Challenges in Adaptation to the Impact of Climate Change and Variability in relation to Mangrove Forests Cover in Zanzibar, Tanzania

Ali Said Ali and Narriman S. Jiddawi

Abstract - Zanzibar coastal areas are continuously affected by extreme events brought about by Climate Change and variability. The Government and local communities have been taking numerous strategies to adapt to this condition. One type of strategy is the use of mangrove forests in reducing the impacts of climate related events, such as erosion and storm surges. The objective of this paper is to assess the challenges of using mangrove forests cover in reducing the impacts of climate change and variability in Zanzibar. The study deployed a mixed method design and data were collected through household questionnaire survey, focus group discussions, observations and key informant interviews methods. A total of 102 respondents from Nyamanzi, Kisakasaka and Fuoni Kibondeni in the West B District, Zanzibar participated in filling the household questionnaires. Findings demonstrated that mangrove forests cover has been decreasing gradually due to the increasing rate of mangrove deforestation. It is revealed from this study that mangrove forests are a panacea to climate change and variability related effects. In spite of their capability to protect the physical environment, mangrove forests have been benefiting the communities, socially and economically, in different ways, including poverty reduction, sustainable farming, provision of nursery areas for fish, food to the people, enhancement of business activities, and temperature regulation. Nevertheless, poverty, lack of willingness among the communities as well as lack of awareness on the importance of mangrove forests were among the observed challenges limiting the use of mangrove forests in adapting to the impacts of climate change in the study area. However, it is pointed out through this study that mangrove forests are not enough following the extent and frequency of the impacts as well as the increasing mangrove deforestation; it is, therefore, recommended that there should be enhancement of mangrove forest adaptive capacity by all stakeholders, including Government, NGOs, and local communities through enforcement on the use of mangrove related adaptation strategies and other options among coastal communities.

Index Terms - Climate change, Adaptation, Mangrove forests, Mangrove cover change, Zanzibar.

1 Introduction

Climate change and variability (CC&V) has become the most serious global problem that receives attention of the people at the local, regional and global levels. This attention is necessary considering the fact that CC&V intervenes the peoples' ways of life by affecting various sectors, including the infrastructure, environment, economies, food security, health and physical resources [9], [5], [6]. While the impacts of CC&V are obvious everywhere, [7] reports that Africa is one of the most susceptible continents and Tanzania is an example of the African countries affected by climatic extreme events (CEEs) such as unreliable rainfall patterns, extreme increase of temperature, floods and intense droughts.

So far, adaptation has emerged as a viable option to reduce the adverse impacts of Climate change in many parts of the world [19] and he continues to emphasize the need for adaptation no matter how efficiently the growth of Green House Gas emissions is managed [19]. Adaptation to Climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in the climate system [16]. The adjustment can be undertaken before or after observing the occurrence and possible impacts of climate change related events (henceforth CCREs) in a particular geographical location [16]. [3] insists that effective adaptation should be socio-economically and environmentally sustainable; contributing to poverty reduction as well as confronting the socio-environmental processes that stimulate problem. Recently, mangrove forests have become a potential option for some coastal communities; including Zanzibar communities in adapting to the impacts of Climate change and its related events such as coastal erosion, floods and strong storm winds [1].

In Zanzibar, mangroves are the second largest forest type after the coral rag forest, which accounts to about 8% of the forest cover [18]. The recent total area covered by mangrove forests in Zanzibar is 17357.48 ha, which are unevenly distributed in various parts of the Islands, including Pemba and Unguja Island [18]. The large stake of mangrove forests occur in Pemba Island contributing to about 73% (12605.89 ha), while Unguja Island covers the stake of about 27% (4751.59 ha) [18]. The largest mangrove stands in Unguja are found in Chwaka Bay, and Ngezi/Micheweni in Pemba. [15] shows that ten species of mangroves are found in Zanzibar of which the most common are red mangroves (*Rhizophora mucronata*), black mangroves (*Bruguieragymnorriza*) and mangrove apple (*Sonneratia alba*). Mangrove afforestation has been taking place in different areas of Zanzibar before the experiences of the impacts of Climate change. For example, Kisakasaka set up a planting programme in which all open and degraded areas are planted with mangrove seedlings of different species [18]. In 2001, the Menai bay Marine Conservation Project (MBMCP) initiated the afforestation programme in Unguja Ukuu mangroves ecosystem, where about 15 ha of mangrove seedlings were planted [18]. The objective of the project was to investigate the role of mangrove forests cover change in adaptation to the impact of Climate Change in Zanzibar, Tanzania. This paper also provides recommendations for increasing the sustainability of this marine ecosystem and, thereby improving sustainable coastal mangrove forests conservation and management in Zanzibar.

2 Materials and methods

The study was conducted in West B District located in the western part of Zanzibar Island between 06°10'S and 039°17'E. It is bordered by the Zanzibar West A District to the North, the Zanzibar Central Region to the East, Kiwani Bay to the South and the Zanzibar Urban District to the West [10]. See Figure 1. The mean maximum temperature in the West B District is 32°C and the mean minimum temperature is 19°C. The area is characterized by bimodal rains with an estimated rainfall of between 1300mm and 1700 mm per annum [10]. The population of West B District was 203, 000 people, consisting of 96,933 (47.75%) males and 106,067 (52.25%) females [11].

A household survey was conducted in the West B District in Urban-West Region of Zanzibar, Tanzania to provide required data for the study. Three villages, Fuoni Kibondeni, Nyamanzi and Kisakasaka, were purposively chosen for sampling. These villages were chosen to represent coastal communities in the West B District that were rich in mangrove forests used by the local communities for various livelihoods and social economic activities.

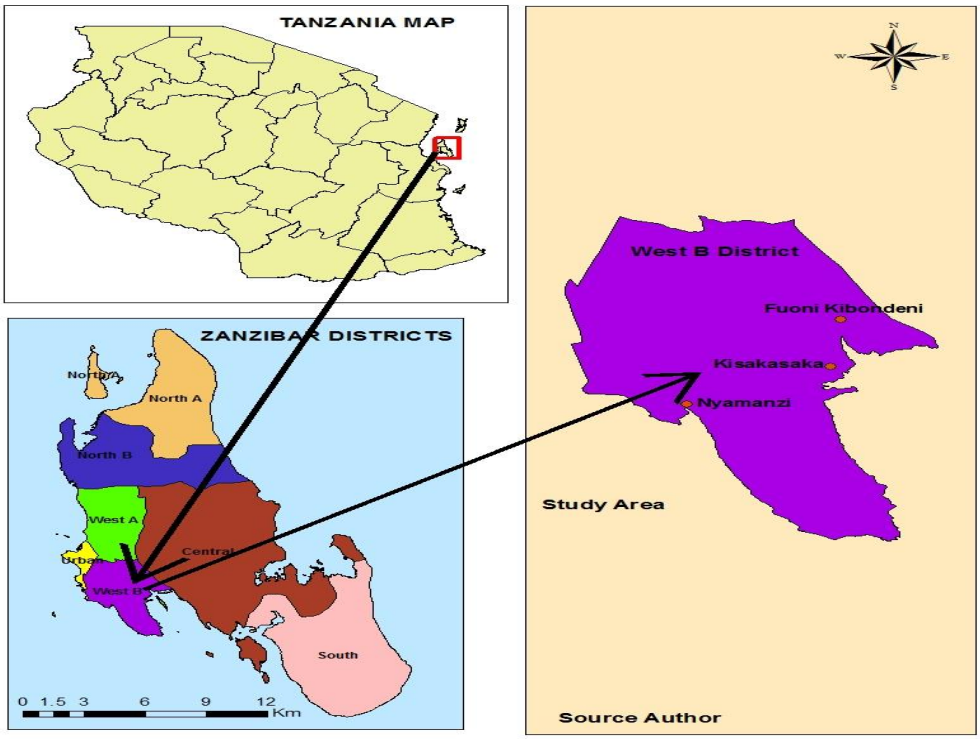

Figure 1: Map of West B District

Data collection was conducted in January 2017 from a total sample of 102 household heads who were available in the study area from three villages, with 50 households (11%) collected from Fuoni Kibondeni Village, 30 (11%) from Nyamanzi Village, and 22 (11%) from Kisakasaka. The households were selected randomly. Purposive sampling technique was used to select district, villages and key informants. Qualitative methods were used to collect the descriptive data that has been obtained from the field through Key informants interviews (KII), and focus group discussion (FGD). As for the quantitative method, Household survey was used to collect the quantitative data and represented them in the form of tables and figures. Both closed and open-ended questions were designed in the questionnaires to obtain information from the respondents. Documentary review was also done to collect secondary data from the secondary sources, including government reports, academic studies, books, journal articles etc on the state of mangrove forests, and trends of temperature and rainfall in Zanzibar. The satellite imagery on the coverage and change of mangrove forests were obtained from GIS laboratory of the University of Dar es Salaam. The mangrove cover change from 2005 to 2015 was calculated using Quantum GIS and the quantitative data collected were analyzed using statistical tool SPSS version 20 aided by Microsoft Excel 2007. The qualitative information collected through FGD and KII were triangulated according to the themes and the objectives of the study. Photographs taken from the field were used to support some key findings obtained from the study area.

3 Results and discussion

3.1 Coverage of mangrove forests

Findings obtained from households' questionnaires during the study showed that there was a change of mangrove cover in the last ten years. Figure 2.

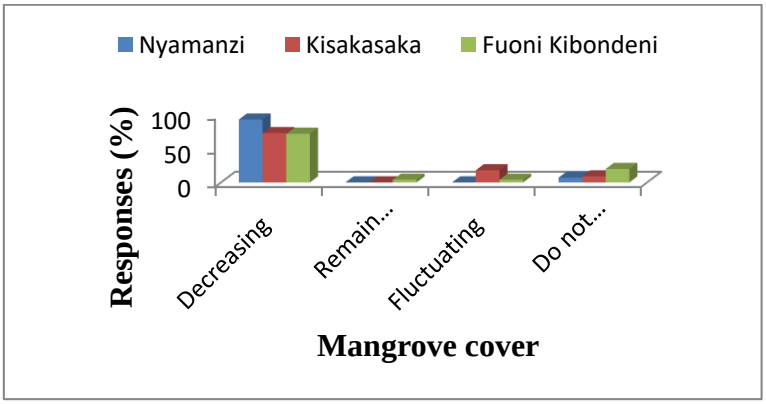

Figure 2: Changes of mangrove forest in the study area

With regards to the villagers' perceptions about the current extent of the mangrove cover, there was a general response that it had changed, and about 93% of respondents from Nyamanzi, 73% from Kisakasaka, and 72% from Fuoni Kibondeni had experienced the decrease in coverage of the Mangrove Forest in their villages as shown in Figure 2. In respect to the information recorded during the FGD, the participants openly revealed the decrease in Mangrove Forest cover in the study area, and intensively said that there was continuous decreasing of mangrove trees in their villages due to over dependence of the villages' members on that resource as observed during the field observation in all three study villages.

The analysis from satellite imagery on the land cover change (LCC) depicted the existence of mangroves cover change in the study area from 2005-2015. The Landsat classification of land cover in 2005 had percentage accuracy of 70% and above and was, therefore, assumed to have performed adequately for the purpose of assessing temporal change in mangrove extent in Zanzibar as shown in Figure 3 which shows the difference in the total area of Mangrove Forest in West B District of Zanzibar which have been reduced dramatically from 2005.

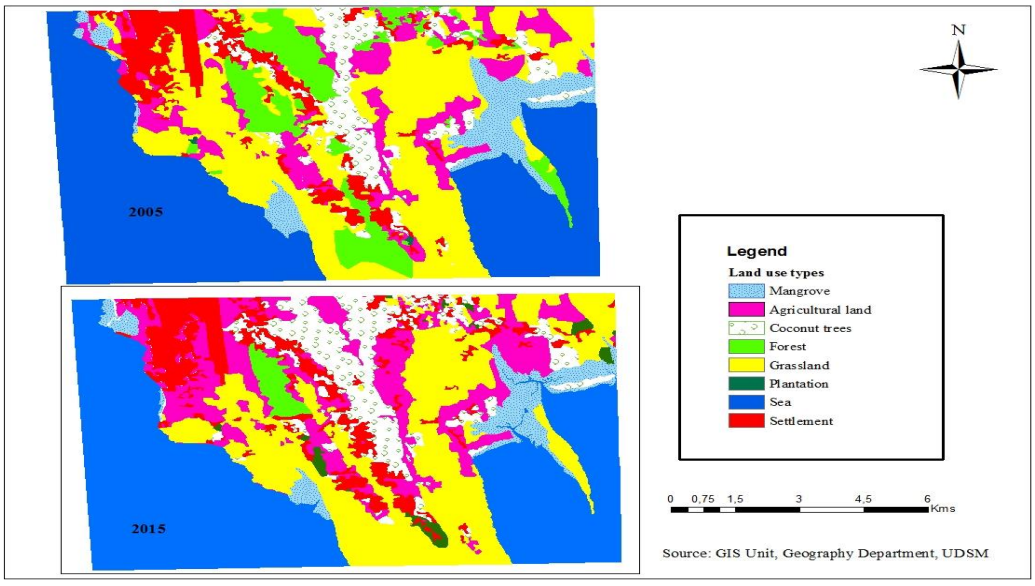

Figure 3: Maps showing land cover change in the study area for ten years

The analysis from satellite imagery also showed what has changed and what has remained unchanged as shown in Figure 4. This is clearly shown through the matrix map representing the area which was once covered by one land type category but after a period of ten years, the same area seemed to be changed to another land type category. For example, Mangrove Forest has currently changed to sea as represented by dark blue color in the map, mangrove to agriculture as represented by burgundy color, agriculture to mangrove as seen in turquoise color and some land type categories in some areas has remained unchanged as shown through aqua blue colour.

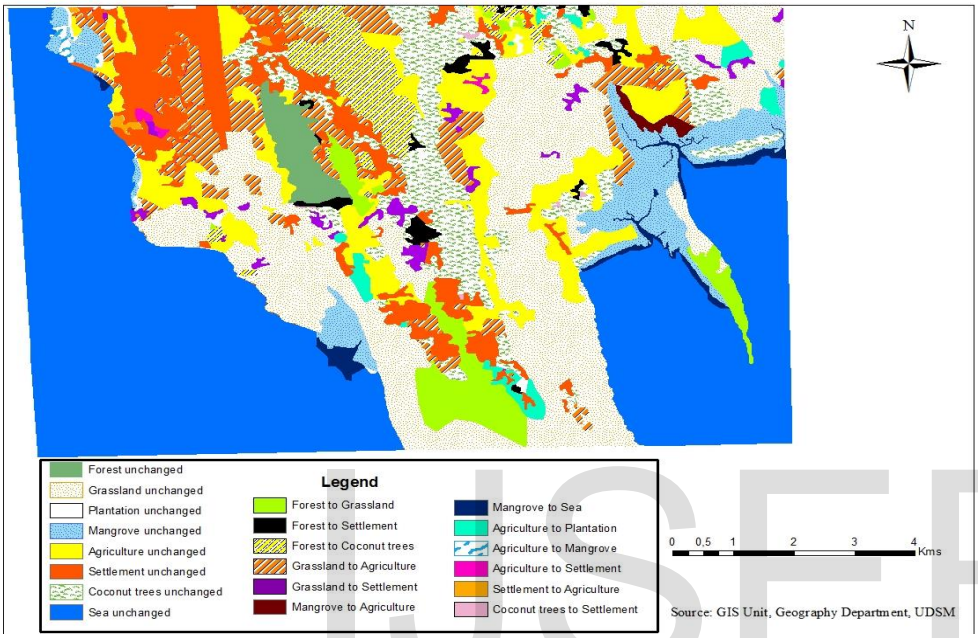

Figure 4**:** Matrix map showing changes from 2005-2015 in the study area

In showing the temporal change in the extent of mangroves in different areas of the study villages, the analysis produced the cross tabulation statistics table to show the extent of those changes of the different land use types. The cross tabulation was also done to show what has been lost or gained and where it has been replaced to for the period of ten years. This is due to the fact that it was not only mangrove forest but also other land use types which have changed to other aspects as shown in Table 1. The cross tabulation table shows that 46.80% of mangroves remain unchanged for the period of ten years. Again the table reveals that 0.24% has changed to grassland, 27.71% has changed to agriculture, 0.1% has changed to settlement, and 0.25% has changed to coconut trees, while 93.6 % has replaced by sea which complete the total change of 121.9 hectares in the study area. Also, the analysis shows that some land use types have changed to mangroves; these included forests 0.05%, grassland 0.09%, agriculture 17.02%, settlement 0.05%, coconut trees 0.1% and sea 1.1% which has reached a total of 18.41%. These results imply that mangrove loss was higher compared to mangrove gain and a large percent of loss was changed to sea and agriculture as observed in the matrix map. And due to these results, it is obvious that Mangrove Forest have been reduced in the study area which, at the same time, affects the social-economic aspects and other coastal resources in the area.

Table 1: Cross tabulation table showing land category changes

Land use types	Forest	Grassland	Plantation	Mangrove	Agriculture	Settlement	Coconut trees	Sea	Total	Loss
Forest	140.4	319.1	0.02	0.05	0.05	77.72	313.85	001	851.3	710.9
Grassland	0.0	1983.52	0.07	0.09	538.89	91.52	0.46	1.79	2616.3	632,8
Plantation	0	0	6.30	0	0	0	0	0	6.3	0
Mangrove	0	0.24	0	46.80	27.71	0.1	0.25	93.6	583.7	121.9
Agriculture	0.0	2.8	95.2	17.2	869.9	13.8	5.9	0.03	1005.1	135.2
Settlement	0.0	0.3	0.01	0.05	16.2	757.2	1.6	0.5	776.0	18.8
Coconut trees	0	1.8	0.2	0.1	1.3	6.6	696.4	0	706.7	10.3
Sea	0	0.3	0	1.1	3.3	0.01	0	3707.1	3712.1	5
Total	140.4	2308.3	101.9	480.5	1457.6	947.1	1018.6	3803.2	10257.7	
Gain	0	324.8	95.6	18.41	587.7	189.9	322.2	96.1		0

In analyzing land cover change, a statistics table was used to show the losses and gains of land use categories, including the mangroves. Summation of the loss and gain was calculated to identify the net changes of each land use type as shown in Table 2. The table shows that 18.41% of mangrove was gained for the period of ten years and 121.9% was lost, which resulted in net change of about -103.49%. Hence, in the 10 years, between 2005 and 2015, West B District lost 121.9% of its mangroves at an average loss rate of 1.9% per year. This indicates massive destruction of mangrove forests in the area. Rates of land type loss and gain varied between areas, and over time. For example, the rate of gain for agriculture was 587.7% higher than other land use types while the rate of loss for plantation seemed to be smaller than the remaining land use categories as shown in Table 2.

Table 2: Land use types loss and gain for ten years

Land use types	**Gain**	**Loss**	**Total change**	**Swap**	**Net change**
Forest	140.4	710.9	851.3	280.8	-570.5
Grassland	324.8	632.8	957.6	649.6	-308
Plantation	95.6	0	95.6	0	95.6
Mangrove	18.41	121.9	140.31	37.4	-103.49
Agriculture	587.7	135.2	722.9	270.4	452.5
Settlement	189.9	18.8	208.7	37.6	171.1
Coconut trees	322.2	10.3	332.5	20.6	311.9
Sea	96.1	5	101.1	10	91.1
Total	1775.11	1775.4	3410.01	1306.4	2104.19

Even though no specific factors can be associated to the observed variations in mangrove cover change, the main causes for cover loss at local and national levels in Zanzibar have been identified as habitat alteration and inadequate control [18]. Likewise, responses obtained from household questionnaires revealed that several factors are responsible for the varying rates in mangrove cover loss in the area, including increase in population pressure as represented by 41% of respondents from Nyamanzi, 55% from Kisakasaka, and 69% of respondents from Fuoni Kibondeni villages; conversion into agricultural land as accounted for 38% from Nyamanzi, 43% from Kisakasaka and 40% from Fuoni Kibondeni villages; climate change as reported by 11%, 18% and 9% from Nyamanzi, Kisakasaka and Fuoni Kibondeni villages respectively; and weak forest management as pointed out by 44%, 52% and 57% from Nyamanzi, Kisakasaka and Fuoni Kibondeni villages respectively (Figure 5), and this is supported in [18].

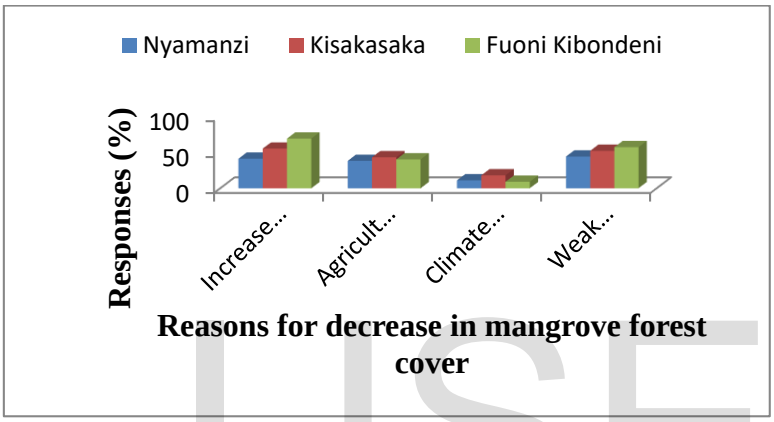

Figure 5**:** Reasons for mangrove cover change in the study area

3.2 Mangrove forests cover and adaptation to climate change

In adaptation to Climate change, Mangrove Forest was associated with climate change related events (CCREs) occurring around the coastal areas, such as sea level rise, storm winds, erosion, flooding and sea waves. Large group of respondents which were represented by 100%, 85% and 95% from Nyamanzi, Kisakasaka and Fuoni Kibondeni villages perceived that Mangrove Forest protect the shores from erosion. The second group of respondents reported that Mangrove Forest reduce the impact of storms, and the responses from this group accounted for 92%, 95% and 93% from Nyamanzi, Kisakasaka and Fuoni Kibondeni villages respectively. This was followed by 81% of respondents from Nyamanzi, 45% from Kisakasaka and 56% from Fuoni Kibondeni villages who perceived that MF control floods. The remaining few responses from the respondents were represented by 48% from Nyamanzi, 51% from Kisakasaka and 62% from Fuoni Kibondeni villages who said that Mangrove Forest stabilize the coastal land as supported in [2] (Figure 6).

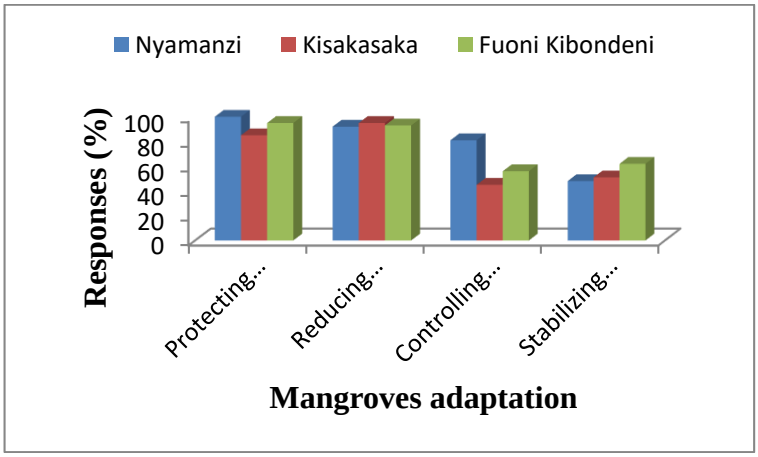

Figure 6: Mangrove forests cover and adaptation to climate change in the study area

3.3 Mangrove forests cover and conservation of coastal resources in the study area

When the villagers during the study were asked on the contribution of mangrove forests in conserving coastal resources in their villages, 100% of respondents from Nyamanzi, 85% from Kisakasaka and 95% from Fuoni Kibondeni villages replied that Mangrove Forest contributed in preventing the shorelines against erosion. However, 48% of respondents from Nyamanzi, 51% from Kisakasaka and 62% from Fuoni Kibondeni villages believed that mangrove forests contributed in stabilizing coast lines. The remaining respondents of about 33% from Nyamanzi, 42% from Kisakasaka and 39% of Fuoni Kibondeni villages said that mangrove forests contributed in protecting coral reefs and sea grasses in their villages (Figure 7).

Results from key informants, especially district officials indicated that there were other interventions for coastal resources conservation such as mangroves in the area, including enforcing village patrolling done by the villagers, tree planting projects such as Tanzania Social Action Fund (TASAF) operated by the government in collaboration with the villagers and Village Environmental Groups (VEGs), coastal conservation groups (CCGs), provision of environmental education, and laws enforcement.

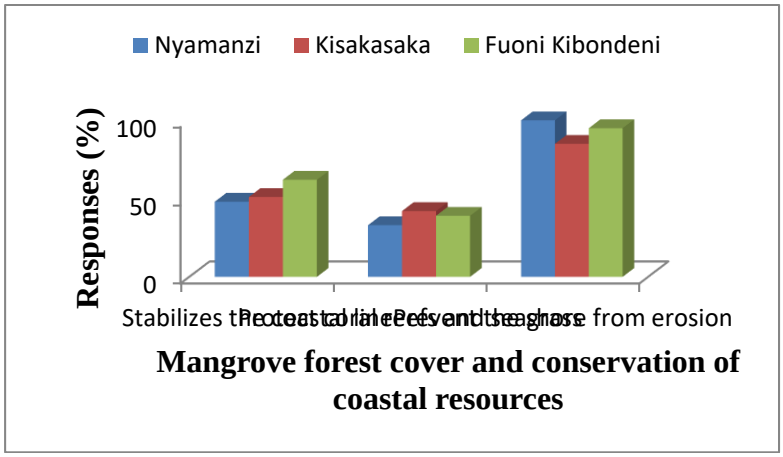

Figure 7: Mangrove forests cover and conservation of coastal resources in study area

3.4 Benefits of mangrove forests in the study area

3.4.1 Social-economic benefits

Based on the data obtained from the field, most of the respondents perceived that Mangrove Forest is the most crucial resource that provides various benefits in their villages, even though the results showed some variations in terms of the kinds of social-economic benefits. This is shown in terms of percentages in Table 3.

Table 3: Social-economic benefits of mangrove forest in the study area

	Villages		
Benefits of mangrove	Nyamanzi (n=30)	Kisakasaka (n=22)	Fuoni Kibondeni (n=50)
Poverty reduction	19 (63)	14 (64)	34 (68)
Sustainable farming	12 (40)	3 (14)	11 (22)
Provision of nursery areas for fish	14 (47)	6 (27)	15 (30)
Provision of food to the community	6 (20)	3 (14)	6 (12)
Enhances business activities	12 (40)	7 (32)	10 (20)
Regulating air temperature	20 (67)	6 (27)	10 (20)

3.4.2 Poverty reduction

It is important to point out that poverty is a serious problem for many developing countries, Tanzania inclusive. Most of the community members in rural developing countries live in poverty. Their average earnings are considerably less than those in urban areas [13]. Similarly, in West B District, the communities, especially in the study area were almost poor due to large dependence on the livelihood activities that are influenced much by climate such as rain fed agriculture.

The use of mangrove forest as adaptation strategy to the impact of climate change has for somehow reduced poverty to the local communities in the area as reported by 63% of the respondents from Nyamanzi, 64% from Kisakasaka and 68% of respondents from Fuoni Kibondeni villages. The data from focus group discussions indicated that even though mangrove forests were taken as adaptation option. The villagers around the area also get income through fishing and sea weed farming in the mangroves areas. These reduce the extreme poverty and hardship of life among the villagers. To verify the above argument, one of the key informants at Nyamanzi village said that: "*We had successfully been using one stone for beating two birds, in our village mangrove forest is used for adapting to coastal erosion and sea waves caused by climate change, but at the same time it provides us with income that minimizes the life difficulties".* These findings confirm the association between [12] and [14] which verifies that mangrove forests alleviate poverty and improve people's living standard as they act as pivotal sources of income for the coastal communities.

3.4.3 Regulating air temperature

The changing condition of climatic parameters has driven increasing trends of temperature in many areas of Zanzibar, including West B District [17]. However, the amount of temperature is unevenly distributed from one district or area to another due to various factors, such as vegetation cover and the distance from the sea.

Mangrove forests, therefore, like other kinds of forests influence the temperature in the study area by reducing the amount of temperature received in the areas. Hence, they provide enjoyable air to the villagers or communities. This is evidenced by the responses from the household questionnaires collected during the study, whereby 67% of respondents from Nyamanzi, 27% from Kisakasaka and 20% of respondents from Fuoni Kibondeni villages agreed on the fact. The data from the key informant at Nyamanzi village added that: *"Though temperature has been increasing rapidly in various parts of our country, the way we are heated in our village is quite different from other areas far from the coast and this is due to the reason that mangrove forests that we have here regulate the amount of temperature. Just take a little observation by going inward from the coast you will notice some changes, even a little"* This implies that the mangrove forest has a contribution to the adaptation on the impacts of climate change in the coastal areas of Zanzibar and other parts of the world.

3.4.4 Provision of nursery areas for fish

Mangrove forests provide breeding, nursery and feeding habitat for the majority of fish and shellfish. This provides a chance for small scale fishers in the study area to exploit various kinds of fish and crabs in most creeks of mangrove ecosystems. The argument is evidenced by the household responses of about 47%, 27% and 30% of respondents from Nyamanzi, Kisakasaka and Fuoni Kibondeni villages respectively. This implies that the commercial fisheries in the area is positively enhanced by mangrove forests as indeed shown clearly in [18] that fishing in mangrove ecosystems is common practice and involves both men and women with varying age size from adults to child of kindergarten. In many estuaries, lagoons and bays there is influx of people collecting different types of fish commonly found in mangroves ecosystems [18]. However, the fisheries activities seemed not to have many benefits to the local communities in the villages due to the emergence of intensive fishing by the fishers from outside the study villages.

3.4.5 Sustainable farming

Mangrove forests of West B District provide sustainable farming for horticulture crops such as peas, banana, cassava, fruits and vegetables along the mangrove swamps. The number of villagers engaged themselves in cultivation following the existence of mangrove forests that protect their farming crops from emerging climatic problems; hence, sustainable farming.

The data obtained from household questionnaires revealed the existence of the sustainable farming in the study area due to the existence of mangrove forests as accounted by 40% of respondents from Nyamanzi, 14% from Kisakasaka and 22% of responses from Fuoni Kibondeni villages. The participants through the focus group discussions added that mangrove forests provide chance for sea weed farming along the coast of the villages in the District which was the major source of income for majority of women. For example, at Kisakasaka Village, women of differing ages have been engaged in sea weed farming so as to earn income for them and their families. Other studies conducted agree on the existence of sustainable farming in many villages of Zanzibar Islands due to the availability of mangrove forests in those areas [18].

3.4.6 Enhances business activities

Business is among the main economic activities of the communities in West B District Zanzibar as represented by 40% of the respondents from Nyamanzi, 32% from Kisakasaka and 20% from Fuoni Kibondeni villages. The introduction of mangrove forests as adaptation strategy came to strengthen business conditions in the area, as currently; the villagers have a wider choice of what to do to sell to

increase their earnings. This is supported by 40% of respondents from Nyamanzi, 32% from Kisakasaka and 20% respondents from Fuoni Kibondeni villages.

When the participants from focus group discussion questioned on how business is related to the mangroves in the area, members stressed on the improvement of business activities in the villages through exploitation of mangrove resources. The participants elaborated that there was burning of lime and charcoal, cutting poles for building and fuelwood for cooking, as well as selling of fishes from the mangrove ecosystems. Common statements in the focus group discussions were: *"The mangrove forests have improved the business activities in the village. We have various works from mangroves, we collect crab, we burn charcoal and lime, and we cut poles and firewood which we sell to get cash".*

3.4.7 Provision of food to the community

Mangrove forests are used in various coastal Islands as source of food for the communities [4]. They provide aquatic products, shellfish species, and vegetables that are used by the majority of people living around the coastal zones [4], [8]. Like in other coastal areas, the mangrove forests in West B District enable the communities to obtain food of various kinds, including but not limited to fishes.

About 20% of households from Nyamanzi, 14% from Kisakasaka and 12% from Fuoni Kibondeni villages have been used mangrove forest products for food in the villages. The data showed that most of women and children in the study area collect those mangrove products which are used by few households and purely for subsistence purposes (food). In verifying this, one of the village key informants from the study area had this to contribute: "*It is from there that we get our food mostly fish of different kinds such as lobsters, prawns and mud-crabs.*"

3.5 Challenges in using mangrove forests in adaptation to the impacts of climate change

The study also found some challenges limiting the use of mangrove forests in adaptation to the impacts of climate change in the West B District of Zanzibar as indicated in Figure 8.

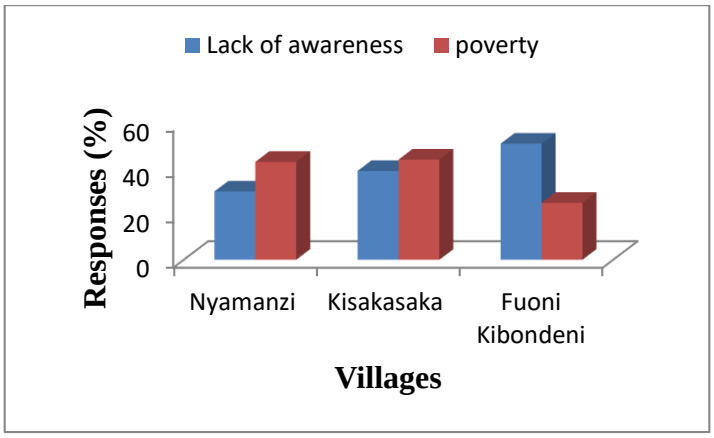

Figure 8**:** Challenges limiting the use of mangrove forests in adaptation to climate change

As indicated in Figure 8, 30% of respondents from Nyamanzi, 39% from Kisakasaka and 51% of respondents from Fuoni Kibondeni villages reported poverty to be the major challenge limiting the use of mangrove forests in adapting to the impact of climate change in the area. This is because the communities depend much on coastal resources, including mangrove forests for their livelihood

activities such as charcoal making. As a result, the existing mangrove ecosystems are competing with human activities through deforestation instead of getting used for adaptation.

Again, lack of awareness among the communities was also reported to be the second challenge in using mangrove forest in the adaptation as revealed by 43% of respondents from Nyamanzi, 44% from Kisakasaka and 25% of respondents from Fuoni Kibondeni villages. The communities were reported to be unaware of the importance of mangrove forests in the area, especially for adapting to the impacts of climate change. The information obtained from village key informants also added that some community members were unaware of the importance of mangrove forests and others were aware but not willing to protect mangroves for adaptation.

3.6 Solutions to enhance the use of mangrove forests for adaptation to impact of climate change

During the household survey, respondents provided some solutions to address the challenges limiting the use of mangrove forests in adapting to the impacts of climate change in the study area as shown in Figure 9.

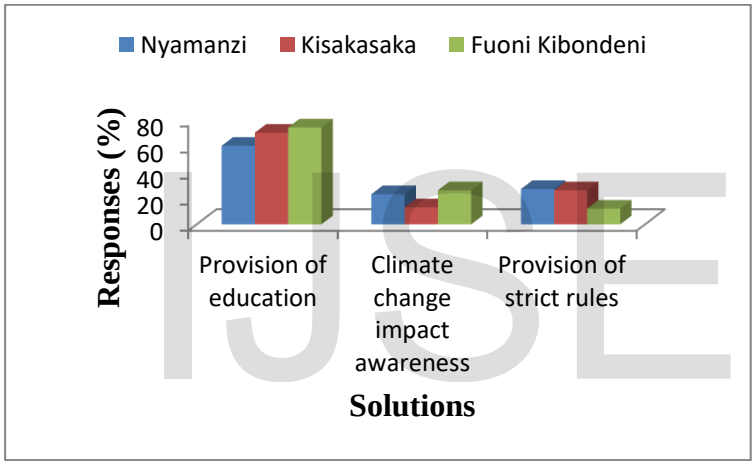

Figure 9: **S**olutions to enhance utilization of mangrove forests for adaptation to climate change

As summarized in Figure 9, 60% of respondents from Nyamanzi, 70% from Kisakasaka and 74% of respondents from Fuoni Kibondeni villages addressed provision of education as a solution to enhance the use of mangrove forests in adaptation to climate change. Some community members need to be provided with environmental education that arouses awareness of the importance of mangrove forests in the villages, especially for the adaptation to climate change. This will help to increase afforestation and conservation of mangrove ecosystems for the sake of adapting to the impacts of climate change in the area.

Other group of respondents of about 23% from Nyamanzi, 13% from Kisakasaka and 26% from Fuoni Kibondeni villages said that communities should be made aware of climate change and its impacts. Based on the information obtained through this study, communities were not yet well aware of the climate change issues and the related impacts to the coastal communities. If the community is made aware of this, it will arouse understanding of climate change to the people and increase their seriousness in conserving the mangrove forests for adaptation to the impacts of climate change.

The remaining group of respondents as represented by 27% from Nyamanzi, 26% from Kisakasaka and 12% from Fuoni Kibondeni villages addressed strict rules as a solution for enhancing the use of mangrove forests in adaptation to the impacts of climate change as indicated in Figure 9.

4 Conclusion

The results of this study reveal that mangrove forests cover have been changing in the study villages. Mangrove forests seem to decrease gradually due to increasing rate of mangrove deforestation for various social economic uses by the local communities. Mangrove forests cover is an effective tool for adapting to the impacts of climate change in the study area. Local people in cooperation with local governments have been taking serious actions by planting mangrove forests in the study villages and outside the villages within the District for protection against erosion, storm winds, sea waves and sea level rise in their villages.

Generally, mangrove forests have serious and useful implication on the adaptation to climate change in the study area. Despite their capability to protect the physical environment, mangrove forests have been benefiting the communities, socially and economically, in different ways. These include poverty reduction, sustainable farming, provision of nursery areas for fish, provision of food to the people, enhances business activities and regulating air temperature. However, poverty, lack of willingness among the communities as well as the lack of awareness on the importance of mangrove forests and the impacts of climate change were among the observed challenges limiting the use of mangrove forests in adapting to the impacts of climate change in the study area.

Therefore, the external force is needed to enhance the capability of this strategy of adaptation. This is due to the fact that the extent of future changes may limit the capability of mangrove forests in adapting to the coming new weather patterns and related extreme events.

5 Recommendations

There should be enhancement of mangrove forests adaptive capacity through the use of mangrove related adaptation strategies and other options, such as diversification of economic livelihoods, irrigation farming, and rain water harvesting as well as awareness creation on climate change information.

Mangrove forest still remains the reliable strategy for adapting to the impact of erosion, storm winds and the rise of sea level brought about by changing climate in coastal communities, such as the study villages. Therefore, there is a need of recognizing and actively promote mangrove forests through incorporating it into climate change policies and adaptation strategies. Incorporating Mangrove Forest can add value to the development of sustainable climate change adaptation strategies that are rich in natural ecosystem, and planned in conjunction with local people.

Various marine species, including fish and shrimp, use mangroves as nurseries during early life stages, Later they move out into nearby reef areas or the open sea. In this manner, mangroves are an important source of replenishing some of the ocean's fish stock. So, there is a need to create awareness among the community on the importance of understanding this issue so as to protect the fish stocks for the benefit of the present and future generations.

Mangrove forests kept on changing due to various reasons. Therefore, there is need to conserve mangrove forests for the sake of using it in climate change adaptation. This can be done through raising the communities awareness on the importance of mangrove forests, facilitating financial assistance to

the communities' projects and environmental groups dealing with mangrove conservation, enhancement and enforcement of renewable sources of energy that are environmentally friendly and sustainable.

Acknowledgement
This work was supported in party by a grant from West Indian Ocean (WIMSA).

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