GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

STATUS OF EXPLOITATION AND REGENERATION OF MANGROVE FORESTS IN PEMBA ISLAND, TANZANIA

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ABSTRACT
The existence of mangrove forests is facing a major blow due to anthropogenic activities especially in developing world. This study assesses anthropogenic impacts in two mangroves of Micheweni (unprotected forest) and Ngezi Nature Forest Reserve in Pemba Island, East Africa. Mangrove distribution, density, regeneration rates, stumps and die off were recorded in addition to interview and questionnaire to collect useful information. The results of mangrove regeneration showed that Micheweni had significantly higher rate than Ngezi forests (χ^2=6.569, DF=1, 0.01<p<0.025). In terms fo species, *Ceriops tagal* had the highest regeneration rate (40%) followed by *Bruguiera gymnorrhiza* (35%) and *Rizhophora mucronata* (25%). It was also observed that Micheweni had significantly higher number of partial cuts, stumps and die off tree than Ngezi mangrove forest (U'=299.0, P=0.04, U'=390; P=0.0001 and U'=297.00; P=0.05, respectively). Generally, the results showed that mangroves of Micheweni have been significantly impacted by anthropogenic activities compared to Ngezi, especially in the upper zone. The most affected species recorded were *C. tagal*, *R. mucronata* and *B. gymnorrhiza*. The presented data emphasized the impact of management on regeneration and healthy of mangrove forest whereby significant lower number of regenerated trees, partial cuts, stumps and die off tree were observed along the Ngezi Nature Forest Reserve"

KEYWORDS: Anthropogenic, conservation, destruction, mitigation, species.

INTRODUCTION
Mangrove ecosystems are among the most important of coastal habitats because of their unique ecological functions and their socio-economic value to local communities and nations. Coastal ecosystems are resilient habitats because of their high functional diversity and coastal communities are socially and economically resilient because of the robustness of the ecosystem upon which they depend through the availability of diverse economic activities (Adger, 1997). However, as resilient as mangrove ecosystems appear, these vital forests are also vulnerable and are being quickly depleted due to intensified human disturbances and poor management practices. Uncontrolled harvesting and destruction of mangrove forests can permanently alter these ecosystems (Pearce, 2002). Like many other parts of the world, the mangroves of Zanzibar are threatened by destruction intimately linked with human activities such as harvesting for timber and fuel-wood (Hussein, 1995; Semesi, 1998), land reclamation for aquaculture and salt-pond construction (Terchunian *et al*.,1986; Primavera, 1995, SONARECO, 2008), pollution and damming of rivers that alter water salinity levels (Lewis, 1990; Wolanski, 1992), oil spills have impacted mangroves dramatically (Ellison and Fransworth 1996).The fundamental cause of overexploitation of mangrove forest is the increase in population pressure along the coast, poverty, lack of livelihood options, change in values and open access nature (Macintosh and Ashton, 2002). Mangroves are also threatened by the impact of global climate change, which has concomitant effects on temperature change, carbon dioxide, altered precipitation pattern, storminess and eustatic sea-level rise. However, the climate change is a consequence of long term effect of anthropogenic activities. Realizing the importance of mangrove ecosystem function, the Government of Zanzibar has been taking serious measures such as establishment of conservation areas including Menai and Chwaka bay in Unguja and Ngezi mangrove creek in Pemba, replanting the mangroves especially on severely damaged areas. As an example, departments of Forest in collaboration with local groups started rehabilitation in different mangrove creeks since mid 90's. It was estimated that about 525 ha of mangroves was planted in 2007/2008 especially in most degraded areas (Jumah *et al*., 2010), however no regular monitoring and evaluation to indicate how much those efforts are successful. This study therefore assesses the status of exploitation and regeneration of mangroves in an open access forest of Micheweni and protected Ngezi-Vumawimbi Nature forest Reserve.

MATERIAL & METHODS
Study area
Pemba Island is forming part of the Zanzibar Archipelago situated of the coast of Tanzania, East Africa in the Indian Ocean. The island lies between 40˚52' and 60˚31' South of equator, approximately 50 km to the north of the main Island of Unguja. It is characterized by tropical climate dominated by binomial rainfall pattern, the main rain season (Masika) occurs between March and June. The

short rains (Vuli) usually start in October and ends in December. Some inter-monsoonal precipitation takes place (Jumah *et al.*, 2010). The relatively cool dry season (kipupwe) occurs between June and September, while hot season (kaskazi) between December and February.

The study was conducted in two mangrove forests, Micheweni and Ngezi- Vumawimbi Nature Forest Reserve. Both sites are found in Northern part of Pemba in the District of Micheweni located at 5^o 2' 0"S, 39^o 45' 0"E. Population of Northern Pemba is estimated at 185,326 by 2008 with annual growth rate 5% which is greater than the national average of 3.1% (RGOZ, 2009). Ngezi- Vumawimbi consists of deep, fertile soil which is a characteristics of western part of the island while that of Micheweni is acidic and infertile rocky coral rag soil which is found on the eastern side of the island (Jumah *et al.*, 2010). Micheweni mangrove forest is freely accessible to the villagers while Ngezi-Vumawimbi Nature Forest Reserve is a protected area under the government authority; as such it serves as control sites in this study as well as a model site for the mangrove protection.

Mangrove Inventory

The transect survey was used for the identification of species distribution patterns and examine the correlation between mangroves association and natural conditions. Due to the tidal level impacts on mangrove species distribution and zonation, three transects were randomly established and the sampling was done during low spring tides. In each of these three transects, thirty eight quadrates of 10m x 10m were measured and they were randomly established in each zone. Within each quadrate, trees and regeneration were counted and identified to species level, height, and diameter at breast height (DBH) were measured and recorded. In addition to that, the nature and quantity of stumps, fallen or standing dead mangrove wood and /or decomposing wood were also counted. A sample survey form was used to record tree inventory data required in this study.

Socio-economic survey

Socio-economic data were collected among key formants include local villagers, a, forestry officers, community groups involved in conservation practices and environmental officers. Focus group discussion was carried out to obtain necessary information related to mangroves such as historical trend (trend analysis) based on human influence and the history of the population such as cultivation, right of use, clearing, felling, hunting and other activities that may affect mangroves.

Statistical Analysis

Data analysis was carried out using the SPSS software (Standard version 13.0 for Windows, SPSS Inc., US) and Excel package of Microsoft Office 2007. Different biostatistical tests such as Chi-square and Mann-Whitney were used to test difference between two or more variables.

Descriptive statistics were used to facilitate determination of important information as means, standard deviations, modes and minimum and maximum values. The qualitative data were analyzed through categorization and content analysis and presented in graphical or tabular form.

RESULTS & DISCUSSION

Mangrove species diversity

A total of 8 species of mangroves belonging to 6 families were observed in the study areas (Table 1). The results of diversity index showed high value of 1.8 and 1.5 for Ngezi and Micheweni mangrove forest respectively indicating more diverse species within various mangrove zones. Species diversity was highest in the upper zone in both mangrove forests (Figure 1). However, the results showed that there was no significant difference in mangrove species diversity among the three levels of the shore (t=0.001, DF=12319.9, p>0.5).

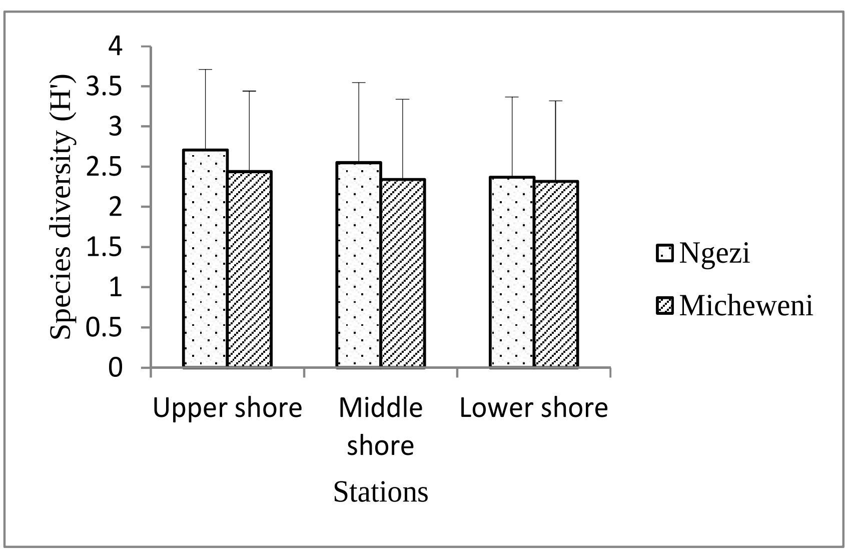

FIGURE 1. Mangrove species diversity per station in Ngezi and Micheweni

TABLE 1. Checklist of mangrove species recorded in the Ngezi and Micheweni mangrove forest, Pemba Island.

NGEZI FOREST			MICHEWENI FOREST		
No	Species	Family	No	Species	Family
1	*Avicenia marina*	Avicanniaceae	1	*Avicenia marina*	Avicanniaceae
2	*Brugiera gymnorhiza*	Rhizophoraceae	2	*Brugiera gymnorhiza*	Rhizophoraceae
3	*Ceriops taqal*	Rhizophoraceae	3	*Ceriops taqal*	Rhizophoraceae
4	*Lumnizera racemosa*	Combretaceae	4	*Rhizophora Mucronata*	Rhizophoraceae
5	*Rhizophora Mucronata*	Rhizophoraceae	5	*Xylocapus granatum*	Meliaceae
6	*Xylocapus granatum*	Meliaceae	6	*Soneratia alba*	Soneratiaceae
7	*Heritiera littoralis*	Sterculiaceae			
8	*Soneratia alba*	Soneratiaceae			

The greater species diversity in Ngezi as compared to Micheweni block may be influenced by the higher cutting pressure, edaphic and other environmental factors. For instance in Ngezi the soil to a large extent consists of a mixture of sand and silt especially in the middle and lower shore while that of Micheweni consists of silt only. The number of mangrove species was observed to increase from the lower zone to the upper zone. The increase in the number of mangrove species form seaward side to the land edge has been cited elsewhere (UNEP, 2001) and could be directly connected with salinity gradient, silt/sand ratio, moisture content and period of exposure (Kathiseran, 1991; Duxbury and Duxbury, 1997; Kathiseran and Bingham, 2001).

Mangrove density

The average density of mangrove trees were 28,066 trees/ha and 27066 trees/ha for Ngezi and Micheweni respectively. In Ngezi, the individual stand density is greater for *X. granatum*, *B. gymnorrhiza* and *C. tagal.* On the other hand, Micheweni mangrove forest forms unique peak for *C. tagal,* followed by *A. marina* and *R. mucronata* (Figure 2). The results showed that there was no significant difference in number of mangrove trees between Ngezi and Micheweni forests (χ^2=0.0001, DF=1, $0.975<p<0.99$).

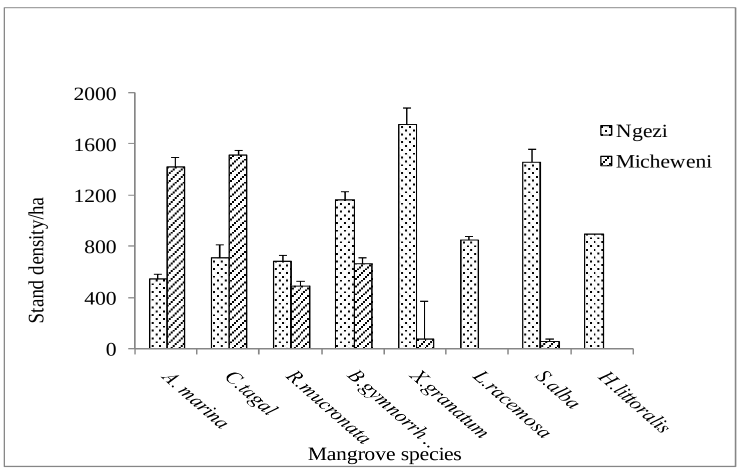

FIGURE 2. Showing species density per block between Ngezi and Micheweni

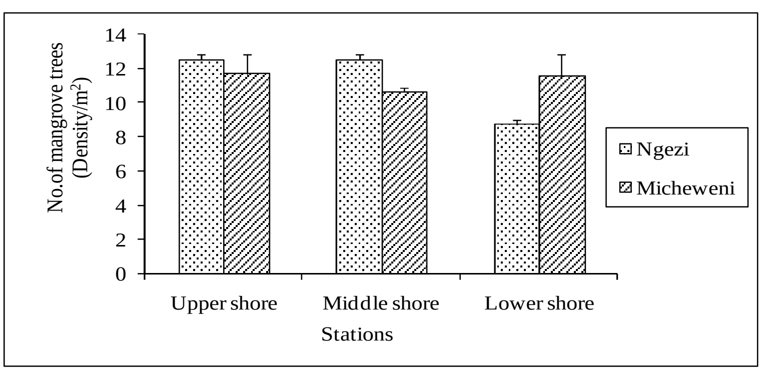

FIGURE 3. Showing the number of mangrove trees per station in Ngezi and Micheweni forest.

The higher density of *X. granatum* in Ngezi is due to its dominance in the upper and middle zone; meanwhile these species were not much preferred by the users as indicated by interview respondents during this study. In contrast, the density of *X. granatum* is lower at Micheweni which could be influenced by its lower regeneration rates (Jumah *et al.,* 2001). These results concurred with the previous findings on the mangrove species found in the Zanzibar Island

(Shunula, 1990; 1996), and distribution of the mangroves in the Western Indian Ocean (WIO) Region (UNEP, 1998; Soud, 2004; Lang'at and Kairo, 2008). For intance, *Rhizophora mucronata* were dominant species, followed by *Ceriops tagal* and *Sonneratia alba* in the Pete-Uzi mangroves (Mchenga and Juma 2010), while *X. granatum*, *B. gymnorrhiz*a and *R. mucronata* were dominant in Ngezi mangrove forest (Saleh, 2012). With exception of lower shore in Micheweni mangrove forest, the number trees were highest in the middle and upper shore in both forests (Figure 3). Furthermore the results showed that there was no significant difference in number of mangrove trees among the three zones in both mangrove forests (χ^2 =2.458, DF =2, 0.1<p<0.25). The highest numbers of mangrove trees in the middle and the upper zone of both forests can be related to the presence of species of higher regeneration rate in these zones. Meanwhile, the lower number of mangroves in the lower zone could be attributed to frequently human disturbance which can easily access this area by means of boats and dhows especially during high tides which could facilitate transportation of mangrove logs (Semesi *et al.*, 1999).

Mangrove Regeneration Rate

The present findings showed that mangrove regeneration was significant higher in Micheweni when compared to Ngezi (χ^2=6.569, DF=1, 0.01<p<0.025). The higher regeneration in Micheweni could be explained by the fact that this area was highly disturbed compared to Ngezi which is reserved forest. Hence in Micheweni mangroves, there is less competition for basic requirements such as light and air between the mangrove trees (species) that provide maximum opportunity for tree regeneration. Based on the zones, mangrove regeneration was significant higher in the upper zone than the middle and lower zones in Micheweni (χ^2 = 77.765, DF= 2, p<0.001) but no significant difference for Ngezi. (t-test t=1.842, DF=5, p < 0.12,). In both sites, the lower zone was generally observed to exhibit lowest regeneration as compared to the upper and middle zones (Figure 4). This is due to presence of fewer mature mangrove trees, excessive salinity and other disturbances that hinder regeneration in this zone (Soud, 2004). Lack of mature trees, absence of seedlings, seed predation and strong tidal waves contributed to low regeneration (Shunula, 2001; Soud, 2004). At species level, *C. tagal* ranked high in regeneration with about 40%, followed by *B. gymnorrhiza* (35%) and *R. mucronata* (25%). No regeneration was observed for *S. alba* and *X. granatum* in the Micheweni block and *L. racemosa*, *H. littoralis* and *S. alba* in the Ngezi mangroves. These results were also supported by the previous works on mangrove regeneration in Zanzibar (Jumah *et al.*, 2001; Soud, 2004).

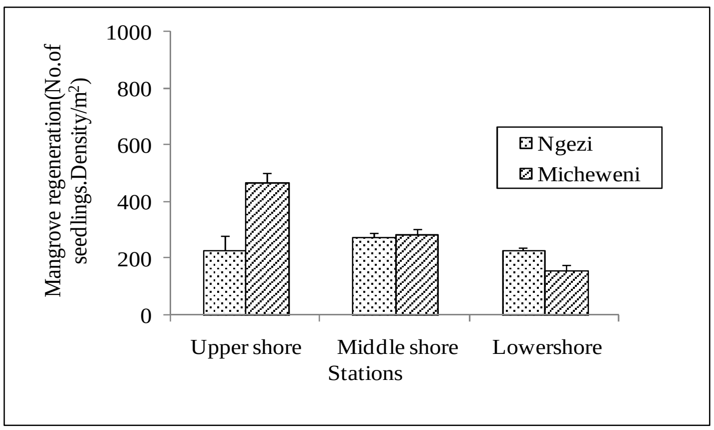

FIGURE 4. Regeneration rates per station in Ngezi and Micheweni forest.

Mangrove destruction information

The results of partial cut mangroves showed a significant higher number in Micheweni when compared to Ngezi forest (an average of 1300 and 800 trees/ha respectively; Mann-Whitney U-statistic=142.00, U'=299.0, P=0.04). Based on zonation, the number of partial cut was significant higher in upper zone than the middle and lower zone in Micheweni (One sample t-test, P=0.011, t=3.928, DF=5) but not significant in Ngezi forest (P=0.058, t=2.440, DF=5). In both forests, the upper zone has the highest number of partial cut while the lower zone has lowest number of partial cut (Figure5).It was observed that Micheweni constituted significant higher number of stumps than Ngezi with average number of dead stumps of 2700 trees/ha for Micheweni in contrast to 1400 trees/ha of Ngezi (Mann-Whitney U-statistic=50.500, U'=390, P=0.0001). Based on the zones, the number of dead stumps was significant higher in the upper zone in Micheweni (One sample t-test P= 0.0003, t=8.741, DF=5) however, no significant difference in zonation for Ngezi (P =0.2817, t =1.206, DF =5). In Micheweni the highest number of stumps was observed in the upper shore and lowest in the lower shore (Figure 6). Furthermore, the results have shown that Micheweni possesses significant higher number of die off than Ngezi with about 3500 trees/ha while that of Ngezi was about 1900 trees/ha (Mann-Whitney U-statistic=144.00, U'=297.00, P=0.054). In both forests, the highest number of die off was observed in the upper shore and lowest value in the lower shore. In terms of the zonation, the number of die off was significant higher in the upper shore than the middle and lower shores. (One sample t-test, P=0.006, t=4.456, DF =5) but no significant difference in die off trees for Ngezi forest (P=0.015, t=3.662, DF=5).This findings can be attributed to greater human disturbance due to unsustainable harvesting of mangroves and its resources in Micheweni as compared to Ngezi mangrove forest which is a protected area.

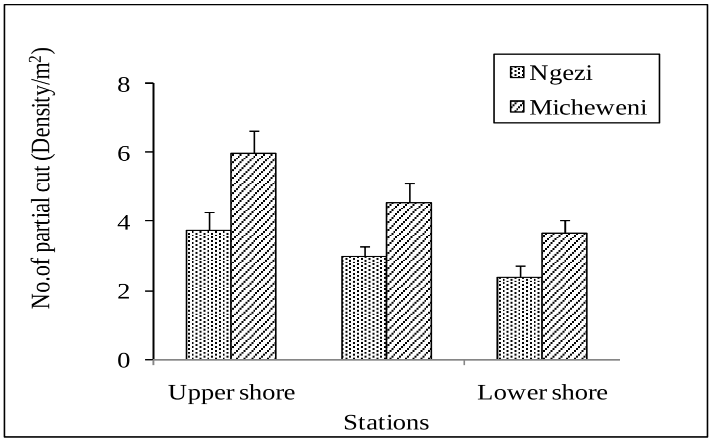

FIGURE 5. Showing the number of partial cut per station in Ngezi and Micheweni forest

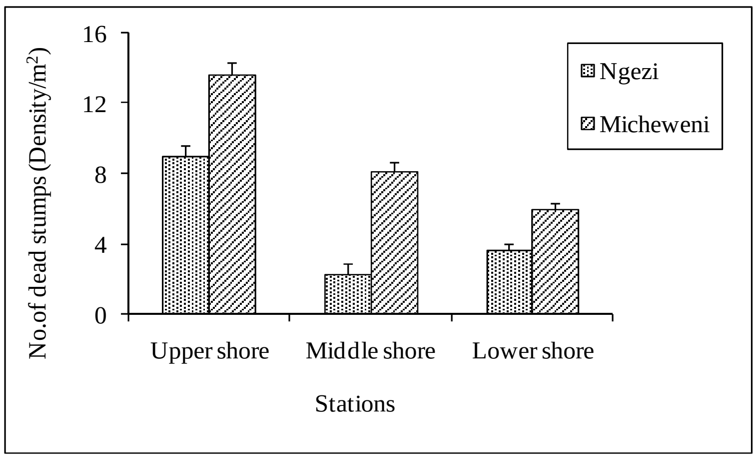

FIGURE 6. Showing the number of dead stumps per station in Ngezi and Micheweni forest

The extent of deforestation was greater on the upper zone as compared to the lower and middle zones in both mangrove forests, with about 57%, 21% and 20% of the total destruction sampled in Micheweni while that of Ngezi is about 38%, 30% and 20 for upper, middle and lower zone respectively. Significant destruction in the upper shore zone could be obviously related to various factors such as its location close to the landward edge or close to the vicinity of the villagers where easily accessible to many people (Semesi *et al*., 1999). Meanwhile, less destruction in the middle zone compared to the upper shore could be attributed to the small sized mangrove trees which could have limited uses. Results of deforestation in the lower zone could be attributed to the availability of large sized mangrove trees, which have been connected with multiple numbers of uses. This zone is also easily reachable by means of boats or dhows especially during high tides which could facilitate transportation of mangrove logs (Semesi *et al.*, 1999).

The most affected species were *C. tagal* were *R. mucronata* and *B. gymnorrhiza*. Higher destruction of these species could be attached to their location, their medium size, availability in both the upper and the middle zones where usually easily reachable by the users. Their small size in terms of diameter could facilitate their removal even by using a simple hand tool. Many studies suggested that *C. tagal* is the most exploited species in mangrove creeks of Zanzibar (Jumah *et al.,* 2010; Othman, 2005; Jumah *et al*., 2010). It was also observed that, species such as *X. granatum, S. alba, A. marina* were minimally impacted. However, since they have low regeneration rate (Jumah *et al*., 2010), deliberate effort should be taken to prevent them from being wiped out.

Mangrove harvesting

Micheweni population have been heavily involved on wood cutting, charcoal burning, lime making, sticks for seaweed farming, cutting of poles for building purposes and wood for boat building. 60% of Micheweni villagers live in houses built up of soil, which usually constructed using a huge amount of mangrove poles. Large quantity of mangrove poles from Micheweni has been transported to other districts for commercial purposes adding more pressure to the existence of mangroves. In contrary, the healthy nature of Ngezi mangrove forest is directly attached to its conservation status, plenty of options of using other plants as fuel wood and strong fertile dark soil favorable for the growth of deep rooted plants/crops. Many studies reported wide-speared of mangrove cutting in Zanzibar Island (Ngoile and Shunula, 1992; Soud, 2004; Saleh, 2012). The most exploited species are those dominant in the upper and middle shore notably *Ceriops tagal, Rhizophora mucronata* and *Bruguiera gymnorrhiza.* Similar observation have been reported in various mangrove creeks of Zanzibar Islands (Ngoile and Shunula, 1992; Wahira, 2005) The coral rag nature of land creating conducive environment for lime and charcoal production as it provides a large quantity of marble and stones, the raw materials in lime production. The activity involves quarrying of stones is usually conducted very close to the mangrove areas. In Ngezi however, it is carried much less compared to Micheweni. This can be directly attributed to the topography of this area, being deep fertile soil that bears no marble/stones needed for lime production.

Conservation efforts

The Government of Zanzibar and other stakeholders have been taking certain measures to either stop or reduce the anthropogenic impacts on mangroves, these include replanting the mangroves especially in most degraded areas, protection and provision of environmental education, integrated management plan such as community forest management agreement (COFMA), creating income generating activities such as beekeeping, establishment of NGO's for mangrove conservation such as NGENARECO as well as establishment of conservation areas such as Ngezi and Menai Bay. Other community management options and ideas include control harvesting plan, searching for alternative energy sources, introduce planned agriculture systems and stop unplanned settlement and development (ICM, 2009).

Most of these efforts such as integrated management plan and income generating projects primarily aims at improvement of livelihood options and in turn reduce the over dependence on mangrove resources. More than 66% of stakeholders revealed that there has been a positive trend in this campaign which resulted into either recovery of some mangrove creeks or flourishing in other mangrove areas. For example "Msitu Mkuu" nearby Micheweni Mangrove forest which is currently under the integrated community forest agreement.

CONCLUSION

Unlike the Ngezi Nature Forest Reserve, mangroves of Micheweni have been greatly impacted by human activities including charcoal and lime production, fuel wood and harvesting for timber and poles for housing. Seaweed farming in further accelerates pressure on mangrove resources through harvest of mangrove poles to support seaweed nursery. Overexploitation is further fuelled by a number of underlying causes, including lack of counter-effective and integrated management regime, poverty and limited livelihood diversification and lack of monitoring and law enforcement. There is therefore an urgent need to take concrete actions to prevent any further anthropogenic impacts by taking effective measures such as establishment of buffer zone (for migration), restoration, connectivity, adaptive strategies, alternative livelihoods, monitoring and evaluation that would guarantee conservation and sustained utilization of the mangrove resources.

ACKNOWLEDGMENTS

We thank the Ministry of agriculture and Natural resources for granting the permission to conduct this study in Ngezi-Vumawimbi Nature Forest Reserve. We would also like to thank the villagers from Ngezi and Micheweni for their field assistance and support during the interview. Special thank due to the Society for Environmental Research and Conservation (SERC) for technical support and critically reading an earlier version of the paper. This work was supported by the School of Social Science, The University of Dodoma (UDOM).

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