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Review Article

A Review of Status of Mangrove Forest in Zanzibar Island, Tanzania

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ABSTRACT

The existence of mangrove forests is jeopardized by the increase in population pressure, agricultural, industrial and urban development, climate change and weak forest management capacity that negatively affected the status of mangroves worldwide. The present review paper provides information on the status of mangrove forests in Zanzibar Island, to inform managers and decision makers on their management and sustainable use of its resources. The extent and distribution of mangrove ecosystem indicates that the mangrove growing stock of the main Islands of Unguja has declined drastically when compared to that of Pemba. Changes in mangrove composition were driven by a combination of rise in sea level, environmental changes and anthropogenic interaction. This review argues for the importance of regular climate change monitoring, mangrove eco-physiological studies and genetic materials which are crucial in providing a basis for the ecological restoration and management of mangrove ecosystem.

Key Words: biodiversity; conservation, degradation, mangroves, restoration, Zanzibar.

INTRODUCTION

The term Mangrove refers to a diverse group of salt-tolerant plants that inhabit the intertidal margins of low-energy coastlines, mudflats and river banks in tropical and sub-tropical areas. Worldwide, there are some seventy known mangrove species within some 19 families. Mangroves of Zanzibar Island comprise of all mangroves species found in Western Indian Ocean countries with ten species of mangroves that are reported along the bays and coastlines of Unguja na Pemba. [1]

Mangroves forests provide various services such as protection of shoreline from coastal erosion and buffering of storm and extreme weather events, absorption of pollutants, thereby indirectly sustaining a wide range of social and economic activities. Mangroves also serve as feeding, breeding and nursery grounds for many invertebrates (shellfish, prawns and crabs) and finfish. [2] Hence, losses of mangroves not only affect coastal dwellers indirectly but also cause direct economic repercussions through loss of the fishing industry.

The coastal belt of Zanzibar comprises of a complex interconnection of mangrove ecosystem, coral reef, sea grasses, algae, and sandy beaches. [3] About 49% of the beaches in Zanzibar are delineated by rock and the rest consist of vegetation

around the top and presence of trees along the beach. Mangroves in Unguja Island are best developed in estuaries and confined to the protected bays such as in the Makoba, Chwaka and Menai bays. They are however more luxuriant in Pemba where they are found along the coast of the entire island (Table 1).

The present paper reviews available information on the status of mangroves, gaps in the information and research needed for better policy, planning and decisions making which will affect the management of mangroves and sustainable exploitation of its resources in the Zanzibar Island.

Mangrove area coverage:

The mangroves ecosystem is the second largest forest in Zanzibar after the coral rag forest; however information on the mangroves area coverage in Zanzibar is still ambiguous. The earlier study [5] enumerated the mangrove species only in some creeks found in both Unguja and Pemba islands (Table 2). It involved a visual estimation of the percentage abundance of the various species in addition to estimating the areas under mangrove cover using a planimeter. The volume and distribution of mangroves were later measured using aerial photographs of 1989, [6] that calculated a total mangrove volume of 641,100 m^3, of which 205,000 m^3 were in Unguja and 436,100 m^3 in Pemba Island. Further studies [7] enumerated mangrove forest of about 20000ha along the coastal line of Zanzibar which is equivalent to 8.6 % of total land cover (232,800 ha), out of it 14,000ha are found in Pemba and 6,000ha are found in Unguja.

The first comprehensive wood biomass inventory was conducted in 1997; this study reported loss of natural forests including mangroves of about 1,000ha annually. This is depicted by a significant decline in mangrove forest of Zanzibar by a total of 19,748 ha, with 5,829ha in Unguja and 13,919ha in Pemba. [9] The updated comprehensive wood biomass inventory of 2012 using Rapid Eye images reported that the mangrove area in Zanzibar is 16,488 ha where 5,274 ha was estimated in Unguja and 11,214 ha in Pemba (Table 3). [10] The validity of mangrove cover estimation in Zanzibar is still debatable and difficult to compare due to the difference in methodologies used between surveys.

It was reported that the mangrove growing stock of Unguja Island has declined drastically with 18.9 m^3/ha which is more than double the decline of 41.0 m^3/ha recorded in the previous inventory of 1992/1993. In Pemba Island however, the mangrove growing stock decline per hectare was negligible from 39.8 m^3/ha to 38.3 m^3/ha. [10] Changes in mangrove ecosystem composition were driven by a combination of factors; sea level and environmental changes, anthropogenic interaction and geomorphological activities. [11-15]

Mangrove biodiversity and ecology:

There are ten different species of mangroves growing in Zanzibar (Table 4). Eight species are commonly found in many creeks and patches of Unguja and Pemba Islands. [9] These are *A. marina*, *R. mucronata*, *B. gymnorrhiza*, *C. tagal*, *X. granatum*, *H. littoralis*, *L. racemosa*, and *S. Alba*. [7, 16] The species belong to six families namely Avicenniaceae, Rhizophoraceae, Lythraceae, Combretaceae, Meliaceae and Lauraceae. Other two mangrove species are rare, the *P. acidula* which has been reported for the first time at Chwaka bay [16] and then at Uzi Island, [17] and *X. moluccensis* which was previously recognised to grow at Micheweni [7] has also been discovered in Chwaka bay area. [16] Several mangroves associated plants were reported in Zanzibar. [17, 18] Seventy plants species belonging to ten (10) main vegetation types were observed in Jozani - Chwaka bay mangroves. The plant species including

algae, sea grass, lichen, ferns, climbers and mangroves epiphytes that were found in water, sand and rocky areas. The lichens, ferns, climbers and epiphytes were mainly observed in areas under the shade of mangroves. [17]

Table 1: Location of the main mangrove creeks and protected bays

Creek	Area	Status
Unguja island		
Jozani-Chwaka bay	Chwaka , Mapopwe, Kinani, Michamvi	National Park
Menai bay	Kisakasaka, Kiwani, Kibondeni, Unguja ukuu, Muungoni, Bweleo, Fumba, Nyamanzi, Kiembe samaki	Conservation Area
Makoba bay	Nyanjale, Muanda, Kigunda	Local management
Mpigaduri	Kinazini, Maruhubi	Local management
Other patches	Bububu, Mto-mchanga, Mkokotoni	Local management
Pemba island		
Micheweni	Micheweni, Wingwi, Shengejuu	Local management
Ngezi-Vumawimbi	Tumbe, Msuka, Gando	Nature Reserve
PECCA	Wete, Pembeni, Pujini, Muwambe-Fufuni, Mkoani, Chake chake, Wesha	Conservation Area

Source: SONARECO [4]

Table 2: Percentage species coverage in some mangrove creeks of Zanzibar islands

	UNGUJA					PEMBA		
	Makoba	**Kisaka Saka**	**Unguja Ukuu**	**Pete**	**Chwaka Bay**	**Chake chake**	**Wete**	**Micheweni**
Species[1]								
Avicennia marina	*25*	15	15	10	10	5	20	10
Ceriops tagal	*20*	15	10	15	15	3	3	10
Bruguiera gymnorrhiza	*4*	20	30	25	30	0	2	30
Rhizophora mucronata	*7*	30	20	35	25	70	60	25
Soneratia alba	*35*	8	20	5	15	2	2	6
Lumnitzea racemosa	*5*	5	5	5	0	15	8	15
Heritiera litoralis	3	2	0	0	2	3	2	1
Xylocarpus granatum	1	5	0	5	3	2	2	2
Xylocarpus moluccensis	0	0	0	0	0	0	0	1
***Total area (ha)[2]**	**520**	**460**	**344**	**320**	**3240**	**1324**	**1128**	**1288**

Sources: *Griffith; [5] Ngoile & Shunula [8]

Table 3: Existing literature on mangroves coverage of Zanzibar Island

Survey	Unguja	Pemba	Total (ha)	Reference
1992/93	5,003	10,943	15946	Leskinen & Silima [6]
1996	6,000	14,000	20,000	Shunula [7]
1997	5 829	13919	19,748	Leskinen *et al.*[9]
2012	5,274	11,214	16488	MANR [10]

Table 4: Mangrove species of Zanzibar Island

Mangrove species	Family	English Name	Local name
1. *A. marina*	Verbenaceae	White or grey mangrove	Mchu
2. *B. gymnorrhiza*	Rhizophoraceae	Large-Leafed Orange/ Oriental Mangrove	Msisi/Msinzi/Mfinzi or muia
3. *C. tagal*	Rhizophoraceae	Yellow mangrove	Mkandaa/Mkoko mwekundu
4. *H. littoralis*	Sterculiaceae	Looking-glass mangrove	Msikundazi or mkungu
5. *L. racemosa*	Combretaceae	Black mangrove	Kikandaa or mkandaa dume/ Kilalamba
6. *R. mucronata*	Rhizophoraceae	Orange mangrove	Mkoko magondi
7. *S. alba*	Sonneratiaceae	Mangrove apple	Mlilana or Mpira
8. *X. granatum*	Meliaceae	Cannonball mangrove	Mkomafi/Mkaumwa/Mkuo/ Mtonga
9. *X. molucensis*[1]	Meliaceae	Cedar mangrove	Mkomafi dume/Mkauma wa kijani
10. *P. acidula*[1]	Lythraceae	Iron wood mangrove	Kilalamba dume

Sources: Shunula [11], Leskinen *et al.*[9], Jumah *et al.*[14]

1: rare species

A number of studies have been conducted on the mangroves fauna of Zanzibar. These involve mangrove creeks of Chwaka Bay and Makoba Bay, [8, 19] Jozani-Pete, [17, 20] Nyeke mangroves at Uzi Island [21] for Unguja, and Ngezi- Vumawimbi

Nature Forest Researve, [20, 22, 23] Micheweni and Wesha [22, 23] for Pemba. Various groups of fauna were reported in these areas including mammals (red colobus and Sykes monkey, Ader's duiker, and suni antelope and blue duiker), molluscs (bivalves, oysters), gastropods crustaceans, fish, insects; and terrestrial fauna including mammals, reptiles and birds. A total of 19 families of fauna comprising 76 species were identified at Jozani-Pete mangroves of which the most common included fishes, crustaceans and molluscs. [18] Diversity of mangrove macro-fauna have shown that there are 159 species from the Nyeke mangrove forest, with total of 34 species of fish belonging to 15 families, 16 species of crabs belonging to five families (Grapsidae, Ocypodidae, Pilumnidae, Eriphiidae and Portunide), six species of gastropods mainly composed of three families (Potamididae, Littorinidae and Neritidae) and mangrove associated insects with 103 species belonging to 49 families. [21] In Wesha and Ngezi mangrove forests a total of 33 species were registered most of them from three classes of bivalves, gastropods and crustaceans. [22, 23] In Ngezi there are at least 57 fish families and not less than 100 fish species. [20] There is no detailed study of mangrove birds of Zanzibar, however, they are frequently observed in mangrove systems and their abundance and distribution is independent of the tidal changes. [24]

A conceptualized model for organic-carbon flux in the ecosystem was proposed based on distribution of mangrove flora, fauna as well as mangrove litter and crabs. [25] It was suggested that the grapsid crabs occupy the terrestrial edge with relatively well-consolidated substrate, while fiddler crabs (ocypodid) occur in mixed area on sandy or muddy shore, mainly free of dense cover of mangrove trees and also in swampy open areas. [25] The distribution of gastropod *C. decollata* is ubiquitous in the upper zone of mangroves occupied by *A. marina*, whereas other species occur at higher density in the middle and lower mangrove zones mainly affected by particular substrate preference of gastropod species. [25] Study on the spatial and seasonal variations of fish assemblages under mangrove creeks of Zanzibar suggested that the densities of juvenile fishes vary among sites and creeks in relation to water depth, turbidity, and the availability and accessibility of food mainly the benthic microalgae. [19, 21]

Only few studies have been conducted on the role of mangroves in the nutrient cycling and productivity of adjacent coastal water in Zanzibar. It is well known that litterfall production and decomposition are important in nutrient cycling and detritus based food chain. In Zanzibar, litter production occurred throughout the year and with few seasonal trends in particular for *A. marina* and *R. mucronata*. [26] There is a strong spatial variability in the nutrients (phosphate, ammonia, nitrate and nitrite) in the mangrove creeks of Mapopwe and Chwaka Bay with concentrations decreasing as the water traverses the waterway towards the open bay. [27]

Limited studies have been focused on crab engineering processes in mangrove forest of Zanzibar. [29, 30] Mangrove crabs are engineers in the sense that they are able to modify surrounding environment by changing the physical state in biotic or abiotic materials through physical structure, mechanical and other actions. Study by Skov and Hartnoll at Maruhubi mangrove forest showed that *N. meinerti* crabs allow *A. marina* leaves age in burrows before consumption, thereby reducing tannin content and C/N ratio. [28] It was reported that Sesarmid crabs preference on mature green *R. mucronata* leaves could be an invaluable component for reforestation of

mangrove ecosystem in Pete-Jozani forest. [29]

Mangrove Degradation: Zanzibar mangroves have been subjected to enormous pressures and threats within the last past decades. There is a long history of exploitation of the mangroves and its products since back in the eighteenth century where mangrove wood was a precious resource that Sultan of Zanzibar harvested and used for building and exported to the Middle East, Europe and America. [6, 30-32] During this period the exploitation was done without any management plan and therefore influenced severe destruction of mangroves resources in particular of Unguja Island. [33]

Overexploitation of mangrove resources has been reported in many areas of Zanzibar Island through many factors especially salt production, fuel wood supply, construction and buildings and urban development. [7, 12, 13, 24, 34] The most exploited species are those dominant in the upper and middle shore notably *C. tagal*, *R. mucronata* and *B. gymnorrhiza*. [8, 35]

The demand for mangrove wood products in Zanzibar has been estimated to be 66702m^3 in 1996 and has been predicted to rise to about 940630 m^3 by the year 2006. Earlier estimates had put the total mangrove volume for the whole of Zanzibar to be about 640,000m^3. [1] Some mangrove swamps have been exploited to such an extent that without human intervention no natural regeneration would occur and they would not recover their ecological functions. [1]

The destruction of mangrove areas reduces the diversity of fauna communities in many creeks of Zanzibar. [23, 36] Despite the growing efforts of management in some mangrove areas, this has not been enough and the biodiversity losses continue. [17, 36] The fauna has disappeared from the mangroves surrounding Unguja Island while in Pemba the health of mangrove stands has remained good and therefore the status of fauna is better even though minor illegal cutting of mangroves was reported. [10] However, there is no baseline study on mangrove fauna in Zanzibar, since this was not recorded in the 1997 wood biomass inventory. Therefore the detection of changes in species diversity is not possible.

Mangrove Restoration: Restoration of an ecosystem is the act of bringing an ecosystem back into its original condition as nearly as possible. According to Field, [37] restoration is a special case of rehabilitation of mangrove ecosystem. Rehabilitation is the act of partially or, more rarely, fully replacing structural or functional characteristics of an ecosystem that have been degraded or lost, or the substitution of alternative qualities or characteristics than those originally present with condition that they have more social, economic or eco-logical value than existed in the disturbed or degraded state.

In Zanzibar, mangroves are usually restored through natural regeneration, where most of the local species occupy the shoreline and natural succession can take place. Many studies suggested that *B. gymnorrhiza* and *R. mucronata* were successful regeneration species in more areas. [4, 14, 16, 38] It was reported that there is a clear relation in natural regeneration and the status of exploitation, while regeneration capacity was proportional with species density. [38] The regeneration of *R. mucronata* in Unguja mangrove areas was recorded to be 1,592 seedlings/ha which is unsatisfactory compared to Pemba Island with 9,549 seedlings/ha. However, general regeneration of forests trees is good in Zanzibar, but the cutting and removal of mangrove root systems may be one factor for poor regeneration of *R. mucronata* in Unguja while regeneration of other mangrove species increase substantially. [10]

Many efforts have been made by both government and non-government actors to save existing mangrove forest from further destruction. Community awareness to restoration has made significant increase in mangrove forest cover in Kisakasaka, Pete, Muungoni and Muwanda in Unguja and Gawani, Mkoani, Kisiwa Panzaa, Makoongwe and Micheweni in Pemba. [39] Since mid-1990 Departments of Forest in collaboration with local groups started rehabilitation in different mangrove creek of Zanzibar. It was reported that about 525 ha of mangroves was planted in 2007/2008 especially in most degraded areas. [16]

Climate Change Threats: Mangroves are also threatened by natural factors mainly the global climate change, which has concomitant effects on rising of temperature, increasing level of carbon dioxide, change in precipitation pattern, storminess and sea-level rise. However, gradual sea level rise in recent years poses significant threat to the mangroves of Zanzibar, if the rising trend will exceed the limit of which mangroves can cope. [14] Several aspects of current and potential future climate change may affect the diversity of flora and fauna as well as the growth and distribution of mangroves in Zanzibar. [40] Increased concentrations of carbon dioxide in the atmosphere and increased average temperatures may lead to increased rates of photosynthesis and growth of many plants, including mangroves. The effects of climate change likely to affect mangroves most strongly, however, are sea-level rise and changes in rainfall, through their impact on sediment budgets. [41] To date there is no thoroughly study on the impact of climate change on mangrove forest in Zanzibar. Current rates of mangrove degradation therefore seriously threaten this fragile ecosystem and reduce its resilience to mitigate climate change effects.

CONCLUSION

Many of the previous researches have been focused on social economic aspects of mangroves and few on social ecological resilience, abundance and distribution of mangrove flora and fauna. Research should shift from current descriptive nature to providing more quantitative data on the status of the resources, population dynamics and resilience to human or natural induced factors that will set sustainable use on the limited mangrove resources. There are a number of ecological studies to be done such as eco-physiological studies on the production structure, functional amount and matter cycling in mangrove forests. Detailed studies on bio - tabulation and nutrient processes, reproductive morphology and mangroves genetic materials are needed for successful restoration of mangrove forest. Studies on maintenance mechanisms of biodiversity in mangrove ecosystems, their application to the conservation of nature and the impacts of climate change on mangrove ecosystem functions also need to be conducted.

Most of the mangrove biodiversity studies have been focused on larger animals and plants, but not on micro-organisms and insects. It is well known that many species use the mangrove forest ecosystem only part of the time (e.g. fish, birds, crustaceans, and shellfish). Thus, the mangrove habitat supports many more species as visitors, or indirectly, and these support functions must be taken into account, and is a crucial aspect of biodiversity for mangrove management and conservation. Many works have been carried out at species level, biological diversity at genetic and ecosystem levels are almost unknown. Further investigations are needed to explain engineering aspects related to crab burrows in the mangrove of Zanzibar. Many issues remain unclear, such as the effects of burrowing crabs on the nutrient cycle, microbial community

structure and function, and enzyme activity which mediate biogeochemical processes in sediments. Future studies should also focus on biological adaption of the mangrove flora and fauna and their morphological and physiological specialisations to the diverse and dynamic habitat characteristics and climate change.

Despite many efforts by the government, there is still not adequate policy, law and institutional provision for mangrove forests management. Mangroves tend to be marginally defined and placed under many institutions with conflicting roles. For example mangroves is under the responsibility of many line ministries including Ministry of agriculture and natural resources, Ministry responsible for environment and Ministry responsible for fisheries and marine resources. There should be a joint mangrove protection and sustainable management by synchronized cross-sector policies for a common goal. Future studies should focus on defining proper policy, law and best institutional arrangements for the management of mangrove forests in Zanzibar.

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