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Land cover changes and their determinants in the coral rag ecosystem of the South District of Unguja, Zanzibar

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This paper presents the findings on the study on land cover changes and their determinants in the coral rag ecosystem of the South District of Unguja. The study is based on data extracted from the 1975, 2009, and 2014 satellite images using remote sensing and geographical information systems (GIS) techniques. Additional data were collected through structured interviews in a household survey, focus group discussions, key informant interviews, transect walks and observation. The major change detected in the study area from 1975 to 2014 was the decline of forests by 28.3% from 43.31 to 15% and the increase of semi-open forest and bush by 24.16% from 10.54 to 34.7%. During the same time, settlements increased from 0.1 to 4.9%. Different factors both direct and underlying have caused land cover change in the study area. Direct causes include shifting cultivation, commercial cutting of wood for fire wood, charcoal, pegs and cutting sticks for seaweed farming, while the underlying ones are population growth, policy reform and policy failure, land tenure insecurity, soil as well as the terrain and underlying rocks. If not properly addressed, land cover changes are likely to affect either positively or negatively the wildlife as well as the livelihoods of the communities. Investment in intensive cultivation and alternative sources of energy is required to reduce over utilization of forest resources and to improve conservation and people's livelihood.

Key words: Land cover change, coral rag ecosystem, fragmentation, forest decline, Unguja Island.

INTRODUCTION

In recent decades, land cover change has been considered as one of the major global environmental problems (Fuchs et al., 2018; Nyamugama and Kakembo, 2015; Schoeman et al., 2013; Ouedraogo et al., 2010). It has become an area of interest to many researchers and scientists including bio-geographers, ecologists and natural resource managers to gain deeper understanding of its causes and consequences to the planet earth. FAO (2016, 2010a) maintains that about half of the world forests have already been cleared and every year the planet earth loses about 16 million hectares of her forests. Accordingly, more than 60% of the annual forest losses worldwide have occurred in the tropics, particularly in Latin America and in Africa. The tropical forests in Ivory Coast, Congo, Gabon, Sierra Leone, Madagascar and the tropical forests in Southern

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and Eastern Africa have been greatly reduced from degradation and deforestation (Chakravarty et al., 2012). Besides, the rate of deforestation in Tanzania is approximately 1.13% per year; approximately, 403,000 ha of forest were being annually lost mostly on village land (FAO, 2010b; Sawe et al., 2014).

Land cover change is complex, involving various interacting factors which vary in space and time (Dalil and Nsini 2014; Misana et al., 2012). On one hand, the variation of factors reflects the dynamic nature of peoples' behavior in the way they interact with their environments, that is, the way they feel, view and respond to their environment in space and time (Orjala, 2008). The way human beings interact with their environment is a response from certain stimuli that are rooted in socio-economic and political decisions at different levels and in different times. On the other hand, the variation of factors reflects the dynamic nature of the physical factors such as soil, climate and morphology (Gao et al., 2015).

Although land cover changes had occurred in the past, they were mostly a result of natural processes and had little effects on the biosphere (Fanan et al., 2011). Recently, the problem has become complex, fast growing, and mostly caused by human activities (Baral et al., 2018; Bayramoğlu and Kadıoğulları, 2018; Mwangi et al., 2017a; Alemayehu, 2016; Dalil and Nsini, 2014; Mdemu et al., 2012; Misana et al., 2012). The major concern on land cover change has emerged following the massive removal of the natural vegetation by human activities (Kull, 2012; Misana et al., 2012). The intensity of changes has been propelled by direct and indirect causes arising from human decisions at global to local levels (Solomon et al., 2018; Mwangi et al., 2017b; Adedeji et al., 2015). The decisions determine the human actions to control and access natural resources, leading to clearing of natural vegetation. The massive removal of natural vegetation in the biosphere has contributed to the imbalance of the radiation budget causing global climate changes, biodiversity loss and threats to human wellbeing (Zaehringer et al., 2015; Misana et al., 2012; Fanan et al., 2011).

Although, Islands are often known to have high percentages of endemic species (Groom et al., 2006), most of the Island environments are subjected to land transformation due to deforestation from cultivation, sand mining/quarrying as well as urban and sub-urban expansion (Devaraju et al., 2015; Azeria et al., 2006; Fahrig, 2003). Island environments are fragile, thus uncontrolled utilization of land and forest resources has great repercussion on both land cover and biodiversity conservation (Calado et al., 2014). Similarly, the size of land is limited (small), while human population is growing fast (Ewel et al., 2013). Thus, there has been increasing pressure on forest resources from utilization and demand for land. Consequently, habitat fragmentation and loss of biodiversity are increasing in many islands (Calado et al., 2014; Ewel et al., 2013; Baider et al., 2010).

The problem of land cover change in Unguja Island is not different from other Islands. Most of her natural vegetation has been removed since colonial period (Siex, 2011). The coral rag vegetation of the South District of the Island, however, has remained as the largest natural vegetation cover, constituting about 63% of the Island vegetation (*ibid*). Accordingly, the ecosystem predominantly consists of indigenous coral rag forests and scrubland, which are recognized as the only remaining important wild habitat in the Island. The natural vegetation is known as 'coral rag vegetation' as the ecosystem constitutes a rubbly limestone of ancient coral reef material (Hettige, 1990). In recent years, however, the natural coral vegetation has been changing due to the increasing human development activities as well as increasing utilization of forest resources (Kukkonen, 2013).

Recognising the importance of the coral rag ecosystem to wildlife and human well being, it has become necessary to undertake a study to understand the nature and extent of land cover changes as well as assess the driving forces behind them. This paper presents findings of the study that was undertaken in the South District of Unguja Island to analyze land cover changes and their drivers. The information generated in this study is vital for conservation of wildlife and forest as well as for sustainable human development.

MATERIALS AND METHODS

The study area

The study was conducted in the South District of Unguja Island. The Island lies off the coast of East Africa in the Indian Ocean slightly south from the Equator (5° - 6° 30′ South and 39°23′ - 39°34′ East) and just 40 km east from Tanzanian mainland (Figure 1). The Island is 85 km long (North to South) and an average of 39 km wide (East to West), with an area of 1660 km^2. Specifically, the study area is located at latitudes 6° 10′ 30′′ South - 6° 29′ 30′′ South and longitudes 39° 23′ 30′′ East - 39° 34′ 30′′ East with an area of 379.3 km^2. Out of 21 Shehias of the study area, 6 Shehias, which are equal to 30%, were selected for the study. The selected Shehias were Mtende, Kizimkazi Mkunguni, Pete, Paje, Jambiani Kibigija and Muyuni 'A'. The Shehias are traversed by the coral rag ecological region.

The climate of the South District of Unguja is described in detail in Klein and Kayhko (2008). Generally, the district receives tropical rains during the short and long rain seasons. Accordingly, the average rainfall is 1100 mm; this amount is below the average for the Island, which is 1600 mm. The average annual daily maximum temperature is 29.3°C and the minimum is 21.1°C. The temperatures are the highest in January and February, with a mean maximum temperature of 32°C.

The district is almost dominated by Quaternary coral rocks. It is characterized by the much younger (Quaternary <2.5 millions years) deposits, that form a succession of cliffs (Klein and Kayhko, 2008). The soil of the study area is shallow and lies above a bed of reefels lime stones. Such soil supports shifting cultivation. The natural vegetation ranges from bush, shrub forest to high forest (predominantly high thicket forest) (Siex, 2011).

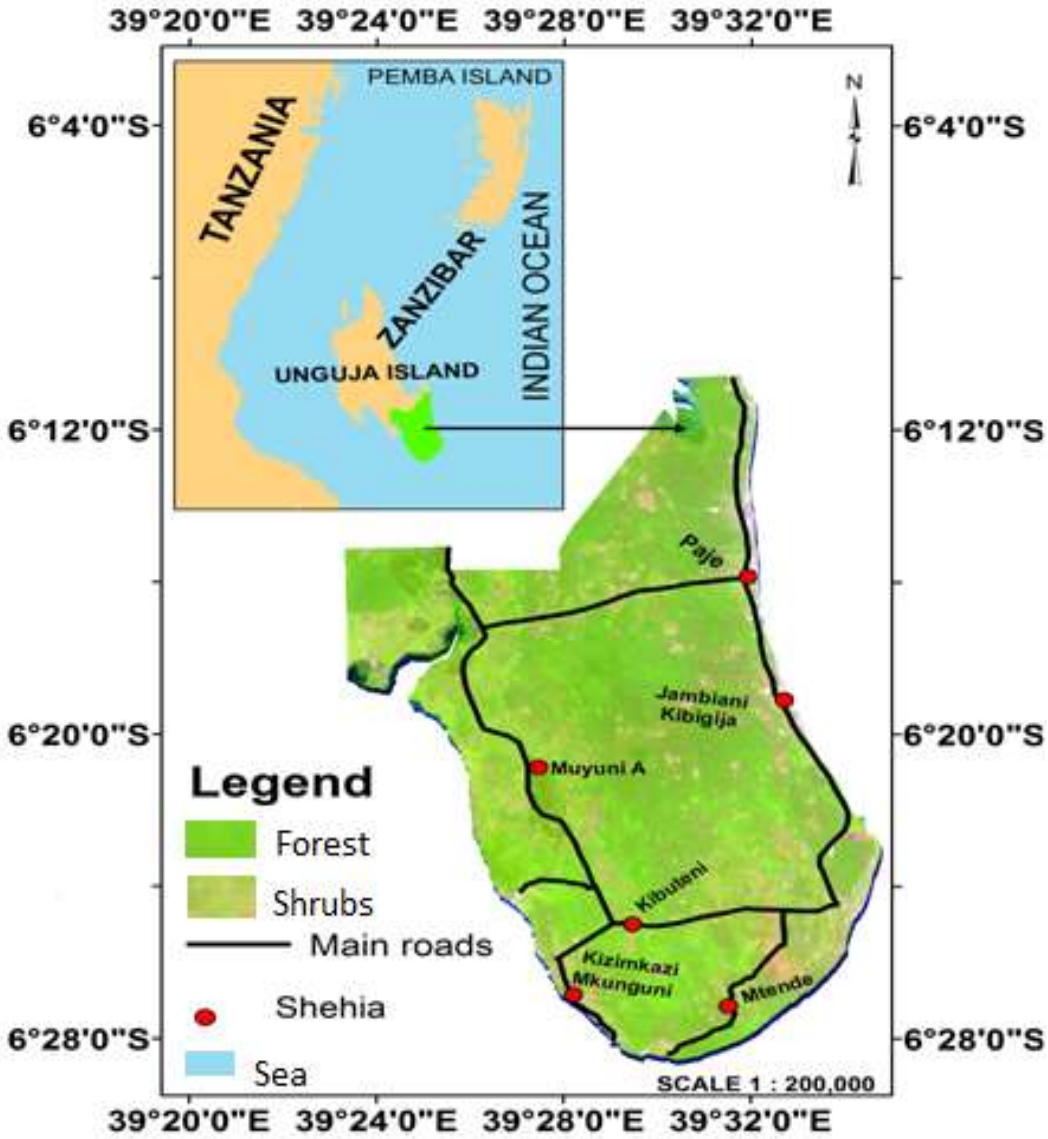


Figure 1. Location of the study Shehias in the South District of Unguja Island.

Accordingly, the South District of Unguja is mostly dominated by *Albizia* and *Diospyros* species. In general, this natural vegetation is identified as part of the larger biodiversity hotspot of the East African Coastal Forests and is commonly known as habitat of the Zanzibar mini-antelopes and other wildlife populations. In very recent times, however, the natural vegetation cover has been modified by exotic species such *Casuarina equisetifolia* which are planted mostly for economic purposes.

Based on the Tanzania population census of 2012, the population in the South District of Unguja Island was 39,242 people in 2012 (URT, 2012). Out of these, 19,342 were men and 19,900 were women. The average household size was 4.2 persons. The sex ratio of the study area is 97 males to 100 females. The main primary economic activity in the South District of Unguja is agriculture. Shifting cultivation is the common method of farming because of the nature of the soil (Kukkonen and Kayhko, 2014). Other common economic activities in the study are commercial cutting of wood and fishing. Tourism, however, has recently emerged.

Research approach

This study applied the political ecology approach (Leff, 2012; Robbins, 2012) to explain land cover changes. Political ecology is basically an inquiry into the root causes of environmental/ecological decay (Robbins, 2012). It tries to understand the complex relations between nature and society from the decisions made at different levels, which impact forms of access and control over resources and their implications for environmental health and sustainable livelihoods (Misana et al., 2012). The approach is relevant to this study, since it provides an insight to the decisions made at different levels that have influenced land cover change of the study area. The approach emphasizes that land use/cover change results from complex interactions between society, reflecting economic, social and political processes, and the physical environment (Olson et al.,

Table 1. Characteristics of satellite images used in the study.

Sensor	Acquisition time	Spatial resolution	Path/Row	Producer
MSS	26/07/1975	60 m	178/064	USGS
ETM+	01/07/2009	30 m	166/064	USGS
Landsat 8	13/06/2014	30 m	166/064	USGS

Source: http://glovis.usgs.gov

2004). Based on this approach, the study has examined a myriad of socio-economic, political as well as physical drivers of land cover change since 1975 to 2014.

Data collection methods

The study required both spatial and non-spatial data as well as qualitative and quantitative data. Therefore, various methods of data collection were employed; these included acquisition of remotely sensed data and image pre-processing, structured interviews, key informant interviews and focus group discussions.

Acquisition of remotely sensed data and image pre-processing

Spatial data were obtained from Landsat MSS 1975, Landsat ETM 2009, and Landsat 8 2014 (Table 1). The selection of images was influenced by two aspects: periods which the study intended to cover and availability of cloud free Landsat images within the respective intended periods of the study. The study covered three periods, that is, before economic liberalization (before 1980s), post economic liberalization (1980 to 2009) and during implementation of Community Forest Management Areas (COFMA; 2010 to 2014), that corresponds with socio-political and economic decisions, which have determined the form of access and control of the natural resources. The cloud free Landsat images were available for 1975, 2009, and 2014. All the images were downloaded from Earth Resources Observation and Science (EROS) of the Geological Survey of the United States of America at http://glovis.usgs.gov. The Landsat images were selected over aerial photographs because the study intended to cover the entire South District of Unguja Island, which covers about 37,926.38 ha. The synoptic coverage of Landsat images (Lillesand et al., 2008) made them more advantageous than aerial photographs.

Two GIS software were used to analyze the selected Landsat images. These were Quantum Geographical Information System (QGIS) 2.8.1 and ArcGIS. The software were used in different stages of analysis. All the three Landsat images were first atmospherically corrected in QGIS 2.8.1 using Dark Object Substraction (DOS). In this operation, the digital numbers were corrected to actual surface reflectance. Then the images were re-projected in ArcGIS to Universal Transverse Mercator (UTM) zone 37 World Global System (WGS 84), south of the Equator standard. The satellite bands were then projected in true colour and then in false colour composite to visualize the images so as to identify land cover classes. Meanwhile, topo-sheets, aerial photographs of different years and the google earth images of the study area were also reviewed. The information from all sources was compared to identify the corresponding land cover classes (Table 2).

Supervised classification was used to create land cover maps. The process involved first, selection of training samples for each land cover class. The training samples were generated based on the researcher's experience and the reviewed information from google map, topo sheet and aerial photographs of the study area. After creating enough representative training samples, classification was performed by using maximum likelihood classification (MLC) tool in ArcGIS 10.1.

The next step involved application of majority filter tool to eliminate unclassified pixels. The majority filter (4×4) operation reduces the number of undefined pixels in the output map of a classified image. The pixel with a large value replaces the neighboring contiguous pixel to eliminate corruption of cellular patterns (Lillesand et al., 2008). Thereafter, the classified images were vectorised using 'Raster to polygon' tool. The operation was performed to convert images from raster format to vector format to correct parts affected by clouds.

Thematic accuracies for the 1975, 2009, and 2014 Landsat images were determined by the error matrix method in QGIS 2.8.1. For the 1975 and 2009 images, the level of accuracy was determined by creation of a region of interest (ROI) in Semi-automatic Classification Plugin (SCP) by using Multiple ROI tool to create new shape files. It involved selection of the number of random points, which represented different land cover classes. Then, the toposheet, aerial photos and google maps of the study area were used to identify and compare the determined points and the generated random points. All random points representing land cover classes were given values corresponding to the classified images (1975 and 2009) and the points out of the boundary (study area) were deleted to produce region of interest image. Then, the level of accuracy was determined by calculating the Error Matrix by using the Error Matrix Tool. The overall accuracies are shown in Table 3.

Accuracy assessment for the 2014 Landsat imagery was determined through ground truthing by using GPS points collected in 2015, which were used to create a shape file in the Arc GIS. Then, the ground truthing shape file was overlaid with the classified image of 2014 by using intersection tool to determine the level of accuracy (Table 3). These accuracies were within the minimum accuracy postulated by Anderson et al. (1976) for satellite-derived land use/cover maps.

The changes in various land cover categories were detected by overlaying maps and performing land use change detection. All polygons of the detected changes were assigned colour using colour nomenclature corresponding to their land cover classes. For clear presentation of change detection maps, however, only major changes were indicated in the legend of the change detection maps.

The study employed cross-tabulation to indicate the proportional quantitative changes. Using a field calculator, area in square hectares was calculated for each land cover class from which matrix tables of change detection and net changes were developed for each image. Summations of loss and gain were calculated to identify the net change for each land cover class. Then cross-classification (qualitative location of changes) was performed using intersect tool in the Arc GIS 10.1.

Structured interview

The structured interview method was used to collect socio-

Table 2. Description of land cover classes identified.

Land cover classes	Description
Dense forest	Land cover class consisting mostly of tall trees with some areas being impenetrable. The canopy cover ranges from 40 to 100%.
Shrub forest	Vegetative land consisting of small trees ranging between 2 and 8 m, with many branches, with dense foliage cover (70 to 100%)
Semi-open forest and bush	Land consisting of sparsely vegetated areas with natural, sparsely planted, or herbaceous vegetation and crop land. The natural semi-open forest and bush consists of very sparse, sparse to mid foliage cover
Built up/settlements	Built-up areas, roads or any other infrastructure
Open/Bare land	Open spaces with little or no vegetation, beaches, dune sands, bare rocks.
Sea/Water bodies	Water courses, water bodies, sea and ocean areas, coastal lagoons.

Source: Adopted from Klein and Kayhko (2008).

Table 3. Summary of the land cover classification accuracy.

Thematic images	Overall accuracy (%)	Kappa index
1975	92.58	0.88
2009	84.93	0.71
2014	94.20	0.88

economic data on factors influencing land cover changes in the South District of Unguja Island. The data were obtained by using a questionnaire containing closed and open ended questions, which captured the main economic activities of the people, land ownership, land cover change and causes of change. A total of 323 households were proportionally and randomly selected from six selected Shehias. Any member in a household who was 20 years and above was selected to represent the entire household. The elder members, including heads of household, however, were given priority. Gender involvement was also considered. The IBM Statistical Package for Social Sciences (SPSS) version 20 was used to analyse quantitative data from the socio-economic survey.

Focus group discussion

Six focus group discussions were conducted, one in each selected Shehia. The focus groups consisted of five to seven participants. The elders who were longtime residents were involved. A checklist of questions of interest was used to guide the discussions. The discussions were conducted to collect information such as the historical trends over time with regard to land cover changes and the causes of the changes. The content analysis method (Kitchin and Tate, 2000) was used to analyse the qualitative information from focus group discussions. The data were analysed during and after discussion. Themes were identified, compared and corroborated with literature.

In-depth interview with key informants

In-depth interviews were conducted on 13 key informants, who included six chairpersons/secretaries of community conservation committees, one from each selected Shehia, six local leaders (Sheha) one from each selected Shehia and one official from Department of Forestry and Non-renewable Resources. In-depth interview method was used to collect information about historical trends and causes of land cover changes. The content analysis technique was used to analyse information from in depth interview.

Transect walk and field observation

Transect walks were made along six transect lines of 1 km each, one in each of the selected Shehias to observe the real situation within the study area. The observation was, however, not restricted to the selected lines. Instead, the researchers were keen to observe the actual situation throughout the study area during field work. Information was collected independently through direct observation in the field without specifically asking questions to the respondents. During field observation, information such as human activities contributing to land cover changes and status of natural vegetation was collected. Data from field observation were recorded by using field note book and camera in the field. Field observation was made to complement both qualitative and quantitative data derived from the other methods.

RESULTS AND DISCUSSION

Patterns of land cover changes from 1975 to 2014

Summary statistics of land cover changes for 1975, 2009 and 2014 are shown in Table 4. The results reveal

Table 4. Summary statistics of area proportions of each land cover class and changes for 1975, 2009 and 2014.

Land cover type	1975		2009		2014		1975-2009	2009-2014	1975-2014
	Area/ha	%	Area/ha	%	Area/ha	%	Net change	Net change	Total increase/decrease (+/-)
Forest	16424.37	43.31	4371.93	11.53	5701.99	15	-12052.50 ha (-31.8%)	1330.10 ha (-3.5%)	-10722.4 ha (-28.3%)
Shrub forest	16581.08	43.72	20626.11	54.39	16488.35	43.5	4045 ha (10.7%)	-4137.8 ha (10.9%)	-92 ha (-0.2%)
Semi-open forest and bush	3998.47	10.54	11201.49	29.53	13143.07	34.7	7203 ha (19%)	1941.6 ha (5.1%)	+9,144.61 ha (24. 1%)
Open/bare land	380.91	1.00	365.24	0.96	220.56	0.6	-15.70 ha (-0.04)	-144.7 ha (-0.38%)	-0.4 ha (-0.001%)
Built-up/Settlements	34.98	0.10	503.58	1.33	1877.11	4.9	468.7 ha (1.2%)	1373.5 ha (3.6%)	4.8 ha (0.01%)
Sea	506.57	1.33	858.03	2.26	495.30	1.3	351.5 ha (0.93%)	362.7 ha (1.0%)	11.3 ha (0.03%)
Total	37926.38	100	37926.38	100	37926.38	100	-	-	-

considerable and fluctuant spatial changes over time, where some land cover classes declined while other land cover classes increased. Generally, forest declined by 28.3% from 43.31% in 1975 to 15% in 2014 (Table 4). Shrub forest slightly declined while settlements/built up area increased during the same time period. A major increase was observed in semi-open forest and bush, which increased from 10.54 to 34.7%. These results correspond to the findings of Kukkonen and Kayhko (2014) in Unguja Island and Solomon et al. (2018) in Wujig Mahgo Waren, Northern Ethiopia

This study has also revealed that since 1975, a large part of the forest has been transformed to shrub forest and semi-open forest and bush (Table 5 and Figure 2). Only about 4129.9 ha had remained as forest in 2014. Meanwhile, 331 ha of the forest were transformed to settlements/built up. These findings are contrary to the findings of Baral et al. (2018) who observed that approximately 60% of a total change in forest cover between 1995 and 2017 was gained from other land use land cover types in a typical Middle Mountain Watershed of Western Nepal.

Further analysis (Table 6) reveals that between 1975 and 2009, a large part of forest (10103.06 ha) changed to shrub forest, which increased from 16,581.08 to 20,626.11 ha. These findings imply that most of the shrub forest has resulted from the modification of forest. In addition, the analysis indicates that most part of shrub forest changed to semi-open forest and bushes.

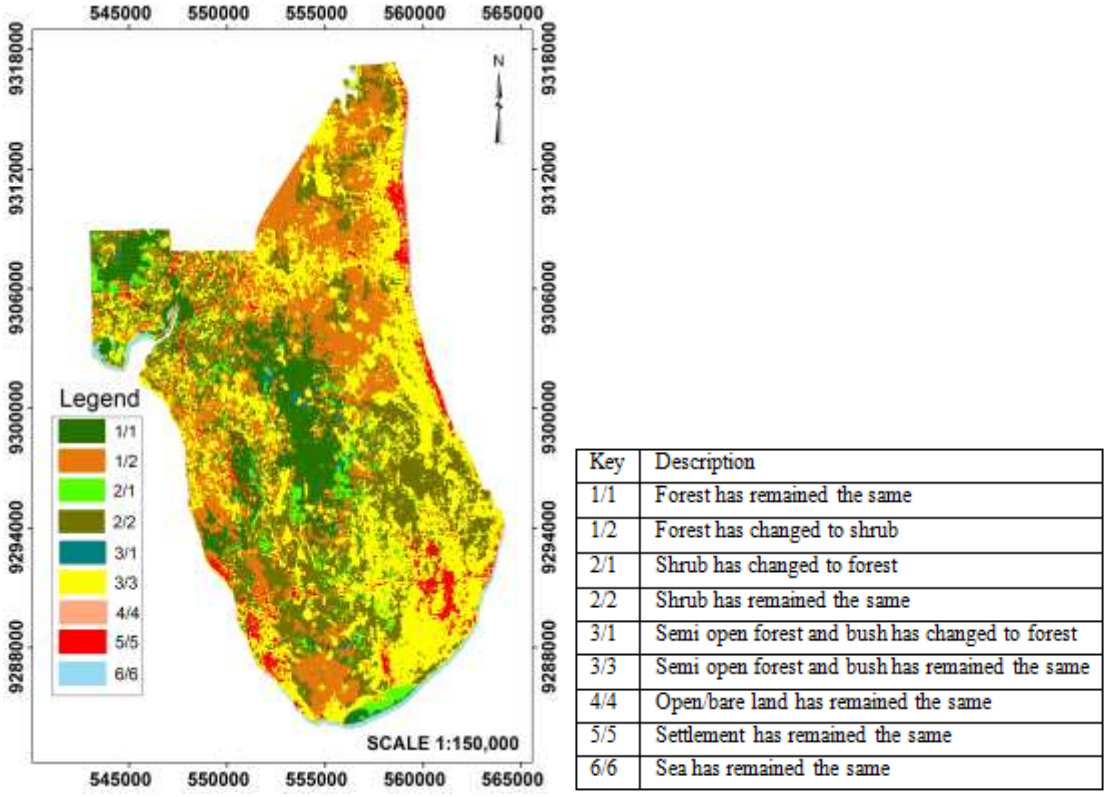
The preceding results generally imply that between 1975 and 2009, the extent of forest utilization was higher than the re-growth, consequently affecting forest morphology. Thus, most parts of the forest changed its form and became shrub. During the same period, some of the forest changed to semi-open forest and bush, open land, settlements/built up area and part was occupied by sea. These findings produce further evidence for the decline of forest, and they correspond with those of Kukkonen and Kayhko (2014) who reported that from 1975 to 2009, about 0.88 km^2 of forests in Unguja Island were lost annually, a total of 29.9 km^2 loss within 34 years.

A similar trend of forest loss was observed between 2009 and 2014 (Table 7) though at a reduced rate. Most parts of the forest changed to shrub forest and semi-open forest and bush. Nevertheless, the forest had a net increase of 1330.10 ha (+3.5%) (Table 4). A large part of the shrub forest (3018.77 ha) had changed to forest. The changes were probably influenced by the establishment of community forest management areas. These results concur with those of Cimini et al. (2013) who noted the spreading of forest and slight decline of shrub from 1989 to 2008 in the Mediterranean mountain landscape due to establishment of conservation areas that led to evolution of forest habitats in areas formerly covered by shrub.

Data in Table 7 further show that some parts of the shrub forest changed to semi-open forest and bush as well as settlements. Further analysis showed that shrub forest experienced the greatest decline of almost -11% (Table 4) between 2009 and 2014 indicating that it was the most utilized cover class. On one hand, the nature of vegetation makes it easy to be cut and cleared by using simple tools because there are no big trees involved. It is also simple to penetrate through it. Thus, it is easy to establish settlements, conduct farming and cut trees for firewood in the shrub forest. On the other hand, establishment of community forest management areas might have restricted people from over utilizing forest areas, thus making people turn to exploiting shrub forest. These findings correspond to those of Helmschrot

Table 5. Summary statistics of land cover changes for 1975 and 2014.

Year		2014						
	Land cover type	**Forest**	**Shrub forest**	**Semi-open forest and bushes**	**Open land**	**Settlements/built up area**	**Sea**	**Total**
1975	Forest	4129.9	8029.06	3864.3	7.3	331	62.8	16424.37
	Shrubs	1233.4	6979.23	7269.28	33.1	1060.3	5.76	16581.08
	Semi-open forest and bushes	319.5	1445.3	1799.08	38.1	352.7	43.8	3998.47
	Open land	1.89	23.96	116.16	91.3	123.6	24.02	380.91
	Settlements/built up area	0	2.2	19.33	2.36	8.08	3	34.98
	Sea	17.3	8.6	74.92	48.4	1.42	355.93	506.57
	Total	5701.99	16488.35	13143.07	220.56	1877.11	495.30	37926.38



Key	Description
1/1	Forest has remained the same
1/2	Forest has changed to shrub
2/1	Shrub has changed to forest
2/2	Shrub has remained the same
3/1	Semi open forest and bush has changed to forest
3/3	Semi open forest and bush has remained the same
4/4	Open/bare land has remained the same
5/5	Settlement has remained the same
6/6	Sea has remained the same

Figure 2. Land cover change between 1975 and 2014.

Table 6. Change detection statistics based on post-classification comparison between 1975 and 2009.

Year		2009						
	Land cover type	**Forest**	**Shrub forest**	**Semi-open forest and bushes**	**Open land**	**Settlements/built up area**	**Sea**	**Total**
1975	Forest	3498.6	10103.06	2578.4	61.4	58.51	124.5	16424.37
	Shrubs	650.23	8787.45	6867	81.42	161.12	33.87	16581.08
	Semi-open forest and bushes	216.91	1715.6	1698.94	103.51	171.15	92.35	3998.47
	Open land	2.44	2.84	38.11	116.95	102.81	117.75	380.91
	Settlements/Built up area	0	4.09	10.46	0.09	7.52	12.74	34.98
	Sea	3.75	13.07	8.58	1.87	2.47	476.82	506.57
	Total	4371.93	20626.11	11201.49	365.24	503.58	858.03	37926.38

Table 7. Change detection statistics based on post-classification comparison between 2009 and 2014.

Year		2014						
	Land cover types	**Forest**	**Shrubs**	**Semi-open forest and bush**	**Open-land**	**Settlements/built up area**	**Sea**	**Total**
2009	Forest	2345.11	1577.74	389.91	6.08	47.1	5.99	4371.93
	Shrubs	3018.77	12226.01	5036.31	10.93	333.07	1.02	20626.11
	Semi-open forest and bush	300.55	2575.15	7202.32	6.4	1104.48	12.59	11201.49
	Open-land	2.69	45.07	133.4	91.21	92.68	0.19	365.24
	Settlements/Built up area	0	39.43	158.93	10.72	294.31	0.19	503.58
	Sea	33.88	25.29	222.43	95.34	5.47	475.62	858.03
	Total	5701.99	16488.35	13143.07	220.56	1877.11	495.30	37926.38

et al. (2015) who also found that shrub land was declining in tradeoff with expansion of settlements and farms in Massili basin, Burkina Faso.

Generally, there has been fluctuation of different land cover from 1975 and 2014 in the South District of Unguja Island. The general trend of natural vegetation cover has been declined while settlements/built up areas have increased. These findings are supported by results from the questionnaire interview, focus group discussions, key informant interviews and observation. Most of the respondents (58.8%) in the questionnaire interview indicated that the natural vegetation cover ranged between 80 and 89% during 1970s and 1980s but declined slightly in the 1990s. Besides, most of the respondents (37.8%) disclosed that between 2010 and 2014, the natural vegetation cover had declined to between 40 and 49% (Table 8).

According to the respondents, the most declined land cover types were forest and shrubs while semi-open forest and settlements had increased. These findings imply that local people were aware that the natural vegetation cover had declined, while artificial land marks had increased. Orjala (2008) also noted that most of the informants in Zanzibar had noticed the decline of natural vegetation in their environment although they could not mention any specific year or decade when the decline had started. This, however, does not mean that the local people of Kiwengwa did not know the time when their environment changed. It might be that the methods used by Orjala could not capture information on the local people's perception of the period they had started to experience declining natural vegetation.

During focus group discussions members revealed that forest was previously very extensive and covered a large part of the coral rag natural

Table 8. Respondent's perception on percentage of natural vegetation cover between 2010 and 2014.

Vegetation cover (%)	20-29		30-39		40-49		50-59		60-69		Total	
Shehia	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Paje	1	1.5	10	15.4	33	50.8	15	23.1	6	9.2	65	100.0
Jambiani Kibigija	2	2.6	8	10.5	23	30.3	29	38.2	14	18.4	76	100.0
Mtende	0	0.0	13	19.4	25	37.3	20	29.9	9	13.4	67	100.0
K/Mkungunu	0	0.0	15	24.2	32	51.6	14	22.6	1	1.6	62	100.0
Kibuteni	1	5.3	4	21.1	2	10.5	8	42.1	4	21.1	19	100.0
Muyuni 'A'	8	23.5	16	47.1	7	20.6	2	5.9	1	2.9	34	100.0
Total	12	3.7	66	20.4	122	37.8	88	27.2	35	10.8	323	100.0

Source: Field Survey (2016).

Plate 1. An improved forest in Mtende following establishment of community forest management areas.
Photo taken by Said (2017).

vegetation. They further reported that the natural forest started to decline during 1990s, but the establishment of community forest management areas restored some of the degraded forest areas (Plate 1). During in-depth interviews one of the key informants in Paje narrated that,

"*Before 1980s, the forest in the south district was very extensive and very dense with big trees. But recently, most of the forest has declined and there are no big trees in many areas. A few big trees are found only in the conservation forest of Muyuni-Jambiani*".

Causes of land cover changes

Different factors have caused land cover change in the study area at different times. These include both direct and underlying causes, which are however inseparable; they function interdependently with each other to cause the observable land cover changes. These factors reflect the complex interactions among the economic, social and political processes, and the physical environment that have operated in the South Unguja District since the 1970s.

Direct causes of land cover change

Various human activities were found to directly cause land cover change in the South District of Unguja. These may be categorized as economic, including shifting cultivation, commercial cutting of firewood and charcoal making, commercial cutting of wooden pegs and cutting of sticks for sea weed farming, as well as social, mainly clearing of land for settlements (Table 9).

Majority of the respondents mentioned shifting cultivation as a causes of land cover change followed by commercial cutting of wood (mainly for fuel wood, charcoal making

Table 9. Respondents' perceptions on direct causes of land cover changes in South district of Unguja.

Direct cause	Cutting of sticks for seaweed farming		Clearing of forest for shifting cultivation		Clearing of land for settlement		Commercial cutting of wood		Total	
Shehias	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Paje	10	15.4	27	41.5	22	33.8	6	9.2	65	100.0
Jambiani Kibigija	15	19.7	23	30.3	17	22.4	21	27.6	76	100.0
Mtende	0	0.0	24	35.8	7	10.4	36	53.7	67	100.0
K/Mkungunu	0	0.0	24	38.7	24	38.7	14	22.6	62	100.0
Kibuteni	0	0.0	7	36.8	0	0.0	12	63.2	19	100.0
Muyuni A	0	0.0	19	55.9	0	0.0	15	44.1	34	100.0
Total	25	7.7	124	38.4	70	21.7	104	32.2	323	100.0

Source: Field Data (2016).

and wooden pegs) and settlements. Only a few mentioned cutting of sticks for seaweed farming. Fujiki et al. (2018) explain that shifting cultivation in tropical regions has remained as the widespread cause of land cover change.

Shifting cultivation

Shifting cultivation has been a traditional agricultural practice in the coral rag zone of the South District of Unguja. The system involves slash and burn of the forested land to maintain or increase crop production until the nutrients in the soil are exhausted then the site is abandoned to recover (Chakravarty et al., 2012). The farmers move on to clear more forest.

During the survey, majority (73.4%) of the interviewed respondents reported that they frequently cleared the forest to access new farm plots or expand their farms because of deterioration of the soil in their old farms. This is an indication that most people in the study area practiced shifting cultivation because of declining soil fertility in their farms. This finding was confirmed during the transect walks, in Muyuni 'A', Mtende, Kibuteni and Jambiani Kibigija where most of the forested lands had been cleared for cultivation (Plate 2). The findings correspond with those of Masoud (2003) who reported that shifting cultivation had become one of the main factors that contributed to deforestation of the coral rag forest in the South District of Unguja.

The findings of this study further revealed that majority of the respondents (64.1%) had shifted to new farms within the last three years (since 2013 to 2016). Jambiani Kibigija and Kibuteni had the highest number of households who had shifted to new farms (Figure 3). These findings concur with those of Nzunda et al. (2013) in Bukoba-Tanzania. Heinimann et al. (2018) has also confirmed that shifting cultivation is still present in many of African countries.

As a result of shifting cultivation, most of the forested land in the study area has been cleared for new farms. There was a statistically significant positive correlation between deforested land and accessed new cultivated land at 0.05% level of confidence with a Pearson Correlation value of 0.564**. These findings indicate that most of the new farms were accessed from forested land. Therefore, as the cultivated land increased, deforestation and fragmentation also increased. This is supported by data from satellite images, which show that 3864.3 ha of forest and 7269.28 ha of shrub were transformed to semi-open forest and bushes (Table 5).

During key informant interviews in all the Shehias it was revealed that based on their by-laws, the local people were required to cultivate their farms for not less than three years, after which, they could request for new farms, locally known as *chenge*, from the conservation committee. Three years of cultivation '*kulima chenge'* have been agreed upon to reduce clearing of natural vegetation. Besides, during the focus group discussions, the participants in all Shehias revealed that most of the people normally engaged in shifting cultivation because the coral rag land does not support cultivation in one area for more than 2 or 3 years.

In general, the practice of shifting cultivation in the study area give an indication that soil fertility in the study area declines rapidly after the land has been put into cultivation; hence, the farmers frequently shift to new farms to maintain crop production. The farmers probably do not use any inputs to improve land productivity. Consequently, more often than not, natural vegetation is removed, thus contributing to changing the physical pattern of the landscape. As Kukkonen and Kayhko (2014) reported Zanzibar has lost most of her natural forest since 1996; most of which has been replaced by cultivation.

Commercial cutting of fuel wood and wooden pegs

Commercial cutting of fuel wood (fire wood and charcoal) and wooden pegs were found to be among the common income generating activities to some people in the South District of Unguja. Although the findings of the study

Plate 2. An area that has been cleared for shifting cultivation in Jambiani Kibigija.
Photo taken by Said (2017).

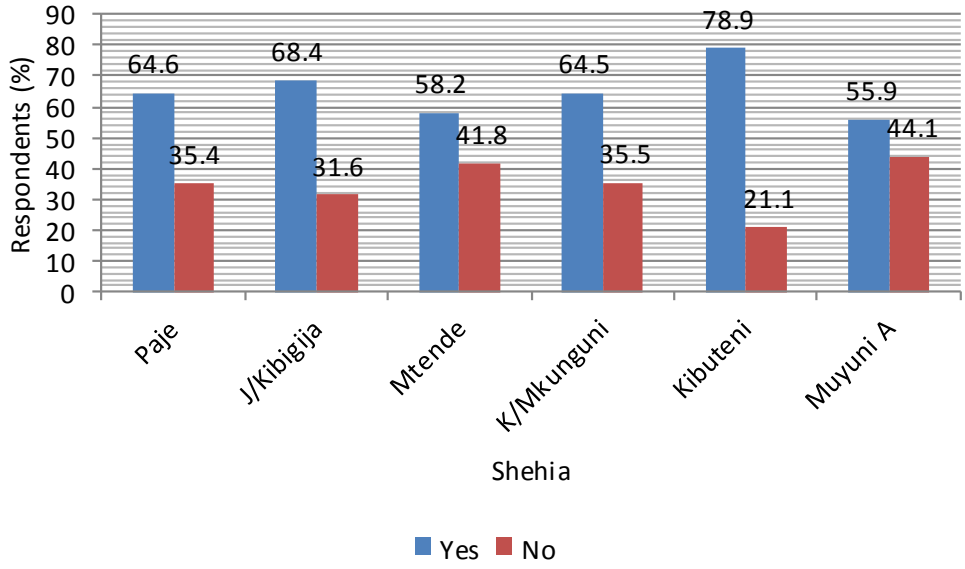


Figure 3. Respondents who had shifted to new farms through shifting cultivation since 2013 to 2016.
Source: Field survey (2016).

revealed that only a few respondents (27.6%) were involved in commercial cutting of wood, its contribution to land cover change was apparently observable. Majority (77.5%) of those respondents who were involved in commercial cutting of wood products were involved in cutting trees for fire wood (Table 10). In all the Shehias, the number of respondents who were involved in fire wood cutting was high when compared with charcoal making and cutting of wooden pegs. This is probably due to the high demand of fire wood in the South District of Unguja and the urban west. RGoZ (2013) reported that the main source of energy in Zanzibar was firewood and that more than 90% of the people used fuel wood as their main source of energy for cooking. Most of the fire wood

Table 10. Respondents involved in commercial cutting of wood for fire wood, charcoal making and wooden pegs.

Shehia	Firewood		Charcoal		Pegs		Total	
	n	%	n	%	N	%	n	%
Paje	7	77.8%	2	22.2%	0	0.0%	9	100.0%
Jambiani Kibigija	21	87.5%	3	12.5%	0	0.0%	24	100.0%
Mtende	12	85.7%	2	14.3%	0	0.0%	14	100.0%
K/Mkungunu	10	83.3%	2	16.7%	0	0.0%	12	100.0%
Kibuteni	7	53.8%	2	15.4%	4	30.8%	13	100.0%
Muyuni A	12	70.6%	2	11.8%	3	17.6%	17	100.0%
Total	69	77.5%	13	14.6%	7	7.9%	89	100.0%

Source: Field Survey (2016).

was being extracted from the coral rag forest in South District of Unguja (*ibid*).

The study also found that those who were involved in commercial cutting of fire wood have been cutting many bundles when compared with those collecting fire wood for domestic use. The mean number of bundles of commercial fire wood cut in a month was 22.56 while that of bundles collected for domestic use was 4.92. Similarly, the maximum number of bundles for commercial fire wood exceeded that for domestic use. During field observation, many bundles of fire wood were found along the main road ready to be transported to town.

Commercial cutting of wood involves mostly cutting of live trees, which is generally unsustainable. This has, to a large extent, contributed to forest degradation and fragmentation of the coral rag forest. During in-depth interviews in Kibuteni, one of the key informants narrated that,

"Commercial cutting of wood is common in our Shehia. Many people both males and females are involved in cutting of tree for fire wood, charcoal and wooden pegs, which are mostly transported to town. Some of them pile their products along the road for selling. Commercial cutting of fire wood, charcoal and pegs has caused forest degradation because many trees are being cut".

As for charcoal making, only 14.6% of the respondents who were involved in commercial cutting of wood were involved in charcoal making. Despite the fact that charcoal making was conducted by few people, its impact on the natural vegetation was apparent. Many areas in the forest reserve were found degraded by charcoal making. During field observation, some charcoal bags were found in the Muyuni-Jambiani forest reserve.

Charcoal making in the forest does not only cause degradation but also it destroys the biodiversity of a place (FAO, 2017; Arnold and Persson, 2003). Sangay (2011) maintained that unrestricted harvesting of vegetation for fuel wood and charcoal may exceed biomass growth, thus resulting in declining supplies and forest degradation. During key informant interviews, it was revealed that most of the harvestable trees have been cut for fire wood, charcoal making and wooden pegs. As such people have now started to cut trees that are not ready for harvesting. Meanwhile, there is no control or limit on the number of fire wood bundles a person is allowed to cut per month and the size of trees to be utilized. Therefore, uncontrolled utilization of the forest has resulted to forest decline and degradation.

The study also found that some respondents were cutting wooden pegs for commercial purpose, though the number was small (7.9%). Commercial cutting of pegs was mostly being carried out in Kibuteni and to a lesser extent in Muyuni 'A' (Table 10) probably because of limited economic opportunities for the people to earn their living. Although few respondents were involved in commercial cutting of wooden pegs, many bundles were being cut because they were highly in demand in the urban areas. The coral rag forest of the South District is the only main repository source of wood products in the Island. Therefore, it is faced with over utilization, which leads to land cover change.

Clearing of land for settlements

Findings from the questionnaire interviews revealed that about 21.7% of the respondents reported that clearing of land for settlements had caused land cover change in their locality (Table 9). This was mostly reported in Kizimkazi Mkunguni, Paje and Jambiani Kibigija. These findings are supported by data from satellite images and GIS analysis, which indicate that built up area/settlement increased from 0.1% in 1975 to 4.9% in 2014. About 331 ha of forest and 1060.3 ha of shrubs had changed to settlement during the same period. Probably, the expansion of settlements in those Shehias, among other things, was contributed by development of the tourism sector.

During key informant interviews, it was revealed that settlement expansion had contributed to clearing of natural vegetation. One of the key informants in Paje narrated that,

"Our village is expanding very fast because our population is increasing and thus people's demand for land for constructing houses is increasing too. Therefore, we have allocated areas for settlement, although some of the people do not follow the procedures. Instead they just clear natural vegetation and establish settlement wherever they like".

Expansion of settlements has been reported to cause forest decline in many areas particularly in developing countries (Alemayehu, 2016; Hariohay, 2013; Ouedraogo at al., 2010). For instance, Alemayehu (2016) reported that settlement expansion had contributed to natural vegetation decline along the coastal areas of Kenya. Similarly, Hariohay (2013) found that settlements expansion caused forest decline and fragmentation of the wildlife migratory passage in Kwakuchinja wildlife corridor in Northern Tanzania.

Cutting sticks for seaweed farming

Commercial seaweed farming has also been found to increase pressure on forest resource utilization. Seaweed farmers cut bundles of sticks for seaweed growing thereby degrading the forest. Since 1989, seaweed farming in Zanzibar has been one of the sources of income particularly to the communities living near the coastal areas (Msuya, 2012). Today Zanzibar is the ninth world producer of sea weeds contributing about 0.63% of the world's seaweed production (Radulovich et al., 2015). Seaweed farming has, however, been contributing to forest degradation in areas where it is being carried out. Among other places, Paje, Jambiani and Bwejuu were found to be the major seaweed producers; hence the natural vegetation in their locality had been affected to a large extent by cutting of sticks. About 19.7 and 15.4% of the interviewed respondents in Jambiani and Paje, respectively, revealed that cutting sticks for seaweed farming had significantly contributed to rapid decline of natural forest in their locality.

During in-depth interviews, key informants in Jambiani Kibigija and Paje revealed that seaweed farming had greatly contributed to decline and degradation of the forest because seaweed farmers cut bundles of sticks, which they used for growing of seaweed. Cutting of sticks was being done in every season of seaweed growing. One of the key informants in Jambiani Kibigija narrated that,

"*Many of the trees nearby have been cut for getting sticks, which are used for growing seaweed. Nowadays, people walk a bit long distance for cutting sticks and some of them buy from other people. Women are the ones who mostly cut sticks for seaweed growing*".

Many bundles of sticks were being used for one growing season (six months) by farmers, after which other sticks would be cut for the next growing season. Msuya (2012) reported that some farmers employed fellow villagers or villagers contracted themselves out to farmers to cut and sell sticks for seaweed farming. Cutting of large quantities of sticks repeatedly results in low plant succession that leads to changing the natural vegetation cover from forest or shrubs to semi open forest and bush. Arnold and Persson (2003) explained that continuous cutting of wood can lead to transformation of forest/woodland to bush, and bush to scrub, over very large areas.

Underlying causes of land cover changes

Several underlying factors have been found to cause land cover change at different times in the South District of Unguja. These include population growth and population density, policy reforms and policy failure, land tenure insecurity and the nature of the soil and terrain. These again are a reflection of the social and political processes as well as the natural environment that operate in the district.

Population growth and population density

Population growth and increasing population density are among the major underlying causes that have influenced the utilization of land, forest and other natural resources in the South District of Unguja resulting in land cover change. Population growth contributes to land cover changes in two ways, firstly, through population pressure within the district and region and secondly through population pressure from the urban-west region.

The population of South District of Unguja has been increasing gradually from year to year. The census data indicate that between 1978 and 1988, the population of the South District of Unguja grew at 1.3% (NBS, 1989). The growth rate, however, decreased to 1.1% between 1988 and 2002 and increased to 2% between 2002 and 2012 (NBS, 2006; URT, 2013). The number of people has grown from 21,952 in 1975 to 39,242 in 2012 (NBS, 1989; URT, 2013). Because of the population growth from both natural increase and immigration, the population density has steadily increased from 56 persons/km^2 in 1978 to 100 persons/km^2 in 2012 (Figure 4). Such population growth and increased densities have led to increased demand for land resulting in land scarcity and expansion of agricultural land and settlement into the forested areas. This has subsequently led to forest decline and fragmentation.

Furthermore, the growth of population in the urban-west of Unguja has also been found to increase pressure on the coral rag forest resource of the South District of Unguja. The population of urban-west has increased dramatically from 208,389 in 1988 to 593,678 in 2012

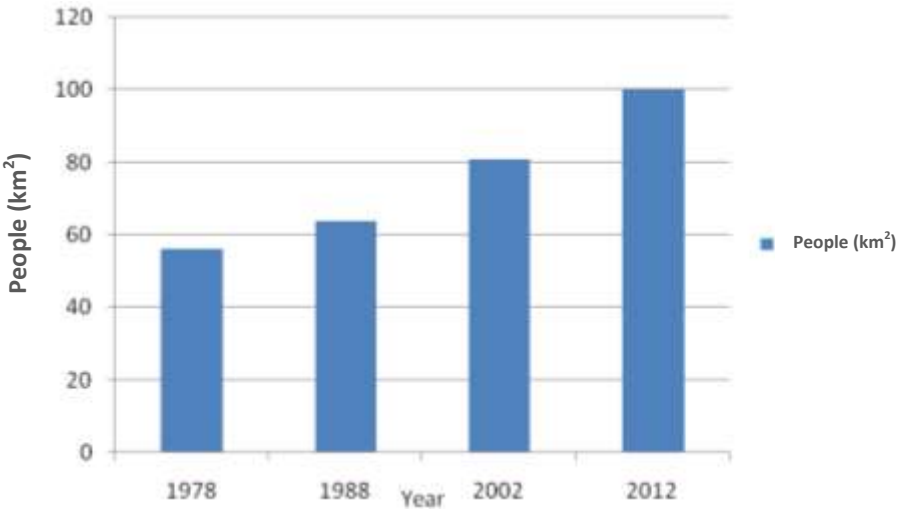


Figure 4. Population density of South District of Unguja between 1978 and 2012.
Source: NBS (1989), NBS (2006), and URT (2013).

(URT, 2013; NBS, 2006). Such an increase of population has led to increased demand for fire wood, charcoal and wooden pegs. This is because the population of urban-west of Unguja has provided a reliable market of wood products. Fuel wood is not only utilized for domestic purpose but it is also being used in hotels and bakeries (RGoZ, 2012). The coral rag forest supplies much of the fuel wood and building materials to the majority of the population in the urban-west. It has been found that hundreds of bundles of fire wood and wooden pegs are transported from the South District of Unguja to the urban market every day. Actual records, however, are missing because there is no monitoring of the amount of wood being cut and transported to the urban market. Nevertheless, such high demand for wood has triggered several individuals in the study area to engage in commercial cutting of wood materials resulting in forest degradation and decline. These results are in line with those of Mwangi et al. (2017) and Alemayehu (2016) who also found that population growth was one of the main causes of land cover change in Kenya.

Land tenure insecurity

Land cover change has also been influenced by land tenure insecurity. Many individuals lack security of tenure of their lands due to political decisions made. In Zanzibar, land is a public property; the powers to decide on the use of land are vested in the President for the interest of the public. The government, however, has established different Acts including the Land Distribution Decree (1966) and the Land Tenure Act 1992 to protect the land and to give individuals the right to use land to improve their livelihoods (RGoZ, 2012). For instance, the Land Distribution Decree (1966) was amended to grant an individual the right to own land on leasehold for periods not exceeding 99 years (*ibid*). Such decisions have influenced the form of access and control of land resources. Despite the existence of such legal systems of land tenure, only few people in the study area particularly investors have this type of land lease. Many of the people have no title deeds; they own land just by traditional ways of written paper that has been endorsed by a community leader. Besides, most people have not acquired land officially from the government office.

During the household survey, it was found out that majority of the respondents had acquired land informally. For example, 77.8% had acquired land just by clearing the forest, 19.2% had inherited it from relatives and 2.8% had borrowed land either from relatives or friends. These findings are in support of those by Tilumanywa (2014) who noted that most of the rural people obtained land through informal ways including inheritance and borrowing. They are, however, contrary to those of Zahor (2014) who found that the majority of respondents (41.1%) in Ngezi had acquired land by inheritance.

The informal system of acquiring land does not guarantee security to majority of land owners. Such a tenure system has restricted land improvement by the majority of people. The Land Tenure Act 1992 specifies that all land is vested in the president for the use and common benefits of the people of Zanzibar (RGoZ, 2012). As such, many people are worried about developing their lands for fear of losing them. Thus, they mostly use them for farming.

Since 2010, the communities in the South District of Unguja have entered into contracts with the government to conserve the forest and land resources. The contracts give the community the right to plan, utilize and conserve

their land but do not give an individual the right to own land permanently. Decisions on land are being made by the community leaders. Hence, during key informant interviews it was found that any community member who wished to get land for cultivation had to request from the conservation committee for a permit to cultivate. The member would be given not more than 1.2 ha (3 acres) for cultivation purposes not otherwise. However, there were many community members who just cleared vegetation without asking for permission, leading to land cover change. Although the decision made aimed to control shifting cultivation, it resulted into transformation of some forested areas to farms.

Policy reforms and policy failure

Land cover change in the South District of Unguja has also been influenced by policy reforms and policy failure. Based on the political approach, one can say that the growing diminish of natural vegetation cover is caused by both national and transnational decisions on policy reformation, which has influenced the forms of access and control of resources. Since 1964 after the Zanzibar Revolution, the Revolutionary Government has carried out various reforms of her policies such as the economic policy, land policy and environmental policy to improve people's livelihoods as well as facilitate proper management of environmental resources. However, some of these policy reforms, particularly those related to the tourism investment policy and the natural resources and environmental policy have brought unintended outcomes to the natural resources, including alteration of the natural cover of the Island.

Tourism investment policy

During the mid-1980s, Zanzibar as part of the United Republic of Tanzania started to implement various structural adjustment programmes under the influence of the International Monetary Fund (IMF), World Bank (WB) and other bilateral donors (RGoZ, 2010). The reforms transformed Zanzibar from socialist economy to free market economy. During the socialist economy, the government was the custodian of operations and provision of economic services. Following the major economic reforms, the government enacted the Private Investments Promotion and Protection Act in 1986 which enabled local people to collaborate with foreigners to participate in tourism investment (Hikmany, 2016).

Since then, the coastal landscape zone of some villages in the South District of Unguja has experienced rapid changes from development of the tourism industry. The industry has caused an influx of people, expansion of settlements and construction of hotels and bungalows. The government also introduced Tourism Zoning Plan under the National Land Use Plan (NLUP) Policy of 1996 to develop sustainable places for tourism (Hikmany, 2016). It proposed 19 areas in Unguja with a total area of 400 ha and 6 areas in Pemba covering a total area of 83 ha. The construction of hotels, however, has been more rapid than it was planned. For instance in the 1990s, the south district of Unguja had only 18 tourism hotels, but this number had increased to 135 in 2016. According to Hikmany (2016), there was an increase of tourism accommodation in Zanzibar beyond the planned carrying capacity. For example, by 2011, the Commission for Tourism had 12,395 bed capacity as compared to the planned capacity of 6,000 beds for the whole of Zanzibar.

The construction of hotels and bungalows has increased the demand for land and wood products, leading to natural vegetation decline. Most of the interviewed respondents in Paje (73.8%) and Jambiani Kibigija (68.4%) revealed that tourism had highly contributed to land cover changes. In Kizimkazi Mkunguni, however, majority of the respondents (53.2%) said that tourism had little contribution to land cover change because only a small area of natural vegetation has been cleared for construction of hotels and bungalows. Many local people along the coastal areas in Paje, Jambiani and Kizimkazi have sold their land to investors for construction of hotels. Thus, they have had to find new lands for settlement. Most of them have established their new settlements towards the forest. Thus, despite the fact that the tourism industry was introduced in order to achieve economic growth while maintaining environmental health, it has been observed to contribute to over utilization of forest resources leading to their decline and land cover change.

Natural resources and environmental policies

Several legislative attempts on conservation of forests have been initiated in Zanzibar including the Constitution of the Revolutionary Government of Zanzibar (1984), the Commission for Lands and Environment Act, 1989, the Land Tenure Act 1992 and Forest Resource Management and Conservation Act 1996. However, despite these efforts, the natural vegetation has continued to decline gradually, with the forests being increasingly degraded and fragmented.

In 2010, a new form of community participation in forest management was introduced under the Forest Resource Management and Conservation Act 1996. The new approach recognized that there must be incentives to the community for sustainable and fair management of forests. Thus, the approach involved the establishment of Community Forest Management Areas (COFMAs) under the *''Hifadhi Misitu ya Asili''* (HIMA) project. Although, these conservation areas have been established to conserve natural forests, forest decline and fragmentation has continued to take place, unabated.

In addition, COFMAs involved demarcation of utilization areas where people were allowed to cut wood for their livelihood so as to preserve the established community conservation forests. This, however, has given rise to uncontrolled harvest, with every member of the community wishing to maximize utilization due to lack of clear guidelines for controlling over utilization. Besides, some of the designated community conservation areas form discrete parcels of conservation land because there was no universal conservation plan for the whole district; every community had their own conservation plan. Such conservation plans do not provide for continuous natural vegetation, which is important for biodiversity conservation. To a large extent, fragmentation of natural vegetation has been increased.

Nature of the soil, underlying rocks and the terrain

The nature of the soil, the terrain and underlying rocks are also driving factors of land cover change in the study area. These factors have been found to influence largely the clearing of vegetation and extraction of large quantities of wood materials resulting in forest decline and degradation.

Most of the underlying soil of the South District of Unguja is categorized as maweni soil (rendzic and lithic leptosols) (RGoZ, 1983). The soil has a high organic carbon content (about 20.3%), an alkaline pH (about 8) with high infiltration (Epper, 2015). Besides, the soil is drained, porous with a shallow profile; it does not store water (*ibid*). Thus, it is so susceptible that it loses nutrients easily when it is exposed to clearing of vegetation. Once the natural vegetation is cleared for cultivation, the soil becomes more drained and it hardly takes two to three years to support crop production. Then, the farmers have to shift to other areas where they clear more forest to prepare new farms. Nyawira et al. (2017) maintain that when natural vegetation is cleared, the soil loses carbon, which is important for soil decomposition. Therefore, for the soil to recover, it depends on the local soil conditions such as soil type, mineralogy, texture and on climate influences, such as good temperature and good soil moisture or precipitation (Nyawira et al., 2016).

The soil condition has become more critical currently than ever before because of the unreliable rainfall arising from climate change. The rain fall seasons are mostly short followed by long dry seasons, thus the soil lacks enough moisture to support productivity. This situation drives people to frequently clear natural vegetation cover to find virgin land to maintain their crop production. Subsequently, the repetitive clearing of forest for shifting cultivation has resulted in forest decline and fragmentation.

Apart from the soil condition, it was observed during the transect walks that most of the study area was flat and characterized by coral rag rocks. This is also supported by Klein and Kayhko (2008) and Hettige (1990) who described the southern part of Unguja Island as being mostly flat lying Quaternary coral rag of low altitude, whose altitude almost ranges between 0 and 30 m above sea level and only few areas elevate between 30m and 60m.

Because of the nature of the terrain, most of the remote forested areas within the study area were being accessed by motor vehicles, oxcarts, and bicycles. The flat lying nature of the landscape and the underlying coral rag rock allow driving, cycling and oxcarts movement throughout the year because of lack of steep slopes. Secondly, the underlying coral rag rocks reduce mud during rain seasons; hence, the area becomes accessible throughout the year. Thus, the nature of the terrain and the underlying rock do not create barriers for transportation of wood materials from remote areas, instead it supports extraction of large quantities of wood all the time.

Conclusion

Major changes of land cover have occurred since 1970's in the coral rag vegetation of the South District of Unguja Island. The major change has been forest decline and increase of semi-open forest and bush. Several factors have caused land cover changes in the study area at different times. These include direct causes such as shifting cultivation, commercial cutting of wood products (fire wood, charcoal and pegs), clearing land for settlements and cutting sticks for sea weed farming as well as indirect causes such as population growth, policy reforms and failure, land tenure insecurity and the nature of the soil, terrain and underlying rock of the study area. Since majority of the people depend on the coral rag ecosystem for their livelihood and the fact that the ecosystem is the only wildlife habitat within the island, continued changes of land cover may affect either negatively or positively wildlife populations and their habitats as well as the livelihoods of the communities.

Given the limited sources of income for the majority of the local people as well as the limited alternative sources of cooking energy in the Island, the natural vegetation will continue to decline because of over utilization by both the rural and urban population. There is therefore need to invest in intensive agriculture to reduce shifting cultivation. It is also important to allocate areas for establishment of plantations for cooking energy to reduce over exploitation of natural vegetation. As a long term solution, the government needs to invest in alternative sources of energy. The Island is located in the tropical area where there is opportunity to invest in solar and wind energy. Possibly, the Indian Ocean waves may also provide reliable energy for the Island. Because, the coral rag vegetation is recognized as an important and the only remaining wildlife habitat within the Island, there is need

to undertake studies to assess the impact of land cover change on the wildlife population and habitat so as to devise appropriate conservation strategies.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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