

Perceptive insight into incentive design and sustainability of participatory mangrove management: a case study from the Indian Sundarbans

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Abstract Incentive design is among the decisive factors behind active community participation and long-term sustainability of participatory forest management. Especially in case of mangroves, where multiple interests apply, it requires a careful integration of several ecological, economic and institutional factors. The primary objective of this paper is to understand the basis of incentive design and make a comprehensive inquiry into the existing incentive mechanism of participatory mangrove management in Indian Sundarbans. The qualitative and in-depth assessment was derived against a conceptual framework that contains three main determinants: (1) resources availability, (2) control mechanism, and (3) perception of end-users. The study deploys the results of various participatory exercises such as structured interviews with forest officials, focus group discussions with 10 Joint Forest Management Committees and semi-structured interviews with 119 mangrove users. In general, we observed an over-cautious, hierarchical and safety-margin-based incentive design with distinct bifurcation of communities over the adequacy and

effectiveness of derived benefits. Although, the incentives are diverse and align well with the overall conservation of mangroves, they are considered to be insufficient by nearly half of the mangrove users. The main issues that were observed to hinder effective community participation can be summarized as (1) serious restrictions on access to economically exploitable mangrove products, (2) passive involvement of vulnerable occupational groups, and (3) lack of trust and conflicting interests between the officials and the communities. Although the existing preventive management of mangroves can be justified considering the magnanimity of the Indian Sundarbans, it can severely impair community participation and emerge as a clear threat to future sustainability. To secure greater participation of the communities, we propose small scale, innovative developmental incentives to supplement traditional forest-resource-based incentives.

Keywords Mangrove conservation · Community based mangrove management · Joint forest management · Community perception

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Abbreviations

EDC	Eco-Development Committee
FGD	Focus group discussion
FPC	Forest Protection Committee
INR	Indian rupees (approximately 1 US\$ = 62 INR as of April, 2015)
JFM	Joint forest management
JFMC	Joint Forest Management Committees
NTFP	Non timber forest products
PCFA	Per capita forest availability
SI	Structured interviews
SFD	State forest department
STR	Sundarban tiger reserve

Introduction

Despite providing nearly 70 valued ecosystem services, globally, mangroves remain at a perilous condition owing to large-scale alteration of its habitats (Dixon 1989; Alongi 2002, 2008; Duke et al. 2007; Sandilyan and Kathiresan 2012). The remaining mangroves continue to suffer from unsustainable use and are feared to disappear completely within the next 100 years (Duke et al. 2007; Ellison 2015). Owing to such a grave scenario and wide adoption of decentralized forest governance policies, participatory mangrove management has been recognized as an ameliorative approach for achieving mangrove sustainability. In the last two decades, many governments and international donor agencies believed that the degeneration of mangroves can be reversed through partnerships between forest administrators and the dependent communities. So far, however, the achievements have been mixed (Datta et al. 2012), in part because appropriate institutional arrangements were lacking and effective benefit-sharing mechanisms failed to motivate the forest-fringe communities. Although there is no empirical generalization of factors leading to the success of participatory mangrove management, Datta et al. (2012) argued that the sustainability of participatory mangrove management revolves around the fulfillment of community self-interest (community well-being), which is best served through appropriate and effective incentives.

Although the mangrove cover has remained steady over the last two decades, there is widespread concern in India over the long-term mangrove conservation, especially under mounting anthropogenic pressure and climate-induced geomorphological changes in the mangrove habitats (Raha et al. 2012; DasGupta and Shaw 2013). Of particular concern is the gradual annihilation of mangrove ecosystem services, which highlights the scope for participatory mangrove management in the country. After the forest policy reform in the early 1990s, the joint forest management (JFM) in India has strongly emerged as a participatory tool for decentralized forest governance. The development of Joint Forest Management Committees (JFMC) as participatory rural institutions is a widely acknowledged cooperative conservation model that aims to improve local livelihood through controlled utilization of forest products (Kumar 2002; Behera and Engel 2006; Bhattacharya et al. 2010; Rishi 2007; DasGupta and Shaw 2013, 2014). Not surprisingly, over the previous years, JFM has evolved primarily as a resource intensive process, and the use of forest ecosystem services as “incentives” still remains a critical design of it.

As argued by Adhikari et al. (2014), an incentive system is the principal variable that affects an individual’s behavior in

the participatory governance of forest resources. Particularly, in developing countries, a number of empirical studies have indicated that the success of participatory forest management is inherently linked with the direct incentives that are provided to the fringing communities based on mutually agreed norms and protocols (e.g. Richards et al. 2003; Suich 2013; Adhikari et al. 2014). The scope of these incentives, however, is broad-based and contextual. Incentives for the participatory forest management can range from financial and technical support, access rights to forest resources, marketing rights for forest products, revenue sharing, tax concession etc. (Devkota 2010). Although the forest provides a number of valued ecosystem services, within the scope of participatory forest governance in developing countries, incentives are primarily derived from the economically exploitable provisioning and/or supporting services of the forest, such as wood, leaves, wax, and tannin. Economic outcomes of certain cultural services, such as tourism or recreational facilities are also often considered as potential incentives for the communities. In majority of the cases, regulating services, such as flood control, carbon sequestration, water purification are not considered as incentives since it is difficult to translate these services into monetary values that can be applied to individuals or groups responsible for forest management. Therefore, the term incentive, as used in this study, refers to the direct benefits provided by the forest departments to the fringe communities in recognition to their participation in cooperative forest management. Within the defined scope of the existing JFM arrangement in India, incentives for the forest-dependent communities are largely derived from the exploitation rights of forest resources such as timber and non-timber forest products (NTFP). These, combined with some direct economic benefits such as small grants or employment opportunities, serve as a potential psychosocial accelerator to ensure effective participation of the communities. Needless to say, the performance of JFM remains primarily dependent on these commercially exploitable forest resources and their implications in economic well-being of the participating communities (Saxena 1997; Paul and Chakrabarti 2011).

Similar to any other inland forests of the country, mangroves along the Indian coasts are also being managed through a combination of protected and jointly managed forest areas, especially in the buffer zones. Although JFM has been vastly credited for halting the massive forest degradation in the country (e.g., Kumar 2002; Behera and Engel 2006; Bhattacharya et al. 2010), understanding its replicability in the densely crowded mangrove habitats is incomplete at present. As argued by Datta et al. (2012), participatory mangrove management characteristically differs from any other community-based natural resource management (CBNRM) because of the uniqueness of

mangroves, its diverse ecosystem services, heterogeneous user groups and various other socioeconomic and governance implications. In particular, sustainability of JFM arrangements for the Indian mangroves is further contested by additional complexities such as highly rewarding alternative uses of mangrove habitats. For example, despite irreversible damage to the coastal environment, alternative uses of mangroves such as conversion to aquaculture ponds are often economically rewarding and serve as a strong motivation for the poverty stricken communities. In addition, mangrove habitats in India are precariously crowded with forest-dependent communities and very often, due to extreme remoteness associated with their existence, ecosystem-based livelihood serves as the only viable source of income generation (DasGupta and Shaw 2013). What it theoretically implies is that the economic share derived from the exploitable mangrove resources may be inadequate or inappropriate as a strong motivator of individuals or groups. Moreover, policy guidelines under the JFM encompass many unresolved issues such as property rights and tenurial security that are not conducive to a participatory environment (Kumar 2002; Pagdee et al. 2006; Bhattacharya et al. 2010; Paul and Chakrabarti 2011). Consequently, we derive a hypothesis that the existing forest-products-based incentives, as have been conventionally used under the JFM arrangement, might be insufficient to infuse a systemically administered behavioral transformation of the fringing communities toward proactive mangrove conservation. In addition, without a systematic understanding of the heterogeneous demands of the mangrove user groups and a rigorous incentive mechanism, sustainability of participatory mangrove management remains under great uncertainty. Consequently, probability of illegal deforestation and alteration of mangroves to other non-forest purposes remain as the single-most pertinent factor endangering mangrove sustainability in future.

Considering the above, here we made a qualitative enquiry whether the current incentives used the JFM arrangements have actually provided the required motivation for the mangrove users and contribute to the socioeconomic sustainability of the forest user communities. The paper also aims to understand whether the existing incentives align well with the ecological carrying capacities of the mangroves that remain crucial for the ecological sustainability of the mangroves. By using various participatory rural appraisal (PRA) techniques, the research principally examines the current incentive mechanism through a proposed resource-control-user (RCU) framework for incentive design and sustainability of participatory mangrove management. In doing so, we aimed to achieve two research objectives. (1) We examined the basis of incentive mechanism for the mangrove-dependent communities,

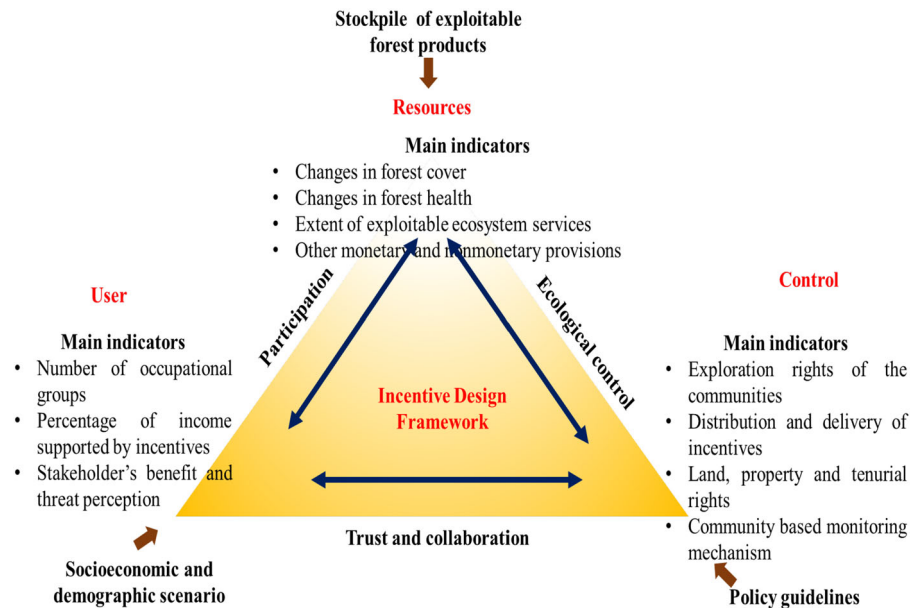
especially by focusing on the offered incentives, institutional and environmental criteria for incentive design and the effectiveness of the incentive delivery mechanism. For this purpose, a set of exploratory research questions were used encompassing a plethora of ecological and governance issues such as trend of resource exploitation, changes in mangrove cover, resource exploitation and delivery mechanism. (2) We then explored and analyzed mangrove users' perception over the adequacy of derived incentives and its contribution in the economic sustainability of the fringe communities. The specific research questions that aim to answer this objective revolves around the understanding of community perception over the derived incentives and understanding of specific economic, psychosocial and governance issues that hinder the effective participation of different mangrove user communities. Field investigations for the study was conducted in the Indian Sundarbans; the largest mangrove forest in the country which coexists with nearly 4.37 million people and fairly represents as an ideal example for complex socioecological system.

Materials and methods

Resource-control-user (RCU) conceptual framework for incentive design

In principle, incentives should be designed out of extensive negotiations between the forest administrators and dependent communities to such an extent that satisfies the economic need of the communities while maintaining the thresholds of sustainable resource exploitation. In addition, incentive design should rely on a sequence of dependent variables that can be broadly represented through the proposed RCU Framework (Fig. 1). As the name suggests, the proposed RCU framework has three major dimensions: resource, control and user. In this section, we argue that these three interlinked dimensions can be used to understand the very basis of incentive design and thereby, useful for examining the long-term sustainability of participatory forest management. Firstly, the term resource, as meant in this study, closely follows the economic definition of resources and relates to the stockpile or supply of materials and other assets that can be drawn by the project implementers to reward the participating communities. Importantly, the notion of resource under the given context differs from the conventional sense of forest resources, since not all the available forest ecosystem services are considered to have potential as an incentive. On the contrary, the capacity of the project implementers to provide direct monetary or other non-monetary rewards may also be regarded within the scope of potential resources.

Fig. 1 Resource–control–user framework for incentive design



Nevertheless, recognizing the customary community dependence on forests, substantial available resources, directly or indirectly, are drawn from the exploitable timber and nontimber forest products. As in the case of JFM in India, commercially exploitable forest products have been extensively used to garner active community participation. In fact, the famous Arabari Experiment, which subsequently led to the much-desired decentralization of forest governance in the county, succeeded by sharing significant forest revenues with the local communities from the rotational felling of *Shorea robusta*. In addition, as shown by Saxena (1997), the diverse NTFPs of *Shorea robusta* paved the way for the development of a community livelihood that ensured the long-term sustainability of the cooperative conservation model. Nonetheless, since these resources are primarily dependent on the forests itself, preconditions such as good health of the forest, consistent production of exploitable products are important variables to account for the available resources. Consequently, the key variables such as forest cover, consistent trend of commercially exploitable ecosystem services remain highly imperative and indicative of a reliable resource.

To restrict overexploitation and to ensure sustainable consumption of resources, state or program leaders often implement a series of control mechanisms overseen by mediators or institutionalized enforcing agencies. Such oversight mechanisms serves as the fundamental components of incentive design that requires careful optimization of ecological sustainability and demands from the local communities. In general, a rigorous qualitative and/or quantitative screening process determines the exploitation limits of the available forest resources. This process,

however, is particularly imperative when the resources are scanty or the demands from the dependent communities are exceptionally high. Control mechanisms are generally governed by federally administrated policy guidelines (as in the case of the JFM arrangement in India) and/or through locally mediated processes. For example, institutionalized community organizations such as JFMCs play an important role in local vigilance. In addition to forest monitoring, JFMCs or similar groups are also expected to act in a way that ensures each stakeholder gets the maximum possible benefit while preserving conservational interests. This practice is achieved through an intermediate negotiating platform. Therefore, structural representation of different forest user groups, management and property rights, collective decision-making, and legal empowerment are some of the major indicators that inform the performance of JFMCs or similar intermediary institutions (Kumar 2002; Bhattacharya et al. 2010; Paul and Chakrabarti 2011).

The perception of end-users over the derived benefits becomes the major narrative of successful participatory forest management. For example, Suich (2013) found that communities will eventually withdraw if the realized benefits are inadequate and that no participatory management is sustainable in the long term without rigorous, people-centric incentives. Community perception is generally shaped by the economic values of the exploited forest products, granted access rights over the resources, its contribution to household income and liabilities in forest management. Nevertheless, provided a fair economic share is ensured, the final outcome, i.e., effective participation of the communities, can most likely be achieved. Importantly, numerous recent reports highlight end-user perception as

the sole narrative of successful cooperative management (e.g., Suich 2013; Adhikari et al. 2014). However, end-user perceptions, despite being a close approximation, are not always indicative of an effective incentive design for the sustainability of participatory forest management. For example, achieving end-user satisfaction without an effective control over resources may be detrimental to ecological sustainability. On the contrary, scanty resources can also be judiciously used to envisage active participation from the communities. Hence, optimization through careful assessment of community need and available resources remain highly imperative—too much or too little control over resources can be equally harmful.

Within the scope of this framework, incentives can be designed in two possible ways. Firstly, a demand-driven approach will essentially identify the community needs, and thereby, utilize the available resources, or even supplement it accordingly. This approach can be regarded as “bottom-up”, people-centric incentive design and arguably has a greater chance to promote long-term sustainability. On the contrary, a resource-driven approach, which normally relies on safety margins and judicial use of available resources, depends heavily on state-enforced control mechanisms and is mostly targeted solely on the conservation of forests.

Methods

Delineation of the study area

Spreading over the vast Ganges, Brahmaputra, Meghna (GBM) delta, Sundarbans is the largest contiguous mangrove forest in the world, disproportionately shared between India and Bangladesh. The Indian counterpart, better known as the Indian Sundarbans, lies between 21°32′–22°40′N and 88°05′–89°00′E (Fig. 2). Although the name “Indian Sundarbans” generally stands for the entire lower Gangetic delta, the present extent of the mangroves is confined to its eastern islands encompassing an area of 2097 km². Because of its tremendous biological diversity and habitat for endangered species including the Bengal tiger, the majority of the mangroves is strictly conserved under different categories of legislative protection (Gopal and Chauhan 2006; DasGupta and Shaw 2015). On the other hand, reclaimed islands surrounding the mangroves are heavily populated and lack infrastructural development. An average population density of approximately 957 persons/km² with 43.5% of communities living under the nationally designated poverty line leaves both the communities and the mangroves exceptionally vulnerable (DasGupta and Shaw 2015). Importantly, despite the large underprivileged population in the vicinity, the protected

areas of the Indian Sundarbans are credited among the best-managed mangroves because it has not suffered much degradation during the more recent past (Giri et al. 2007; Singh et al. 2010). Nevertheless, vast sections of the protected areas are protected naturally by their inaccessibility, remoteness and topographical hostility. The nonprotected buffer areas at the forest fringes, on the other hand, have been considerably degraded (Giri et al. 2007).

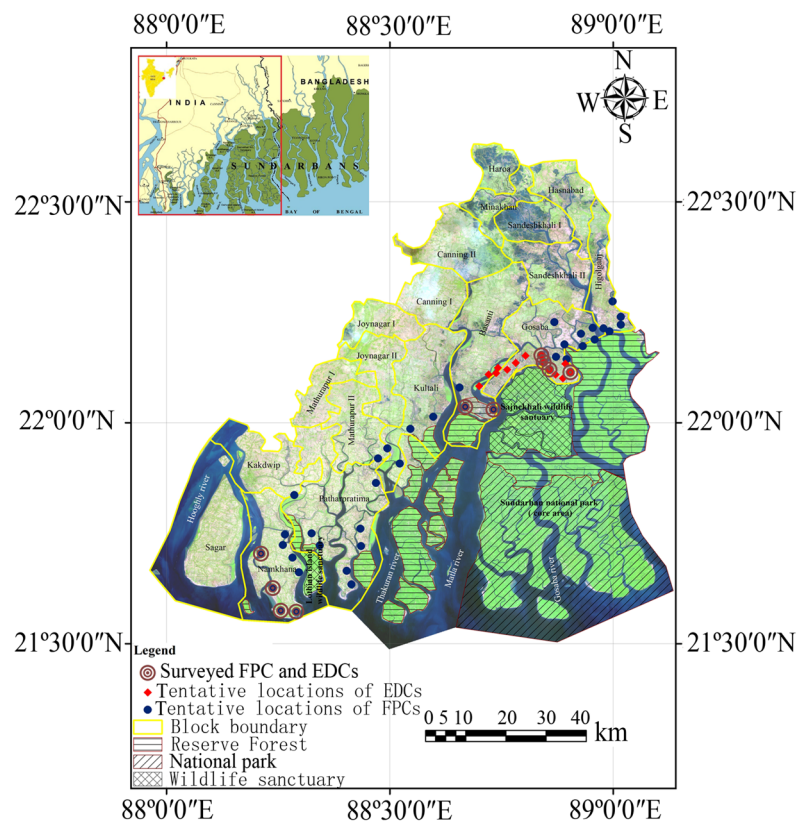
Two government forest agencies, the State Forest Department (SFD) and the Sundarban Tiger Reserve (STR), are essentially responsible for managing the Sundarban mangroves. SFD is primarily responsible for the buffer areas. Conversely, the STR, established under the national initiative of Project Tiger, is responsible for managing the core and immediate buffer areas designated for tiger conservation. Following years of hierarchical “top-down” management that restricted community use of the mangroves, participatory mangrove management was formally introduced in the region in 1993, soon after the adoption of the JFM notification. Presently, 65 JFMCs including 14 Eco-development Committees (EDCs) and 51 Forest Protection Committees (FPCs) are responsible for the protection and conservation of 632.17 km² of mangrove forests. Involving 35,079 local villagers, the scale and the magnitude of jointly managed mangroves are unique because the average per capita forest availability (PCFA) reaches close to 1.8 ha/person. This average is significantly higher than the average PCFA from other JFM experiences in eastern India (0.5–1.5 ha/person) (Bhattacharya et al. 2010).

Data collection and analysis

In a qualitative, in-depth, thematic analysis of the entire incentive mechanism for participatory mangrove management of Indian Sundarbans, we adhered to the proposed resource–control–user framework to understand the basis of incentive design. The three major steps of this research were (a) assessment of available “resources” (i.e., primarily the commercially exploitable ecosystem services and other direct economic benefits), (b) qualitative analysis of control measures, and (c) interviewing end-users to gather their perceptions on the adequacy of the derived benefits. In each of the steps, empirical data was collected in close association with forest administrators and the village communities through different participatory rural appraisal (PRA) tools such as focus group discussion (FGD) and structured/semi-structured interviews (SI) (Table 1). Field surveys were conducted during July and August 2014.

The initial step, accounting for the available resources was undertaken by interviewing the higher forest officials

Fig. 2 Location map of Indian Sundarban delta



of STR and SFD and by exploring the official time series data of forest resource exploitation. We interviewed the key forest administrative officers, i.e., administrative head of SFD and the Field Director of STR, and four other local officers (rangers). Before the interviews, we designed an open-ended questionnaire. During the interview, we characteristically enquired about the trend of forest cover and health to capture an idea of the overall ecological performance of the mangroves. We also asked officials about legally exploitable mangrove products and management constraints such as violation of forest laws/illegal exploitation from the previous years. We also enquired about nonforest resources and any other provisions to the local communities in exchange for their participation in the existing JFM arrangements (Table 1).

In the next step, we held focus group discussions with 10 JFMCs to understand the existing control mechanisms. The 10 JFMCs include four Eco-Development Committees (EDCs) and 6 FPCs (Fig. 2; Table 2). The JFMCs surveyed encompass distinct variations in their forest areas, PCFA and proximity to the core-protected areas. In addition, we intentionally chose both EDCs and FPCs in recognition of their slight differences in structure and administration. Hence, the surveyed populations were fairly representative of the 65 operational JFMCs. The main objective of the FGDs was to understand the structural representation of

different user groups, collective negotiation mechanism, legal and property rights granted and overall management and monitoring activities related to mangrove conservation. Importantly, all the JFMCs include the local forest administrator (Beat Officer) as the convener of its 7–9-member committee; hence, the FGDs were presided by the relevant “beat” officers. Each of the FGD consisted of 4–7 JFMC members (excluding the beat officer). The discussion time varied from 40–50 min based on a predefined set of questions (Table 1). Commentaries during the discussion were noted, and audio and/or video transcripts were made in most cases.

The final step involved interviews with different forest user groups including JFM beneficiaries. For this purpose, we identified five different user groups namely farmer, fishermen, forest product (honey and wax) collectors, prawn seed collectors and groups involved in tourism. In semi-structured interviews, 119 mangrove users were asked about their expectations and the adequacy of the benefits received. Based on a predefined set of open- and close-ended questions, the users were typically asked about their perceived benefits from the existing JFM arrangements and the barriers to achieve a sustainable livelihood from the current incentives. As in the case of the FGDs, issues pertaining to individuals and groups were carefully noted and recorded.

Table 1 Outline of RCU framework and PRA tool used for the survey

Theme	Stakeholder	Main variables	Objectives	PRA tools	Key questions
Resource accounting (<i>n</i> = 6)	Higher forest officials of SFD and STR	Forest cover Forest health Exploitable ecosystem services	To collect information about changes in forest cover, forest health and available ecosystem services To understand the extent and adequacy of commercially available mangrove resources To analyze trends in resource use	Structured interviews (with secondary data collection)	What are the legally permitted exploitable forest and other resources? How existing resource utilization policies shaped? Whether any significant changes of forest cover and its associated ecosystem services have been observed over the previous years? How do forest officials perceive the adequacy of the forest resources (in shaping community perception toward participatory management)?
Control mechanism (<i>n</i> = 10)	Beat/range officers, joint forest management committees	Role in resource allocation Structural representation of different user groups in JFMCs Exploitation and property rights	To identify the roles and responsibilities of JFMCs To understand the exploration rights shared with the user groups To identify the existing mechanism for control and delivery mechanism	Focus group discussions	To what extent the JFMCs are involved in participatory decision-making? What are the roles and responsibilities of JFMCs to control overexploitation? What is the extent to legal sanctity of the JFMCs?
User perspectives (<i>n</i> = 119)	Farmers (<i>n</i> = 52), fishermen (<i>n</i> = 37), honey and wax collectors (<i>n</i> = 9), prawn seed collectors (<i>n</i> = 8), persons involved in tourism (boat drivers, guides) (<i>n</i> = 13)	End-user satisfaction Perceived benefits Perceived threats Key issues related to benefit sharing	To understand the perceived benefits and threats from the JFM arrangement To understand the main motivation for conservation To understand the key issues pertaining to economic sustainability of occupational groups	Semi-structured interviews	Whether the present incentives are satisfactory and to what extend? What are the major concerns over the incentives? Can you make a sustainable living from these incentives? What key areas need improvements to have active participation?

n = sample size

The qualitative and quantitative data were later analyzed using conventional techniques. For quantitative data, such as trend of resource exploitation and share of household income from the forest resources were analyzed using simple arithmetic functions such as sum and average and generating bar diagrams in Microsoft Excel (Redmond, WA, USA). For qualitative data, the documented

information and the audio/video transcripts were firstly transformed into thematic reports containing specific issues, key statements and observations. As suggested by Berg 2001, this technique is standard for data reduction to summarize huge amount of unprocessed qualitative information. The summary reports were further subjected to a directed content analysis to identify key observations from

Table 2 Details of the surveyed Joint Forest Management Committees

Name of the JFMC/governing agency	Range/beat	Year established	Registered members	Protected area (ha)	Per capita forest availability (ha/person)
Jamespur EDC (STR)	SWLS/Sajnekhali	1998	347	960	2.76
Dayapur EDC (STR)	SWLS/Sajnekhali	1998	326	650	1.99
Pakhiralaya EDC (STR)	SWLS/Sajnekhali	1998	517	480	0.93
Bally EDC (STR)	NP(W)/Bidya	1998	258	770	2.98
Jharkhali-3 FPC (SFD)	Matla/Herobhanga	2004	1496	638	0.42
Jharkhali-4 FPC (SFD)	Matla/Herobhanga	2004	578	586	1.013
North Bhakkhali FPC (SFD)	Bhakkhali/Bhakkhali	2004	5400	300	0.05
South Bhakkhali FPC (SFD)	Bhakkhali/Bhakkhali	1994	1593	244	0.15
Patibunia FPC (SFD)	Bhakkhali/Bhakkhali	1997	1033	550	0.53
Maushuni FPC (SFD)	Bhakkhali/Bhakkhali	2004	640	1950	3.04

each FGDs and interview sessions and to categorize them under a defined codes or labels (Hsieh and Shannon 2005). Thereafter, we conducted a manual frequency/repetition search to identify the relevance of certain issues, especially in identifying the user's perception over the existing incentives.

Results and discussions

Account of available resources

Data from interviews with higher forest officials suggest that even with profound human intervention, mangroves of Indian Sundarbans remain virtually intact with marginal reduction of forest cover over the last decade. The negligible reduction is attributed to natural decay and an improved satellite-based resource accounting methodology (Giri et al. 2007; Forest Survey of India 2013). However, as feared by the bulk of researchers, officials also mentioned that several important species like *Sonneraita caseolaris* are now almost on the verge of extinction and the mangroves are in a phase of readjusting to changing environmental boundary conditions (Gopal and Chauhan 2006; Mitra et al. 2009; Mandal et al. 2010; Raha et al. 2012; DasGupta and Shaw 2013). When asked about whether this change has adversely impacted the exploitable ecosystem services, product quality and commercial values, officials revealed that they found no significant reduction in the observed trend of product exploitation over the last decade. As depicted in Fig. 3a, b, decadal time series data of exploited honey and bee-wax clearly showed that the trend has remained grossly unchanged. A sharp decline during 2009–2011, however, relates to the loss of lives and assets during cyclone Aila.

The theoretical implications of these data, in particular from the resource-accounting perspective, leads to the

potential conclusion that despite some adverse changes in canopy cover, commercially exploitable mangrove products of the Indian Sundarban mangroves remain unaltered. Further, it can be also argued that, so far, the exploitation of wax and honey has been within the carrying capacity of the mangroves. However, unlike the inland JFM arrangements where a percentage of revenue is shared with the communities because of rotational felling, the most critical design of existing participatory management of Indian Sundarbans is the complete prohibition on collection of wood-based resources. For example, Golapata (*Nypa* sp.) and Hental (*Phoenix* sp.), which were collected earlier by the fringing villages was discontinued since 1978 and 1991, while controlled felling has been completely stopped since 2001 (Vyas and Sengupta 2012). Thus, the provisioning services are partly used for incentives due to an enhanced safety-margin-based incentive design that was probably instituted because of a fear of overexploitation. In addition, fishing communities are only allowed to exploit a very small portion (about 25%) of the potential fishing areas (as supporting services of mangroves) due to several territorial restrictions within and around the mangroves (Patel and Rajagopalan 2009). An additional complexity led by a ban on the collection of dry leaves and shredded branches visibly impedes the community to obtain a sustainable living from the mangroves. However, as Fig. 3c suggests, cultural services such as tourists frequenting the mangroves have increased by nearly 400% since the last decade, which positively impacted the poverty-stricken rural economy. As informed by the officials, 25% of the revenue collected from ecotourism spots are shared with the communities as per the stipulated guidelines. In addition, official also mentioned small-scale plantation-based job opportunities for a limited number of communities. However, an increasing trend of cognizable forest crimes, as depicted in Fig. 3d, severely impairs the entire participatory mechanism and triggers the debate over its long-

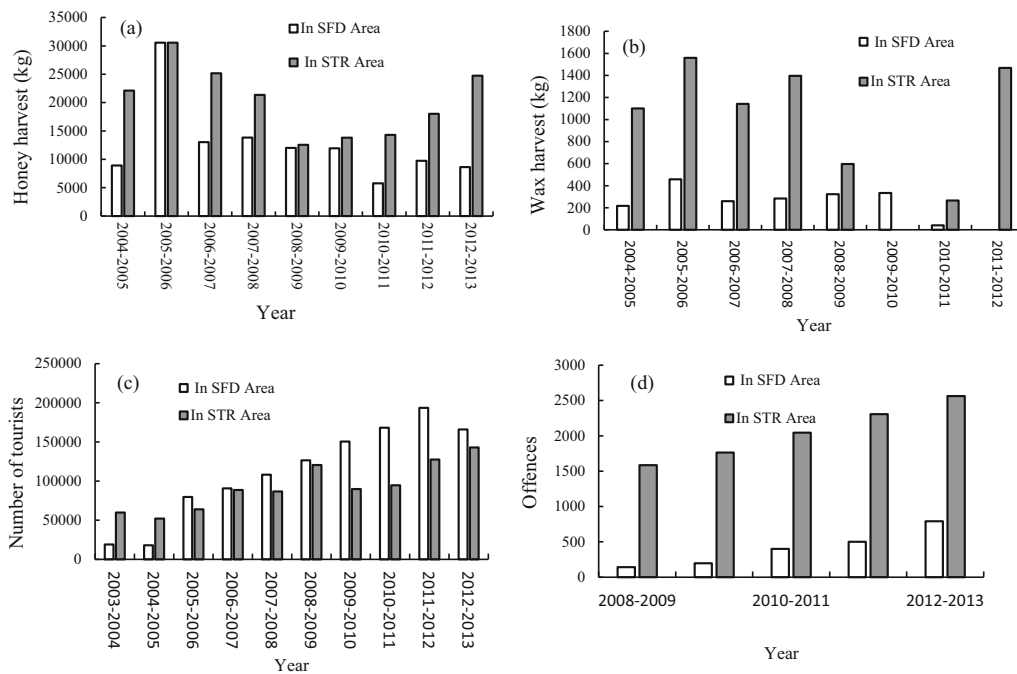


Fig. 3 The data of exploited honey and bee-wax, number of tourists visiting and reported cases of forest offences in different years. **a** Honey harvested in the Indian Sundarbans from 2004 to 2013.

b Beeswax harvest in the Indian Sundarbans from 2004 to 2012. **c** Number of tourists visiting the Indian Sundarbans from 2003 to 2013. **d** Reported cases of forest offences in the Indian

term sustainability. Most reported forest crimes consist of illegal entry into restricted areas, unauthorized logging and wildlife poaching.

In summary, despite the vast available forestry-based resources that can be relied on for potential incentives, only a small portion is being used as incentives, and the incentive design is primarily aimed to enhance the safety margin of resource exploitation. As revealed by the officials, obstacles to achieving a better incentive design centered on the community relate to the lack of an in-depth carrying capacity assessment such as a maximum sustainable yield (MSY) for fishing and other forest products and to the high population density, lack of trust on the communities, political unrest and bifurcation within the beneficiaries. Acknowledging that the incentives are not enough to support community livelihood, especially considering the size and structure of the communities, officials pointed to the lack of alternative livelihoods and the geographical isolation of the communities as the major challenges to achieving mangrove sustainability.

Control mechanism

Being at the core of participatory forest management, JFMCs provide an interface between the forest administration and the user groups, administering a tangible piece of forest. While higher officials or policy planners decide the permissible amount of exploitable timber or NTFPs,

these committees are ideally responsible for monitoring, distributing and delivering the incentives to the communities. Given the finite available forest resources, the role of JFMCs as a local authority is crucial for equitable distribution and effective conservation of the forests. Representation of different occupational groups, relationship with the forest officials, management rights, legal and tenurial security are additionally the key determinants for active and impartial functioning of the committees (Pagdee et al. 2006; Behera and Engel 2006; DasGupta and Shaw 2014).

Survey results from the 10 JFMCs, however, reveal that, presently for the Indian Sundarbans, JFMCs have little role in the decision-making for resource allocation. In all cases, we observed that their major functioning is primarily restricted to “community policing” and reporting forest crimes. As described by Garcia and Lescuyer (2008), utilizing the community network for monitoring forest crimes or “community policing” is an effective tool for participatory resource management; however, apart from reporting forest crimes, no significant role of the JFMCs could be identified. On the contrary, we observed several structural deficiencies that impeded the institutional sustainability of the JFMCs. Firstly, the allocation of JFMCs are based on administrative territory (mostly in accordance with the village boundary), which results in the PCFA varying from 0.05 to 3.04 ha within the surveyed JFMC (Table 1). Although local forest officials argue that the PCFA model

is only valid where timber based products are exploited, we found that larger landholdings are evidently attached to increased participation and sense of belonging. Secondly, despite their existence under the same administrative framework, EDCs and FPCs derive differential benefits, leading to a substantial difference in participation. For example, all the surveyed EDCs mentioned about an annual benefit of INR 100,000 (approximately) from ecotourism activities promoted by STR, whereas similar provision is not in place for the FPCs. As mentioned by all four EDCs, the amount is spent for collective benefits such road construction and pond excavation.

As mentioned, none of the surveyed JFMCs are involved in broader decision-making (such as microplanning, pricing and marketing of forest products), and the legal awareness of the committee members is also severely limited. A majority of the committee members perceive that their responsibilities are only confined to forest protection, while incentives or rights to forest product exploitation are under the jurisdiction of the local forest administration. For example, one committee member of Jharkhali III FPC mentioned that-

“Our responsibilities are attached to prevent tiger poaching and illegal forest exploitation.... Earlier (before the formation of JFMCs), people used to kill tigers and indiscriminately chop the mangroves... but, this scenario has changed a lot... if we get any such information (violation of forest laws), we immediately inform the forest personnel...”

It is, however, true that the surveyed JFMCs have no significant role in resource allocation to its members, except some small plantation based work-opportunities promoted by the forest officials. As mentioned by the JFMC members, allocation of fishing rights and honey collectors' pass to enter protected areas are strictly governed by the local forest administrators. In addition, as mentioned during the FGDs, the committees are formed for only year and undoubtedly lack tenurial rights. They further revealed that the committees are also dissolved or retained at the sole discrimination of the local officials. However, local beat officers highlighted that political influences are the major determinants for sharing tenurial rights. For example, at least in half of the cases, predominance of political leaders and local elites in the core committee does not effectively represent the issues and challenges of different occupational groups. In order to address the requirements of diverse stakeholders, where multiple interests apply, assimilating different voices and translating them to well-defined collective decisions is crucial. However, a lack of such mechanism is clearly evident in the present arrangement.

The results of the FGDs with 10 representative JFMCs reveal that their roles and responsibilities are vastly

circumscribed to monitoring of violations, for which the committees are partly successful, whereas their influence in decision-making and collective negotiations is almost entirely restricted. Designed to communicate community issues, JFMCs clearly lack robustness as a result of their vested political interests; thus, weak, nonfunctioning JFMCs, fueled by political motivation, were identified as the key reason that community issues and demands were misrepresented.

Mangrove users' perspectives

Farmer's perception of existing JFM arrangements

Among the five identified mangrove user groups, communities involved in agriculture, including the agricultural labors, are passive forest users, while the rest are directly dependent on the mangroves. Despite the fact that agricultural workers have no direct stake in the existing participatory management, they are the largest occupational group as well beneficiaries of the existing JFM arrangement. Located close to the mangroves, the farmland in the Indian Sundarbans is characterized by non-irrigated monocrop rice cultivation with comparatively low productivity. Additionally, storm and tidal flooding with saline water, as gravely experienced in the aftermath of Cyclone Aila in 2009, are the main hindrances that compel the agricultural communities to exploit the mangroves as an auxiliary livelihood option. Among the surveyed population of 52 farmers, 31 mentioned that they depend on a secondary source of income and rely mostly on the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), a federal government initiative to provide at least hundred days' assured employments in a year to the rural, unskilled population. However, inconsistent job opportunities and payment delays were the compelling stressors that adversely impacted household income. The major benefits derived from the JFM arrangement, as revealed by the interviewed farmers, are the plantation programs executed by the forest departments and some of the training/capacity development activities. Our sample population perceived that these benefits roughly corresponded to approximately 10% of their overall monthly income. Although, not specific to their occupation, farmers revealed three main reasons hindering their active participation: (1) Prohibition of fuel wood collection, (2) political interference and favoritism in the JFMCs, and (3) lack of institutional and administrative support for improvement of agricultural productivity. For example, one interviewed farmer in the Jharkhali III FPC mentioned “We are badly in need of a sluice gate to prevent saline water to come in... we want the forest department to provide one. If we get it, we will more actively participate in forest protection.” When

enquired about their willingness to participate in the JFM arrangements, over 90% of the farmers recognized the importance of mangroves, especially its role in disaster risk reduction, and mentioned that they are willing to actively cooperate within the existing participatory mechanism.

Fishermen's perceptions of existing JFM arrangements

Considered as a traditional livelihood of the region, estuarine and onshore fishing is a primary form of living, deeply rooted into the society and culture of the Indian Sundarbans (Patel and Rajagopalan 2009). Communities involved in fishing, therefore, emerge as the most exhaustive and important stakeholder, representing nearly one-third of the JFM beneficiaries. However, the scenario of fishing in the tide-dominated creeks and river systems is both structurally heterogeneous and spatially complicated. For example, fishing is carried out both individually or in groups. The designated fishing area in and around the mangroves are divided into several “go” and “no-go” areas. Forest offices issue each fisherman an identity card and an accidental life insurance plan, which needs to be renewed on a temporal basis. Additionally, a nontransferable boat license is also allotted to each fishing group. Fishing is legally permitted only when the fishermen are equipped with a valid boat and fish trading license.

Among our sample population of 37 fishermen, 23 mentioned that they are involved in a secondary occupation, mostly during the breeding season (April to June) when fishing is prohibited. Interviews with the fishermen highlighted that 70–75% of the household income is derived from estuarine fishing. This economic dependence is a crucial factor that determines their perception about the JFM arrangement. Notably, fishermen are also blamed as frequent offenders of local forest rules, such as by entering “no-go” areas. During our interviews, we noted several issues pertinent to their livelihood sustainability: (1) Due to the increasing number of fishermen, individual benefits are decreasing (lower per capita fish catch). (2) Catches of commercially important and profitable fish species, which are becoming extremely rare, have decreased by 30–50%. (3) When catches are poor, more fishermen try to enter the protected areas. Their claims of reduced fish catch, however, could not be verified with reliable scientific data. Unlike the farmers group, which, in general, accepts the existing JFM mechanism, fishermen own completely different perception. According to their view, the existing arrangements are forcefully restrictive and cannot support a sustainable living. Three major demands, which were mentioned by the overwhelming majority of the interviewed fishermen, are (1) permission of fishing in core and otherwise restricted areas, (2) access to the leaves and

shredded woods, and (3) permission to carry country swords/weapons while fishing. For example, a fisherman in the Pakhiralaya EDC mentioned, “Maunds (traditional unit of mass used in British India) of fallen woods, tree branches every day floats on the rivers. Yet, if we try to collect those, we are unnecessarily penalized. Our boats are seized and we are physically harassed”. A fisherman from Dayapur EDC stated, “We don't carry country swords to chop the trees but to protect ourselves from pirates or sudden tiger attacks. However, forest guards feel differently and penalize us.”

These statements clearly highlight the lack of motivation for and trust in the existing JFM present among the fishing communities. Additionally, fishermen also mentioned the necessity of appropriate markets to sell their products. Consequently, growing mutual distrust between the local forest officials and the fishing communities emerged as a clear threat to future sustainability.

Prawn seed collector's perceptions of existing JFM arrangements

Prawn seed collectors comprise a very small group of socially and economically marginalized women (dominated by widows or separated women) who collect seeds and larvae of crustaceans from intertidal areas of estuarine rivers and creeks. The seeds are typically sold to middlemen who then sell the seeds to aquaculture farms. The process of prawn seed collection is risky for both human and the aquatic ecosystems, and provides poor financial return. The collected seeds are sold at a mere price of INR 40–50 per 1000 samples. Considering the long-term adverse ecological impacts of the collections, regulations stipulated by STR are posed for a complete ban of these activities (Patel and Rajagopalan 2009). Yet, the forest officials and the JFMC members ignore these activities for humanitarian reasons. As argued by many, the process is a serious threat to continual ecosystem services and environmental sustainability of the region (Patel and Rajagopalan 2009; Das et al. 2012). The entire sample size of 8 prawn seed collectors mentioned that they are solely dependent on this activity because they do not have any other skills or agricultural land for an alternative livelihood. None of them, so far, have received any voluntary aids or support from the JFMCs. In addition, the majority of the surveyed collectors is socially isolated and poorly represented within the JFM arrangement, despite of being the most vulnerable mangrove user. Unable to identify any tangible benefits from the existing JFM arrangements, most of our sample population feared that strict implementation of forest laws might adversely affect their livelihood.

Honey and wax collector's perceptions of existing JFM arrangements

Honey and beeswax are the minor forest products collected during the month of April and May. The entire collection process is closely supervised, monitored and documented by the relevant forest offices. Each year, a license is issued for these activities. Of the sample population of nine forest product collectors, all use this opportunity for auxiliary income. When asked about their perception about the benefits derived from the forest products, most expressed satisfaction over the entire arrangement. However, some issues, especially related to marketing and distribution rights of the collected forest products were identified: (1) all the collected honey products need to be sold to the local forest offices, and (2) the local office price paid for each unit of honey traditionally has been poor (INR 75–100/kg) (open market price are almost double), and (3) revisions of the prices paid for the collected forest products are rare. Some of the honey collectors find it objectionable as depicted in the following statement from a collector in Bally EDC: “Despite of our hard work, we get only half of the existing market value. We lose a good amount of money.” However, we also encountered contradictory statements such as one from a honey collector in Pakiralaya EDC: “Since we don't have an access to the distantly located urban markets in Kolkata, it would have been difficult to sell all our products in domestic market. There is very little demand. It is good that forest department is taking all of it.”

Importantly, these issues are not relevant to wax and it can be directly sold to an open market. In general, the surveyed forest product collectors appreciate the overall arrangements and are satisfied with the derived incentives.

Tourist guide's perspectives of existing JFM arrangements

As depicted in Fig. 3c, tourist visits to the Indian Sundarbans have increased significantly over previous years, creating more opportunities for communities involved in ecotourism (e.g., boat drivers, tourist guides, lodge owners). These groups roughly correspond to approximately 2–5% of the JFM beneficiaries and are expanding with demands. Among our sample size of 13 boat drivers and local tourist guides, most expressed their profound interest in participating in JFM activities, mostly because of the direct economic opportunities extended to them. They mentioned that it is now mandatory to use tourist guides and registered boats for rides in and around the mangroves. Additionally, around half of them received short-term training by the local forest offices. Although, many are also involved in other small-scale livelihood activities, roughly 60% of their household income is derived from

tourism activities. The surveyed population, however, have some key concerns such as (1) fear about increasing competition as more become guides and most importantly, (2) the influx of competing outsiders, especially city-based tourist companies. Despite these concerns, we observed that this group was the most satisfied among the five major occupational groups involved in the existing participatory arrangements.

Table 3 summarizes the stakeholder's perception of the existing JFM arrangement. The results clearly indicate contradictory opinions and participation in the five major occupational groups. We additionally observed that communities, in general, are bifurcated into supporters (e.g., agricultural communities, forest product collectors) and critics (e.g., fishermen, prawn seed collectors) of the JFM arrangements, and the division has strong correlation with the share of household income derived out of forest benefits. Interestingly, the relationship is somewhat inversely proportional, i.e., the perception generally tends to be negative with higher dependence on mangroves. The theoretical implications of this observation can be interpreted in two ways: (1) although most of the community members recognize regulating, sheltering or recreational services of mangroves, they only rely on the access to economically exploitable forest products in making crucial decisions. (2) Any hindrance to such access is considered as a threat to their livelihood and prosperity, thereby affecting their spontaneous participation. The results also closely correspond to our stated hypothesis and are indicative of the fact that addressing the demands of multiple stakeholders with diverse interests, as in the case of mangroves, can be confounding. We identified numerous additional factors, such as lack of market and price of forest products as playing a significant role in shaping user perception.

It is, however, imperative to understand whether the existing incentives are really exhaustive or designed in an arbitrary manner. In this regard, end-users' perspective, alone, is not conclusive as it largely defines the level of individual satisfaction. Interestingly, the wider perspective derived from the analysis using the “resource-control-user” framework evidently illustrates an overcautious, an incentive design based on prevention and safety margins that is probably related to a long history of protected area management in this region. As evident from the analysis, the existing JFM arrangement is heavily skewed toward the forest offices and did not facilitate the basic transition of power between the forest department and the communities. Several management deficiencies, such as undermining the JFMCs, passive representation of occupationally vulnerable groups, local political influences were found to have impacted the overall performance of the participatory mangrove management. Although communities to some extent are effectively used to monitor this vast inaccessible

Table 3 Stakeholder analysis

Stakeholders	User group	A (%)	B	C	D	E	F (%)	G (%)	H	I	J
Farmers and agricultural labors	Distant	50–60	Leaves and timber	Buffer and nonforested areas	Low	INR 2000–5000	60	<10	No opinion	Small scale plantation program executed by JFMCs	Rise of salinity and flooding incident, loss of agricultural productivity
Onshore/ estuarine fishermen	Direct	25–30	Fish, crabs and NTFPs	Buffer Areas	Moderate	INR 3000–5000	52	70–75	Restriction of fishing into core and designated areas	Organized fishing activities, insurance and government identity cards	Rights for fishing in core and restricted areas
Prawn seed collectors	Direct	1–3	Prawn seeds	Buffer areas	High	INR 800–1200	0	100	Strict enforcement of laws	Nil	Alternative livelihood/ rehabilitation
Forest product (honey/wax) collectors	Direct	3–5	Honey and beeswax	Core and buffer areas	Moderate	INR 2500–4000	100	50–60	Loss of marketing rights	Organized exploitation, provision for sale	Price of honey, marketing rights etc.
Individuals involved in tourism	Direct	2–5	Tourist/commissions of travel guide	Buffer Areas	High	INR 3000–5000	31	60–70	Nil	Sharing of Revenue, increment in tourist activities	Increment in revenue sharing and competitors outside the JFM arrangement

A is composition of community; B is Main interests; C is territorial distribution of operation; D is ecological influence; E is average monthly income; F is % of sample population involved in secondary occupation; G is % share of monthly income from mangrove or allied resources; H is perceived threats and I is perceived benefits from JFM arrangements; J is key issues related to occupation

mangrove forests, their demands are rarely taken into consideration during the meticulous incentive design.

Conclusion

In a qualitative, in-depth assessment of the incentive design of the existing JFM arrangement in Indian Sundarbans and the communities' perception over the derived incentives, we used the RCU Framework to understand the very basis of the incentive design and its role in long-term sustainability of the existing participatory arrangement. We primarily found that the incentive design was based on a precarious safety margin that largely restricts the overall goals and objectives of JFM, i.e., ecological conservation through improvement of community livelihood. The analysis also suggests that despite the large pool of economically exploitable mangrove resources (i.e., a vastly reliable resource), the existing incentives are not inclusive; rather, they were developed with a high safety margin from fear over-exploitation and possible loss of biological diversity. The lack of scientific resource accounting (e.g., MSY of exploitable mangrove products) and the ineffective distribution and delivery mechanism are clear narratives of an incompetent control mechanism, which remains heavily skewed toward the forest departments. Additionally, the supplementary non-forestry resources used as incentives are also insignificant, and do not uplift economy of the diverse mangrove-dependent communities.

From the user perspective, nearly half of the mangrove users, especially the estuarine fishers, do not consider the incentives to be substantial, and they clearly lack the motivation to comply with the existing forest rules. Most importantly, some also consider the existing JFM arrangement as a forceful restriction over their livelihood and economic sustainability. Therefore, the prevailing incentive mechanism, as discussed in the RCU Framework, evidently follows the second pathway of resource-driven incentive design and depicts a top-down, preemptive, hierarchical incentive design without any rigorous assessment of the community needs and expectations. As mentioned previously, long-term sustainability of such hierarchical arrangements remain heavily contested.

The existing incentive design, as we previously discussed, is possibly deeply ingrained into the long history of preventive management of mangroves in Indian Sundarbans. Following the decentralization of forest management in India, participatory management of mangroves were mostly retrofitted within the existing protected areas. Consequently, despite acknowledging the customary rights of the communities over the mangroves, forest administrators principally adhered to restrictive forest governance. Lacks of mutual trust and interference by local political bodies

have further fueled their adverse perception about the communities, and the existing participatory arrangements have been reduced to mere tokenism. This situation is clearly evident from a recent proposal (2012) to additionally designate a new wild-life sanctuary within the Indian Sundarbans (Sundarban West consisting of 462 km²). Needless to say, if implemented, this designation will undoubtedly further reduce motivation among communities, in addition to lowering mutual trust and per capita benefits. Although, it is irrational to argue the effectiveness of protected areas and marine sanctuaries in the conservation of Indian Sundarbans, excessive inclination toward preventive management is of serious concern. In particular, emergence of the Recognition of Forest Rights Act, 2006, which now provides wider authority and exploitive rights to the fringing communities, turns out to be a substantial threat for such preemptive, top-down' incentive design and may widely promote conflict of purposes and indiscriminant exploitation of mangrove resources.

The complexity of the situation, therefore, demands an ameliorative incentive design and a holistic reform in participatory approaches for mangrove conservation. For this purpose, we argue that in cases where both protective and participatory management measures are placed in tandem, conventional forestry-based incentives alone are insufficient to cater to the heterogeneity of demands. To overcome these challenges, forest administrators need to harvest a significant amount of nonforestry resources to supplement the customary forest-based incentives. As reflected in this study, small-scale developmental incentives such as construction of local markets, competitive pricing and storage facilities, sluice gates and water-harvesting structures can potentially serve to repair community trust. These will not only facilitate a truly participatory environment, but also play a significant role toward comprehensive and inclusive regional development. Nevertheless, to determine the extent to which developmental incentives should supplement the existing ecosystem-based incentives requires an intensive assessment of community needs and aspirations and examination of the ecological carrying capacity in an unbiased, participatory environment. A people-centered approach and bottom-up incentive design perhaps are keys to the future sustainability of the Indian Sundarban mangroves.

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