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Assessing the Role of Community Forest Management: A Geographical Information System (GIS)-based approach

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Abstract
The aim of this study was to assess the contribution of community forest management using Geographical Information System (GIS) techniques. Specifically, the study focused on quantifying land use changes before and after CoFMA implementation and examining the level of people's satisfaction with forest products and income generation. The study was conducted in Cheju, Unguja Ukuu and Chwaka wards. The study targeted participants from communities surrounding Jozani forest and government forestry officials. A total of 111 respondents (13 percent of the entire population) were selected as a sample. The aerial image of 2005 and Landsat 8 ETM+ imagery of 2017 were used to assess land use changes. Besides, community mapping with semi-structured interview together with field observation were used to acquire spatial knowledge through integration with GIS. Methods of data analysis consisted of pre-image processing, image analysis and accuracy assessment using Quantum GIS. Tables, plates, and maps were used to present findings. The findings show that despite the presence of CoFMA, the forest is still declining both within and outside the reserve. However, this does not mean that CoFMA has not helped forest management. In fact, without this programme, the degradation rate would have been worse. While CoFMA's benefits are noticeable, consumer pressure on forest resources is high as evident in people's complaints about their declining economic opportunities from the forest. As such, it is recommended that conservation efforts should be balanced to ensure sustainable livelihoods. Applying multiple values approach and changing livelihood strategies for forest communities are also crucial.

Keywords: Geographical information systems, community forest management, land use, land cover change, forest products
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Introduction

The loss of forest cover has been increasing worldwide since the nineteenth century (Boer *et al.,* 2020). The Food and Agriculture Organization (FAO) estimated that in the last decade, the global loss of natural forest cover was 16.1 million hectares per year. Alarmingly, 15.2 million of these hectares were lost in the tropics only. During the decade reviewed, deforestation is said to have been highest in Africa and Southern America. Individual countries with the highest net loss in this decade included Argentina, Brazil, Democratic Republic of Congo, Zambia and Zimbabwe (FAO, 2016; UNEP, 2020).

Tanzania is one of the developing countries with high annual deforestation rates with losses of between 400,000 and 500,000 hectors per year (FAO, 2010; FAO, 2016). This rate is primarily attributed to land demands from activities such as crop cultivation practices, grazing, logging, and reliance on forest products such as firewood, building materials and traditional medicine (Alesina *et al*., 2019; Hosonuma *et al*., 2012). In Tanzania, Zanzibar's state of deforestation is not different from what is happening in Mainland Tanzania (Anderson *et al.*, 2009). For example, Jozani forest in Unguja Island suffers from surrounding communities' reliance on forest resources to meet their domestic and economic fuel demands (Balsem, 2011; Tamrini, 2009). Due to the inability to afford electricity, most rural

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communities in Zanzibar are heavily reliant on firewood and charcoal for cooking hence continuing to present a major threat to Zanzibar's forest resources. All regions of Unguja and the remaining patches of coral thicket forests are severely threatened by the very high human population density (400 individuals/km2) of the area, which is increasing at an estimated rate of five percent per year (3 percent native and 2 percent immigration) (DCCFF, 2020).

The Government of Zanzibar has taken considerable direct and indirect measures to ensure that the forest is well protected and both plant and animal species continue to survive. The government has worked with the Department of Forest and Non-Renewable Resources (DFNRR) and village conservation councils to establish ecological monitoring of Jozani forest (URT, 2012). Nevertheless, these efforts have not solved the problem of deforestation (Balsem, 2011, Bernhard *et al.,* 2020, FAO, 2016). Given the growing threats to many forest areas in Unguja Island, forest protection efforts have been moved swiftly to completely protect the remaining forests and corridors before many of them are lost forever. As a result of these efforts, the Community Forest Management Agreement (CoFMA) was established in 2003. This is an agreement between the government and local people on forest resource management; this, of course involves some zoning of village lands, essentially into three categories (high protection zones, low impacts use zones and private land). According to this agreement, the Forest Act requires management agreements prepared by the central government to be jointly and formally made with local communities adjacent to state forests before any joint forest management (JFM) initiative starts. It was proposed that the arrangements should be updated every 5 years and that monitoring and evaluation should take place continuously.

Community forest management is increasingly being recognized as one of the key strategies for tackling the loss of forests and achieving sustainable use of forest ecosystems (Alesina *et al*., 2019; Bernhard *et al*., 2020). Community forestry began in the 1970s when stakeholders started to recognise that communities can be actors of positive change at the heart of forest management (Alesina *et al*., 2019). Today, although reliable global data on the impact of community forestry is generally lacking, governmental and non-governmental organizations agree that communities' involvement in forest management has a positive impact on livelihoods and the environment (Baynes *et al*., 2015). In fact, there is growing evidence that stronger community have resulted in better managed forests, reduced levels of deforestation and improved livelihoods (Dfaz *et al.*, 2018). Obviously, Community Forest Management (CFM) has become an influential approach for managing forests around the world (MNRT, 2020) such that many international organizations, donors, NGOs, and governments today advocate it. However, despite the presence of a policy and legal framework that require the involvement of local communities in sustainable management of forests, the arrangements formed under them continue to be ineffective for unclear reasons. As such, encroachment of forest reserves like Jozani in Zanzibar continue.

In other words, evidence confirming the potentiality of local communities' participation in reducing deforestation pressure on Jozani forest is not clear. Therefore, the increasing attention paid to sustainable management of forest resources in Zanzibar calls for an exploration of the role of rural communities' participation in community-based forest management. This is necessitated by the need to verify the validity of arguments stating that community participation results in feasible, appropriate, and coherent natural-resource management strategies. The need for more research on this subject is particularly highlighted by the fact that majority of studies that have been conducted on the subject (e.g. Hassan and Pedro, 2020, Tamrini, 2009) have paid attention to ecological risk assessment while others have focused on sustainable forest management based on building communities' capacity

(DCCFF, 2020; Winowiecki *et.*, *al* 2016). As such, there is limited knowledge on the role of community participation in sustainable forest management and improvement of livelihoods As a result, a study that used a GIS-based approach as a lens to better understand how successful CFM institutions are in terms of improving livelihoods and forest conditions has been conducted and this paper reports its findings.

Unlike other methods, Geographical Information System (GIS) is a promising technology for evaluating community forest projects. It is powerful tool for planning, evaluating, managing and decision making. The technology provides a platform through which managers can generate informative data and information that can be used to show how successful conservation efforts have been and highlight areas for improvements to ensure sustainable resource management. Given the rapid advances in the use of GIS data and the relative ease of use of GIS software, assessing communities' contribution to resource management through GIS technology is crucial (Sathees & Nazeer, 2021). The main objective of this study was to assess the contribution of community participation to sustainable forest management and improvement of livelihoods through geospatial technology. Specifically, the study sought to examine the state of Jozani forest before and after CoFMA inception and determine the level of people's satisfaction with forest products and income generation.

Community based conservation models

Benefit-based model of conservation has become a common approach for governing natural resources in many resource rich countries of Africa (Sachedina, 2008). The model is built on three major arguments. To start with, the model argues that local communities can only be motivated to support the conservation of natural resources if they have a stake from the resource being conserved. The model also argues that alternative incomes from resource conservation can facilitate the reduction of environmental destruction activities (Sulle, 2011). Lastly, the model also argues that national parks and forest reserves cannot be sustained in the midst of surrounding poor communities.

Many international development organizations, environmental NGOs and governments have adopted community benefits as a condition for supporting and funding many conservation initiatives in Africa (Noe, 2013). The sponsors of such initiatives believe that the application of economic incentives is essential in addressing resource degradation (Noe, 2013). This normally happens when local communities are considered as the major threats to protected areas (USAID, 2013). Where conservation does not make economic sense to local communities, people are pushed to engage in environmentally destructive activities, particularly when they benefit from doing so (Sachedina, 2008; Sulle, 2011). This model guided this study in examining the contribution of COFMA to the improvement of forest condition and human life.

Empirical Review

The Extent and Rate of forest deterioration

Forests have essential ecological functions and provide numerous ecosystem services, such as habitat provision, water and soil conservation and biodiversity preservation (FAO and UNEP, 2020). However, forest disturbances widely affect the ecological functioning in provision of ecosystem services and hence affects people livelihoods (FAO and UNEP, 2020). As reported recently, the area of global forest loss reached 1.78 × 106 km2 between 1990 and 2020 (FAO and UNEP 2020), which was mainly caused by anthropogenic factors, such as forest exploitation and land-use conversion (Aragão et al. 2018; FAO and UNEP 2020); and has also been altered by natural environmental changes and disturbances, such as drought (FAO and UNEP 2020). Most of this forest disturbances occur at regional scale and evolve over long periods (Fonseca *et al.*, 2019). According to FAO, (2016) deforestation remains a problem for developing countries rather than developed countries. Africa is reported to be a more severely deforested continent than other continents. Recent estimates show that about 4 million hectares of land are being deforested annually in Africa (FAO, 2020). Although the rate of deforestation is high in Africa, its magnitude varies from one country to another. In Tanzania, the forest was thought to cover half of the country's land cover (44 million hectares) in 1993. This declined to 33.5 million hectares in 2000 and is estimated to be reduced to 28.4 million hectares by the year 2020 (FAO, 2020).

The Impacts of forest Change to the people livelihoods

Deforestation and forest degradation affect the development process directly and in directly as argued by (FAO, 2020). Alesina *et al.*, (2019) noted that in the tropics, extensive forest areas have been occupied by a large number of poor people that depend on forest for their livelihoods. Poverty and other socioeconomic factors could limit various social and physical conditions of rural poor that could also play an important role in the forest destruction process. Therefore, forest loss can have adverse effects on livelihood directly and indirectly. Most important, deterioration deprives the forest-dependent people who live in forests their means of livelihoods. This is because forests provide these communities with edible plants, fruits, honey, shelter firewood and many other tangible goods and intangible services such as cultural and spiritual values (Alesina *et al.*, 2019). Therefore, forest change could lead to loss of long-term income and increase economic hardships for the local people.

Community Based Forest Management

Between the 1970s and 1990s, the institution of community-based forest management models emerged in the global south. From that time several countries in Africa and Asia like Ghana, Madagascar, Tanzania, Malawi, Zimbabwe, Cameroon, India, the Philippines and Nepal introduced reforms to define community forestry (CF) institutions and practices (Dfaz *et al.,* 2018; FAO 2016). From then, governments have been promoting community participation in forest management, largely by decentralizing authority over managing natural resources to local or community governments that are closer to those resources. There has also been an increasing recognition that many of the world's poorest people live in areas of very high biodiversity. And that given the opportunity, traditionally forest-dependent communities can ensure that forests are managed sustainably (MNRT, 2020). Community-Forest Management (CFM) approach is believed to be a proper way forward for alleviating pressure in forest reserves (Peterson, 2008). It is generally promised to improve forest governance, forest stock and livelihood of the surrounding communities. Lately, economists and conservationists have begun touting community-based forest management as a way to alleviate poverty and reducing ecological degradation. CFM's role has also been highlighted in talks about the UN's global initiative to mitigate climate change known as Reducing Emissions from Deforestation and Forest Degradation (REDD+).

In case of Zanzibar, before 2000, forest management was based on top down approach however; this traditional approach failed to adequately protect forests in Zanzibar.

Due to the intensive deforestation and degradation in Zanzibar, it was necessary to design a comprehensive protected areas network to conserve Zanzibar's remaining coral forests and their biodiversity. To achieve this total of 65 Community Forest Management Agreements (CoFMAs) have thus been formed in Zanzibar to support Shehia communities in managing community forest resources. Today, community-based forest management enjoys the support of governments, conservation NGOs and international donor agencies. But does this conservation strategy work properly in Zanzibar? Has CoFMAs delivered on its promise to improve both forests and people's lives? The study tried to find out.

Research Gap

Many literature sources have addressed the importance of community forest management at national level (e.g. Dfaz *et al.*, 2018; Peterson, 2008) while others have covered rules and regulations governing CoFMAs' implementation (FAO, 2016; MNRT, 2020). Other literatures have addressed the extent and socio-economic issues related to deforestation and rural wood energy consumption in African countries (FAO, 2020, Lambin *et al.*, 2003). In contrast, the role of CoFMAs in ecological conservation processes and wellbeing of the people has received little research attention. As such, accurate assessments of forest cover, rates of forest loss and a clear identification of proximate sources are needed to establish a deeper understanding of the primary mechanisms and driving factors behind forest change. This study has used GIS to fill this research gap. The system has been used as a basic tool for exposing the problem of forest change since 2003 through using maps to convey the extent of the damage caused inside and outside Jozani forest by human activities.

Research Materials

The Geographical Location of the Study Areas

Jozani forest is located 37 km south of Zanzibar Municipality. The area is found between coordinates 53°80' to 54°41^{1}S and 9°32^1 to 9°34^{1}E.

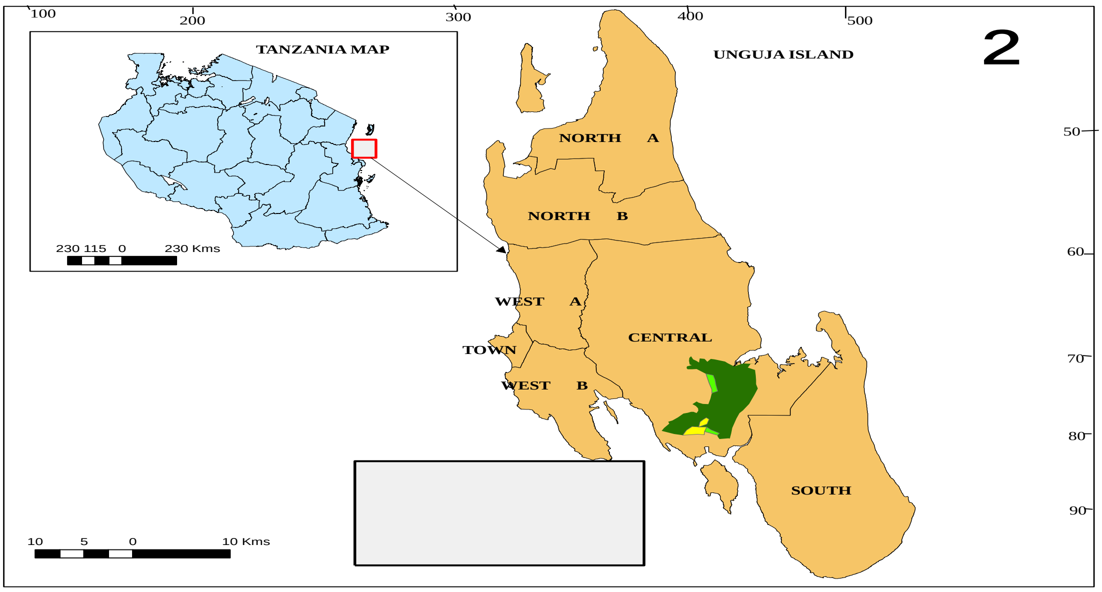

Figure 1: The Map of Study Area

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Source: Author, (2017**)**

This location has been selected because it is among the areas being conserved so as to protect different species of natural forests. At the moment, Jozani forest is under tremendous threat from activities of surrounding communities (DCCFF, 2020). This state persists despite the initiation of Community Forest Management System (CFMS) and Integrated Conservation and Development Project (ICDPs) targeting reducing such a threat. Thus, this study seeks to apply GIS to assess the contribution of community participation in the management of forests in the area.

Sample Size and Sampling Procedures

The study was conducted in the central district of Unguja. The district has 8 wards and 14 villages. A Purposive sampling method was used to draw 3 wards from which 6 villages were selected for inclusion in the study. Of these 6 villages, 4 were selected because of their adjacency to Jozani forest and CoFMA status. The other 2 villages were selected because they were not under CoFMA for comparison purposes. Kothari (2005) suggests that for a sample to be representative enough for statistical analysis, at least 10 percent of the population targeted should be included in the study. Thus, 111 (13 percent) of the 855 households in the 6 selected villages were included in this study (see Table 1).

Table 1: Target number of households and sample size

Wards	**Village**	**Pop**	**HH**	**Sample**	**Women**	**%**	**Men**	**%**	**Total %**
Chwaka	Kairo	600	180	23	12	50	11	50	12.8
	Gulioni	550	120	16	8	50	8	50	13.3
Cheju	Chuchumile	350	70	9	4	50	5	50	12,9
	Mapopwe	250	60	8	4	50	4	50	13.3
Unguja U. Kaepwani	Kwebona	900	225	29	15	50	14	50	12,9
	Chichi	800	200	26	13	50	13	50	13.0
	Total	**3,450**	**855**	**111**	**56**		**55**		**13.0**

Source: NBS, 2012

In order to ensure each of the selected villages made a statistically sound contribution to the total sample size, the proportionate formula shown in equation 1 was used (Kothari, 2005). The number of households to be used as sample in each ward is presented in table1.

$$n_h = \frac{N_h}{N} n \qquad \textit{(Equation1)}$$

Where,

n_h = proportional sample of each sub-ward/street,

N_h = the number of households of each sub-ward/street,

N = total number of households in the study area

n = total sample size of the study population

The study required a sample size of 111 households (n = 111) which was drawn from a sample frame of 855 households (N = 855), grouped into six strata (villages). The strata had the following population sizes; N1= 180, N2 = 120, N3 = 70, N4 = 60, N5 = 225 and N6 = 200. Proportional sample contributions of each stratum were calculated as shown below:

$n_1 = \frac{180}{855} x 111 = 23$ $n_2 = \frac{120}{855} X 111 = 16$ $n_3 = \frac{70}{855} X\ 111 = 9$ $n_4 = \frac{60}{855} X 111 = 8$

$n_5 = \frac{225}{855} X 111 = 29$ $n_6 = \frac{200}{855} X 111 = 26$

As seen in the calculations, 23, 16, 9, 8, 29 and 26 respondents were picked from Kairo, Gulioni, Chuchumile, Mapopwe, Kwebona, and Chichi, respectively and included in the sample.

Data Collection Techniques

The study used both primary and secondary sources of data. Secondary data were collected from documents and records available at various relevant institutions and local, national, and international organizations. Primary data were collected through satellite images, Global position system, semi-structured interviews with community mapping, field observations.

The aerial image of 2002 and Landsat 8 ETM+ image for 2017 were used for image classification to identify land use patterns and create LULC maps. The Landsat images were acquired from USGS through their earth explorer web portal (https://glovis.usgs.gov/). The Landsat ETM+ image data consists of twelve spectral bands, with a 30 m spatial resolution. Only images with cloud cover of less than 10% were selected to ensure quality of spatial data. Aerial image of 2002 and Landsat data of 2017 were used to find the spatial and temporal changes in the study area. A supervised classification of the image was performed using signature files and a maximum likelihood rule was used as a parametric rule. Google Earth, street map and public map datasets were also utilized as baseline for reference and better understanding of land use types and distribution.

One and half hours long semi-structured interviews with community mapping session was used to gather data from each informant. The most recent digital geo-referenced satellite image of 2017 which covered Jozani forest and all surrounding villages were printed at a scale of 1:10000 on laminated paper sheets for data collection. Before interviews respondents were oriented on how to use the information on the map in relation to the ground facts and realities. This exercise aimed at enabling local people to understand the image map clearly so as to help them to respond to the questions correctly. The interviews were divided into three sections: questions on respondents' demographic information, questions focused on understanding people's perceptions of CoFMA; and questions seeking to establish the status of Jozani forest before and after CoFMA implementation. Data such as changes in both plant and animal species were collected. Pebbles with different colors were used to locate site of their responses. Data transformation was done manually in the field by reallocating the marked points from the map to A3 hard sheet map using coloured pencils.

This is a scientific method of collecting data whereby a researcher personally investigates an issue without asking respondents questions. In this study, the researcher was guided by a set of definite items outlined in a field observation sheet. These were: boundary and areas agreed for CoFMA implementation; the current state of the forest, both in high and low protected zones; forest products that were on sale; villagers' past and current land use activities in utilization zones and protected zones, and socio-economic statuses of the villagers. The observation took place immediately after interviews in each village. The researcher recorded data using handheld Global Position System (GPS), mobile GPS and a digital camera.

Data Processing and Analysis

All the data collected were checked against their questions in order to ensure consistency in the information collected. Spatial data collected by community mapping interview documents were georeferenced to add spatial reference information. The process involved identifying a series of ground control points known as x, y coordinates that linked locations on the raster dataset with locations in the spatially referenced data (target data). Then, the data were permanently transformed using the rectify command on the Georeferencing toolbar. The spatial data were digitized independently and a total of 119 points were recorded in the point shape file. Characteristics of the points were stored in the attribute tables. Then, the data was cross-checked for double-records, equal representation of all informant numbers and ensuring that all the villages and ward names are correctly spelled. Remote sensing image processing was performed using Quantum GIS software. The satellite images were analysed and processed (geo-referencing, mosaic, and extraction) to correct its geospatial imagery. Multiple band combinations were used to identify land use patterns within the Landsat images. Visible bands (red, green, and blue) 4, 5, and 6 were used for Landsat-8 image. Landsat images were spatially projected to Arc_1960_UTM_Zone_37S. The study area of Jonzani was then extracted from the projected datasets to create a raster for image classification. The accuracy of classified maps was assessed by comparing the created land use maps with the referenced google satellite imagery and public land use maps.

After data refinement, followed data analysis, whereby data from households' survey were coded into specific categories leading to the generation of simple statistics such as frequencies and percentages. Statistical Product and Service Solution (SPSS) was used to analyze non-spatial quantitative data while Geographical Information System (GIS) was used to analyze spatial data.

The research question on people's perceptions of the status of Jozani forest before and after CoFMA implementation and the aerial image of T1 (2002) were reclassified into two main classes namely; forest and non-forest. The forest class was further divided into two sub-classes of coral bushes and thickets, while the non-forest class was divided into agricultural areas and human settlements. This procedure was repeated for T2 (2017). After this, two polygon shaped files were created and all spatial data sets were mosaicked into UTM South map coordinate system (DatumArc, 1960). Shape files were then added into workspace for digitizing. The images were digitized to create new features directly on the underlying surface. The characteristics of these land use types were stored in the attribute table, including information about types of land use and the areas covered in terms of meters and hectares. After this exercise, the map was visualized to show qualitative changes. In order to acquire quantitative changes, the map layers were converted to raster format. Forest change was analysed quantitatively using Quantum GIS software and cross tabulation matrices via analysis tool and cross tab window. In addition to that, latest map T2 (2017) was added in the raster math and commanded to subtract T1 (2002). The result of this method was the change direction (increase and decrease of forest patches). For comparison of changes in land use categories between T1 and T2, tabulation matrices were established. The output of this process was a map showing potential areas for forest change and gives a picture of the orientation of Jozani forest after the implementation of CoFMAs hence enabling prediction of the future of the forest.

While GIS tool was used to show the status of Jozani forest before and after CoFMA adoption; structural functional analysis technique was used to break down local communities' perceptions into smallest meaningful units including values and attitudes of respondents regarding the forest and problems associated with its conservation. Then data on perceptions were classified and grouped accordingly. The data were then identified and organized into coherent categories that summarized and brought meaning to the responses.

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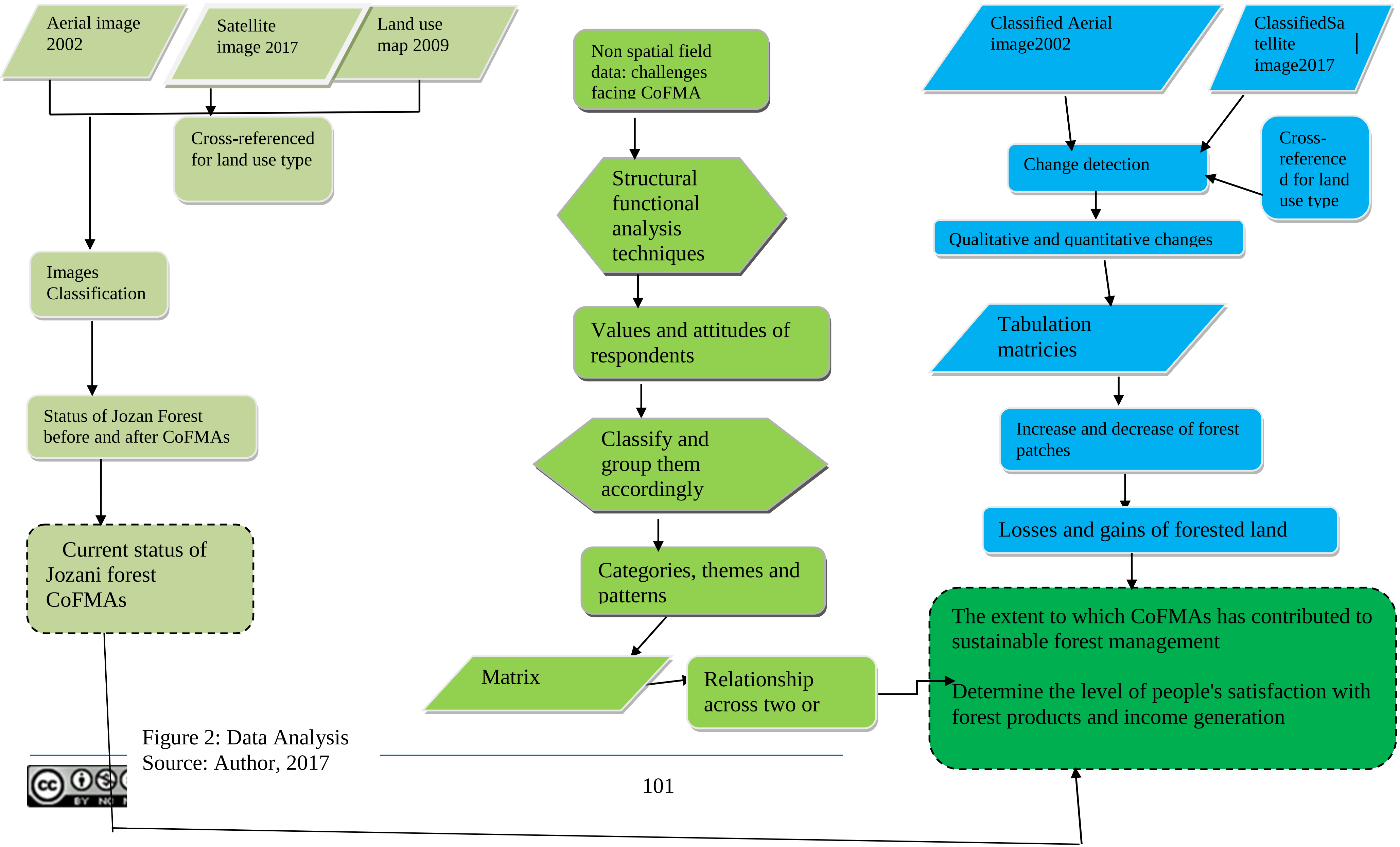

Figure 2: Data Analysis
Source: Author, 2017

Table 2: Sumarry of Research Methodology

Specific objectives	Methods of Data collection and Images used	Data source	Data analysis	Output
1. To examine local peoples' perceptions of the status of Jozani forest before and after CoFMA inception	• Semi structured interview with community mapping • Field Observations • Literature review	• Fieldwork • Review of books, journals, reports, files, publications, unpublished materials, statistics and internet sources	• GIS, Content and structural functional analysis techniques • Percentages and Frequency • using Ms Excel 2003 and Ms Excel 2007 and SPSS version 20	• The local residents' perceptions on Jozani forest before and after CoFMAs implementation.
	• Aerial Photo of 2002 and satellite image of 2017	• **(**DoSup, 602), Zanzibar • Open source	• GIS for map visualization • Change detection analysis	• Map showing potential areas for forest change before and after CoFMAs implementation. • Other sensitive forest areas that will be at risk and need attention.
2. To determine the level of people's satisfaction with forest products and income generation	• Households' survey • Observation • Literature review	• Fieldwork • Review of books, journals and reports	• Quantitative analysis: • Percentages and Frequencies	• Forest condition • Socio-economic achievements that CoFMA has attained in respective communities.

Results and Discussion

People's perceptions on Jozani forest change after the inception of CoFMAs

The local communities living near Jozani forest acknowledged that the forest plays an important role in their wellbeing. Majority of respondents (95 percent) said that the forest is an important source of livelihood opportunities in form of supplemental income and agricultural land, and serves as a habitat for several species. In addition to recognising the livelihood benefits of the forest, local communities are also aware that the wellness of the forest has changed. Fifty-nine (53.2 percent) respondents admitted that the forest is in an awful condition with high likelihood of worsen in the near future if necessary interventions are not made. The presence of major roads in the study area has been associated with acceleration of usage of forest land to expand residential areas and exploitation of resources. Communities in the study area also understood that built-up areas, the ocean and barren land have increased over the past years, decreasing the protected land. According to Lee and Han (2019) and Hassan and Pedro (2020), overdependence on and unsustainable extraction of natural resources such as forests, land, and water without alternative economic strategies results in serious environmental problems including biodiversity loss and disintegration.

Table 3: People's perceptions on forest condition

Perception	Frequency	Percent
Good condition	52	46.8
Awful condition	59	53.2
Total	**68**	**43**

Source: Fieldwork, 2017

Specifically, majority of respondents indicated that they have noticed a decrease in animal and plant species in the study area. Among these, some explained that have come to notice this change is a result of the increase in the time it now takes them to find some forest products. The respondents also added that there are now more destroyed and dead trees and dry tree branches while the number of common tree species has decreased. The respondents placed dots on the southern and western parts of the map to specify the most affected areas. In contrast, the forests in the eastern zone which go deep inland were indicated as relatively unexploited. The results of this study is related to what was observed by Boehm (2012), Lee and Han (2019) who noted the disappearance of many large trees, increase in the number of dead trees, decrease of tree species and increase in the number of monkeys as indications of forestland degradation in the south western region of Saudi Arabia. Overall, there was a good number of respondents that felt that Jozani forest has improved since the start CoFMA implementation although they also admitted that there are several issues that continue to pose serious threats to the improved forest.

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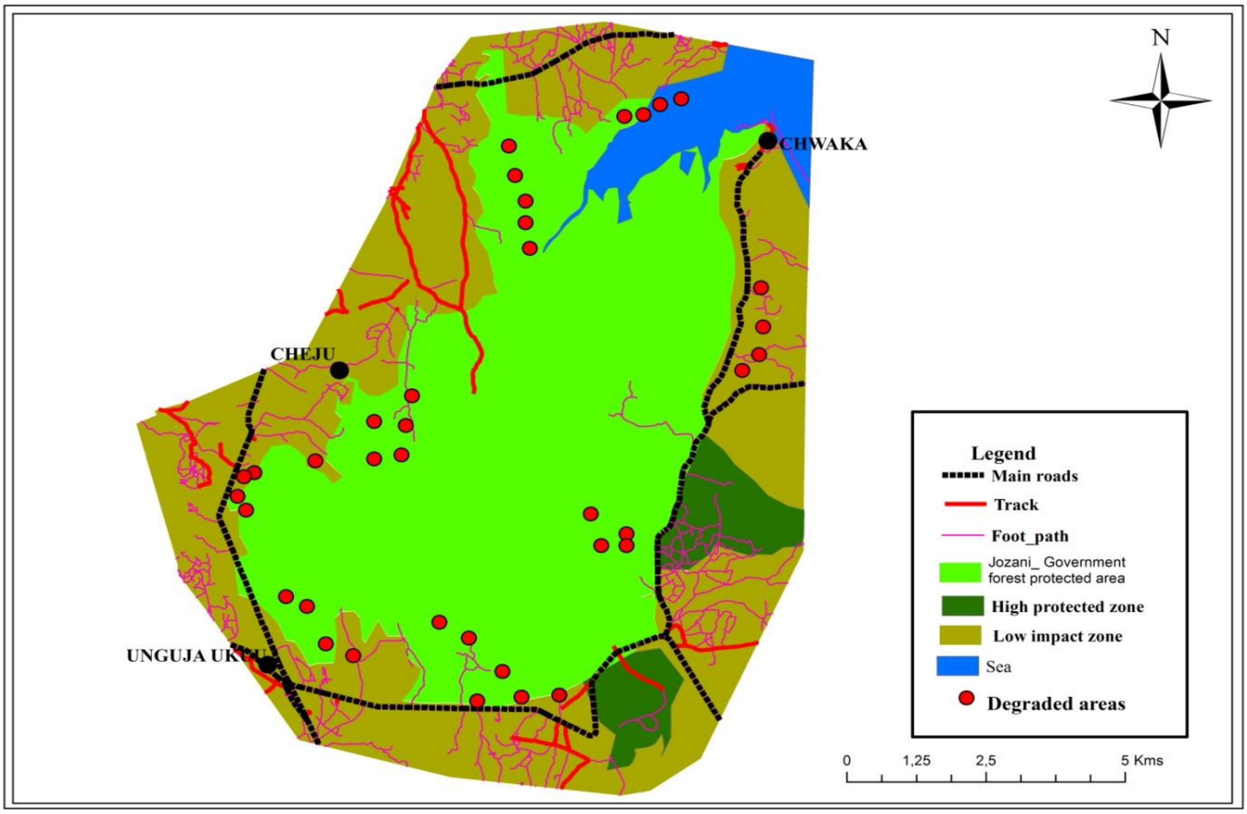

Figure 3: People Perception on Forest Change
Source: Author, 2017

Geospatial analysis of forest and land cover changes before and after CoFMA project implementation

Although peoples' perceptions can provide valuable long-term data on forest change, they are not always sufficient enough to exhaustively represent the truth on the ground. Noting this challenge, this study applied Geographical Information System (GIS) as a comparison tool for land use changes since CoFMA implementation started. As indicated in Table 4, between 2002 and 2017, about 6077 ha of forest did not undergo any change. However, about 174 ha changed to private land, 185 changed to low impact zones and 294 and 170 ha changed into sea and patches respectively. Furthermore, the table reveals that out of 638 ha of highly protected forest zones, about 600 remained unchanged while about 20 and 18 changed to private land and low impact zones respectively.

Table 4: Geospatial analysis of forest and land cover

	Government Forest	Protected	Private	Low impact	Wildlife corridor	Sea	Patch	Total	Loss
Government	6050	30	174	185	0	294	170	6903	826
Protected	0	600	20	18	0	0	0	638	38
Private	5	0	3835	0	0	0	0	3840	**5**
Low impact	20	0	147	188	0	0	0	355	67
Wildlife corridor	0	0	82	0	685	0	0	767	**82**
Sea	0	0	0	0	0	319	0	319	**0**
Total	**6102**	**630**	**4258**	**391**	**685**	**613**	**170**	**12822**	

Gain	25	30	423	203	0	**294**	**143**	

Source: Field survey, 2017

The findings further show that private land, low impact zones, and the sea have significantly increased compared to the area covered by Jozani forest. Similarly, high protected zones and governmental forest areas have decreased in size during the analysed period with change rate measured at -0.9 and -0.1 percent per year respectively. On the other hand, private land, which comprised of agricultural and human settlement areas, has increased by 0.8 and 0.7 respectively during the same period. The above findings supported the findings of other studies like findings by (Kashaigili et al. 2013; Boehm 2012).

Table 5: Annual changes in land use types

Land use classes	**2017-2002 (%)**
Governmental forest	-0.9
High Protected	-0.1
Private land	0.8
Low impact zone	0.7
Wildlife corridor	-0.9
Sea	5.0
Patch	38.2

Source: Author, 2017

A visual interpretation of the classified map (see Figure 4) has revealed that since 2002 dense areas in Jozani forest remained only within the inner part and eastern zone of the reserve while agricultural patches appeared mainly in western zone where Cheju ward is located. The forest outside Jozani forest, which is very important in the preservation of the government forest is extremely deforested (see Figure 4) and left with limited forest cover. This is the same situation happened in Masito-Ugalla ecosystem in Kigoma (Hosonuma *et al.*, 2012, URT, 2014). This state could further deteriorate if the government of Zanzibar does not introduce and execute proper forest management strategies and protection measures.

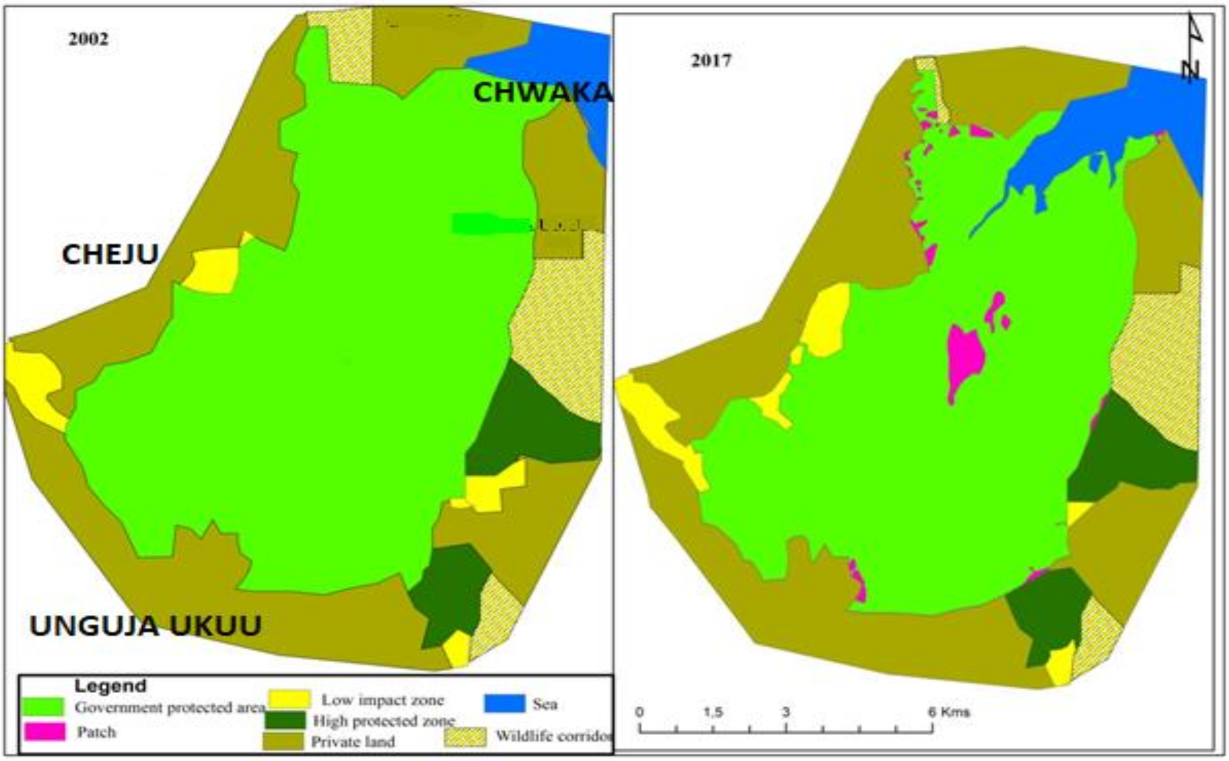

Figure 4: Land Use Types in the Study Area
Source: Author, 2017

The changes that have occurred in Jozani Forest during this period have been caused by an increase in agricultural activities (expansion of agricultural land) clearing forests for timber, charcoal and construction see figure 4 and 5. The expansion of farm land can be attributed to the increasing agricultural related demands resulting from growing household sizes as well as ambitions to get more yields from both cash and food crops.

These findings are in line with those from other studies such as Su *et al*., (2011) which indicated that deforestation in the Masito-Ugalla ecosystem was due to an increase in human practices such as farming and reliance on charcoal and firewood. In a way, this study confirms an observation made by Kekkonen and Käyhkö (2014) who concluded that unlike the relative stability of forest cover in Zanzibar between the year 1975 and 1996, negative changes have been happening ever since. Since the period between the year 1996 and 2009, forests have been losing coverage more rapidly main due to increasing human practices such as farming, cutting down trees for charcoal and firewood. Likewise, studies conducted by Hosonuma *et al*., 2012, and Su *et al*., (2011), revealed that deforestation in tropical forests of many African countries is caused by agricultural, forestry products, and domestic demands.

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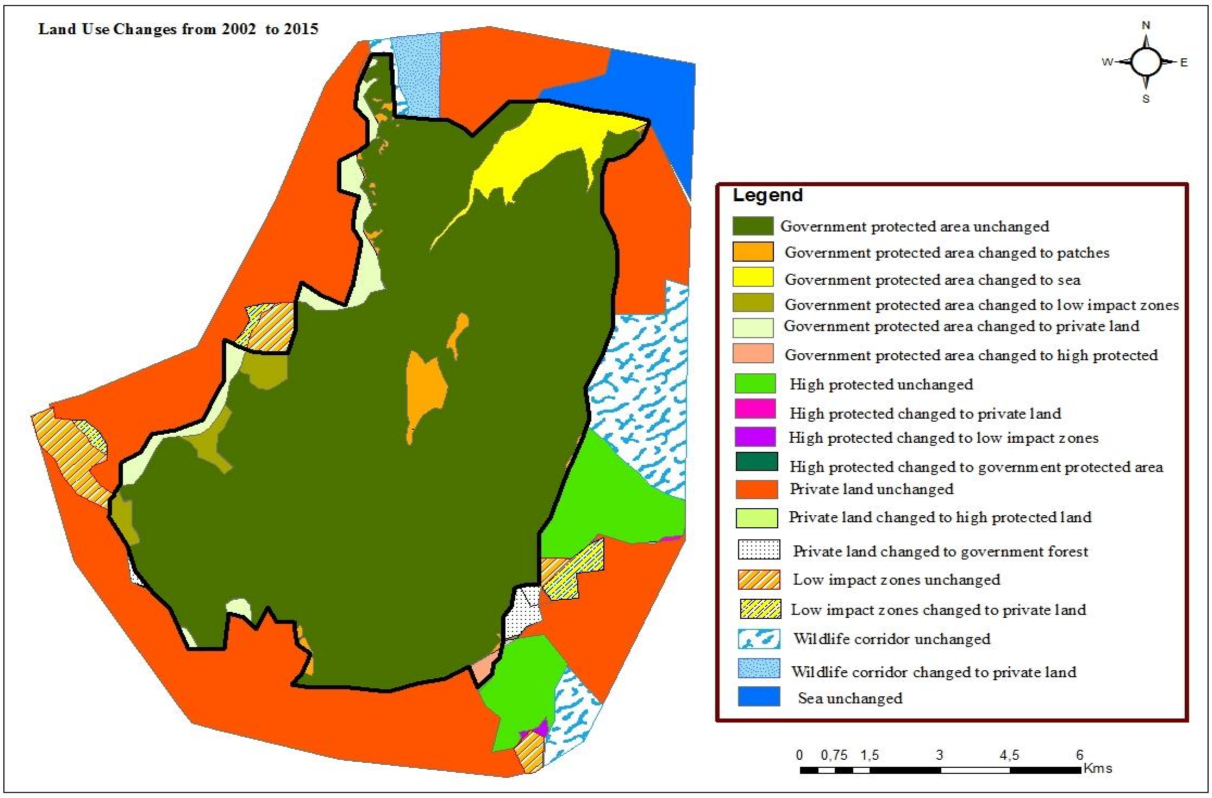

Figure 5: Matrix Land Use Changes Map from 2002- 2017
Source: Author, 2017.

Contribution of CoFMAs to Jozani forest management and people livelihoods

Environmental Benefits of CoFMA

Majority of respondents acknowledged the environmental benefits that the Community Forest Management Agreements (CoFMA) program has brought. In fact, over 56 percent of the respondents were in support of the program.

Table 6: Environmental Benefits of CoFMA

Environmental Benefits	Frequency	Percent
Benficial	**63**	**56.8**
Not beneficial	**48**	**43.2**
Total	**111**	**100.0**

Source: Fieldwork, 2014

As Table 6 shows, majority of respondents felt that CoFMA is environmentally beneficial. According to the respondents, the program encourages people to plant seaweeds, establish tree gardens, and engage in agroforestry activities. All these are aimed at reducing dependency on forest reserves. In fact, according to the findings of this study, the majority of residents of the villages that are part of CoFMA implementation are, in one way or another, actively involved in the improvement of forest conservation and environmental management. The residents take part in planting seeds of mangroves on degraded areas, village meetings, and sensitizing each other about observing laws and regulations seeking to keep the area environmentally sustainable. Messages about conservation efforts are said to be sent to residents through formal and informal education channels such as primary, secondary, and Islamic (madrasat) schools to actively involve children in protecting the environment. This mass education approach is also supported by Winowiecki *et al.*, (2016) who claimed that environmental education helps to provide information about nature and history, and promotes the infusion of pro-environmental attitudes among local people, including children.

The establishment of CoFMA has helped to generate and sustain a variety of ecosystem species which eventually play an important role in the wellbeing of the local communities. Respondents have identified four major zones where forest restoration was taking place under CoFMA. Two of these are located in Cheju, one in Chwaka and one in Unguja Ukuu Kaepwani Ward.

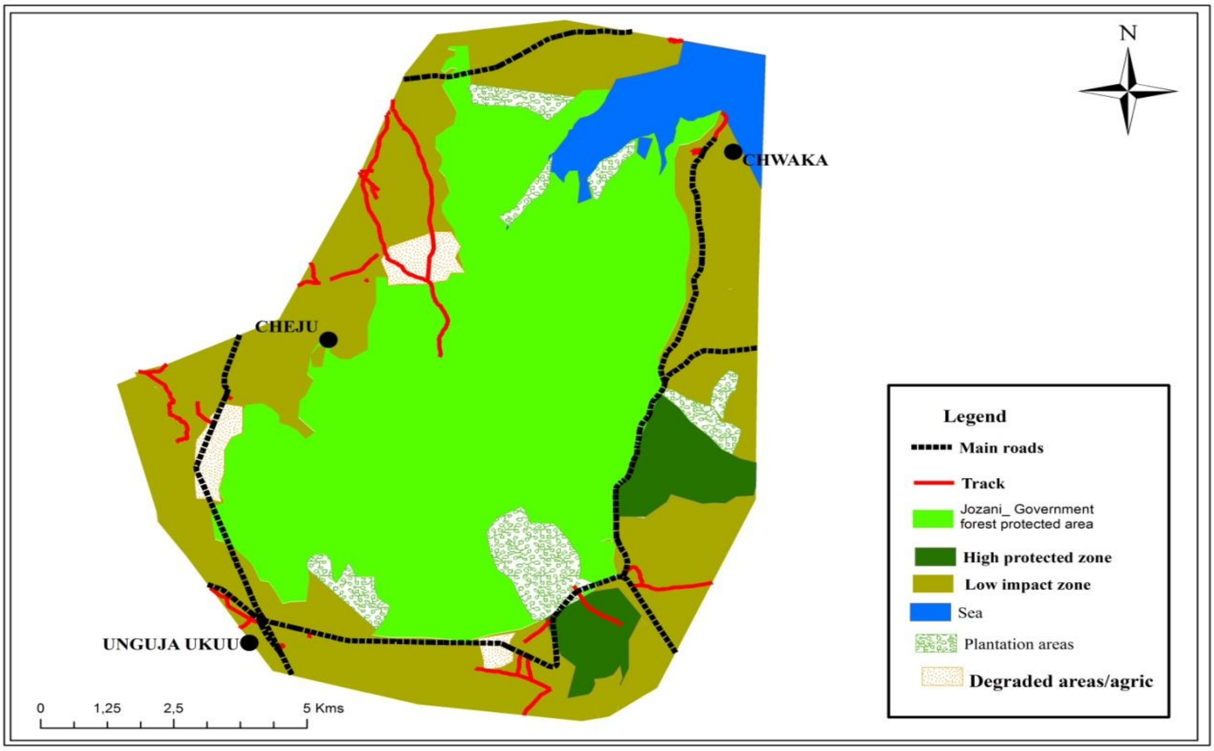

Figure 6: Jozani forest Management
Source: Author, 2017

Public education and awareness programs are inevitable when seeking to enhance the sharing and utilization of information on the protection and restoration of mangroves and other forest types. These findings are supported by Omar and Cabral (2020) who proved that awareness of the importance of managing forests had increased in the last ten years in the coastal zones of India because of community-based programmes.

Plate 1: People participating in tree planting in Mapopwe village, Cheju ward, Zanzibar

Plate 2: Community members and students involved in tree planting in Kairo village, Chwaka, Zanzibar

Despite the benefits that CoFMA has brought, there are some respondents who believe that the programme has not succeeded in conserving the forest. Instead, the respondents feel that the programme has created a more vulnerable and difficult environment for people surrounding Jozan forest. This difference in perception can be explained by the fact that Cheju and Chwaka communities do not have diverse income sources and therefore largely depend on Jozani forest to meet their daily needs. This, understandably resulted in majority of respondents (local people) disagreeing with the introduction of a forest resource gathering fee suggesting that having a fixed quantity of resources that can be harvested within a set period is a sufficient restrictive measure. The fee was said to favor people that can afford it on the expense of the poor that are also the majority surrounding the forest. Members of these communities also blamed the system of requiring people to ask for permission from authorities on the amount of forest resources to collect and the places to collect them from. They argued that such strict rules resulted in many incidents of illegal entry into CoFMA-protected areas to collect forest products. In other words, enacting strict forest conservation does not guarantee positive results because sometimes it may worsen an existing problem **(**Winowiecki *et al.*, 2016).

Income generation from Forest Products Consumption

The study further investigated whether or not there was increased consumption of forestry products in areas where CoFMA was being implemented. Over 44 percent of respondents reported a significant decrease in the consumption of forest products as well as a change in consumption habits. According to the respondents, as a result of increased mobilization and awareness on the importance of conserving the forest, community members have come to understand the consequences of relying on the forest. Through the program, people's freedom to do whatever they want in the forest has been greatly minimized (see Table 7).

Due to population growth, demand on and consumption of forest products are also increasing especially those to do with construction, firewood, traditional medicine, production of fruits and handcraft materials. A large part of the residents of these villages, regardless of location, reported that generating cash income from forest resources is now problematic and brings a lot of uncertainties and risks. Before CoFMA implementation, Jozani forest was the major source of income at household and community levels. For instance, people used to sell forestry products such as mats and baskets to supplement their income. Money generated from these activities was used to cover school fees, healthcare, local transport and served as pocket money. After CoFMA started, failure to access forest resources to supplement cash income has increased, and so have hardship for local people. The study has found that the establishment of CoFMA has resulted in the reduction of farmland and collection of non-timber forest products hence lowering incomes of local communities' dependent on these activities, putting both the resource-base and people's livelihoods at potential risk (Su *et al.*, 2011; Winowiecki *et al.*, 2016, IPCC, 2014).

Table 7: Degree of Freedom on Generating Money from Forest Products

Ward	**Freedom**		**Total**
	Yes	**No**	
Unguja Ukuu Kaepwani	32 (58.2%)	23 (41.8%)	55 (100%)
Cheju	1 (5.9%)	16 (94.1%)	17 (100%)
Chwaka	4 (10.3%)	35 (89.7%)	39 (100%)
Total	**45**	**66**	**111**

Source: Fieldwork, 2014

Despite complaints about the benefits of CoFMA, villagers generally maintain positive attitudes towards the program as it has been reported in locations where CoFMA extension services have been provided. The communities still see the programmme's contribution to forest conservation and are willing to continue supporting it.

Conclusion

In general, the findings obtained through the Geographical Information System (GIS) method confirm that the status of Jozani forest has changed significantly due expansion of farm land, settlement, and the sea. The GIS results have shown that although the forest's health has changed optimistically since the beginning of CoFMA implementation, deforestation and degradation are still observable outside and inside the forest reserve. Nevertheless, CoFMA initiatives' value is obvious in some areas where the forest has benefited, this study concludes that to achieve sustainable forest management, there is a need of balancing socio-economic demands of local communities and the value of forest biodiversity conservation. In other words, conservation efforts should be regulated to provide assurance of sustainable livelihoods. This will contribute to the reduction and prevention of land-use tensions between communities surrounding Jozani forest and conservation authorities and advocate.

Changing forest utilities to multiple values and changing communities' livelihood strategies are highly needed in the study area but with clear regulation of resource use. Conservation related income generating projects such as planting trees outside the reserve, beekeeping, poultry, cultivation of fodders for animals, agricultural extension services, savings and loan associations, introduction of solar lamps, as well as improved seeds should be adequately promoted and supported in the study area so as to help the poor. The government subsidy policies and increased transparency in public decision making are likely to lead to strategies that enhance incentives to a more sustainable forest management. The sectoral conflicts, the mismatch between the forest policy and other sectors and lack of a comprehensive environmental policy that harmonizes different sectoral policies have significantly contributed to the encroachment and deforestation of Jozani forest. For that reason, the paper suggests that there should be more harmony and synergies created between different sectors, such as agriculture, forestry, energy, and land to avoid policy inconsistencies and contradictions which currently exist. This paper not only emphasize the capacity building to environmental organizations in Zanzibar, but also is challenging their mission on finding sustainable forest land use and superior management strategies. Generally, the findings from this paper are important in providing useful inputs to the planners, policy and decision makers on management of coastal forests resource within the context of resource use to improve livelihood.

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