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Review

Community based mangrove management: A review on status and sustainability

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ABSTRACT

Community Based Mangrove Management (CBMM) has been advocated by both academia and governing agencies as a viable alternative for sustainably managing the ecologically important mangrove forests which are disappearing rapidly worldwide. Drawing insights from diverse sustainability issues, capabilities and performances of worldwide CBMM initiatives were examined in this paper. Higher numbers of CBMM initiatives were reported from South Asia and lesser from South America and Africa. Identification of the causes of degradation at a site and use-specific zonal replantations with respect to species associations were identified as major criteria of ecological sustainability. Regarding economic sustainability, transformation of potential uses of mangroves known by local communities into actual ones was found to be necessary. Proper disbursement of accrued benefits among community members irrespective of their socio-cultural status is also a major concern. Restructuring of CBMM institutions by ensuring participation of subsistence based users in decision-making and resource sharing have been identified as a prime determinant of institutional sustainability. However, limited number of studies on socio-political and institutional aspects as well as impacts of globalization induced socio-cultural transformations of communities on CBMM had been actually found. More focused researches on these aspects had been recommended for better community management of these highly stressed forests.

1. Introduction

Mangroves are among the most productive ecosystems on earth and occupy brackish water zones along tropical and subtropical coasts (ITTO, 2002). Mangrove ecosystems are widely recognized for their habitat functions for fish and crustacean of commercial value as well as for effective sediment trapping, nutrient recycling and protection of shorelines from erosion. Mangrove forests also offer a great number of goods such as food, fuelwood, timber, honey, wax and tannins (FAO, 2007). Apart from their ecological importance, mangroves have aesthetic, historical, and cultural values (Grasso, 2000). In recent years, however, mangroves are declining at an alarming rate worldwide. A global reduction of approximately 25% has been observed since 1980 and the mangrove area today is less than 15 million ha (FAO, 2007). In general, mangroves are threatened by increasing consumption pressure, unsustainable production of fish and prawns, mixing of waste water effluents from urban-industrial areas and oil-spill. Mangroves are generally found along the coasts of tropical developing countries where coastal populations largely depend on these forests for their livelihood. Owing to the perilous condition of mangrove ecosystems as well as wide-scale adaptation of decentralized governance policies in many developing countries in the last fifty years, the concept of community based mangrove management (CBMM) has therefore become imperative. The rationale of CBMM lies in the potential of local communities' involvement in accomplishing the vital activities of resource identification, priority development, choice and adaptation of appropriate technologies for formulating and implementing sustainable management practices. CBMM is integrated to the broader concept of community based natural resource management (CBNRM), which refers to decentralization of rights, responsibilities and authority from government to local communities in managing natural resources (Alcorn et al., 2002; Carson, 1999). An increasing number of ecologists, geographers, sociologists as well as development researchers and practitioners are championing the features of multiple benefits and ecological achievements gained by the CBNRM systems (Harrison and Suh, 2004; Quarto, 1992; Sudtongkong and Webb, 2008). However, the concept of CBMM becomes rather distinctive from other CBNRM systems primarily due to the uniqueness of mangrove as an ecosystem and consequently due to the related socio-economic as well as governance implications. These implications include

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valuation of coastal protective and erosion resistant functions, competition with commercial aquacultural practices, disputes regarding transnational boundaries, need of high initial capital investments and low economic returns etc. Yet, numerous CBMM programmes had been implemented worldwide by governments and associated institutions in last three decades with mixed outcomes of success and failure. From these initiatives, it was realized that the probable success of these programmes were often dependent on the complex mechanisms of community–environment interactions which at the same time intersect, overlap and cut across the diverse realms of ecological, economic, socio-cultural and political sustainability. Against this backdrop, the paper seeks to examine the present condition, role and functioning status of CBMM initiatives through a rigorous and in-depth review of hitherto published literature. Finally, this paper tries to outline the future directions of research and best practice methods for implementing sustainable CBMM.

2. Methodology

A comprehensive literature search had been performed with the help of the literature database of ISI Web of Knowledge, version 4.6 (www.isiknowledge.com), for necessary information. Commercial search engine like scholar.google.com was also used for retrieving referred articles. Moreover, several hardcopy research articles, books, monographs, and project reports available in the workplace of present authors had been consulted in this regard. Based on the available literature, it was found that status of sustainability of any CBMM initiative can be assessed almost inclusively if the analysis adequately addresses all the major components of sustainability, i.e. ecological, economic, socio-cultural and institutional (Armitage, 2002; Harrison and Suh, 2004; Glaser and Diele, 2004). In the subsequent sections, discussions on all these aspects as well as on the extent and status of global mangrove cover had been done.

3. Global distribution and status of mangroves

Information on worldwide distribution and exact amount of mangroves is still unavailable but approximately 112 countries have mangrove stands within their political boundaries (Adeel and Pomeroy, 2002). Among the continents, Asia has both largest extent and highest species diversity of mangrove ecosystems (ITTO, 2002). Conversely, Oceania has the smallest areal extent and Africa has the least species diversity (Duke et al., 1998; Saenger et al., 1983). A brief description of the extent and diversity of mangroves had been given in Table 1.

Local communities traditionally managed and harvested the mangroves. However, during the colonial and post-colonial periods, these forests came under direct control of state governments, which subsequently gave impetus to commercial logging and large-scale shrimp farming (Gunawardena, 2001). Under this commercial forestry regime, mangroves were solely managed and utilized by state-run forest departments (FDs). In general, local communities were barred from using mangrove resources (Chaudhuri and Choudhury, 1994). Consequently, these communities gradually became alienated from the forests and they started to perceive these forests as only the means of extra income. Eventually, uncontrolled logging, indiscriminate shrimp and crab farming devastated these already vulnerable ecosystems (Zorini et al., 2004). Several authors have reported on these high rates of mangrove destruction in the pre-CBMM period (Alongi, 2002; Spalding et al., 1997). Mangrove deforestation is still an active phenomenon along East African coasts (Abuodha and Kairo, 2001; Kairo et al., 2008). It is only in the last three decades that a paradigm shift in the whole orientation of mangrove management and utilization is observed in which livelihood rights and indigenous knowledge of local communities have been acknowledged by state administrations and public funding agencies (Walters, 2005). At present, CBMM is a common term in both academic and applied fields of community forestry. The nature and pattern of spread of CBMM initiatives had been evaluated in the next section.

Table 1
Estimated global distribution and species diversity pattern of mangroves (Source: Biswas et al., 2009; Giri et al., 2011; Saenger et al., 1983; Spalding et al., 1997).

Continent	Mangrove area (ha)	Number of species found (flora and fauna combined)	Countries with more than 200000 ha of mangrove cover
Asia	8000000–8200000	1800–1850	Bangladesh, India, Indonesia, Malaysia, Myanmar, Philippines
Africa	3300000–3350000	550–600	Guinea-Bissau, Madagascar, Mozambique, Nigeria
America (North and South)	4900000–4950000	900–920	Brazil, Cuba, Mexico
Oceania	1800000–1900000	1250–1300	Australia, Papua New Guinea

4. Worldwide CBMM initiatives

The essence of CBMM lies in the concept that “people first and sustainable mangrove forest management will follow” (Melana et al., 2000). It means community participation in management increases when ‘well being’ of the members of community is ensured. Worldwide adaptation of CBMM approach, especially in the tropical developing countries, and its popularity among coastal communities directly stem out from this perspective of ‘well being’. In fact, lack of income generating options incites local communities to practice unsustainable methods of mangrove exploitation (Zorini et al., 2004). Following this notion of community involvement, CBMM is primarily prevalent in South and Southeast Asian countries as these were once the most damaged areas caused by rampant destruction of mangroves. Few countries of East Africa, Central America, and South America now have also initiated CBMM replacing the earlier government controlled management approaches (Kairo et al., 2001; Masoud, 2001; Smith and Berkes, 1993). In some countries like Thailand, the CBMM programme is truly community oriented as ownerships and rights of extracted resources are with local communities only, whereas in countries like India, the approach is rather a mixed one as state government and village communities jointly manage the mangroves and share the usufructs. However, CBMM initiatives are practised in sectoral and sporadic manners in Kenya under direct supervision of state agencies (Kairo et al., 2008). In other countries like Tanzania, control of state and influence of international donor agencies in management activities are very prominent (Mohammed, 2004). Due to these differences in the nature of management initiatives, the level of success in conservation varies. A summarized description of the major characteristics of CBMM programmes in various countries had been shown in Table 2.

Apart from those mentioned in Table 2, several other countries like Cambodia (Bann, 1997), Sri Lanka (Wattage and Mardle, 2007), Bangladesh (Islam and Wahab, 2005), Iran (Ghasemi et al., 2010), St. Lucia (Smith and Berkes, 1993), Honduras, Ecuador, Brazil and Panama (ITTO, 2003) have committed themselves in CBMM programmes. However, countries like Myanmar (Oo, 2002), Kenya (Rönnbäck et al., 2007), Egypt (Cabahug, 2002), Gabon, Congo, Madagascar (Rasolofo, 1997), Columbia and Venezuela (López-Hoffman et al., 2006) have huge potential for CBMM but they are yet to follow the right path of implementation (ITTO, 2003). In the

Table 2
Status of implementation of CBMM in different countries.

Country	Initiation period	Level of success achieved by the programme till now	Salient features of the programme	Reference
India	1990s	Moderate	i Village institutions function under the state initiated Joint Forest Management (JFM) programme. ii Protective duties and usufructs are shared by both communities and state-run FD. iii Sharing amount of benefits differ across the states.	Selvam et al., 2003; Singh et al., 2010
Indonesia	1980s	High	i NGOs and research organizations promoted CBMM first and government initiatives came later. Few programmes were also funded by UNDP and international funding bodies. ii Composition of rehabilitated and restored mangrove forests is becoming far different from the original forest structures due to introduction of silvo-fishery and agroforestry programmes.	Babo and Froehlich, 1998; Sidik, 2008
Pakistan	1990s	Moderate	i Local communities are engaged in mangrove management through community based organizations (CBOs) supported by WWF and EU. ii The province of Baluchistan is mainly covered under CBMM programme.	Shah and Jusoff, 2007
Philippines	Originally in 1957 in one island, but on a national scale in 1990	Moderate	i CBMM initiatives were taken as a component of the comprehensive coastal management programme comprising management of all coastal resources like sea-grass beds, coral reefs and coastal fisheries along with mangroves. ii Indigenous devices and technologies have been developed for management of mangroves and fisheries.	Melana et al., 2000
South Africa	1990s	Low	i CBMM, in its true sense, was implemented in the post-apartheid period. ii Most of the mangroves and estuarine habitats are still not covered by CBMM.	Traynor and Hill, 2008
Thailand	1980s	High	i Highest number of successful CBMM initiatives helped to maintain the desirable nationwide mangrove cover of more than 2000 sq. km as mentioned by the country's National Development Plan (2002–2006), obtained the 'Green Globe Award' in 1995–2005 period. ii Achievements of grass-root communities have made the state agencies to modify the legislation and support the initiatives accordingly as well as allocate financial assistances for them. iii Institutional sustainability achieved in most of the management initiatives as coastal communities have realized the need of CBMM through their own experiences and started the programmes voluntarily. These efforts were further strengthened by the transfer of appropriate technologies from NGOs and public bodies.	Chotthong and Aksornkoae, 2006
Vietnam	1990s	Moderate	i Mostly implemented under national and international directives, initiation from user communities is less. ii Once the projects terminate, future of the management programmes and ownership patterns are unclear.	Hue, 2002
Tanzania	1990s	Moderate	i CBMM is carried out through Community Forest Management Groups (CFMGs) and Coastal Resource Management Committees (CRMCs) with funding from USAID ii Controlled logging is permitted and issue of logging permits are entirely conducted by the CFMGs iii Adoption of ecotourism practices is still low.	Masoud, 2001; Mohammed, 2004

subsequent sections, the key issues regarding achievement of sustainability in CBMM had been identified and elaborated.

5. Ecological sustainability issues

Community driven management and rehabilitation of mangroves are not path-breaking ideas. In fact, indigenous communities are practicing these from time immemorial. Even government agencies around the world are conducting reforestation projects for the last 50 years but complete acknowledgement of all the products and services provided by mangroves including ecological benefits, both tangible and intangible, are missing in these efforts. In general, basic motivation for management and reforestation was increase in timber production (Walters, 2005). Of late, some authors made appraisal of true valuation of mangroves in coastal livelihoods from an ecological perspective (Baran, 1999; Kairo et al., 2001).

Field (1999) highlighted the need of multiple use oriented management plans for sufficiently accommodating the ecological characteristics and necessity of native mangrove stands along with fresh replantations. In many cases, conflicting nature of targets set under CBMM projects and erroneous management systems aimed to increase the production of timber, charcoal and commercial shrimps led to extermination of mangroves. Identification of the causes of mangrove degradation at a site, selection of appropriate rehabilitation sites, arrangement of suitable seedlings and timely planting, regular monitoring of the outcomes and conservation of revived mangrove stands were recognized as essential steps for mangrove regeneration. Failure to properly assess any of these can lead to disastrous consequences for the marginal communities as CBMM initiatives are generally associated with high investment of their capital and labour.

In Indian Sunderbans, wood pilferage, wildlife poaching, indiscriminate fishing, catching of prawn seeds, human-animal conflicts and unplanned diversion of tidal creeks for inland aquaculture led to the degradation of mangroves. The preponderance of these factors were curbed after initiation of Joint Forest Management (JFM) programme in this area (Roy et al., 2001). Here, creation of alternative sustainable livelihood opportunities like integrated paddy cum fish culture with rainwater harvesting facilities, piggery, duckery, honeybee rearing, sericulture, and mangrove afforestation were found to be necessary for ecosystem conservation. However, large variations in the benthic food web structures were observed in the virgin and reclaimed islands of Sunderbans as natural ecological processes almost ceased to exist in the reclaimed islands

(Ray, 2008). Excessive alteration of land use and land cover patterns as well as near absence of mangrove plantations in these islands were identified as the primary factors for these variations. Moreover, Sarkar and Bhattacharya (2003) reported that, apart from the targeted collection of tiger prawn seeds (0.25–0.27%), all the other shrimp larvae (70–75%), finfish larvae (20–25%) and macrozooplanktons (4%) were destroyed in a single catch by any fisherman of Sunderbans. These practices are persisting in this area due to lack of socio-economic and institutional potentials of JFM in diverting the communities from these financially lucrative activities to more conservation oriented small-scale fisheries and shrimp cum crab farming options. For these reasons, zone-wise management of Sunderbans was suggested in accordance with the planning strategies of the state FD's 'biosphere reserve' concept (Datta et al., 2011). Scopes of livelihood generation for local communities through activities based on non-timber forest products (NTFPs) and mangrove rehabilitation in the buffer zones under JFM initiative were forwarded as viable management options. However, the core zone under National Park management was allocated for biodiversity conservation. In Pondicherry, India, NGO led mangrove rehabilitation project engaging local villagers had found higher rate of success than that of the government departments because of choice of appropriate species and suitable planting sites based on the traditional knowledge of locals. While villagers planted *Rhizophora* species, government departments opted for *Avicennia* mainly. This distinct difference between the two initiatives was visible at the time of the Indian Ocean Tsunami (26th December, 2005) when even one-year old *Rhizophora* plantations managed by the villagers survived but most of the government plantations were destroyed (Saravanan, 2005).

Sudtongkong and Webb (2008) observed greater level of ecological success in community managed mangroves than state managed mangroves in Thailand as basic forest structure indicators like basal area, tree diameter and tree height were of superior status in community ones. In spite of having homogenous biodiversity status, basal areas of some community mangroves were even greater than that of state controlled mangroves, which UNESCO has designated as a World Heritage Site. In state mangroves, higher stem density values were reported because of periodical exploitation of state forests through logging and thus regeneration rates were higher than the community ones meaning more number of new saplings. However, number of trees with medium to large stems is greater in community mangroves because of their multiple use strategy of resources and grass-root level protection endeavours.

Community driven mangrove rehabilitation projects in Philippines also found greater level of success than heavily funded national and international programmes (Primavera and Esteban, 2008). Several such rehabilitation projects failed because of widespread faulty planting of *Rhizophora* species irrespective of site and situation as it has a tendency to grow in the protected landward zones, i.e. behind pioneer mangrove stands. Selection of appropriate species that were locally adapted had been suggested for a particular site like *Avicennia marina* and *Avicennia alba* as natural colonizers in seaward tidal zones.

Bosire et al. (2008) made a noteworthy observation that community managed and properly restored mangroves have remarkable recovery potential for biodiversity provided these restored forests are permitted for adequate gestation periods without harvest. In contrary, establishment of mono-specific mangrove stands under CBMM may become inappropriate as these are prone to pest related diseases and are not conducive for biodiversity regeneration (Walters et al., 2008). Since 1960s, a general worldwide trend of plantation of *Sonneratia apetala* and *Avicennia officinalis* in mangrove afforestation was noticed (Saenger and Siddiqi, 1993). Although these plantations are conducive for increasing timber production and consequently to improve the livelihood status of local communities, the aspects of biodiversity maintenance and conservation are, however, not addressed enough as these are largely dominated by a few species. Another important aspect often overlooked in CBMM is the conservation of faunal diversity that can, in turn, affect the whole ecosystem composition. Hence, increase in productivity and maintenance of biodiversity always does not have a direct positive relationship (Johnson et al., 1996). Moreover, even small-scale logging in a mangrove forest for a prolonged period can severely disturb the stand characteristics and soil biogeochemistry by reducing the amount of canopy cover, biomass etc and increasing the amount of dissolved solids, metals and ammonium which eventually lead to increased soil salinity in an already salinity affected area (Alongi and de Carvalho, 2008). Identification of an optimum as well as sustainable method of management, which can be adopted in a particular community mangrove, therefore becomes the primary function of a CBMM initiative. Neither a method only inclined towards increasing productivity for greater economic benefits nor a system solely oriented towards conservation of biodiversity can become appropriate for long-term sustainable CBMM. In this regard, introduction of ecotourism practices becomes essential as these have unique potential for biodiversity conservation and generation of economic growth simultaneously. Moreover, multiple use based mangrove management with an optimized land use plan should be implemented giving adequate attention to different land uses like protected mangroves, small-scale shrimp ponds, afforestation plots aimed for timber or NTFPs harvest, plots for development of tourism infrastructure etc. In many Southeast Asian countries, management of coral reefs, sea-grass beds and coastal fisheries have been carried out by local communities along with CBMM making these highly praiseworthy efforts especially from the perspective of biodiversity conservation (Melana et al., 2000; Suutari and Marten, 2007).

6. Economic sustainability issues

Mangrove products are major sources of income for coastal communities throughout the tropics. Although fishing and related activities are generally the prime livelihood options, harvest of mangrove wood and other NTFPs are supplementary sources of income contributing substantially to the subsistence needs of these communities who are in general the most economically backward and marginal ones (FAO, 2003). Resource managers and planners engaged in formulation of CBMM practices thus need to consider the ecological and environmental services of mangroves along with direct product based services for achieving economic sustainability for dependent communities. In this regard, actual and potential uses of mangrove resources in favour of a sustainable CBMM are listed in Table 3.

Historically, coastal communities made prolific use of mangroves in the form of fuelwood and construction materials (Bandaranayake, 1998). But due to large-scale availability of alternative fuel sources (petroleum, natural gas, electricity), only the remotest and most marginal parts of the coastal communities still use mangroves as source of fuel (Walters, 2003). Kovacs (1999) observed wide variations in the actual and potential using patterns of mangrove resources by local fishing communities across regions in Mexico. Although communities know several uses of mangrove resources, few of those are actually practiced on a regional basis. Only economically viable uses with respect to local markets are recognized as popular utilization options. Moreover, selection of a particular mangrove species by local communities for logging as well as harvest of other tree parts depends on the performance of its wood in different weather conditions. In the past, mangroves were exploited primarily for wood and energy and indirectly as fishery sites within permissible limits of natural regeneration but these

Table 3
Actual and potential products and services offered by mangroves.

Role of mangroves in CBMM perspective	Specific use	References
Ecological/protective	Sediment trapping	Kamaruzzaman and Ong, 2008
	Source of nutrients and organic matter	Gong and Ong, 1990
	Carbon sequestration	Twilley et al., 1996
	Wastewater treatment	Ewel, 1997
	Protection of shorelines	Badola and Hussain, 2005
	Wildlife habitat	Hutchings and Recher, 1983
Commercial/raw material/subsistence	Plant parts as food	Lieth, 2008
	Fodder	Pattanaik et al., 2008
	Fuel (Charcoal)	Bhattacharyya, 1990
	Construction material	Semesi, 1998
	Medicine	Bandaranayake, 1998
	Honey, wax and alcohol	Chaudhuri and Choudhury, 1994
	Tannin and dyes	Pattanaik et al., 2008
	Rayon and paper	Bhattacharyya, 1990
	Industrial chemicals	Lieth, 2008
	Ornamental goods	Lieth, 2008
	Fishery	Glaser and Diele, 2004
	Shrimp culture	Huitric et al., 2002
	Tourism	Abidin, 1999
	Butterfly farming	Muriithi and Kenyon, 2002
Aesthetic/miscellaneous	Landscaping	Sykes, 2007
	Shelter of fishing boats during storms	Williams et al., 2007
	Cultural/ religious importance	Ruitenbeek, 1992

activities are becoming unsustainable with huge increase of both commercial and subsistence exploitations in the last century. For example, Rasolofo (1997) mentioned almost extirpation of *Ceriops tagal* stands from few areas of Madagascar due to over exploitation by local fishermen. This sort of instances is becoming common across the globe not only for over utilization of mangroves, but also for the absence of sustainable resource utilization strategies and their subsequent implementations.

Suitable management plan addressing the issues of species choice for replantations and sustainable harvest based on local needs is required before implementing CBMM initiative at any particular site as choices and uses of mangrove species vary spatially. Several researchers had pointed towards the lack of information on actual uses of mangroves at local levels as a major hindrance in proper implementation of CBMM (Kaplowitz, 2001; Sneadker, 1986; Walton et al., 2006). In addition, contrasting opinions exist among researchers regarding perceptions of local communities on proper valuation of mangrove ecosystems. In Mexico, while local population of a lagoon gave greater importance to mangrove ecological services like storm protection, recreation, ecotourism and fisheries (Kaplowitz, 2001), traditional wood based activities were given priority in another lagoon area (Kovacs, 1999). A noteworthy study had been done by Ewel et al. (1998) on the diverse kinds of goods and services provided by three types of mangrove forests viz. riverine forest, basin forest and fringe forest. Few types like the fringe ones, for example, have greater protective functions against storms and sea surges but lesser harvest-oriented functions compared to other two types. Similarly, inland basin forests are more preferable for commercial activities like logging, shrimp culture and NTFP harvesting than others. Thus, formulation of zonal databases on specific use options for any mangrove site is essential in order to materialize the dual aims of CBMM i.e. conservation of ecology and generation of sustainable livelihood.

Proper identification and evaluation of both use and non-use values including social values of mangroves with respect to local stakeholders are highly significant in CBMM (Wattage and Mardle, 2007). For example, continuation of community based sustainable harvests from the mangrove wetlands had been preferred than implementation of large-scale commercial shrimp farming projects in Sri Lanka based on comparative estimates of total economic values (TEVs) (Gunawardena and Rowan, 2005). As shrimp aquaculture often drastically modify the hydrological regimes and disturb environmental services of mangrove ecosystems, socio-economic impacts of these projects are overwhelmingly negative and long standing. In addition, local communities often do not earn the profits derived from such projects as external commercial establishments initiate and operate them. Similarly, undervaluation of mangroves due to institutional failures had been identified as the major obstacles in implementing sustainable management in the Pagbilao Bay of Philippines as all possible eco-friendly livelihood inventories were not explored (Spaninks and van Beukering, 1997). Localized estimations of TEVs of specific community managed sites are particularly important in this regard as the attributes and dimensions of costs and benefits of CBMM vary considerably in space and time. Moreover, public funding agencies should recognize the significance of CBMM initiatives in providing services like protection from storm and sea surges as well as resistance of coastal erosion. Arrangement of extra funds will become necessary for these agencies to prevent coastal erosion through highly expensive civil engineering works if the mangroves are damaged or removed (Bennett and Reynolds, 1993). Thus, CBMM may be championed as an economically viable option for coastal management in its campaigns for acquiring proper funding.

Amount of willingness to pay (WTP) for ecosystem conservation by local communities can be gauged by assessing their levels of awareness on the benefits offered and delivered by mangroves. WTP is regarded as a major determinant of success of any CBMM initiative as the initial investments of capital and labour for management have to be made by the communities themselves in general (Wattage and Mardle, 2007). Thus, all management activities may be hampered in absence of sufficient village common funds or labour forces. In Bhitarkanika mangroves of India, local farmers, being aware of the livelihood generation potentials and ecological functions of mangroves, showed willingness in paying higher prices for mangrove conservation (Badola and Hussain, 2008). However, lack of coordination between market and public forces, which failed to suitably represent the role of local stakeholders in decision-making and resource sharing, led to destruction of mangroves in that area apart from excessive consumptive pressure. In mangroves of Egypt, Cabahug (2002) identified potential sites for community managed ecotourism and possible options for sustainable livelihood generation based on multi-dimensional criteria. Participation of local Bedouin people, especially women, in mangrove rehabilitation projects and in introducing alternative income sources such as cultivation of mangrove seedlings, beekeeping, landscaping, urban greening and production of mangrove based handicrafts were recognized as the positive aspects for initiating CBMM.

In many countries, marginal people still use mangrove woods for construction of houses though most mangrove trees do not produce high quality long and straight poles (more than 8 m) essentially needed for construction. In South Africa, more preference of coastal communities towards mangrove woods rather than expensive non-mangrove materials (e.g. mud, sand and brick) for construction purposes was causing damage to mangroves (Traynor and Hill, 2008). Locally driven participatory management failed to yield success in popularizing non-consumptive but income generating uses like tourism and recreation as well as in providing affordable sources of construction materials for these marginal communities. These were due to shortcomings in capacity building

and collaborative efforts between communities and government agencies. In Indian Sunderbans, forest fringe communities extract a wide range of NTFPs like tree bark (for tannin), honey, beeswax and lime (from shellfishes and oysters) for both subsistence and commercial purposes (Singh et al., 2010). These NTFPs together with crab (mainly *Scylla serrata*) and prawn seed collection in the estuaries constitute substantial portions of annual incomes of many agricultural labourers and small-scale fishermen. Community cooperatives collect honey and wax but the afterwards processing chains are still underdeveloped here. Thus, installation of purification and bottling facilities for these products under community leadership will not only ensure a sustainable yearlong availability of these high demand products but also financially empower these marginal communities (Datta et al., 2011).

Community managed mangroves in many cases were found to be economically beneficial but their ecological contributions were questionable as biodiversity issues were not always taken into consideration (Walters, 2004). Several other researchers also supported these findings as community efforts, in many instances, turned more towards commercial resource harvest than ecological conservation (Hackel, 1999; Primavera and Agbayani, 1996). These commercially exploitative characters may prove to be ecologically harmful while replanting mono-specific stands in the sites previously occupied by naturally diversified mangroves. Similarly, inept practice of mangrove replanting as well as management in virgin and ecologically fragile sites may initiate further environmental degradation. Consequently, this can lead to economic failures in future in terms of both livelihood generation and recovery of capital investments.

Therefore, judicious choice of appropriate sites and caution in implementation are needed to initiate any CBMM project. Emphasis should be given on the prospect of income generation not merely by timber harvests but through diversified NTFPs collection and non-consumptive uses of other mangrove resources that act as livelihood supplements. CBMM can only become economically sustainable in the long run if diversity and habitat factors of mangroves are given adequate importance and natural ecological dynamics are maintained. Knowledge and perception of local people can be beneficial in this regard (Begossi et al., 2000). As the primary uses of mangroves vary geographically, site and situation specific management plans are the only optimum solutions to resist environmental degradation. For example, aquaculture oriented mangrove landscapes of Southeast Asia need different management solutions from those of charcoal cum wood production oriented East African landscapes or logging dominated South American landscapes (Gunawardena and Rowan, 2005; López-Hoffman et al., 2006; Rönnbäck et al., 2007). Conversion of erstwhile shrimp and fishponds to potential replanting sites within affordable cost of communities is more of a concern in South Asia. However, replantations in degraded forest areas of East Africa need more attention towards choice of appropriate timber and fuel supplying species. Accordingly, CBMM planners have to formulate their own customized management plans for specific sites with respect to their different use options and related environmental consequences like land use changes, biodiversity losses and habitat modifications. In addition, the issues of livelihood support in gestation period, distinction between reserved or virgin mangroves and plantations, determination of utilization choices in different mangrove zones, accessibility to logistics and technological back up, level of state intervention and legislative support in usufruct sharing need thorough examination in any community endeavour. Failure in proper handling of any of these concerns can generate considerable financial crisis in a community initiative as these are noticed to be the major factors responsible for heterogeneous levels of success of CBMM projects throughout the world.

7. Social sustainability issues

Assessment of the issues related with social sustainability of CBMM projects are relatively new inclusions in sustainability studies than their ecological and economic counterparts. These often possess multi-dimensional and seemingly unrelated attributes with respect to balanced development (Bell and Morse, 1999). Social sustainability is a life enhancing condition within communities manifested by a strong sense of societal cohesion and a consign where people live, work and thrive in a vibrant social milieu (Glaser, 1999). Management of mangrove resources traditionally encompasses wide spectrum of social components like level of community participation, performance of women, shaping of social space, social justice and rights, politics of poverty and exclusion, utilization and reproduction of social capital, quality of life, presence of various forms of social norms and cleavages based on religion, class and ethnicity. Moreover, uniqueness of mangrove habitats as ecotone zones has given rise to diverse patterns of cultural as well as aesthetic traits and identities for coastal communities throughout the tropics. In spite of these facts, deficiency in appropriate quantification and measurement procedures of societal components with predominantly qualitative character hinders the inclusion of social indicators in sustainability studies. However, evaluation of social sustainability is increasingly becoming an important component of holistic appraisals of CBMM projects.

In many remote coastal parts of the tropics, mangrove ecology and livelihood opportunities have coalesced with the social fabric of local communities forming an inseparable milieu of harmonious ways of living with nature. However, recent evidences of worldwide extermination of mangroves due to failure in implementing sustainable CBMM show the possibility of effacement of these harmonious interrelationships in the future. For example, although local people in Tanzania traditionally use mangroves in a sustainable way but degradation occurs mainly due to extensive exploitations by external businesspersons (Semesi, 1992). Krause and Glaser (2003) highlighted the problems of socio-economic disparities and disintegration of traditional rural societies in the wake of increasing mangrove depletion and consequent coastal erosion in northern Brazil. Here, socio-economic development through amelioration of household-based mangrove resource processing units was identified as a necessity for environmental conservation (Glaser, 2003). However, loss of social sustainability despite apparent stability in economic and ecological realms occurred in mangrove crab fisheries of this region due to the absence of any sustainable management regime and influx of external immigrants (Glaser and Diele, 2004). Rise in the incidents of alcoholism and school absenteeism along with other mass-deviant behaviours were reported as instances of eroding social bonding and '*genre de vie*'. Moreover, roles of women in post-capture processing of crabs and domestic works are severely undermined in traditional societies despite their crucial roles in transcending vital knowledge and cultural values on crabmeat processing from one generation to the next (Magalhães et al., 2007). Here, the entire process is male dominated and family controlled whereas community or cooperative processes are markedly rare. Similarly, reduction of socio-economic vulnerability was found to be essential for strengthening the CBMM programme in Indian Sunderbans by improving social infrastructure of forest fringe villages chiefly in the education and health sectors (Saha, 1999). Success of this programme depends on the performances of village institutions and government bodies in providing alternative livelihood opportunities and basic civic amenities to the most marginal sections of local population. For this reason, socio-economic upliftment comprises a considerable portion of the CBMM activities in Sunderbans for constructing a socio-cultural consensus and 'human shield' to protect the mangroves. Sidik (2008) assessed that social

vulnerability was increasing in the Mahakam delta mangroves of Indonesia due to aggravated problems of mangrove deforestation and resource depletion. Failure in implementing realistic CBMM initiatives against outsider controlled commercial activities, which suppressed other social forces, resulted in recurrent conflicts between local people and outsiders on ownership issues of mangrove resources. Hence, social welfare and sustainability in such societies are difficult to achieve unless varied forms of disparities are removed.

Assessment of perceptions and participation levels of community members are of paramount significance in sustainability studies of CBMM programmes. While comparing sustainability status of mangrove aquacultural systems of Philippines and Sri Lanka, Bergquist (2007) recognized some key socio-economic factors responsible for sustenance of any such system like management abilities of farmers, status of empowerment, prevailing cultural traits, quantum of participation of local poor, nature of competition in sharing resources and level of poverty. Marginalized populations of South Asia are often engaged in environmentally undesirable livelihood activities like mangrove cutting, shrimp catching along riverbanks and poaching of wildlife as large-scale export oriented aquaculture farms developed on erstwhile mangrove wetlands give rise to uneven economic prosperity in favour of local elites. Hence, more socially equitable and community oriented aquacultural practices are needed in these areas in place of monopolized extensive farms to prevent further degradation of mangrove ecology. Many authors had forwarded community-controlled paddy cum fish culture and fish-shrimp polyculture as viable alternatives (Dewalt et al., 1996; Hein, 2002). Regarding social perception of local inhabitants on conservation of mangroves and possible restoration options, Khan and Ali (2009) found that most of the coastal population of southern India had reservation against pioneering the conservation measures and generally rely on government efforts. Failure of village institutions in providing sustainable livelihoods, lack of perceptions on community control and ownership of local resources were cited as major causes of these sorts of mass behaviours. In this aspect, roles of NGOs, government agencies, academic institutions and funding bodies become extremely important as these are effective agents of awareness generation and initiation of pilot projects (Datta et al., 2010; Rasool et al., 2002). In reality, ecosystems like mangroves are so interwoven in the ecological, economic and social landscapes of the tropics that any kind of management initiative barring the 'poorest of the poor' and 'voiceless' sections of the coastal population will not become successful. These sections of population, who are prime dependents of mangrove resources for subsistence, have strong cultural bonds and traditional knowledge on mangroves.

Social perceptions on CBNRM and level of participation in these initiatives are often viewed in terms of information transfer, individual socio-political status and location specific decision-making endeavours. Success of any community organization in natural resource management, either internally constructed or externally imposed, depends on its flexibility to include all possible stakeholders irrespective of socio-economic as well as political linkages and its capacity to mould itself according to the changing social relations of community members and outside stakeholders in a constantly varying quasi-natural environment. Saunders et al. (2010) demonstrated the way intra-village socio-political conflicts and illusive perceptions of communities on the functioning of a CBMM organization affect management activities in Zanzibar. Similarly, Armitage (2002) explored the influence of socio-economic and political hierarchy in control and access over local mangrove resources in Indonesia. Here, indigenous people were marginalized and placed at the bottom of that hierarchy while immigrated outsiders belonging to influential ethnic groups controlled the economically lucrative aquacultural ponds. Thus, traditional knowledge on sustainable use and conservation of mangroves remained largely neglected in these mainstream production systems resulting in the degradation of mangroves. In Indian Sunderbans, people were brought from other parts of India during colonial periods in order to initiate paddy and shrimp farming by clearing mangroves. As a result, present extent of Sunderbans is actually less than half of the forest that existed two centuries ago (Chaudhuri and Choudhury, 1994). Even the existing management policies and institutions are more inclined towards the aspirations and customs of 'higher caste' immigrants overlooking the interests of indigenous tribes and 'social outcastes'. In many areas, local people perceive community institutions as analogous to the state in general and to the ruling political groups in particular. Many of them also reject these institutions as symbols of opposition to the state sponsored initiatives based on mere political differences. Hence, in order to continue the CBMM initiatives sustainably, radical reforms and reorientation towards more socially equitable and inclusive programmes are necessary in many parts of the world.

8. Institutional sustainability issues

CBNRM practices had experienced a mixed level of success and appreciation from both worldwide in-situ stakeholders and research communities (Pagdee et al., 2006). Despite ensuring sustainability issues with respect to ecology, economy, and society, many CBNRM efforts did not accrue expected level of success as well as sustainability in the long run (Galli, 2007). In many cases initial euphoria among local communities wither away after withdrawn of external assistance and community institutions fail to keep themselves active amidst resurfaced intra and inter-community conflicts (Dasgupta and Chattopadhyay, 2006). Therefore, sustained functioning and adaptive capacities of community institutions are the vital factors for these initiatives to remain useful for extensive periods. Institutional sustainability refers to the institution's competence in coordinating human interaction in order to facilitate decision-making and execute sustainability policies (Pfahl, 2005). It requires more than just preserving the institution. In reality, institutions must adhere to socio-political processes, encourage participation in decision-making and be accountable to sustainability policies and political mechanisms. Regarding CBMM, the issues of institutional sustainability need more attention as initial investment of high socio-economic capitals and low resource outputs often threaten the survival of both institutions and programmes. The following discussion had been primarily structured after the facilitating conditions of Wade (1994) and eight designing principles of Ostrom (1990) on sustainable common property institutions but emphasis had been given on CBMM case studies.

As noted by many, prime aspects of institutional sustainability are sharing of property rights, means of exercising power in resource distribution and access by individuals who cumulatively form the local institutions (Brechin et al., 2002; Brown, 2003). Interests of communities in forest management emanate from the incentives members are going to accrue in this process through well-defined property rights. Property rights are subsets of institutional arrangements, which encompass several factors like tenure security, ownership types and implementation of rules, regulations and sanctions. Users without these rights can engage in ecologically undesirable activities leading to over exploitation of resources and community conflicts (Pagdee et al., 2006). Moreover, in order to elicit greater participation of people in CBNRM, Ostrom et al. (1999) pointed out that national governments should not undermine local authorities' decision in supporting institutional causes. In reality, proper appreciation of property rights and institutional arrangements of community endeavours by national governments can

promote institutional sustainability as cited by Beitl (2011) regarding mangrove fisheries of Ecuador. However, most of the so called 'decentralized' and 'local level governance' initiatives toward natural resource management do not succeed because of the perpetual inequality and monopolized leadership structures within the institutions that hinder equitable development and social justice. Existences of socio-political hierarchy and consequent manipulation of management strategies based on class, ethnicity (caste in Indian subcontinent) and gender frequently deter the proper functioning of institutions. Virtual exclusion of the underprivileged sections of people from management procedures eventually leads to the degradation of natural resources like mangroves as they are left with the only choice of succumbing to illegal extractive practices although they actually thrive on and care for these resources. In Indian Sunderbans, local leaders of major political parties predominantly control the CBMM institutions. A strong nexus exists between those local leaders and lower ranked bureaucrats, comparatively affluent sections of rural masses and powerful elites represented by corporate sectors. Management decisions taken by these institutions are, therefore, bound to be partial and aligned in favour of the elites (Datta et al., 2010). Subsequently, these institutions are experiencing continuous loss of mass support and initial enthusiasm because none of them has proved competent enough to practice CBMM sustainably in their present orientation and capacity. In contrary, appropriate recognition of the requirements of multiple stakeholders in institutional decision-making through mixed land use and resource utilization methods could foster both ecological sustenance and economic prosperity as exemplified in case of Philippines (Macintosh and Ashton, 2002) and Vietnam mangroves (Christensen et al., 2008).

Another vital aspect of institutional sustainability is the adequacy of management policy towards implementing CBMM and proper application of legal as well as institutional functioning regulations. In general, communities must enhance their will and capacity to protect and use the mangrove resources in a sustainable way. It requires a long-term process of community organization and presence of well-defined management strategies including scopes of judicial sanctions and fines. These sanctions and processes of law enforcement should be clear, transparent and egalitarian with respect to all stakeholders for better acceptance of the institution as a capable management platform among the local populace. Primavera and Esteban (2008) demonstrated the way by which vast tracts occupied by illegal shrimp ponds in Philippines could not be taken under CBMM initiatives chiefly due to lack of institutional strength and political inaction. Similarly, Pulhin (1996) highlighted the existing development-interventionist and programmatic character of government organizations towards community forestry in Philippines. These sorts of government control through blatant territorial jurisdiction suppressing local community endeavours are also documented in other parts of the world (Grima and Berkes, 1989; Huitric et al., 2002).

Thirdly, presence of exemplary leadership qualities and self-reliance among members of a particular village community not only facilitate CBMM in that village but also encourage and attract nearby villages to adopt this kind of management strategies (Ostrom, 1990; Soontornwong, 2006). In general, application of traditional knowledge and practices had been advocated for better CBMM performance (Maconachie et al., 2008). However, this is not the norm always as it can also bring along some negative impacts like slash and burn agriculture, intensive fishing and prawn seed collection. In mangrove areas populated with newly settled immigrants of agrarian background, application of their traditional knowledge may not be useful as those are primarily driven by farming motivations rather than conservation and management based ones. In these cases, roles of leaders and local governments become vital, as they need to embrace new scientific ideas replacing the redundant traditional customs (Sudtongkong and Webb, 2008). Most importantly, they have to convince ordinary villagers about the appropriateness of these new ideas. However, community management becomes troublesome in vastly stratified traditional societies of India, Indonesia, and Sri Lanka as the leadership is limited within a particular section of society (Egbuche et al., 2008). While judicious leadership can definitely enhance community's willingness to carve out diverse sustainable livelihood options through CBMM (Marschke and Sinclair, 2007), biased or corrupted leadership can bring serious troubles in institutional functions by transferring ownership and access rights of land and resources to outsiders for fulfillment of their vested interests (Armitage, 2002).

Fourthly, sufficient provisions of finance and technology are required for sustenance of any CBMM institution since arrangement of alternative livelihood options and conservation of mangrove ecology in a rapidly evolving coastal environment demand constant technological modifications and capital investments. These can be ensured if the institutions are capable enough to provide income to its members through sustainable mangrove utilization and make scopes for arrangement of loans, incentives and even insurances for them. The roles of Self Help Groups (SHGs), cooperative banks and microfinance organizations (e.g. emerging community banks of Africa and Bangladesh) are supremely important in this regard. Success in management can be achieved if these organizations function in coordination with the CBMM institutions. Too much dependence on the funding of national and international donor agencies often weakens institutional functionality and reduces the urge for self-reliance (Pagdee et al., 2006; Stone et al., 2008). As mangroves exist in the tropics not only along rural areas but also near coastal urban areas, financially stable and functionally self-dependent urban local bodies (e.g. municipalities, corporations and urban development authorities) can therefore effectively contribute in CBMM as a solution to storm protection, sewage recycling and landscaping concerns (Agdalipe, 2003).

Lastly, continuous monitoring and assessment of the functioning status of institutions by regional authorities, public forums, mass media and academia are necessary. Most of the CBMM institutions function on their own and often their functioning are impeded by socio-political, financial and technological constrains due to dearth of adequate information, long-term planning strategies and environmental awareness (Maliao and Polohan, 2008). Better coordination between these institutions and regional authorities for continuous flow of necessary information, technological expertise and policy wise interventions are thus necessary (Hue, 2002). Moreover, funding agencies should ensure the presence of these aspects of institutional sustainability in the CBMM draft proposals and agreements. If needed, necessary modifications should be made in those proposals by keeping provisions for monitoring and intervention even after the completion of assistance or aiding periods. In this context, roles of government agencies become highly significant as designers of CBMM proposals, mediators and interlocutors in inter-community conflicts as well as disseminators of technological expertise (Ostrom et al., 1999; Pagdee et al., 2006).

9. Future directions in management and research

In the imminent years, sustainable management of mangroves will become a matter of paramount concern as climate change induced rise of sea levels and other environmental hazards will enhance the vulnerability quotient of coastal communities in terms of their existence. Consequently, roles of stakeholder communities as managers of common property resources (CPRs) like mangroves will enhance considerably as parts of climate change mitigation and adaptability strategies.

Several facets of CBMM initiatives will be under researchers' scanner as success levels of these projects vary depending upon micro-level management plans. Firstly, accurate valuation of local mangroves should be done before initiation of any CBMM project by taking into account all their environmental benefits and subsidies (Marshall, 1994). In this regard, construction of comprehensive quantitative database will help immensely to judge the actual possibility of success (Ostrom, 1990). In particular, the aspects of aquatic faunal biodiversity and overall wildlife management will be of greater concern in the cost-benefit evaluations of CBMM projects (Lewis, 2005; Tri et al., 1998). Secondly, specific research on zonal classification of mangroves based on uses like timber and fuelwood harvest, collection of NTFPs, ecotourism and landscaping, wildlife conservation and protective functions will be of major concern (Iftekhar and Takama, 2008). Moreover, scientific literature on the possibility of introduction of exotic species depending on local environmental conditions and existing species associations will be beneficial for CBMM (Rubin et al., 1998). As pointed out by Field (1999), site-specific researches in assisting the communities to sort out practical problems like site selection, choice of species and zonation, monitoring and maintenance measures, estimation of gestation periods and usability of resources should be the focus at present. Similarly, matters of biodiversity conservation, introduction of biotechnology, ecological modelling, estimation of anthropogenic impacts and enhancement of global database on CBMM will attract the attention of scientific community. Moreover, application of cheap or open source satellite images in CBMM monitoring will become more popular especially in the developing countries (Selvam et al., 2003). Restoration works in CBMM projects will be based on advance assessments on the nature of degradation, either natural or anthropogenic or quasi-natural. A major area of enquiry will be the monitoring of restoration levels of natural ecological processes in rehabilitated mangroves because human interventions frequently disturb natural restoration process and consequently the primary aims of management may be hampered in future (Paphavasit et al., 2008).

The socio-cultural and institutional dimensions of CBMM are still underdeveloped areas of research. Focused studies on the complex relations between mangroves and local history, art, language, ethno-medicine, politics, and even social structure are needed for exploring the nature of cultural heritage, symbolism, identity and religious implications of mangroves on indigenous communities (Saunders et al., 2010). From an institutional perspective, these aspects become more crucial for sustenance of CBMM in the wake of commercialized and consumerist lifestyles and neoliberal globalization (McManus, 2006). Changes in beliefs, uses and value systems brought by these phenomena are even transforming the social milieu of remotest communities and consequently their aspirations, usufruct sharing and power relations regarding CBMM initiatives are also changing. Accordingly, site-specific studies with wider theoretical bases than contemporary CPR theories are required as the existing CPR theories are unable to comprehend these complex realities.

Newer horizons will be explored in the subsequent years concerning researches on mangrove management in general. Among these, appraisal of waste water treatment potentials of mangroves, fate of toxic elements trapped by mangroves after certain residence times, actual resistance potential of particular mangrove species against storm and sea surges, response of mangroves towards pollutants originating from different sources are the noteworthy ones (Tam and Wong, 2002). In addition, studies on more refined methods of sustainability evaluation like criteria and indicators (C&I), forest certification, habitat suitability indices will be beneficial for CBMM (Datta et al., 2010). For this purpose, indicators based on ecotourism potential of mangroves will become highly valuable (Abidin, 1999).

10. Conclusion

Depletion of coastal mangroves is a persistent global phenomenon and scientists are now not ruling out the possibilities of a world without mangroves under changing climatic patterns and anthropogenic disturbances (Duke et al., 2007). A successful CBMM initiative can become an appropriate example of apt adaptation strategies in this regard. However, higher numbers of CBMM initiatives were reported from South Asia and moderate numbers from South America but only few pioneering initiatives were found in Africa. Identification of the causes of degradation at a particular site and use-specific zonal replantations with respect to species associations were identified as major ecological criteria for sustainability. Wide variations exist between actual and potential uses of mangroves by local communities throughout the world. These potential uses have to be transformed into realistic ones in order to make the CBMM initiatives economically viable. Proper disbursement of accrued benefits and services among community members irrespective of their positions in socio-cultural hierarchies is also a major concern. Regarding CBMM sustainability in South Asia, more socially equitable and community-controlled aquacultural practices along with mangrove plantations are needed. In general, restructuring of CBMM institutions in favour of actual subsistence based users by ensuring their participation in decision-making and resource sharing had been identified as a necessity for achieving institutional sustainability. Strengthening involvement of women in management activities had been found as an important prerequisite in this context. As successful CBMM measures need substantial database and wisdom on all the related aspects, the present paper thus can be viewed as a positive logical step in this regard by reviewing and enumerating the possible linkages between ecology, society and economics of CBMM. This paper may also contribute considerably in the critical analyses of CBMM projects of South Asia and Africa as there is a dearth of comprehensive literature on these matters. However, comprehensive sustainability with respect to all the issues discussed here may not be actually possible as well as necessary to achieve in most of the CBMM initiatives in reality. Hence, depending on location, historical function and user preferences of the mangrove stands, emphasis should be given on either ecological or socio-economic sustainability if achievements of both are not possible together. In any case, issues related to institutional sustainability should be of primary concern of decision makers as long-term success cannot be ensured without attaining these. Yet, few of the studies covered here were actually found to be concentrating on the socio-political and institutional aspects of CBMM. Moreover, studies on cultural linkages of coastal communities with mangroves and impacts of globalization induced socio-cultural transformations of these communities on overall mangrove management are conspicuously absent. In these regard, more focused studies and their critical reviews will, therefore, certainly accentuate the knowledge-gathering endeavour of scientific communities in the quest of making CBMM sustainable in the long run.

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