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REPORT

Effectiveness of Marine Protected Areas in Managing the Drivers of Ecosystem Change: A Case of Mnazi Bay Marine Park, Tanzania

Milali Ernest Machumu, Amararatne Yakupitiyage

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Abstract Marine protected areas (MPAs) are being promoted in Tanzania to mitigate the drivers of ecosystem change such as overfishing and other anthropogenic impacts on marine resources. The effectiveness of MPAs in managing those drivers was assessed in three ecological zones, seafront, mangrove, and riverine of Mnazi Bay Marine Park, using Participatory Community Analysis techniques, questionnaire survey, checklist and fishery resource assessment methods. Eleven major drivers of ecosystem change were identified. Resource dependence had a major effect in all ecological zones of the park. The results indicated that the park's legislations/regulations, management procedures, and conservation efforts are reasonably effective in managing its resources. The positive signs accrued from conservation efforts have been realized by the communities in terms of increased catch/income, awareness and compliance. However, some natural and anthropogenic drivers continued to threaten the park's sustainability. Furthermore, implementation of resource use and benefit sharing mechanisms still remained a considerable challenge to be addressed.

Keywords Drivers of ecosystem change · MPA management effectiveness · Resource dependence · Mnazi Bay

INTRODUCTION

The protection of coastal aquatic habitats is a comparatively recent concept compared with the conservation of terrestrial areas. Only 0.45 % of the world's oceans, which is equivalent to 1.6 km^2 of the total water area of the world, are currently protected as opposed to 11.6 % of land, which is equivalent to 17.3 million km^2 of the total protected land area of the world (Wells et al. 2007). Consequently, coral reefs worldwide are suffering massive declines due to anthropogenic activities (Wilkinson 2004), and fisheries are declining fast enough to be exhausted by the year 2048 if no proper management regimes are employed immediately (Worm et al. 2006). Hence the management of marine resources for protecting biodiversity and securing fishery production is undergoing dynamic change; establishment of the protected areas emerges as a leading strategy and efforts to reverse ongoing losses in biodiversity (Mora and Sale 2011).

The situation in Tanzania is not an exception; the natural resources of the country have come under increased pressure over the past three decades due to anthropogenic activities (Silva 2006). Various kinds of coastal ecosystems in the country, especially corals and mangroves are under increased pressure from over-exploitation; coral reefs have been blasted and mangroves have been cut indiscriminately (URT 2006). The government has responded to protect coastal and marine resources by enacting the Marine Parks and Reserves Law of 1994, which allows for the creation of marine protected areas (MPAs) (URT 1994). In 1997, the government developed a national environmental policy to address issues pertaining to exploitation of natural resources. Despite these coastal conservation efforts in Tanzania, it is still uncertain how effective the creation of MPAs for managing marine resources.

The development of MPAs in Tanzania goes back to the 1970s when several sites were legislated as marine reserves. However, due to the lack of capacity to actively manage those reserves, they became merely "paper" reserves (Bryceson 1981). Declaration of the establishment

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of MPAs can easily showcase the increased commitment for environmental protection, but it only provides a false sense of security (Mora et al. 2006). Hence, there is a need for the evaluation of the effectiveness of MPAs as a tool for coastal resources management, especially the degree to which management actions are achieving the goals and objectives of the MPAs in an optimal effective manner (Mangubhai 2001). Since the long-term success of MPAs depends on demonstration of its usefulness and appropriateness as an effective natural resources management tool (Mangubhai and Wells 2005), such evaluations should reveal the desirable effects of management interventions through evidence of results, rather than on the basis of educated guesses (Jones 2000). Evaluation of protected areas is critical since their failure to protect biodiversity could erode public and political support for conservation (Mora and Sale 2011). However, management interventions in the country are currently measured by relying on short-term project evaluation reports with a limited evidence base.

The Mnazi Bay Ruvuma Estuary Marine Park (MBREMP) in Tanzania was gazetted in 2000. The park was designed to use participatory approaches in managing its resources. The objectives of MBREMP are to: (1) protect, conserve, and restore the species and genetic diversity of living marine resources and ecosystem processes; (2) manage marine and coastal areas to promote sustainability of the use and to reclaim and recover areas and resources that have been over-exploited; and (3) to ensure that resource users who lives in the villages situated inside and in the vicinity of the park are involved in the planning, development, and management of the marine park, sharing the benefits of the protected area operations and have priority in the resource use and other economic opportunities (URT 2005). The park ranks among the highest diversity sites for soft and hard corals in East Africa (Obura 2004). The area is also classified as an "Important Bird Area" (IBA-28) due to high densities of migrating crab plovers *Dromas ardeola*. Other resources include mangroves, corals, and natural gas.

This study was conducted to assess the effectiveness of management practices of the MBREMP in Tanzania for managing the drivers of ecosystem change and to sustain marine fishery resources. The study included the evaluation of current state of fishery resource, identification of current drivers of ecosystem change, analysis of regulatory framework, and stakeholder's compliance for regulatory measures. The main research questions posed in this study are: (i) What is the current status of perception based fishery resource systems in MBREMP? (ii) What are the major drivers of ecosystem change and their impacts? (iii) What are the existing management frameworks, i.e., regulations and management procedures? (iv) Do stakeholders comply with regulations and what benefits are derived by complying? (v) How effective are those management regimes to reduce adverse impacts from human activity systems? It is expected that this evaluation will be useful to develop guidelines for the management of MPAs elsewhere in the tropics.

MATERIALS AND METHODS

This study was mainly based on the evaluation of perceptions of local community on the drivers of ecosystem change and the effectiveness of the marine park management procedures supplemented with a household survey and brief evaluation on the fishery resources use in the marine park.

Study Area

The MBREMP is located between 10°34′46″S, 40°16′13″E and 10°34′25″S, 10°16′02″S and 10°07′29″S, 40°28′10″E and 10°09′28″S, 40°13′56″E in Mtwara District (Fig. 1). The location is where the South Equatorial Current (SEC) meets the African mainland after crossing the Indian Ocean. It is also the source point for the East African Coastal Current (EACC) and Mozambique Current/eddies (Ruitenbeek et al. 2005). Consequently, the area is forming a critical node for the accumulation and dispersal of marine organisms for East and Southern Africa. The park covers an area of 650 km^2 comprising 220 km^2 of terrestrial areas and the remaining 430 km^2 are marine environments. The northern side of the park extends from Ras Msangamkuu at the entrance of Mtwara Port stretching southwards on the seaboard along the coastline 45 km to the Ruvuma River, where it extends inland along the Ruvuma River to Mahurunga village. Features of the park include the three Islands of Namponda, Mmongo, and Kisiwa Kidogo; Msimbati channel, Mnazi Bay, Ruvula Peninsula, and Ruvuma Estuary. According to the "Gazettement order No. 285 of 2000" the park had 11 main villages and three sub-villages. However, due to the split of two villages and extension of the park jurisdiction, the number of villages has increased to 15. The park's villages have been categorized into three ecological zones; namely, Seafront villages, Mangrove surrounding villages, and Riverine villages. The study was conducted in six villages; namely, Msimbati and Mngoji in the seafront zone; Litembe and Tangazo in the mangroves; and Kitunguli and Mahurunga in the riverine zone.

Data Collection

The data collection was carried out in three stages: Stage 1 involved Participatory Community Analysis (PCA) techniques (Electronic Supplementary Material Appendix S1). Stage 2 involved a checklist for key informants' interviews and a households/questionnaire survey

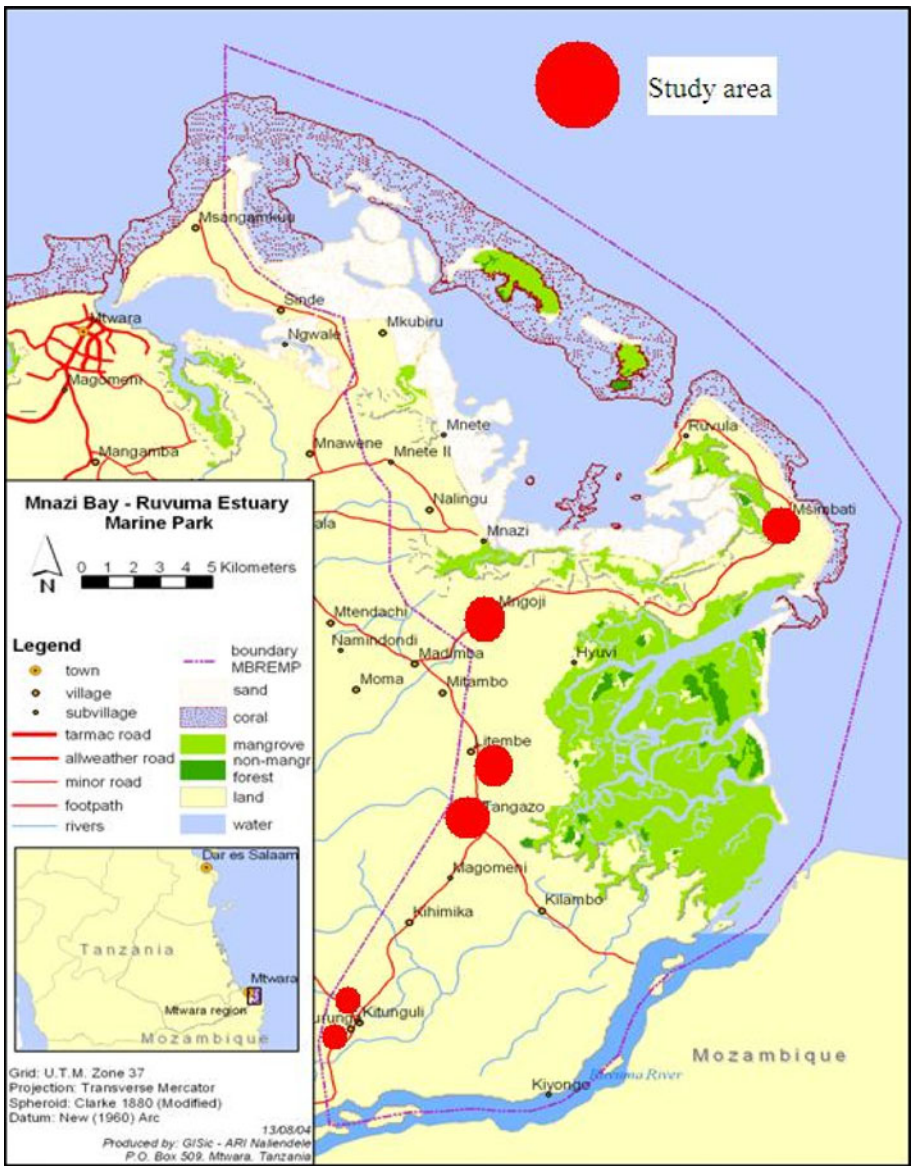

Fig. 1 Map of the study area

(Electronic Supplementary Material Appendix S2). Stage 3 was the assessment of resources status, which mainly focused on fish catch and their income. Multiple and complementary data collection methods were employed in this study to allow triangulation of findings for more in-depth and meaningful data interpretations.

Participatory Community Analysis (PCA)

The PCA techniques were based on open dialog and mutual sharing to make the methods effective. The methods were designed in such a way that they quickly generated information about local conditions, livelihoods, and social formations within the MPA, referring to research questions (ii) and (v). In each study village the participants in the PCA exercises were grouped in four categories each comprised five participants; namely, (1) women; (2) youths (22–40 years), (3) elders (60–86 years), and (4) village leaders. A total number of 120 participants, from six villages (20 × 6) participated in the PCA. The participants went through the following exercises; resource mapping, documentation of resource historical changes, trend analysis, and identification of the drivers of ecosystem change.

Household Survey

The household survey as a major tool for data collection was carried out using a structured questionnaire, which was designed to collect socio-economic and the rest of the research questions data. Both open and close ended questions

were used to collect information. In open ended questions respondents were free to give their own answers while in close ended questions a number of alternative answers were provided. A stratified random sampling method was used in selecting the households for the survey. People in each village were grouped into relatively homogeneous sub-groups with respect to their wealth such as, income, assets, and social status; namely, rich, middle/moderate, and poor/deprived. From each of the wealth cluster, 15 heads of households were randomly selected for interviews. Thus, 270 people from six villages (45 × 6) were interviewed in this survey.

Key Informant Interviews

A checklist for key informants was designed to collect qualitative information of perceptions and experiences. Collected information supplemented other research tools. Key informants included both clientele and informed outsiders who are accessible, willing to talk and have great depth of knowledge about the research topic. Thus, 30 key informants comprising village leaders, MPA staff members, and other key stakeholders encompassing natural resources officers, ward executives, policy makers, and government officials were interviewed.

Resource Status Assessments

Resource status data were collected from fish catch/income. The data were collected twice a week at four landing sites located on the seafront and mangrove areas in June and August 2010, using the same forms used in 2006 which were designed to record the weights of fish landed in a boat, number of fishers, income and fishing time. The objective of the assessment was to understand recent status/trends of fish catch and income obtained from fish sales compared to the past by using monitoring data of the same stations and period in 2006. The results of fish catch/income would help to verify fish status information collected from other research tools.

Data Analysis

PCA data were analyzed in the field with help of the communities, since in this study people were not regarded as clients or beneficiaries but as partners. The data derived from resource status and standardized questionnaire surveys were analyzed for both descriptive and inferential statistics using SPSS software version 16 for Windows, at 5 % level of significance. Paired *T* test was used to compare quantitative data of fish catch, income and fishing effort between 2006 and 2010. Frequency, means, and percentage were used in descriptive statistics. One Sample *T* test was used to test for differences between respondent's income and the country's income per capita. Weighted Average Index (WAI) was used to identify major drivers of ecosystem change, involvement of community in management, and resource status indicators.

$$\mathrm{WAI} = \frac{\sum S_i f_i}{\sum f_i}$$

where S_i is the weight assigned to ith in the scale of importance, f_i is the frequency of the respondents who choose the ith order from available options of the scale of importance, and $\sum f_i$ is the total number of respondents. Content and Structural–Functional Analysis techniques was used to analyze qualitative data and information from verbal discussions held with respondents. In this way, recorded dialogs were broken down into smallest meaningful units of information or themes and tendencies.

RESULTS

Resource Status

Trends in Fish Catch and Their Income

The fish catch, income from fishing and fishing effort data collected in 2006 and 2010 were compared to evaluate their trends. The results showed that there was a significant increase in the amount of fish caught per boat/canoe from 2006 and 2010 ($P < 0.01$). The mean/average of fish caught per boat was 8.93 kg in 2006 and 47.78 kg in 2010. Each fisher had an average of 5.6 and 23.9 kg of fish catch per day in 2006 and 2010, respectively. There was also a significant increase in the income from fish sales between 2006 and 2010 ($P < 0.01$); the mean income per boat was US$ 4.49 in 2006 and US$ 27.30 in 2010. Moreover, a significant increase in the number of fishers ($P < 0.05$) and a decrease in time for fishing ($P < 0.01$) were noted. It was observed that the increase in the number of fishers per boat was small relative to the changes observed in fish catch and income. This indicates that despite using fewer hours for fishing, the fish catch and income per boat have increased in 2010 compared to 2006 (Table 1).

Resource Status Indicators

The resource status indicators are factors which were perceived by the stakeholders as major threats or complements for managing the marine park ecosystem were used to measure the resource status. The local community perceived that coral mining and mangrove harvesting have been decreased considerably, whereas compliance of regulations and fish catch have been increased (Fig. 2).

Table 1 Status of fish catch, income, and fishing effort in 2006 and 2010 per fishing boat or a canoe (Paired *T* test; $N = 132$)

Parameter/boat	Mean		Std. error mean		Sig. (2-tail)
	2006	2010	2006	2010	
Fish weight (kg)	8.93	47.78	1.94	6.94	0.01
Income (US$)	4.49	27.30	0.93	3.85	0.01
Number of fishers	1.58	1.98	0.08	0.18	0.04
Fishing duration (h)	6.11	4.22	0.14	0.26	0.01

Increased Income

The majority of respondents (67 %) mentioned that their income has relatively increased after the establishment of the MPA due to conservation efforts. The rest of the respondents expressed that their income increased due to other factors, particularly agriculture. The household income data showed that there was a significant increase in the annual income of the park's residents over Tanzania's income per capita in 2010, ($P < 0.01$). The mean annual income of the respondents was US$ 748 which was above the Tanzanian's income per capita of US$ 500.

Drivers of Ecosystem Change and Their Effects in the MPA

Twenty-two drivers of ecosystem change in the MPA were identified by the respondents. WAI showed that there are 11 major drivers with a moderate to high effects on the ecosystem in the three geographical zones of the MPA. Resource dependence for livelihoods was identified as a common driver that affects all three ecological zones of the MPA. It was observed that there is a relatively higher level of impact on the ecosystems in the mangrove surrounding villages, followed by the seafront and then the riverine zone. Migration of outsiders, both local and fishers to the MPA and political patronage were identified as important causes of change in the seafront and mangroves ecosystems. Shifting cultivation, clear-fell of forest/mangrove and deliberate forest fires affected the mangrove and riverine ecosystems. The rest of the drivers were ecosystem specific; namely, oil/gas exploration/exploitation and over-harvesting of natural resources adversely affected the seafront zone; destructive fishing gear and clear felling of forests/mangroves were identified to have adverse effects on the mangrove zone and floods were identified as having undesirable effects on the riverine zone (Table 2; Electronic Supplementary Material Appendix S3).

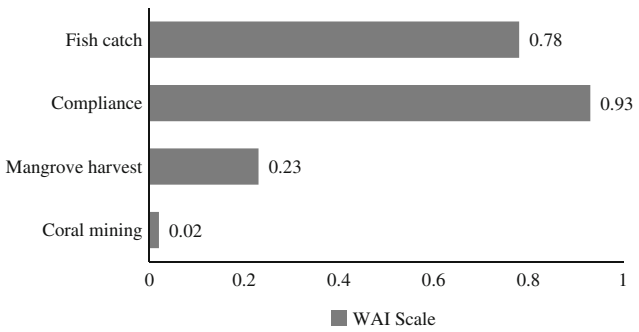

Fig. 2 Resource status indicators results

Regulatory Framework

Legislation/Regulations and Conservation Efforts

The majority of the respondents (65 %) perceived that management of the MPA has been progressing reasonably well or very progressive towards reducing adverse impacts of the drivers of ecosystem change (Fig. 3). The term progressive in this context means "making progress towards a better condition". However, slightly over 1/3 of respondents felt either there is no progress or progressing too slowly.

The respondents had different opinions on the reasons that brought about the progress of the management of the MPA; 56 % of the respondents narrated that the park has been progressing well due to the presence of legislations, regulations, and management procedures. Marine Parks Act and Fisheries Act were mentioned to be effective for resource conservation and management. The rest interpreted that the progress was due to the implementation of conservation efforts such as awareness campaigns and supporting various activities aimed to reduce over-dependence of resources, particularly, Alternative Income Generating Activities (AIGAs; Fig. 4).

As per the query of enforcement mechanisms of the management rules, 69 % of respondents said that they have been participating in enforcement of legislations/regulations geared towards management of the park's resources. However, participation mechanisms were different from one respondent to another. Three participation mechanisms for assisting the enforcement or regulations were mentioned: (1) through reporting illegal activities to the relevant authorities (60 % of the respondents); (2) through raising awareness to their fellow community members on do's and don'ts (31 % of respondents); and (3) through participation in carrying out patrolling activities (12 %) especially, Village Liaison Committee (VLC's) members.

Management Procedures

Management procedures in the Marine Park are mainly focusing on philosophy of participatory approach and its

Table 2 WAI test for the drivers of ecosystem change

Drivers of ecosystem change	MPA geographical areas		
	Seafront ($n = 90$) WAI	Mangrove ($n = 90$) WAI	Riverine ($n = 90$) WAI
Local migration	0.67**	0.59**	0.43
Tourism	0.14	0.00	0.00
Fishers migration	0.66**	0.64**	0.38
Investors development	0.19	0.01	0.01
Research	0.20	0.04	0.00
Oil and gas exploration/exploitation	0.64**	0.01	0.00
Port/harbor	0.04	0.05	0.06
Multiparty system	0.24	0.29	0.13
Political patronage	0.52**	0.50**	0.15
Improved living standard	0.45	0.26	0.23
Resource dependence	0.73**	0.74**	0.69**
Market demand	0.39	0.33	0.29
Traditional practices	0.20	0.21	0.18
Spiritual inspiration	0.11	0.11	0.11
Over-harvest of resources	0.51**	0.37	0.21
Destructive fishing	0.40	0.60**	0.22
Sea level rise	0.29	0.22	0.00
Floods	0.06	0.33	0.67**
Pesticide application	0.29	0.28	0.27
Deliberate forest fire	0.38	0.67**	0.68**
Shifting cultivation	0.24	0.50**	0.52**
Forests/mangroves clear-fell	0.31	0.54**	0.46

0 = No effect, 0.25 = Low effect, 0.5* = Moderate effect, 0.75** = High effect, and 1*** = Very high effect

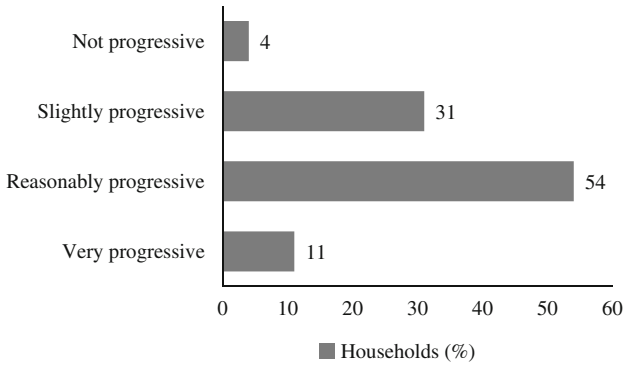

Fig. 3 Respondents' opinions on the effectiveness of MPA management

associated actions. In this study management procedures have been evaluated through involvements of local communities in management activities, resource use, and benefit sharing mechanisms.

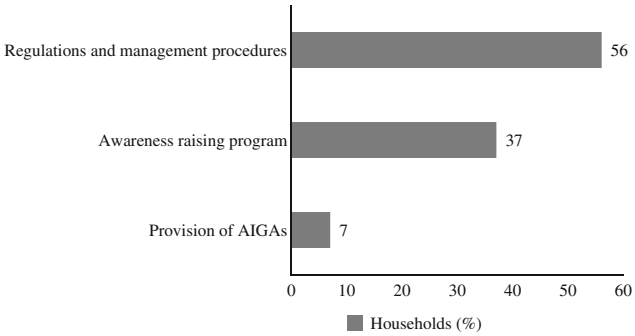

Fig. 4 Respondents' opinions on the reasons towards effectiveness of regulatory framework vis-à-vis conservation efforts

Involvement of Local Community in Management

The majorities (96 %) of the respondents pointed out that people are involved at different levels of management such as the decision making process on the resource-use, implementation of conservation activities, monitoring of resources, and evaluation of conservation projects. The results showed that overall WAI for all involvement categories ranged between 0.51 and 0.63 (Table 3) indicating that respondents from all three zones were satisfied with their involvement.

Resource Use Mechanism

The results of resource use mechanism indicated that about 50 % of the respondents have been accessing marine resources after being granted permission from relevant authorities. The remaining 36 % access the resources freely and 16 % they pay the required fee prior to accessing and utilizing the park's resources.

Beneficiaries and Benefit Sharing Mechanism

Ninety percent of respondents emphasized that the main beneficiaries of the MPA resources are the local communities since they use park resources to earn their daily livelihoods. About 7 % of the respondents mentioned MPA staff as the main beneficiaries as they are getting salaries and other fringe benefits for managing MPA's resources, while 3 % had opinions that village leaders were the beneficiaries. On the issue of MPA benefits sharing mechanism, 50 % of the respondents said that decisions/priorities on benefit sharing are based on the village development activities and households' needs rather than the existing rules and regulations, the rest had different views (Fig. 5). However, 27 % respondents were in the view that there is no benefit sharing mechanism.

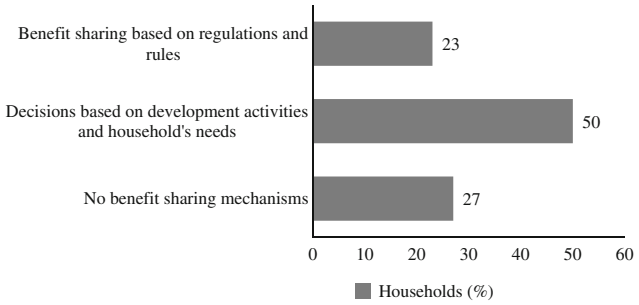

Fig. 5 Respondents' opinions on benefit sharing mechanisms

Table 3 Community's involvement at management levels 0 = No opinion, 0.33 = Unsatisfactory, 0.66 = Satisfactory, 1 = Very satisfactory

Management levels	Seafront ($n = 90$) WAI	Mangrove ($n = 90$) WAI	Riverine ($n = 90$) WAI	Overall ($N = 270$) WAI
Activities implementation	0.61	0.62	0.66	0.63
Decision making	0.62	0.64	0.57	0.61
Benefit sharing	0.45	0.5	0.56	0.51
Monitoring	0.53	0.58	0.55	0.55

DISCUSSION

Informed stakeholder participation to set societal goals and cooperation among the participants to take actions towards achieving them are key principles in integrated coastal management. Thus, participatory assessment of the success and failures was used in this study as a major tool for evaluation of the effectiveness of management practices of the MBEREMP. However, it should be noted that participatory assessments do not reveal underlying ecosystem mechanisms but the current status as perceived by the stakeholders.

Resource Status

Before establishing the MPA, MBREMP displayed the highest indicators of over-exploitation and destruction, particularly, the commercial fish species which had been highly degraded due to excessive exploitation (Muhando 1999). However, the results of this study showed that fish catch and their income have been increased in the MBREMP and the increased contribution from fishery has also been one factor to improve income of park's residents above the country's income per capita, which could be attributed to the success of MPA management actions. These may be due to enhanced biomass through reducing the threats for aquatic biodiversity. Mora (2008) showed that the effective implementation of MPAs increased the biomass of fish populations and coral reef builders. Micheli et al. (2004) and Lubchenco et al. (2007) stated that when such positive results are found, the usual explanation is that the processes threatening the survival of species have been removed or reduced inside the boarders of protected area. Lubchenco et al. (2007) stated that such trends indicate the positive results on local biodiversity of some large, well-connected, and well-managed protected areas. Kamukuru et al. (2004) found that the target species was over four times more numerous and individual sizes on an average 37 % larger on reefs in the Mafia Island Marine Park (MIMP) compared to the adjacent intensively fished areas.

Although the conservation measures can play a key role in fishery management, there are other factors besides management regimes which could have also contributed to the increased fish catch. For example, as MBREMP is located at the area where SEC meets the East African Coast and forming critical node of marine organism's accumulation might have increased supply of propagules (Ruitenbeek et al. 2005). Likewise, MBREMP's coastal habitats such as, estuaries and mangroves provide critical nursery habitat for organisms including fish spend their lives offshore (Mumby et al. 2004). Since these aspects were not evaluated in this short study, it is premature to arrive at a final conclusion on the underpinning causes for the enhancement of the fishery resources.

The community members stated that coral mining and mangrove harvesting have been drastically reduced and compliance has been increased (Fig. 2), and as a result mangroves in MBREMP also show a positive trend. The prohibition of commercial harvesting activities would also have contributed to this positive trend. Wagner et al. (2004) reported that the mangroves of the MBREMP appear to be among the best mangrove forests in Tanzania. Similarly, coral reefs have been restored due to regeneration, stoppage of coral mining activities and control of dynamite fishing to a certain degree, hence a very high level of recruitment of corals has been observed in the MBREMP (Obura 2004).

Effects of the Major Drivers of Ecosystem Change

Resource Dependence

Resource dependence creates adverse effects on the park's ecosystems and cause disruption on human well-being (Table 2), because of the harvesting beyond the maximum sustainable yield of biological resources. Resource dependence seems to be the underlying cause of many anthropogenic drivers such as migration from inland areas to the coastal MBREMP. Demographic trends, coupled with requirements of economic growth in developing countries, suggest that pressure on coastal areas and their associated

resources will continue to increase (Tsontos et al. 1998). Hence, there is a need for continued monitoring of migratory activities as 20 % (approximately 8 million) of Tanzanian population already lives in the coastal belt (Ruitenbeek et al. 2005) and the numbers are likely to increase.

Protection of Large Marine Ecosystems (LMEs) requires the design of MPAs that are large enough to avoid the mortalities of wild animals crossing their boarders (Mora 2011). LMEs management approach used by MBREMP allows it to hold large sections of various sub-ecosystems such as 220 km^2 of terrestrial area, which prompt people, especially poor, to extract park resources. McClanahan et al. (2005) found that big MPAs have not produced tangible results that would like to see as poverty reinforces constant or increased resource extraction. However, the goal of ecosystem-based marine management is to maintain a core resource base that can sustain human uses of the ocean and provide the goods and services to satisfy humans wants and needs (Foley et al. 2010).

Floods

Flood was identified a major driver of ecosystem change by the stakeholders (Table 2) as it regularly affects the riverine villages and causes erosion in the mangrove areas. Apart from the floods and river flow, erosion is also brought about by wave action, tidal movement, and ocean currents in the coastal areas (URT 2005), which affects the mangroves along the Ruvuma River. Floods also destroy natural land cover, displaces indigenous plants and animals, uproot mangrove trees and cause mortalities of mangroves by trapping excessive loads of sediment on their roots. Benthic habitats are also destroyed through deposition of thick layers of mud in the riverine zone, which may favor opportunistic or invasive species against endemic species to settle in the habitats (Miralles et al. 2006). Floods bring nutrient-rich and pollutant contaminated water from up-stream cashew nut agricultural lands that cause pollution to the marine environment, develop algal blooms that adversely affects marine organisms due to oxygen depletion (Veron 2008).

Fishers and Local Migration

The survey results showed that there is an influx of people migrating from inland to the MBREMP, particularly in the seafront zone for fishing, fish trading, and work in gas exploration/exploitation activities and other business ventures. Malleret and Simbua (2004) realized that MBREMP seafront villages particularly Msimbati attracted more people as it was the main marine product trading center in the Mtwara region. Increases of people in the seafront areas could be associated with an increased demand of resources, which in turn caused over-exploitation of park's resources. This is in line with Horrill et al. (2000) who stated that the growing numbers of people living along the coast and their increased demands for marine resources have not only caused over-exploitation but also improper exploitation of these resources. Similarly, Mora and Sale (2011) reported that an increase in human population size likely to be accompanied by an extension and intensity of anthropogenic disturbances.

Oil and Gas Exploration/Exploitation

The seafront villages situated on the natural gas deposit in the MBREMP have various activities related to gas and oil exploration. Though it is mandatory to conduct Environmental Impact Assessment (EIA) prior to implementation of any development activities in the marine park (URT 1994) and close monitoring of those activities by the park's management, it was still difficult to control strong flare lights and noise pollution created by generators and machines which were significantly affecting all forms of life in the MBREMP. For example turtle hatchlings decreased from 2122 in 2004 to 514 in 2006 was associated with gas exploration activities (MBREMP unpublished data). Moreover, some people were displaced and resettled elsewhere to pave the way for the gas exploration activities. This might be either due to weak impact assessments or assessment teams that are trying to protect the interest of multinational proponent rather than the impacted people and/or environment (Goodland 2005). In order to curb such weaknesses internationally accepted environmental management and protection standards should be applied in the EIAs.

Shifting Cultivation, Clear Felling of Forests, and Deliberately Forest Fires

Shifting cultivation is an agricultural system common throughout the tropics and subtropics for a temporary period of crop production (García et al. 2007). Shifting cultivation is a common practice in the MBREMP's riverine area, where this cultivation practice has been influenced by floods which changed the topography of land and tree coverage of the area and increase soil nutrients. Reductions in tree coverage also alter water, energy, and plant–animal dynamics (Breshears et al. 2011); water can no longer inundate in some riverine areas and hence it would be impossible to carry out farming. Such changes have forced farmers to rotate farms from one location to another by clearing the trees. Clearing forest also involves

cutting of mangrove poles for construction and wood for fuel, such anthropogenic activities are often a prime cause for mangrove depletion (Duke et al. 2007).

Although not intended to damage the ecosystem or disturb human well-being, the deliberate setting of forest fires for crop cultivation, weed control, and wild animal hunting are common in the MBREMP. Some species of indigenous plants and animals are believed to becoming extinct in the riverine and mangrove zones where fire setting is a common practice. It is evident that populations and species will suffer when their habitat becomes degraded or is lost completely (Hanski 2005).

Political Patronage

Political patronage has brought about negative impact on conservation efforts in Tanzania including MBREMP. For example, when the general elections were approaching, some community members decided to use illegal methods of fishing in the MBREMP. Culprits who were arrested for committing such offenses were either given penalties which were not commensurate with the gravity of committed offenses or many of them were acquitted using political patronage to win votes from community members during the general election. The situation affected conservation efforts and was closely related with suggestions made by Jameson et al. (2002) that it is possible to establish a perfect MPA but still could fail to protect its resources if there is no sustained political and community capacity at local and national levels.

Over-Harvesting of Resources

Poverty trap can force harvesters into continued exploitation of even depleted resources due to inability to move to alternative jobs (Cinner 2007). For example, many artisanal fishers in the seafront fish in shallow waters that serve as feeding and breeding grounds for marine organisms. Fisher overcrowding is aggravated by MBREMP's narrow continental shelf in which the extent of fisheries-rich coral reefs and sea grass beds hardly goes 1–3 km (Muhando 2001). Over-harvesting of resources also creates unbalanced ecosystems; as mentioned by Muhando (1999) and some commercial fish species had been seriously degraded around the MBREMP coral reefs.

Use of Destructive Fishing Gear

Despite the efforts made by the MBREMP's management to eliminate use of destructive fishing gear, these practices are still prevail to some extent. People in the mangrove villages confirmed that they hear or see the use of dynamite explosives, other unsustainable fishing gear like small mesh size nets and beach seines were also reported to be seen occasionally. Various studies have hypothesized that destructive fishing gear, which can destroy habitats, capture high proportions of juvenile fish and eventually reduce yields, are primarily used by the poorer segments of people. (Cinner 2009) and Silva (2006) reported that poverty increase the likelihood of using destructive fishing gear. However, experience in East Africa show that management that limits the use of spear gun and beach seine nets has considerable support from coastal communities (McClanahan et al. 2005). Some coastal areas of Madagascar have shown to limit the use of specific gear and closure of certain fishing ground (Cinner 2007). Local communities usually recognize the importance of managing their natural resources that provide them their own immediate needs and those of their children (Pendzich 1993). The majority of the MBREMP's dwellers raised their concerns on the resurfacing of destructive gears which do serious harm to their livelihood resources.

Effectiveness of MPA in Resource Management

Presence of Regulatory Framework and Conservation Efforts

In general, the MBREMP management is progressing reasonably well in managing adverse impacts of the drivers of ecosystem change (Fig. 3), this could be due to enforcement of legislations/regulations and management procedures that helped in shaping and changing people's attitude towards natural resources management. People are also supporting enforcement of regulations; however, such a support depends on how people perceive degradation (Thomassin et al. 2010). The majority complies willingly with regulations due to their involvement in all the phases of MBREMP development including regulations. This confirms empirical evidence that adopting manageability criteria during the planning of MPAs could lead to increase in voluntary compliance (Read et al. 2011). In addition, voluntary compliance can be optimized by gaining both public support and social acceptability of an MPA. This concurs with Thomassin et al. (2010) who defined social acceptability of the MPA as measure support towards a set of regulations, management tools or an organization by an individual or a group of individuals. The awareness of MBREMP communities on how they should participate in enforcement of regulations is essential in effective implementation and increased participation of stakeholders in the resources management (Catedrilla et al. 2012).

Though the MBREMP pays more effort in awareness campaign and most community members are aware of the park's management objectives and their role towards conservation. For this reason, the local community supports and participates in the MBREMP conservation activities,

increases public awareness of the environmental problems arising from human pressure (Mora et al. 2006). Hence, awareness enhancement should be continuous process because the conservation issues keep changing and the new generation should be kept aware of various environmental issues that they would face if they do not manage their natural resources to sustain MBREMP.

Promotion of AIGAs is often a component of MPA management strategies to reduce fishing pressure and address poverty concerns (Silva 2006). Despite the MBREMP implementing AIGAs, the results show that this area needs to pay a considerable effort to achieve the intended objectives. It has also been realized that AIGAs is a slow process which should involve local communities from the beginning and the benefits from AIGAs must be realized before their implementations.

Management Procedures

MBREMP is using participatory philosophy to manage its resources. Satisfaction in management involvement as expressed by respondents indicates that the philosophy is reasonably effective. Through involvement a sense of ownership on park's resources has increased among local people, thus, it is easy to win a certain degree of their support and commitment towards achieving the MPA's objectives. The long-term success of an MPA depends on effective management and community participation (Mangubhai and Wells 2005).

As far as resource use is concerned, many of the respondents mentioned that they do not strictly follow the procedures of accessing and utilizing marine resources as stipulated in the Act and MBREMP's General Management Plan (GMP). This indicates that resource use pattern is still an issue which needs more attention. Mora and Sale (2011) stated that at the global scale, harvesting is one of the primary threats to biodiversity. This situation could be attributed to high dependence of MBREMP communities on marine resource for their livelihoods.

The results indicated that the great beneficiaries' of the MBREMP's resources are community members as they use its resources for their livelihoods. Despite of the MBREMP communities being aware of the benefits accrued from marine resources, still the focus is only on the benefits to humans and neglect many important benefits accrued to nature (Angulo-Valdés and Hatcher 2010). As far as benefit sharing is concerned the MPRs Act states that 10 % of the net revenue borne from the park's resource use should be allocated for the park communities (URT 1994). However, the majority of stakeholders are not satisfied with tangible benefits, particularly the revenue accrued from conservation activities. This is similar to their fellow communities from MIMP who have become disenchanted as they witness tangible benefits reduced due to those fees (Benjaminsen and Bryceson 2012).

The results also show that in some cases addressing the issues related to benefit sharing is not only dependent on the Act; sometimes the discretions of park's management based on existing priorities. Part 3 section 5 of Marine Parks Act state that the warden has power to administer the park subject to authority of board (URT 1994), through this section warden can either propose development activities for funding or issue use permit wherever is appropriate. Considering such scenario, respondents were not satisfied with this provision in the legislation as this could lead to uncertain benefit sharing mechanism. People wanted issues related to the benefit sharing to be transparent and implemented as per legislation. This might be the reason for some of respondents to state that there is no benefit sharing mechanisms in MBREMP (Fig. 5).

CONCLUSIONS

The majority of local community members are aware of the drivers of ecosystem change; they identified 11 major drivers in the MBREMP. The identified drivers include both anthropogenic and natural causes that lead to not only change of ecosystems conditions and their services, but also have impacts on human well-being. The study results show that the park has been reasonably effective in managing the resources due to the presence of regulations and management procedures. In addition, the park management has been effective in implementation of some management procedures and associated actions to a certain degree such as involvement of local community members at different levels of management, and increased awareness among the communities on the importance of conserving the natural resources. However, more adjustments are needed in implementation of resource use strategies, AIGAs, benefit sharing mechanisms, EIA and monitoring programs. In addition, some drivers of ecosystem change, both man-made and natural, continue to threaten the park's sustainability. No mechanisms have been developed to overcome or to mitigate the impacts from the climate change. Since understanding the direct effects of climate variability and changes on ecosystems and indirect effects on human activities is essential for adaptive planning (Hoel and Olsen 2012), this should be a priority task for the park management to deals with in the near future. Floods and some of the anthropogenic drivers such as poverty and resource dependence are only partially addressed. The resource dependence has shown adverse impacts in all three ecological zones and seems to influence processes and/or effects of other anthropogenic drivers such as man-made

forest fire and increase migration of fishers and other people looking for livelihood opportunities.

In conclusion, the MPA is reasonably progressing well towards attaining its objectives. There are also positive signs voluntary compliance for park's regulations and accrued benefits from increased resource bases such as enhanced fish catch and household incomes, and regeneration of mangroves and coral reefs. Learning from these positive effects, MBREMP should make more efforts to address the remaining challenges.

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AUTHOR BIOGRAPHIES

Milali Ernest Machumu (✉) is a Principal Marine Conservation Officer at Marine parks and Reserves Unit in Tanzania, a doctoral student at Asian Institute of Technology (AIT) in the Field of Aquaculture and Aquatic Resource Management (AARM), School of Environment Resources and Development (SERD), Pathumthani, Thailand.
Address: Aquaculture and Aquatic Resource Management (AARM) Field of Study, School of Environment Resources and Development (SERD), Asian Institute of Technology (AIT), P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand.
e-mail: chumuson2002@yahoo.com

Amararatne Yakupitiyage is an Associate Professor at the Asian Institute of Technology (AIT), Aquaculture and Aquatic Resources Management Field of Study, Pathumthani, Thailand.
Address: Aquaculture and Aquatic Resource Management (AARM) Field of Study, School of Environment Resources and Development (SERD), Asian Institute of Technology (AIT), P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand.
e-mail: amara@ait.ac.th