of West Bengal in India and the Khulna Division in Bangladesh (see Figure 1). The region, which contains the world's largest mangrove forest, is a significant reservoir of biodiversity. It is also home to some of the most poverty-stricken people on earth. The population and the ecological integrity of the forest are threatened by a diverse set of factors which are discussed in the literature review herein.

Figure 1 Sundarbans Region of India and Bangladesh (see online version for colours)

This paper uses the literature and surveys of more than 4,300 households to demonstrate that the region is unified from cultural, socioeconomic and ecological perspectives and, until 1947, from political and historical perspectives as well. It also demonstrates that despite these unifying factors, the region is planned and managed by agencies in India and Bangladesh that have made only limited progress in coordinating their efforts. We were motivated to prepare this paper because of a lack of attention (by planners, policy makers and development scholars) to the Sundarbans as a unified system that would benefit from greater bilateral collaboration in regional planning and management. The literature contains a gap in that it does not elaborate on the potential gains that could result from enhanced binational cooperation in managing the region. This paper

contributes to the literature by filling that gap, and in doing so it also explains why bilateral collaborative projects have not progressed as quickly as some had hoped. Another contribution of the paper is the empirical data it presents to enhance an understanding of Sunderbans' inhabitants and their responses to extreme weather-events that are common threats in the region.

2 Literature review

The common cultural history of the Sundarbans in India and Bangladesh is well established in the literature and therefore will not be elaborated here (Bhattacharyya, 2011; Chakrabarti, 2009; Eaton, 1993). As a whole, the Sundarbans is part of the area known historically as Bengal, which is formed by present-day Bangladesh and the Indian state of West Bengal as well as parts of other Indian states. The Sundarbans region has been inhabited since at least the 4th century BC (Mandal, 2003). The modern intensification of land use started with the trading posts of the English East India Company in the 18th century and continued under the rule of India by a Governor-General appointed by the British in the 19th century (Gupta, 1962).

2.1 Commonalities in threats faced by the region

The portion of the former Bengal that constitutes the Sundarbans remains united by a shared language (Bengali or Bengla). The people of the Sundarbans also have a common cultural heritage. Moreover, until 1947 when the British withdrew from the area, they also shared a political history. In addition to having these things in common, both the Indian and Bangladesh Sundarbans face a number of similar challenges and threats. These include major cyclonic storms, such as those that hit the Bangladesh Sundarbans in 2007 and 2009, and the West Bengal side in 2009. Cyclones in the region can be severe, with some having wind speeds of over 200 km/h (Karim and Mimura, 2008). Some researchers believe that such extreme-weather events are expected to intensify as a result of climate change (Hoyos et al., 2006; Indian Network for Comprehensive Climate Change Assessment, 2010). The high winds and storm surges associated with cyclones cause loss of life as well as devastating effects on homes, crops, and livestock (Bhunia and Ghosh, 2011; Paul, 2010; Penning-Rowsell et al., 2013). Damages have been intense, in part, because households living in poverty have limited means to prepare for cyclones in advance and cope with them when they occur. Storms severe enough to breach embankments (built to prevent flooding) have also caused longer term impacts, including higher salinity in soils and water, and disruptions in drinking water availability.

Sea level rise is another threat faced by both parts of the Sundarbans. Consequences of sea level rise include land inundation and, among other things, decreased suitability of water for drinking, and diminished agricultural productivity as a result of increased salinity intrusion and waterlogging (Awal, 2014; Bhuiyan and Dutta, 2012). More generally, the impacts of sea level rise and other aspects of climate change have already had significant adverse effects on the mangrove forest and the water supplies and livelihood options of Sundarbans' residents (Rasid and Paul, 2014).

Other threats concern the growth of aquaculture, particularly shrimp farming. Sundarbans residents on both sides of the border use practices for harvesting shrimp

larvae for aquaculture that have caused significant damage to aquatic ecosystems (Ahmed and Troell, 2010; Islam and Ahmad, 2001; Sarkar and Bhattacharya, 2003).

The Sundarbans is one of the most bio-diverse ecosystems in South Asia, with high levels of floral and faunal diversity, including numerous threatened species, such as the Royal Bengal tiger, estuarine crocodile, Indian python, and several species of river dolphins (Danda, 2007; Gopal and Chauhan, 2005). The region has about 300 species of trees and herbs and roughly 425 species of wildlife (Cornforth et al., 2013). In the past, government interventions to protect biodiversity have been ineffective, and other government actions have directly or indirectly led to ecosystem degradation (Biller and Sanchez-Triana, 2013).

The two parts of the Sundarbans are a single ecological unit that faces major threats. The following forces have led to significant adverse effects on the areal extent, ecological integrity and biodiversity of the mangrove forest: sea level rise, salinity increases, land conversion, and non-sustainable resource extraction (Danda, 2007; Giri et al., 2007; Hoq, 2007; Islam et al., 2014). Some parts of the region are losing up to 200 metres of coast annually (Cornforth et al., 2013). Pethick and Orford (2013) argue that the rate of increase in high water maxima, which they refer to as 'effective sea level rise' (ESLR), is the appropriate measure of sea-level change as a threat to embankments in the Sundarbans, where levels of tidal creeks have been influenced by embankment construction. They estimated ESLR for parts of the Bangladesh Sundarbans: "The combined impact of land subsidence, eustatic sea level rise, tidal range amplification and a decrease in fresh water input results in an average rate of increase in ESLR in the Pussur Estuary of 14.1 mm a–1 rising to 17.2 mm a–1 in the densely populated Sundarban Impact Zone at Kuhlna" [Pethick and Orford (2013), pp.244–245]. Diminution of the mangrove forest is likely to make matters worse because the forest provides a biological shield that buffers the inland areas from the destructive effects of cyclonic storms. Another dimension of sea level rise is the diminution of tiger habitat, which threatens the survival of the Royal Bengal tiger and has led to increases in the number of dangerous (and sometimes fatal) human-tiger interactions (Loucks et al., 2010).

2.2 Differences in disaster management programs

Given that devastating cyclonic storms and associated floods are common in the Sundarbans, both West Bengal and Bangladesh have disaster management programs in place. Both programs include elements such as warning systems, shelters and emergency relief. While there are similarities, the program in Bangladesh is arguably superior in effectiveness.

In response to recurrent cyclones during the past 50 years, Bangladesh has implemented disaster management programs that have significantly reduced cyclone-related deaths. Disaster management activities have included: a modernised system to forecast cyclones and provide early warnings, campaigns to raise community awareness of cyclone warning systems, and construction of multi-purpose cyclone shelters. Today, Bangladesh's early warning system, although not without its challenges, is viewed as an example of a community-based program that takes advantage of indigenous knowledge for disaster risk reduction (Habiba et al., 2013). Established in the aftermath of Cyclone Bhola in 1970, the program covers 13 districts in the coastal areas and involves close to 60,000 cyclone response volunteers who provide the public with weather information in

advance of a cyclone landfall. Volunteers also implement evacuation orders and direct the public to cyclone shelters.

The role of the Government of Bangladesh is also notable. When cyclones form in the Bay of Bengal, the Bangladesh Meteorological Department monitors their intensity and projected landfalls and issues daily bulletins, which are transmitted to relevant agencies, media outlets and the public. Habiba and Shaw (2012) characterise the cyclone risk management approach in Bangladesh as both unique and remarkable and argue that it can be adopted elsewhere in South Asia.

In West Bengal, by comparison, early warning systems are still in their early stages of development. Given that West Bengal's coastal area remains at risk of high intensity cyclones, the state's limitations in disaster management are notable. In West Bengal (and India more generally), the disaster management framework is more vertically integrated and centralised than in Bangladesh, and it has a comparatively weaker interface with communities. Communication of cyclone events to communities is expected to be coordinated through district magistrates' offices and local authorities. There appears to be no equivalent to the well-organised volunteer structure and door-to-door communication efforts found in Bangladesh. Shortfalls in India's cyclone risk management system have been detailed in a number of studies (DRCSC, 2012; Mirza, 2003; Revi, 2008).

2.3 Forest management programs

Both countries face common forest management problems in the Sundarbans: poaching of tigers and other wildlife; encroachment on forest land and forest resource exploitation; human-tiger conflicts; damaging shrimp farming activities (particularly bi-catch issues in obtaining shrimp larvae); fish stock reductions due to overfishing; increased soil and water salinity; and threats linked to global climate change, especially sea level rise (Islam et al., 2014; Loucks et al., 2010; Rahman et al., 2010).

The forest management issues in Bangladesh are compounded by the inhabitants' lack of confidence in the Bangladesh Forest Department. It has been argued that causes of illicit tree felling include: "(i) a lack of cooperation between management authorities and neighboring forest-dependent communities and (ii) corruption within the forest managers" [Biswas and Choudhury, (2007), p.637]. In addition, based on a survey of 412 households in forest dependent communities, Roy et al. (2013) determined that 92% of respondents felt that corruption in the Bangladesh Forest Department was the primary reason for rapid forest degradation over the past 30 years. The role of corruption in the illegal logging of trees (particularly the *Sundari*) in the Bangladesh Sundarbans has also been described by Rahman (2011).

The situation in West Bengal is different. As the first state in India to use a joint government-community forest management strategy, West Bengal has had some success in defusing once tense relations between the West Bengal Forest Department and communities living near the forest who depend on forest resources for their livelihoods. Using this strategy, people living near the forest become part of forest management activities, and in return they are allowed to share in forest benefits. Based on a study of joint forest management in West Bengal, Banerjee (2007) found that it led to significant improvements in the relations between the Forest Department and people living on the forest fringe.

2.4 Lack of attention to the Sundarbans as a unified system

Failure to recognise the unity of the Sundarbans region can lead to significant negative outcomes. Arguably, one of the most dramatic illustrations of the adverse effects of inadequate bilateral coordination and cooperation in the Sundarbans involves construction in India of the Farraka Barrage, which has caused adverse effects in Bangladesh in terms of sea level rise and soil and water salinisation, among others (Mirza and Sarker, 2005). The barrage has also had negative consequences in India. Adverse effects in two states within India have been characterised as "huge sedimentation, increasing flood intensity and increasing tendency of bank failure" [Banerjee, (1999), p.5]. The barrage has also had impacts on the fisheries and hydrology of the Hooghly Estuary in West Bengal as well as areas upstream of the barrage (Sinha et al., 1996).

The literature on planning and management for the Sundarbans supports our contention that the Sundarbans has not been viewed as a single region by development scholars. Instead, the common management challenges faced by the two countries in the Sundarbans have been viewed separately. Examples from Bangladesh include Iftekhar and Islam (2004), who discuss management inadequacies and alternatives that may help to conserve the Bangladesh Sundarbans. As another example, Islam (2013) examines barriers to climate change adaptation strategies by Bangladeshi fishing communities. In addition, Islam (2006) looks at management in response to cyclonic storms, but only for Bangladesh. An analogous situation exists for the Indian Sundarbans. For example, Philcox et al. (2010) offer management recommendations aimed at minimising adverse impacts of shrimp aquaculture in the Indian Sundarbans. As another example, Sarkar and Bhattacharya (2003) call for grass-roots public education to help inhabitants in the Indian Sundarbans support resource conservation activities.

The common problems faced by inhabitants of both parts of the Sundarbans together with the varying experiences of management agencies in both countries suggest mutual advantages in bilateral cooperation. Both countries can engage in mutual learning about the effectiveness of management strategies already tried individually as well as possibilities for cooperative management approaches in the future.

3 Data gathering – household surveys

The data used for this paper include two unpublished household surveys implemented in the Sundarbans in 2011 by World Bank staff and local consultants. One survey was conducted in the Bangladesh Sundarbans and involved 2,144 households; the other was conducted in the West Bengal Sundarbans and included 2,188 households. Survey questionnaires were similar in both cases and were administered in person by well-trained enumerators. Questions were grouped into about a dozen categories, such as dwelling type, employment, use of forest resources, migration, use of government disaster management programs during recent cyclones and floods, and household-level changes made to prepare for future extreme-weather events.

In Bangladesh, the household survey was implemented by the Bangladesh Centre for Advanced Studies. The study area consisted of the SIZ, which the Government of Bangladesh defines as the area within 20 km from the boundary of the Sundarbans Reserve Forest. The 2,144 households were selected using a two-stage stratified random sampling approach.

The West Bengal Sundarbans survey was conducted by Economic Information Technology, with participation by Professor Guatam Gupta of Jadavpur University in Kolkata. Here also, households were selected using stratified random sampling. The sample was taken from the two administrative units (called 'districts') within the Sundarbans in West Bengal: the North 24 Parganas district, which contains 22 subunits called 'blocks', and the South 24 Parganas district, which has 29 blocks. Only19 of these 51 blocks are within the Sundarbans.

4 Household survey results

4.1 Religious heritage and language

Although the British partition of predominantly Muslims in the east and predominantly Hindus in the west took place in 1947, those religious distinctions are less striking in the Sundarbans today as Muslims and Hindus co-exist on both sides of the international border. However, the proportions of Muslims and Hindus in each part reflect the historical division. In the West Bengal Sundarbans, 76.3% of surveyed households were Hindu and 23.6% were Muslim. In the Bangladesh Sundarbans, the proportions were almost reversed: 81.8% of the households were Muslim and 16.8% were Hindu. In both parts of the Sundarbans, survey results indicate that in times of emergency, religion does not influence the great majority of households willingness to assist neighbours in need. When asked about whether they would be willing to offer emergency assistance to other households after a natural disaster "no matter what religion members in the household belong to", 76.9% of surveyed households in West Bengal agreed as did 81.0% of those in Bangladesh.

Surveyed households on both sides of the India-Bangladesh border have similar views about their religious faith in times of natural disaster, although expressions of faith were somewhat more prevalent in the Bangladesh Sundarbans. When presented with the statement that "when a natural disaster affects my household, it is punishment from God/Allah", the majority of respondents in both countries agreed: 51.1% of the households in West Bengal and 83.2% for Bangladeshi households. Similarly, the majority of surveyed households in both countries agreed that "when a natural disaster affects my household, I find comfort in my religious faith": 69.3% of households in West Bengal and 90.3% of Bangladeshi households.

Literacy statistics in both parts of the Sundarbans are similar in terms of the percent that can read and write in Bengali only, but higher in Bangladesh for people who can read and write in both Bengali and English. Details for West Bengal are as follows: 38.9% of members of surveyed households can read and write in Bengali only, and 38.6% can read and write in both Bengali and English. Corresponding figures for members of surveyed households in Bangladesh are: 27.1% can read and write in Bengali and 52.5% can read and write in both Bengali and English.

4.2 Socio-economic characteristics

Socio-economic characteristics of households on both sides of the border are similar. In the West Bengal Sundarbans, households face high poverty levels and experience social marginalisation. Over 55% of the surveyed households in West Bengal belong to

scheduled castes and another 6% belong to scheduled tribes. Nearly 43% are officially classified as being below the poverty line. About 68% of the households lived in one room, non-permanent dwellings with mud floors, and the average family size was 4.6. All surveyed households in the Indian Sundarbans reported that at least one household member owned or cultivated land and paddy rice was the most commonly grown crop. Land holdings are small: about 55% of households owned less than 0.20 acres (0.081 hectares).

Survey results from the Bangladesh Sundarbans are generally similar. Households are poor, with average annual household income below 1400 US dollars. About 40% of the surveyed households occupied non-permanent dwellings; and nearly 83% had only a single room and most had floors of mud or soil. The average number of persons per household was about 4.3, slightly lower than in the West Bengal Sundarbans. About 85% of surveyed households owned or cultivated land. As in West Bengal, paddy rice was the most common crop. The average landholding size per household was 0.94 acres (0.38 hectares) and the median value was 0.30 acres (0.12 hectares). Landholdings are generally larger than in West Bengal, where the majority of households owned less than 0.20 acres (0.081 hectares). Respondents noted that crop yields have been falling as a result of increased salinity in water applied to fields and in groundwater. About 24% of households that once cultivated paddy shifted to growing shrimp and/or fish after paddy fields became inundated by saline water.

Many Sundarbans residents on both sides of the India-Bangladesh border rely on the mangrove forest. When asked about use of the forest, 18.0% of surveyed households in West Bengal indicated that household members used the forest for fishing and 43.4% used it for crab fishing. In the Bangladesh Sundarbans, 31% of respondents indicated that members used the forest for fishing only, and another 28.7% used it for both forest and fishing-related activities. Surveyed households on both sides of the border used the forest for honey collection, and more than 90% of surveyed households in both countries said they would not use the forest if they had other options.

4.3 Out-migration in response to cyclonic storms

Migration has been a strategy for coping with climate-related pressures in India's Gangetic plains for centuries (Gupta et al., 2006). The household surveys probed the migration issue. Results for West Bengal show that 31.7% of residents in surveyed households moved in search of work after Cyclone Aila. Of the total number of household members who migrated, 19.4% went to Kolkata, 8.2% went outside the Sundarbans to places other than Kolkata, and 4.1% migrated to places within the Sundarbans. More than 98% of those who migrated did so to find better employment opportunities.

For the households surveyed in Bangladesh, 18.9% had one or more members migrate to other places following the cyclone(s) and/or flood(s), and most did so to find employment. About 36% of the Bangladeshi migrants went to other locations within the SIZ. Other major destinations for the migrants included: Khulna City (13.6%), Dhaka (11.6%), and other parts of the Khulna District (7.1%). About 25% migrated to other locations within Bangladesh, and fewer than 3.5% migrated outside of Bangladesh.

The recent extreme-weather events in the Sundarbans have led to significant temporary migration, but household survey data in both West Bengal and Bangladesh showed no statistically significant relationships between cyclones and floods and

permanent migration. These migration-related findings are consistent with results of work with focus groups by Penning-Rowsell et al. (2013) in rural Bangladesh. They found that, except when places become permanently uninhabitable (e.g., soil salinisation makes farming impossible), people may migrate temporarily in the face of natural disasters, but they frequently return to their villages because that is where they have dwellings, sources of food and social networks. In addition, rural dwellers in their study were aware of the challenges of permanently relocating in unfamiliar and sometimes dangerous urban areas.

4.4 Household responses to adverse weather-events

Most surveyed households in Bangladesh have not improved significantly their preparation for future adverse weather events. In comparison to the five years before the survey, about half (50.2%) of the surveyed households said they were 'barely' in a better position and nearly a quarter (23.6%) said they were not better prepared at all. Only 4.6% of surveyed households said they were 'fully prepared'. The most common preparatory measures included: engage in rain water harvesting (72.8%), store more food during flood seasons (45.9%); accumulate savings (41.0%); make dwelling more resilient to floods (35.3%); and reduce reliance on agriculture (20.0%). For West Bengal, the survey results regarding preparation for future adverse weather events indicate even less attention to preparedness. Approximately 80% of the surveyed households in West Bengal said they were either not at all better prepared (42.8%) or 'barely' in a better position (39.5%) to deal with future adverse weather events. Only 3.3% of surveyed households said they were 'fully prepared'. In contrast to Bangladesh, where the vast majority of responding households had taken at least one preparatory step, a large fraction of the households in West Bengal had taken no steps to prepare.

The household survey results also signal the relative performance of disaster management systems. Among households affected by a major cyclone or flood during the 2006–2011 period, 73.4% of households in Bangladesh were notified of the event beforehand versus only 3.6% in West Bengal. Notwithstanding the striking differences in percent of Bangladeshi and Indian households notified of the extreme-weather event, the percentages of surveyed households that evacuated their homes were similar: 58.6% in Bangladesh and 55.4% in West Bengal. Of the Bangladeshis who evacuated, 25.8% went to shelters (and 10.1% went to schools) compared to West Bengal, where only 2.2% of those who evacuated went to shelters (and 26.0% relocated to schools). In both parts of the Sundarbans, many evacuees went to the nearest embankments or elevated roads: 22.9% in Bangladesh and 42.8% in West Bengal. These are among the most exposed places during cyclonic storms.

5 Bangladesh-India collaboration in the Sundarbans

The region's unity, demonstrated by the above-described household survey, provides a foundation for pursuing the goal of achieving mutual gains for Bangladesh and India by more extensive cooperation and coordination. Below we consider the ways and means for creating these mutual gains.

The following two bi-national agreements, signed in 2011, have created opportunities for cooperation: the Memorandum of Understanding on Conservation of Sundarban ['the MOU', Governments of Bangladesh and India (2011a)]; and the Protocol on the

Conservation of the Royal Bengal Tiger of the Sundarban ['the Protocol', Governments of Bangladesh and India (2011b)]. The actions facilitated by these agreements are as follows:

- *Joint tiger census* – The MOU indicates a commitment to "organize joint tiger estimation at regular intervals" (Governments of Bangladesh and India, 2011a).
- *Human-tiger interactions* – The Protocol calls for creating a "special committee … in each country to examine human casualties that take place in the Sunderban by tiger attacks with a view to sharing experiences from either side, and to act in consultation with the other side, if necessary" (Governments of Bangladesh and India, 2011b).
- *Control of poaching* – The MOU mandates "[e]xecution of patrolling exercises by the Forest and other relevant Officials of both the Parties along the respective borders to prevent poaching or smuggling of derivatives from wild life" (Governments of Bangladesh and India, 2011a).
- *Information exchanges on forest management* – The MOU indicates a commitment to "[p]romote… exchange visits of Forest Officials of field level in order to better understand and share ideas and problems of management, biodiversity conservation, climate change adaptation and promotion of sustainable socio-economic development, and ecotourism" (Governments of Bangladesh and India, 2011a). The Protocol reinforces this with a call for "Forest Officers or Park Directors from both the countries [to] hold periodic meetings on either side of the Sunderban alternately, with a view to sharing management strategies and creating innovative and common management approaches." (Governments of Bangladesh and India, 2011b).
- *Training of forest management staffs* – The MOU calls for the "exchange [of] personnel for training and promotion of education in forestry, including at the Wildlife Institute of India, Dehradun financed by the Government of India." (Governments of Bangladesh and India, 2011a). Moreover, the Protocol mandates the reservation of "at least four seats for personnel from Bangladesh in the nine months Diploma Course at the Institute" (Governments of Bangladesh and India, 2011b).

The MOU and Protocol establish plans and aspirations for joint work, but formal action in response to the MOU and Protocol has not come as rapid as some had hoped. It is taking time to establish efficient procedures for formal communication between government officials in Bangladesh, India and West Bengal. While the formal, government-to-government collaborations in the Sundarbans have been unsteady, the MOU and the Protocol represent progress in the context of the sometimes fractious relations between India and Bangladesh. Many contentious issues are being addressed by the two countries (Bhattacharjee, 2012). In their negotiations, the Governments of India and Bangladesh have not given the Sundarbans the same high priority as some of the issues recently subject to discussion, such as the treaty on sharing of the Teesta River waters, and an agreement regarding an exchange of near-border 'enclaves'; i.e., parcels of Indian and Bangladeshi territory surrounded completely by the other country's land. As these high priority issues are resolved, increased priority is expected for bilateral cooperation on the Sundarbans.

Notwithstanding the halting progress of government-to-government collaborations, possibilities for mutual gains through collaboration have been pursued recently by civil society organisations and international aid agencies. Illustrative examples include:

- *Biodiversity characterisation* – With support from the World Bank, Indian and Bangladeshi scientists – in cooperation with WWF and the International Union for Conservation of Nature (IUCN) – have been working on a soon-to-be completed set of volumes that characterise the state of biodiversity in the entire Sundarbans.
- *Environmental flow assessment* – Collaborators from the School of Oceanographic Studies at Jadavpur University (Kolkata), the Indian Institute of Technology (Roorkee) and the Centre for Environmental and Geographic Information Services (Dhaka) are developing estimates of the quantity, quality and timing of fresh water flows in the Sundarbans needed to maintain navigation as well as the ecosystem. Maintenance of the ecosystem is being measured by the ability to support three indicator species: Gangetic dolphins; Sundari trees; and Hilsa shad (*Tenualosailisha*). This is part of an IUCN initiative supported by the Government of the Netherlands (International Union for Conservation of Nature, 2012).
- *Fisheries management* – As a result of joint research by scientists at the University of Dhaka and the School of Oceanographic Studies at Jadavpur University, the Government of West Bengal instituted a ban on fishing for Hilsa shad that was broadly consistent with a ban that had been underway already in Bangladesh. This effort is helping to stabilise what had been the diminution of the Hilsa shad population as a result of overfishing in the Sundarbans and surrounding waters (International Union for Conservation of Nature, 2014).

Collaborative efforts are also being moved forward by the South Asia Water Initiative (a multicounty partnership supported by the UK, Australia and Norway and the World Bank), which held its first Sundarbans Consultation Meeting in June 2014 in an effort to further encourage multi-stakeholder dialogue.

6 Conclusions

The Sundarbans is clearly a single ecosystem, but it is also unified in other ways. The household survey data presented herein demonstrates that the region's inhabitants on both sides of the India-Bangladesh border are similar in terms of: cultural heritage; literacy rates and language; livelihood opportunities; and levels of poverty. On both sides of the border, Sundarbans' residents face livelihood challenges that cause them to rely for survival on the use of the mangrove forest in non-sustainable ways; e.g., tiger poaching and illegal logging. Sundarbans' residents in India and Bangladesh also face the threat of rising sea level and cyclonic storms that often overpower defences based on embankments; the resulting floods have caused loss of human life and livestock and destruction of property.

Migration in response to cyclonic storms is common on both sides of the border, but this migration is generally temporary. Analyses of the household survey data in both West Bengal and Bangladesh showed no statistically significant relationships between cyclones and floods and permanent migration. Sundarbans' residents in West Bengal and Bangladesh showed notable differences in terms of levels of preparation taken for dealing

with future cyclonic storms. In contrast to Bangladesh, where the vast majority of responding households had taken at least one preparatory step, a large fraction of the households in West Bengal had taken no steps at all to prepare for the next storm.

In recognition of the potential for mutual gain from cooperation, in 2011 the Government of India and the Government of Bangladesh signed an MOU on conservation of the Sundarbans and a Protocol on the Conservation of the Royal Bengal Tiger. However, formal procedures under the MOU and Protocol are still being established and progress in implementing joint projects has been slow. Nonetheless, some progress has been made (e.g., a jointly produced study on Sundarbans' biodiversity) and more is expected as some of the more contentious issues between the two countries are resolved by negotiations.

Closer cooperation in managing the Sundarbans can provide notable gains for both India and Bangladesh. In terms of government-to-government collaboration, the gains are not yet evident. However, civil society organisations with support from international aid organisations have recently started to engage in bi-national collaborative efforts and some of these (e.g., Hilsa fisheries management) have already demonstrated that significant mutual gains are possible. Future research could profitably be directed toward evaluating the net benefits from bilateral cooperation between India and Bangladesh in the Sundarbans.

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