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Evaluation of tropical coastal land cover and land use changes and their impacts on ecosystem service values

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ABSTRACT
Understanding about land cover and land use (LCLU) changes, as well as the associated impacts on ecosystem service values (ESV) is extremely important in the management of coastal ecosystems globally. Thus, this study assessed temporal LCLU changes, the underlying socio-economic drivers and dynamics of ESV in the coastal zone of Tanzania. The LCLU data for 2000 and 2010 were from the Globe Land 30 mapping products at 30-meter spatial resolution developed by National Geomatics Center of China, while 2016 images were produced from Landsat 8. Classification of images was done from Landsat TM/ETM+ for 2000, 2010, and 2016 years complemented with MODIS and Normalized Difference Vegetation Index time series, and Chinese HJ imagery. LCLU categories and ecosystem service coefficients were used to compute ESV on each LCLU categories. Between 2000 and 2016, farmland, shrub land, waterbody, and artificial surface expanded while forest, grazing land, and wetlands declined. The ESV increased on farmland, shrub land, and waterbody, while the decline was found on forest, grazing land, and wetlands. The ESV and the total population ratios declined from $80.4, 63.8, and $46.0 million in 2000, 2010, and 2016, respectively. Perfect positive correlation was on LCLU change and ESV, population and households in crop farming, livestock keeping, and bioenergy use. Population pressure and socioeconomic activities have amplified the degradation of the coastal ecosystems. If not abetted, there is a danger of further impairments on these ecosystems. We advise to regulate population and socioeconomic activities to avoid more negative impacts of coastal LCLU change.

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Introduction

Change in land cover and land use (LCLU) is among the major drivers of biodiversity loss and ecosystem's degradation at both global and local levels (Nkonya et al. 2012; Kindu et al. 2016; Quintas-Soriano et al. 2016; Xu et al. 2017). These changes have significantly affected almost all terrestrial biomes (Baumgartner and Cherlet 2016; Borrelli et al. 2017; Zhou et al. 2017). To underpin this, Baumgartner and Cherlet (2016), Scull et al. (2017), Temesgen and Wei (2018) confirmed that these impacts are pronounced in Sub-Saharan Africa. Besides, numerous anthropogenic disturbances have amplified the problem by affecting the ecosystem functions and services (Cork and Shelton 2000; FAO 2011; Temesgen et al. 2018). Concurrently, changes on natural settings of land also affect the function of ecosystem and service values (Dale and Polasky 2007; Keenan et al. 2015; Yirsaw et al. 2016).

Spatially, the coastal ecosystems across the world are among the systems that are at risk of degradation due to anthropogenic interventions posed by development pressures among the coastal communities (Schmidt, Moore, and Alber 2014; Santha 2015; Ligate, Wu, and Chen 2017). This pressure is exerted by rapid population growth and expansion of socioeconomic activities (Madriñán, Rickman and Ye 2012). Anxious socioeconomic activities are associated with unprecedented agriculture, expanding settlements, industrialization, and other investments (Zhao et al. 2004; Xu et al. 2017). In addition, weak management institutions and climate change that threaten the ecological potentials (Maitima et al. 2009; Keenan et al. 2015; Xu et al. 2017) amplify the negative impacts of land use changes along the coastal zones.

Apparently, human-based pressure and other stressors have contributed to the transformation of the naturally covered land systems (especially forest) and open grassland into farmland and bush/shrubs encroachment (Fetene et al. 2015; URT 2015; Temesgen et al. 2018). The transformation in LCLU categories affects ecosystem processes and services (Fujita et al. 2013; Hu, Liu, and Cao 2008; Smith et al. 2014; Zhang et al. 2015a). Obviously, human

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decisions about land use affect the status and potentials of ecosystem service provision (Quintas-Soriano et al. 2016; Temesgen et al. 2018). Therefore, the processes and human activities, which bring changes on LCLU are continuously and severely affecting ecosystems in various biomes (Szuster, Chen, and Borger 2011; Song et al. 2014; UNEP 2015).

Tanzania, which is located in Sub-Sahara Africa, is among the worst affected countries in terms of forest degradation. In 2015, it had a net loss of 372 thousand hectare per year, while a generalized global trend shows that during the same year, there was net gain in land cover (FAO 2015; Keenan et al. 2015; UNEP 2015). This loss placed Tanzania at number five among the top ten countries with significant annual loss of land cover in regard to forest (FAO 2015; Keenan et al. 2015; Patra, Dey, and Das 2015). The major reasons for this loss being: land is lost for urban development, is claimed for agricultural purposes (crops and livestock grazing), forests are harvested for small and large-scale commercial investments of timber and for subsistence and commercial fuel wood reasons (Sloan and Sayer 2015; UNEP 2015).

Tanzanian coastal ecosystems provide critical ecological functions, such as protection of the coastal zone and habitats of many living organisms, including human beings (Luc Van Hoof and Kraan 2017; Kubiszewski et al. 2017). However, human activities threaten the viability of coastal ecosystems located within the coastal zone like many other global systems (Zhao et al. 2004; Kindu et al. 2016; van Hoof and Kraan 2017). Despite of the posed threats, the documentation of the Tanzania coastal LCLU change and its implications on the dynamics of ecosystem services suffer numerous challenges. Therefore, a study that addresses LCLU change and its implications on the value of ecosystem services and human–ecosystem services interplay along the coastal zones is quite imperative (Otsuka and Place 2014).

Previously, there were some studies conducted on LCLU and ecosystem service values (ESV); however, they had different focuses. Costanza et al. (1997) evaluated the global ESV and laid a foundation for evaluation of global ecosystems, while Zhao et al. (2004) reported on the decline of ecosystem services. Furthermore, Li et al. (2007) showed a significant conversion of forests and grassland into shrub land and cultivated land. Literally, Eva, Brink, and Simonetti (2006) and Maitima et al. (2009) pointed out that land use changes largely contribute to modification of Africa's land cover. On top of that, Nkonya et al. (2013) and Otsuka and Place (2014) specified farmland as a leading form of land use change in the Sub-Saharan region. Moreover, Warinwa, Mwaura, and Kiringe (2016) and Temesgen et al. (2018) studied LCLU and ESV in Kenya and Ethiopia, respectively.

These studies show a continuous loss of many tropical ecosystems because of land use change (UNEP 2015; Temesgen et al. 2018). In addition, projections from various models indicate that Sub-Saharan Africa will continue to experience the fast LCLU changes because of the rapid human population pressure and regional expansion of agricultural land (Van der Esch et al. 2017). However, the direction of any land cover or land use depends on the nature, location, activities, and temporal variations of human activities (Rautiainen, Virtanen, and Kauppi 2016). With that respect, human activities consequently affect ecosystems to the direction of gaining or losing service values (Bhagabati et al. 2014; Warinwa, Mwaura, and Kiringe 2016; Yirsaw et al. 2016).

There has been a great deficit on the documentation of the interplays between LCLU change and impacts on ecosystems' service values in the tropical coastal zones (particularly in Tanzania). This deficit is challenging ecologists, economists, policymakers, and the public (Costanza et al. 1997; Cork and Shelton 2000; Zhao 2004; Van der Esch et al. 2017).

To address this deficit, this assessment was conducted by using field surveys and satellite imagery to attempt (1) investigation of the socioeconomic activities, which contribute to LCLU change in the coastal zone of Tanzania; (2) mapping changes in the area of each LCLU category in 2000, 2010, and 2016 reference years; (3) valuation of the dynamics of ESV along the coastal zone of Tanzania across 16 years. Practically, we investigated the area and ESV of seven major ecosystems, namely: artificial surfaces, farmland, forest, grazing land, shrub land, and waterbody and wetland ecosystems. These categories were selected because they are the major suppliers of many recognized services, locally and globally (Marc, Babu, and Hamilton 2005; Pan et al. 2011; Kubiszewski et al. 2017).

The information generated in this evaluation is crucial because it can validate the ESV (Cork and Shelton 2000; Zhao et al. 2004; Temesgen et al. 2018). Furthermore, this work is expected to improve the current national and coastal development planning (Guerry et al. 2015). Indeed, it can promote the understanding of the mutual interplay across the dynamics of human population, socioeconomic activities, LCLU, and ESV (Willcock et al. 2016). Eventually, knowledge about this interplay can be used as a tool for decision-making on management of coastal ecosystems (Thompson et al. 2016; van Hoof and Kraan 2017; Temesgen and Wei 2018).

Methods

Study area

This investigation was conducted in the coastal ecosystems located along the coastal zone of Tanzania (Figure 1). This zone stretches within 850 km from the boarder of Tanzania and Kenya in the north, and Tanzania and Mozambique in the south (van Hoof and Kraan 2017). The coastal zone was purposely chosen because it is among the areas with the leading land cover loss in Tanzania, especially between 2000 and 2016, mainly brought about by human population pressure. The current total population of the coastal zone of mainland Tanzania is 11 549 190, representing the populations of Tanga, Dar es Salaam, Pwani, Lindi, and Mtwara regions (URT 2016).

The process of computing LCLU and ESV

The process of quantifying and analyzing ecosystem services value followed a methodological flow chat as in (Figure 2). This work adopted ecosystem service evaluation approaches as laid down in Costanza et al. (1997); Zhao et al. (2004); Li et al. (2007); Hu, Liu, and Cao (2008); and Temesgen et al. (2018). Unlike in the previously applied methodologies, in this investigation the data of each LCLU category for 2000 and 2010 were from the Globe Land 30 mapping products at 30-meter spatial resolution developed by National Geomatics Center of China (NGCC 2014), while 2016 images were produced from Landsat 8. The Globe Land 30 mapping products provided LCLU data with higher resolution compared to earlier sources of data that were taken at 1 km and 300 m resolution (Han et al. 2015; Zhang et al. 2015a).

Therefore, these sources of data helped to overcome the empirical inherent problem in producing ecosystem services evaluation in Costanza et al. (1997). The classification of images was done from Landsat TM/ETM+ data, covering the reference years 2000, 2010 and 2016. These data were complemented with MODIS NDVI time series data and Chinese HJ imagery (Han et al. 2015). The NDVI was used in

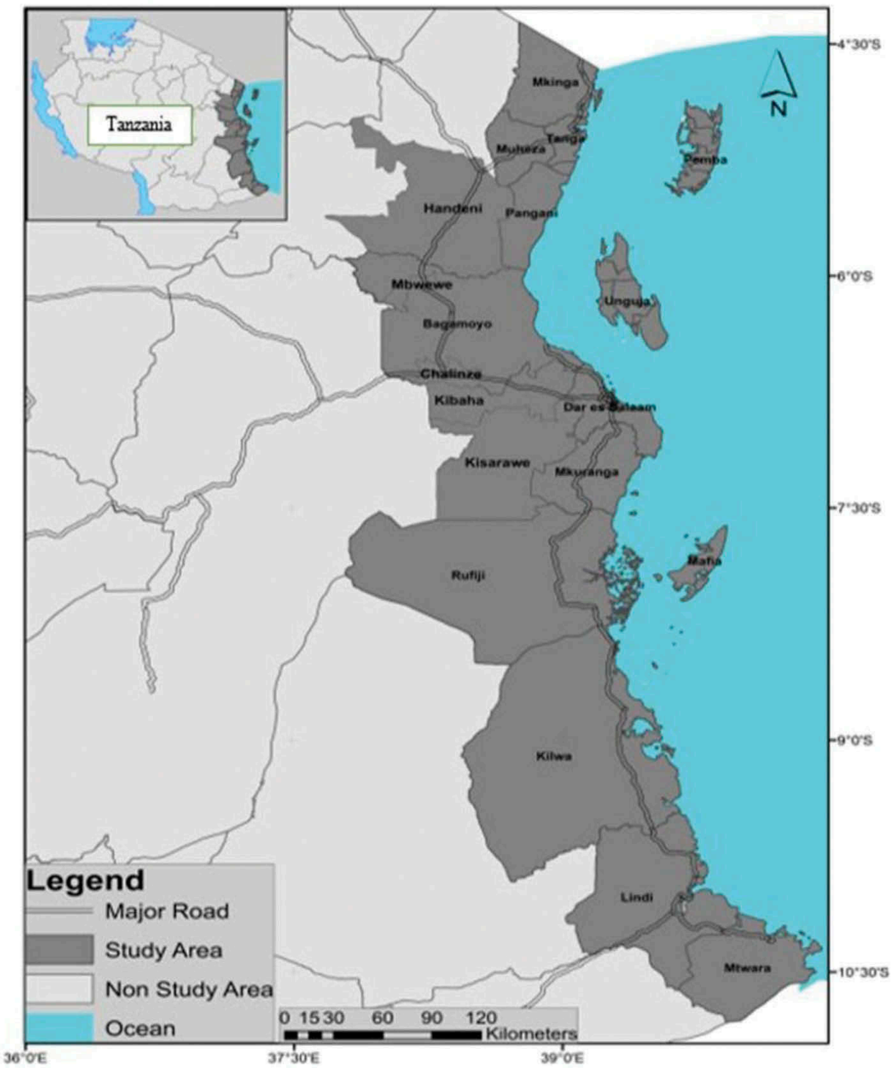


Figure 1. The study area (Tanzania coastal zone).

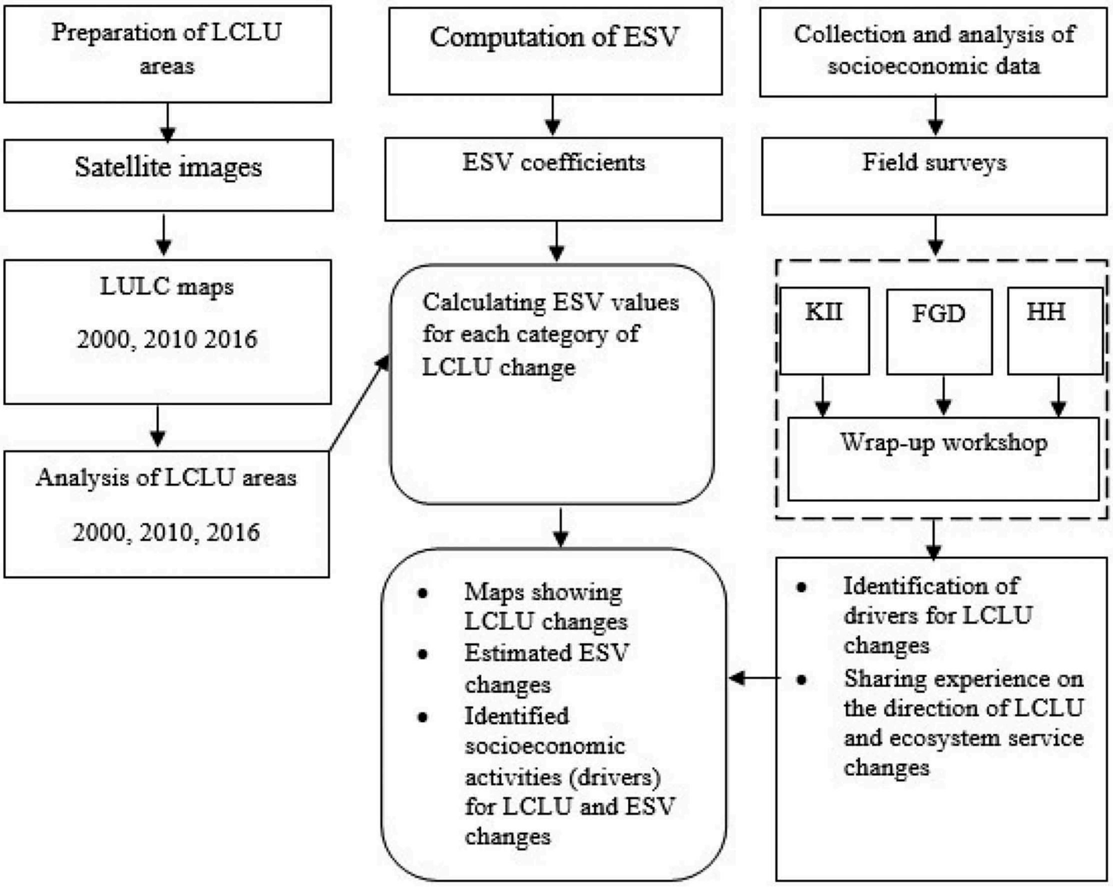


Figure 2. Methodological flow chat (LCLU= land cover and land use, ESV= ecosystems service values, KII=Key Informants interviews, FGD= Focus group discussion, HH= household surveys).

LCLU classification, together with Support Vector Machine (SVM) classifier, to indicate characteristics of vegetation (Zhang et al. 2015a). The 2000, 2010, and 2016 LCLU data were mapped in ArcGIS, overlays and changes were established based on LCLU's total area.

Land use classification

The classification of LCLU along the coast produced seven land categories, as representing the estimated areas from S37 00, S37 50 to S37 50, S37 10 geographical coordinates. The seven LCLU categories included (i) farm land (crop land used for agriculture, horticulture, and gardens, including paddy fields, irrigated and dry farmland, vegetation, and fruit gardens); (ii) forest (land covered with trees and vegetation cover over 30%); (iii) grazing land (grassland/rangeland/land covered by natural grass with cover over 10%); (iv) wetland (land covered with wetland plants and waterbody including inland marsh, lake marsh, river flood plain wetland, forest/shrub wetland, peat bogs, mangroves, fish, and salt marshes; (v) shrub land (land covered with woody perennial plants ranging between >0.5 m and <5 m); (vi) waterbody (waterbodies in the area including rivers, lakes, reservoirs and fish ponds; and (vii) artificial surfaces (land modified by human activities for settlements, industrial and mining areas, transportation, and urban zones) (IPCC 2003; Maitima et al. 2009).

Area changes were detected based on differences between imagery identification of the changed areas. Each changed category of LCLU was obtained from remotely sensed imagery acquired in years 2000, 2010, and 2016 (Chen et al. 2013a; Kindu et al. 2016). The LCLU information was used to compare land changes and socioeconomic activities and the dynamics of ESV in the coastal zone (Chen et al. 2013b).

Computing the ESV

The ESVs for each of the seven LCLU categories were computed. The most representative biomes for each category were used as the proxy for a particular land category (Costanza et al. 1997; Temesgen et al. 2018) (Table 1). Nevertheless, this assessment adopted ecosystem service coefficients as modified and used in Temesgen et al. (2018). These coefficients were used under the assumption that they represented standardized coefficients' values from tropical areas, mainly Sub-Sahara Africa. Indeed, these values were used because are suitably developed for computing ESV from low income countries, Tanzania inclusive (Van

Table 1. Description of the representative biomes with their respective ecosystem service valuation coefficients globally and locally from Costanza et al. (2014) and Temesgen at al. (2018), respectively.

LCLU type composition equivalent biome			Coefficient value ($/ha/y) Global value	Local value
Forest	Forest land, open forest land	Forest	969.00	1093.20
Grazing land	Moderate coverage grassland and high coverage grassland	Grasslands	232.00	355.50
Shrub land	Grass/rangelands	Woody perennial plants, >0.5 m and <5 m	232.00	897.00
Farmland	Paddy field, maize, and sesame field	Cropland	92.00	169.20
Wetland	Wetland plants and water bodies	Wetland	14785.00	2856.10
Waterbody	Rivers, land reservoirs fishery, and lakes	Lakes/rivers	8498.00	3226.80
Artificial surfaces	Residential, commercial, Settlement, and roads	Urban	0.00	0.00

der Ploeg, De Groot, and Wang 2010; Kindu et al. 2016; Temesgen et al. 2018). However, in this work, we didn't identify or gauge factors which affect local community ecosystems services utilization. We constantly assigned the coefficients values across the community for all ecosystem settings under assumption that other factors (e.g., access, priorities and availability of ecosystems services) are kept constant. This meant that the randomly sampled communities have equal access and priorities etc. to ecosystems services. Therefore, land area (ha), coefficients and monetary (US$)) methods were used to evaluate the trend of ESV (Kubiszewski et al. 2017; Costanza et al. 2014).

Quantifying LCLU changes

LCLU dynamics for each land use category were computed to map the quantity change across 2000, 2010, and 2016. The change for each LCLU categories was compared quantitatively to show the differences across 16 years of changes. The rate of change was evaluated as in Equation 1 (Tang, Shi, and Bi 2014; Yirsaw et al. 2016; Temesgen et al. 2018).

$$K = \frac{Ub - Ua}{Ua} \times \frac{1}{T} \times 100 \qquad (1)$$

Where K is the single land cover dynamic index; Ua and Ub are the areas of a certain LCLU class at time "a" and time "b" respectively; T is the time span from time a to time b. When T is in a unit of year, then K is the annual rate of change in area for this land cover type. The values of K range from negative one to one. When $K < 0$ it means that the land cover type is in a state of depletion (Tang, Shi, and Bi 2014; Yirsaw et al. 2016). The interpretation criterion is that the larger the absolute values of K, the more intensively land has been depleted. If the values of $K \geqq 0$, it means that such land category was not intensively depleted.

Assessment of ESV

The total value of the ecosystem service represented by each of LCLU categories was obtained by multiplying the estimated size of each land category by the value coefficient of the biome used as the proxy for that category as in Equation 2.

$$\text{ESV} = \sum (\text{Ak} \times \text{Vck}) \qquad (2)$$

Where ESV is the evaluated ESV, Ak is the area and Vck is the value coefficient ($/ha/yr) for land use category k (Li et al. 2007; Kindu et al. 2016). The change in ESV was evaluated by calculating the difference between the values for each land cover category in 2000, 2010, and 2016. The percentage ESV changes were calculated as in Equation 3.

$$\text{Percentage ESV change} = \left(\frac{ESVfy - ESViy}{ESViy}\right) \times 100 \qquad (3)$$

Where by ESV = total estimated ESV, $ESVfy$ is the ESV in the final year, $ESViy$ is the ESV in the initial year. Positive values suggest an increase while negative values show a decrease in ESV (Li et al. 2007; Kindu et al. 2016).

Human to ecosystem services values

Human beings cause LCLU changes. From LCLU changes, the wellbeing of the human community is affected. The interplay across LCLU change and ecosystem service dynamics was used to understand the direction of a human-to-ecosystem service values (H-ESV). The H-ESV indices for each LCLU category helped to assess the relationship between the human population and the ESV. This index was obtained by dividing the ESV to the total population of a given reference year (2000, 2010, and 2016) as in Equation 4 (Yirsaw et al. 2016).

$$H - ESV = \frac{TESV}{TP} \qquad (4)$$

Where $H\text{-}ESV$ is the H-ESV, $TESV$ is the total ESV of each land use, and TP is the population of the coastal zone in 2000, 2010, and 2016 years.

Socioeconomic data

Collection of socioeconomic data began with a desk review of the published literature/documents from different sources. The sources included books, articles and reports from the Ministry of Natural Resources and Tourism of the United Republic of Tanzania. Thereafter, a cross section research design was employed to collect field data from May 2017 through August 2017. The data were collected deliberately from Mbwewe, Kwaluhombo, Kwang'andu, and Kwamduma villages, because they are located within the coastal zone of Tanzania.

Focus group discussions and field observations

Prior to intensive households and key informants survey and interviews, focus group discussions (FGD) were conducted from each village to learn about local conditions in relationship with land use and socioeconomic activities. Ten members formed one heterogeneous group, whereby the composition of each group considered gender, sex, occupation, and age differences. Direct field observation and note taking supported FGD during data collection. The purpose of FGD and observations were to collect information for opening up discussions with respondents on LCLU and socioeconomic activities changes.

Household surveys

The households were randomly picked from the village register books in which all households' heads were listed. In villages where register books were absent, the names of people were recorded with the assistance of village leaders from each hamlet and random selection was employed so as to avoid/reduce bias. Simple random sampling technique was used to get households, which were listed as farmers (crop producers), livestock keepers, charcoal producers and sellers, house constructors, carpenters, village security and environmental committee members. It took between 30 to 60 min to complete one survey followed by immediate memos production.

Key informants interviews

The purposive sampling techniques were used to interview village and ward executive officers, and district forest, environmental, livestock, and agricultural officers. These officers formed a key informant group category. The purpose of key informant interviews and group discussions was to deepen and clarify the understanding of the factors contributing to coastal zone disturbances and socioeconomic activities trends across 16 years. The in-depth interviews took between 60 and 120 min including memos production.

Wrap up workshop

To fine-tune the research findings, a one-day triangulation workshop was held just after partial data analysis. The aim of the workshop was to present preliminary results to the households, key informants and group discussion representatives before final production of the results. In addition, the workshop functioned to minimize the possibilities of generating biased final results because the composition of the workshop members considered all the categories which were interviewed in their respective categories.

Tools for data collection

Socioeconomic data were collected by means of household questionnaires and checklist for key informants and FGD. All discussions from spoken interviews were recorded using tape recorders and then transcribed to produce memos on the themes of local community understanding about LCLU changes and socioeconomic activities changes over the past 16 years. The following questions guided the surveys, interviews and discussions (1) how local community, leaders, and experts gauge the trend of LCLU change along the coastal zone of Tanzania; (2) how sets of socioeconomic activities have taken place and what sets have changed over the past 16 years to affect LCLU along the coastal zone; (3) why the degradation of coastal ecosystems has been increasing in the past 16 years. These questions generated both qualitative and qualitative information which were used to complement each other in the discussion of the results. The data were subjected into further analysis by using the Statistical Package for Social Sciences (SPSS version 22) and Microsoft Excel computer software.

Results

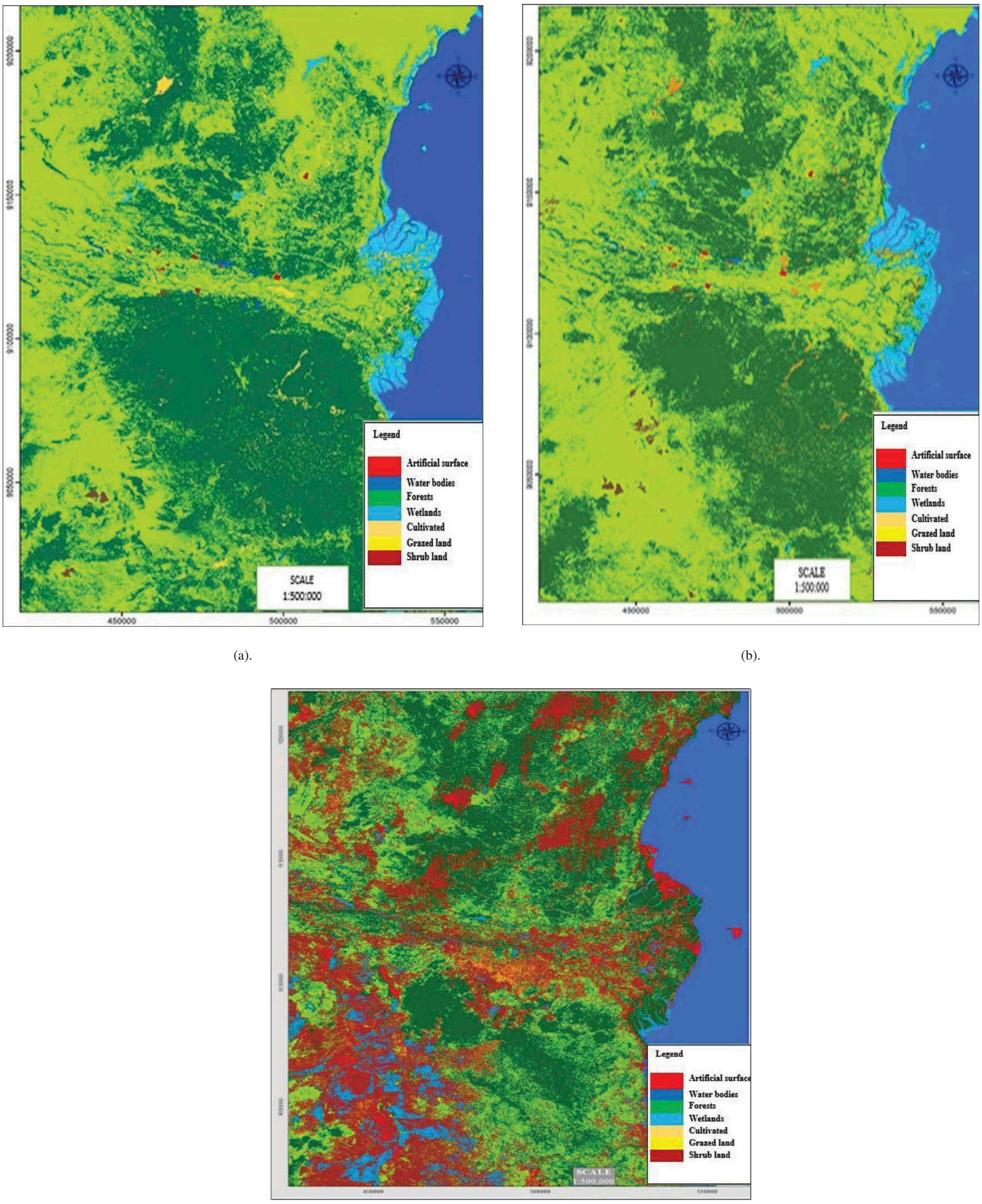
LCLU area across 2000, 2010, and 2016

In 2000, our study area (ha) had 46% forest coverage with 39% grazing land, while farmland use was 9%, shrub land covered 4%, wetland 1%, artificial surface by 0.4% and waterbody by 0.3%. In 2010, forest area was 42%, grazing land was 39% while farmland and shrub land covered 13% and 5%, respectively. Wetland had 1% while waterbody and artificial surface each had 0.3% coverage. In 2016, forest covered 41%, grazing land 38%,

Table 2. Estimated area and change for each LCLU category.

	Total area coverage (ha) across the study periods			Gain/loss in land area		
LCLU	2000	2010	2016	2010–2000	2016–2010	2016–2000
Forest	353041 (46%)	322637 (42%)	316600 (41%)	−30404 (−9%)	−6037 (−2%)	−36441 (−10%)
Grazing land	301707 (39%)	296680 (39%)	295360 (38%)	−5028 (−2%)	−1320 (0.4%)	−6347 (−2%)
Shrubland	31538 (4%)	40342 (5%)	43288 (6%)	8804 (28%)	2946 (7%)	11751 (37%)
Farm land	70495 (9%)	96645 (13%)	101001 (13%)	26150 (37%)	4356 (5%)	30506 (43%)
Wetland	5825 (1%)	5766 (1%)	5713 (1%)	−59 (−1%)	−53 (−1%)	−112 (−2%)
Waterbody	2061 (0.3%)	2303 (0.3%)	2340 (0.3%)	242 (12%)	37 (2%)	279 (14%)
Artificial surface	2691 (0.4%)	2986 (0.4%)	3056 (0.4%)	295 (11%)	70 (2%)	365 (14%)
Total	767358	767358	767358			

Values in percentage are indicated in brackets.



(a). (b). (c).

Figure 3. Land cover and land use changes: (a) in 2000, (b) 2010, and (c) 2016.

farmland 13%, and 6% shrub land. Wetland, artificial surface, and waterbody were more or less equal to that in 2010 (Table 2).

Gain or loss of LCLU across 2000, 2010, and 2016

There were some changes on the area for each LCLU category (Figure 3). Between 2000 and 2016, farmland expanded more than other land categories at 43%, followed by shrub land, which increased by 37%, and waterbody and artificial surface increased by 14%. Between 2000 and 2016, forest decreased by 10%; grazing land and wetland decreased by 2% each. Although forest coverage dominated the study area (ha) across all years, this land shrank from 353 041 in 2000 to 322 637 in 2010 and then to 316 600 in 2016. Wetland size (ha) decreased from 5 825 in 2000 to 5 766 in 2010 and 5 713 in 2016. Grazing land (ha) decreased from 301 707 in 2000 to 296 680 in 2010 and 295 360 in 2016. Hence, the highest relative proportions of decrease in the study area were largely recorded in forest, grazing land, and wetland (Table 2).

Changes of ecosystem service values

ESV (US$) varied across LCLU categories. Forest had 69% of the total ESV in 2000, which declined to 66% in 2010 and 65% in 2016. Grazing land had the second higher ESV at 19% in 2000 and 20% in both 2010 and 2016. Shrub land ESV was 5% in 2000 and 7% in both 2010 and 2016. Farmland ESV was 2% in 2000 and 3% in both 2010 and 2016. Wetland had 3% while waterbody had 1% across 16 years. Between 2000 and 2016, the net ESV gains were in farmland, shrub land, and water body, while the net losses were recorded for forest, grazing land, and wetlands.

The annual ESV change was highly affected by loss in forest and gains on shrub land and farmland. The aggregated loss of forest, wetland and grazing land surpassed the gains accrued in shrub land, farmland and waterbody. Hence, the overall ESV was negative across 2000, 2010, and 2016 (Table 3). There was perfect positive linear correlation between area changes and ESV in forest, shrubs, farmland, wetlands, and waterbody (p = 1.00). Additionally, only the grazing land had strong positive correlation (p = 0.768), and the correlation was significant at the 0.01 level (Figure 4).

Human to ecosystem service values

The assigned monetary values of each LCLU category and their total human to ESV varied across 2000, 2010, and 2016. The benefits of human welfare from coastal ESVs declined across LCLU categories in the 16 years. The total H-ESV ratio declined from 80 in 2000 to 64 in 2010, and then to 46 in 2016 (Table 4). Of these changes, forest and grazing land highly contributed on the total H-ESV decline. This trend illustrates a negative relationship between ESV and population across the study years.

Interviewed population

The study interviewed 490 (22%) at Mbwewe, 540 (24%) at Kwaruhombo, 522 (23%) in Kwang'andu and 697 (31%) at Kwamduma villages. The village firewood collectors, crop agriculturists, charcoal business people, and livestock keepers provided the socioeconomic information. One district and one ward agriculture officer, two district and regional forest officers, one ward executive officer and eight village leaders were interviewed during the spoken surveys. The findings from these sample sub-categories were generalized as shown in Figure 5.

Population data show an increase along the coastal zone of 23% of between 2000 and 2016. Indeed, during this time, some major socioeconomic activities increased tremendously. For example, there were a perfect positive correlation between population increase and households involved with crop farming (R^2 = 0.8587), livestock keeping (R^2 = 0.9846), and bioenergy use (R^2 = 0.9846) (Figure 6).

Table 3. Ecosystem service value (US$) and their changes across 2000, 2010, and 2016.

	Total ESV across the study periods			Gain/loss in ESV across the study periods		
LCLU type	2000	2010	2016	2000–2010	2010–2016	2000–2016
Forest	3.9×10^8 (69%)	3.5×10^8 (66%)	3.5×10^7 (65%)	-3.3×10^7 (9%)	-6.6×10^6 (2%)	-4.0×10^7 (12%)
Grazing land	1.1×10^8 (19%)	1.1×10^8 (20%)	1.1×10^8 (20%)	-1.8×10^5 (2%)	-4.7×10^5 (1%)	-2.3×10^6 (2%)
Shrubland	2.8×10^7 (5%)	3.6×10^7(7%)	3.9×10^7 (7%)	7.8×10^6 (28)	2.6×10^6 (7%)	1.0×10^7 (27%)
Farm land	1.2×10^7 (2%)	1.6×10^7(3%)	1.7×10^7 (3%)	4.4×10^6 (37%)	7.4×10^5 (5%)	5.1×10^6 (30%)
Wetland	1.7×10^7 (3%)	1.6×10^7 (3%)	1.6×10^7 (3%)	-1.7×10^5 (1%)	-1.5×10^5 (1%)	-3.2×10^5 (2%)
Waterbody	6.7×10^6 (1%)	7.4×10^6 (1%)	7.5×10^6 (1%)	7.8×10^5 (12%)	1.2×10^5 (2%)	9.0×10^5 (12%)
Artificial surface	-	-	-	-	-	-
Total	5.6×10^7	5.3×10^8	5.3×10^8	-2.2×10^7	-3.7×10^6	-2.8×10^6

Value in percentage are indicated in brackets.

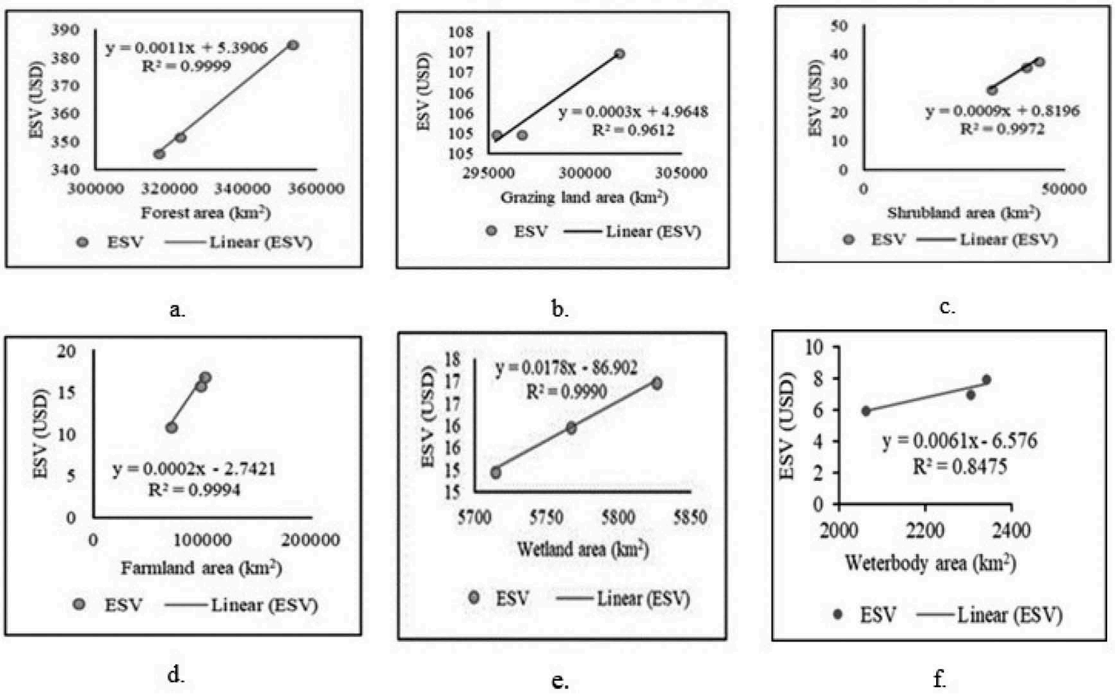


Figure 4. Correlation between LCLU and ESV changes: (a) forest and ESV, (b) grazing land and ESV, (c) shrubland and ESV, (d) farmland and ESV, (e) wetland and ESV, and (f) water body and ESV.

Table 4. Human-ESV across LCLU categories and years.

	Human-ESV across the study periods			Percentage gain/loss in H-ESV		
LCLU type	2000	2010	2016	2010–2000	2016–2010	2016–2000
Forest	55.8	42.1	30.0	−24.5	−28.9	−46.3
Grazing land	15.5	12.6	9.1	−18.7	−27.8	−41.3
Shrubland	4.1	4.3	3.4	5.7	−22.2	−17.7
Farm land	1.7	2.0	1.5	13.3	−24.2	−14.1
Wetland	2.4	2.0	1.4	−18.2	−28.2	−41.2
Waterbody	1.0	0.9	0.7	−7.6	−26.3	−32.0
Artificial surface	-	-	-	-	-	-
Total	80.4	63.8	46.0	−20.6	−28.0	−42.9

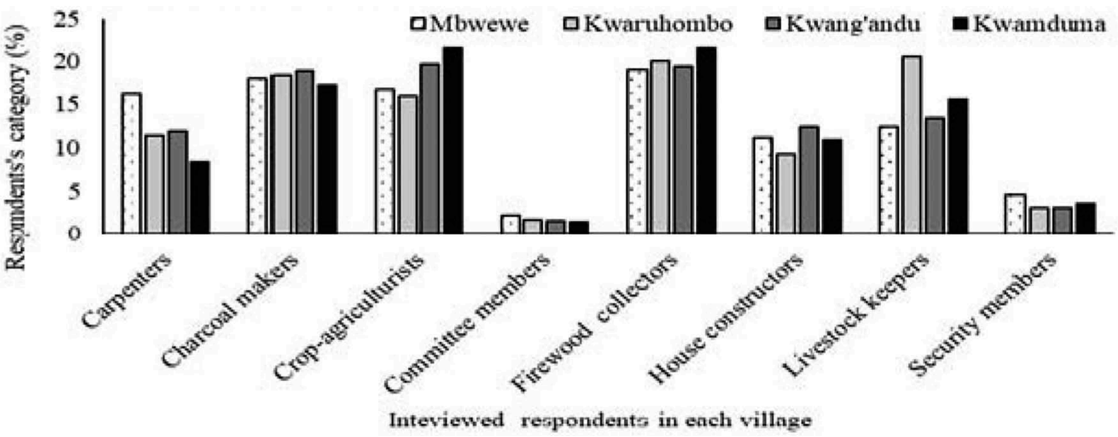


Figure 5. Interviewed respondents from the representative study sites.

Community awareness on factors causing LCLU change

A major factor contributing to LCLU change was bioenergy (i.e., woods for cooking and heating) and clearing virgin land for development of crop farming. Other activities identified by local community were uncontrolled livestock grazing, and collection of materials for construction (e.g., timber, poles, and ropes). Interestingly, uncontrolled fire and urbanization ranked at the lowest than other LCLU change factors across all the study sites (Figure 7).

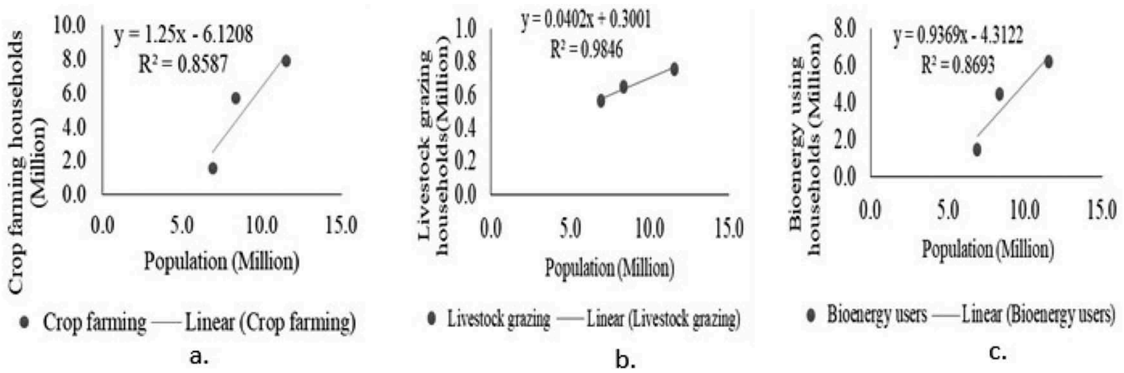


Figure 6. Correlation across population and the major drivers of LCLU change. (a) Farming households and total population; (b) Livestock grazing and total population; (c) Bioenergy users and total population.

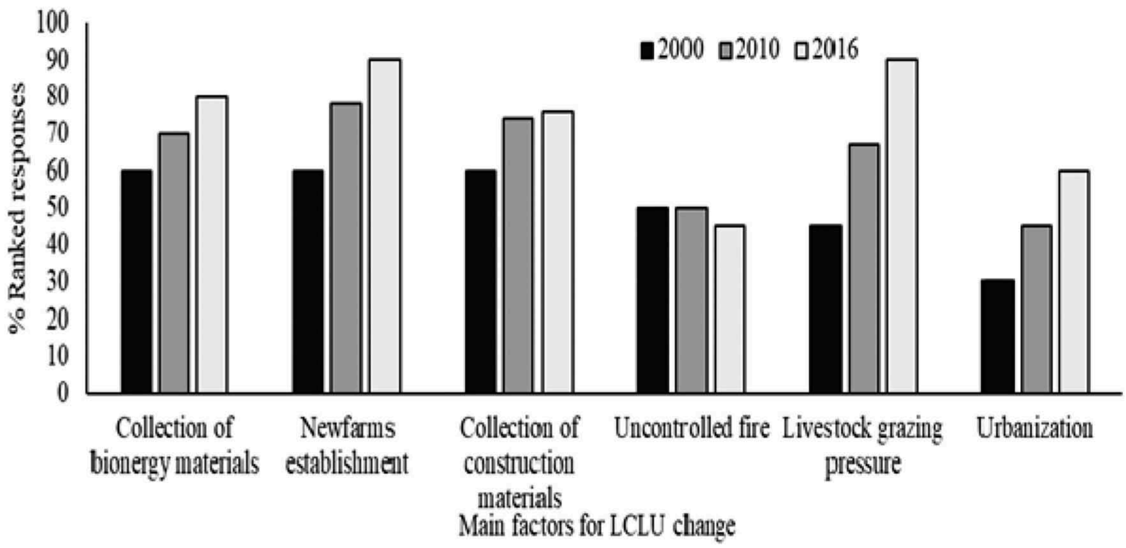


Figure 7. Respondents' awareness on socioeconomic that cause LCLU change.

Discussion

Farmland expansion

Our findings indicate that along the coastal zone of Tanzania, LCLU categories have changed over the past 16 years. Significant gains in areas are observed on farmland and shrub land, as well as water body implies that the major driver of land LCLU change along the coastal zone is crop-agriculture. Obviously, crop farming that has increased in 16 years is threatening the health status of the coastal zone, like many other Sub-Saharan African ecosystems, as supported by Scull et al. (2017) and Temesgen et al. (2018). The net increase in farmland indicates a substantial expansion of cultivated land for crop production. This expansion is supported by Ryan et al. (2016) and Sonneveld, Keyzer, and Ndiaye (2016), implying that farming is the persistent driver of land cover change globally.

Farmland expansion is characterized mainly by small land holdings and commercial agriculture. Farmers produce paddy (*Orryza sativum*), maize (*Zea mays*), sesame (*Sesamum indicum*), cassava (*Mannihot esculentum*), and pineapples (*Ananas comosus*). Large-scale commercial agriculture is mainly for production of cashews (*Anacardium occidentale*), Sisal (*Agave* sp.), oranges (*Citrus* sp.), and mangoes (*Mangifera indica*). Peri-urban agriculture is the emerging practice mainly characterized by vegetable production. Production of these crops contribute to the conversion of natural vegetation into cultivated land and then into shrub land when the farms are abandoned.

Farmland and shrub land expansion

Although we did not compute the matrix of LCLU dynamics in order to locate areas of gains and losses (i.e., we have not indicated which LCLU category has been converted to which category and vice versa), we can establish the interplay between farmland and shrub land expansion by using the existing literature (Foley et al. 2005). Thus, expansion of farmland can be related to shrub land development in agreement with Foley et al. (2005); Nkonya et al. (2013); and Rautiainen, Virtanen, and Kauppi (2016). Shrubs develop on the abandoned farmland because farmers practice shifting cultivation, especially with production of annual crops. The major reason for abandoning farms is that, nutrients get depleted on farm lands since crop farming across the coastal zone usually do not apply additional fertilizers. Shrubs succession and development in disturbed sites supports the findings in Fetene et al. (2015).

As farms become infertile, they are left for two, three, or four years to regain fertility naturally. It is during the time of fallow that shrubs first overgrow on old farms before other vegetation as supported in Warinwa, Mwaura, and Kiringe (2016). This succession stage implies that, it is possible to allow natural regeneration to take place on the degraded systems supporting findings in Rautiainen, Virtanen, and Kauppi (2016). Remarkably, shrubs are among the early successors of the disturbed farmland because they can survive in the degraded and nutrient poor soils (Kuenzer et al. 2011).

However, the correlating increase of shrubs with farm land expansion is contrary to the findings in Madriñán et al. (2012) and Wu et al. (2013). This controversial relationship implies that different geographical locations and climatic conditions permit different vegetation responses post land disturbances. Interestingly, it is possible that the abandoned farms are microsites to promote rejuvenation of forest species as supported by Rautiainen, Virtanen, and Kauppi (2016). Therefore, the potential to rejuvenate is an important factor promoting many tropical ecosystems to succeed in regeneration (Bharathi and Prasad 2015).

Farming and impacts on wetlands and waterbodies

Clearing land for crop cultivation affects vegetation and infiltration of water into the soil and ground water systems (Ryan et al. 2016). Expanded farming has impacts on wetlands and on increasing of water in open areas (mainly characterized as seasonal dams or floods) (Madriñán et al. 2012; Smith et al. 2014). However, the increase of waterbody in open or bare lands across the coastal zone is contrary to arguments of Blumstein and Thompson (2015). Yet, we can establish that clearing land for any anthropogenic purpose accelerates flooding in open areas as supported by Smail and Lewis (2009) and Ryan et al. (2016). This observation is pronounced on the produced images, as well as supported by local communities and key informants that there is higher occurrence of floods on residential and farm area in the recent years. Although the matrix to map the interplay between wetlands and waterbodies was not established, we can use the existing literature to support the direction between these two lands uses (Aighewi, Ishaque, and Nosakhare 2014). The shrinkage of wetland aggravates flooding in the open areas because disturbances on wetlands reduce their capacity to regulate flooding (Chaudhary et al. 2017; Temesgen et al. 2018). This interchange must be well understood because the danger of compromising the interplays between loss of wetlands and waterbody should be reexamined by coastal ecosystem management to protect wetlands and avoid further flooding along the coastal zone.

Population and commercial activities dynamics

Gains or losses in LCLU categories, such as farmland usage correlate well with human population changes along the coastal zone in agreement with Fetene et al. (2015) and Guerry et al. (2015). Population growth triggers changes on land cover whereby these changes occur parallel with higher conversion of large areas into housing and commercial activities (Blumstein and Thompson 2015). As in many tropical countries (Tanzania inclusive), population growth is also related to intensive and extensive clearing of land for crop agriculture as the major contributor to the households' income and economy (Foley et al. 2005; URT 2014; Sloan and Sayer 2015). Therefore, our findings confirm that there is a large-scale decline in forest land cover across the coastal zone of Tanzania like in many Sub-Saharan African areas (Keenan et al. 2015). This decline indicates that population growth is significantly related to expansion of economic activities associated with progressive transformation of land into crops and built areas (Sonneveld, Keyzer, and Ndiaye 2016; Scull et al. 2017).

However, expansion of some investments and human activities, for example, farmland does not necessarily mean increase in yield per unit area (Sonneveld, Keyzer, and Ndiaye 2016). In some cases, land degradation is associated with declining yields in agreement with Sonneveld, Keyzer, and Ndiaye (2016) and Borrelli et al. (2017). To compensate for the farmland nutrition deprivation, farmers opt to open new farms, consequently triggering further land degradation; this view is in agreement with Otsuka and Place (2014) findings. Moreover, some findings do not support that population growth and urbanization promote the expansion of cultivated land (Madriñán et al. 2012; Quintas-Soriano et al. 2016).

This contradiction is useful to narrate that differences on the primary socioeconomic activities determine LCLU changes in a particular area. For example, the coastal zone of Tanzania is influenced mainly by agricultural activities, while in highly developed coastal zones industrial activities or tourism dominates (Quintas-Soriano et al. 2016). Under these alternative livelihood activities, overdependence on farming activities to influence LCLU change is reduced (Quintas-Soriano et al. 2016). Therefore, identifying and promoting livelihood activities that have minimum LCLU transformation should be encouraged to manage coastal ecosystems.

The reality is that in a country or a zone where the major livelihood activity is crop agriculture, there is direct interplay between population growth and farmland expansion, which finally affects land cover.

Urbanization and LCLU change

The urban environment has increased tremendously across the studied periods. Such an increase contributes in altering vegetation cover along the coastal ecosystems (Schmidt, Moore, and Alber 2014; Blumstein and Thompson 2015; Yirsaw et al. 2017). The growth and expansion of urban and exurban areas along the coastal zone of Tanzania are among the factors contributing to LCLU changes. Also, in these areas included are establishments of transportation systems and many other dispersed built-up sites supporting the findings in Maitima et al. (2009) and Temesgen et al. (2018).

The expansion of towns and other infrastructure correlates well with increased investments and developmental activities (Otsuka and Place 2014; Sloan and Sayer 2015). The major impacts of rapid expansion in urban settlements and commercial activities is the decline of forest areas and wetland shrinkage (Zhao et al. 2004; Zhang et al. 2015b; Warinwa, Mwaura, and Kiringe 2016). Therefore, our findings are within the existing documentation that many tropical ecosystems suffer from urbanization supporting the conclusions of Wu et al. (2013), Xu et al. (2017) and Zhou et al. (2017). These findings that support each other imply that locally and globally unplanned urbanization is a threat to coastal ecosystems (Zhou et al. 2017).

Grazing land use change

Grazing land declined during the 16 years. This land category was highly affected by livestock grazing pressure as also reported in other studies (Scull et al. 2017; Temesgen et al. 2018). Records show an increase in the number of livestock mainly from Tanzania's inland toward the coastal zone (URT 2014). The major factors for the inland to coastal livestock movement include inadequate pasture and scarcity of water in other ecological zones emanating from land degradation and prolonged dry seasons in the inland areas of the country than the coastal zone. Indeed, the coastal zone is a livestock immigrant area because it harbors livestock fodder and has promising weather conditions, unlike many other inland zones (Maitima et al. 2009; UNEP 2015).

Moreover, livestock pressure on the coastal zone is increased by the promising livestock market in Dar es Salaam city. This city is the major international market and is also the prominent outlet of live animals and by-products. In addition, livestock keepers and livestock business people prefer to keep domestic animals (mainly cattle) along the coastal zone either permanently or temporally to capture market opportunities. Therefore, livestock grazing pressure contributes to the decline of grazing land and deforestation locally and globally (Fetene et al. 2015; Maitima et al. 2009).

Wetland change

Water draining activities contribute to the wetland decline along the coastal zone. These activities are mainly due to crop farming, commercial and residential development, and livestock grazing (Raburu and Kwena 2012). Modification of terrestrial ecosystems alters the ecohydrological processes as stated in Reeves and Champion (2004) and Duku et al. (2015). There is a clear relationship between shrinkage of wetland and farming activities (Duku et al. 2015). For example, crop production and livestock grazing take place within wetlands, hence creating the interference of the drainage systems (Duku et al. 2015).

Farming activities and overgrazing in riparian areas reduce streamside vegetation and prevention of runoff while also lessening the wetlands filtration and recharge of water (Reeves and Champion 2004; Warinwa, Mwaura, and Kiringe 2016). Expansion of farms for crop production and livestock grazing in wetlands have intensified along the coastal zone in recent years because of rapid commercial investments (URT 2016; Zhang et al. 2015b). Moreover, some wetlands located in urban areas are converted into built land and urban-agriculture contrary to observations made by Temesgen et al. (2018). This contradiction shows that the direction of wetland spatially and temporally change variably in the tropics. However, our findings suggest that wetlands in the coastal zone are on high pressure of degradation; this is also reported in Aighewi, Ishaque, and Nosakhare (2014). These wetlands need attention; otherwise, this land category will continue to shrink like other similar wetlands in the tropics (Chapungu and Hove 2013).

Forest land change

Deforestation along the coastal zone is produced by clearing land for farming activities, as well as developing settlements and infrastructure (Warinwa, Mwaura, and Kiringe 2016). Activities, such as collection of poles and timber for construction and harvesting of trees for fuel wood and charcoal also prevail in the coastal zone and highly affect coastal forests like many forests globally (Keenan et al. 2015; Fetene et al. 2015; Chaudhary et al. 2017).

Indeed, clearing land for salt extraction and sand mining identified by local community and key informants as other significant contributor to coastal forest loss. Also, coastal aquaculture and livestock pressure threaten the coastal forests (Bryceson 2002; van Hoof and Kraan 2017). In addition, there is higher community dependence on bioenergy at the expense of forest disturbances and degradation. Likewise, bioenergy dependence is prominent along the coastal zone because different households cannot afford to use gas or electricity for domestic cooking, heating, and lighting (Temesgen and Wei 2018).

Furthermore, encroachment for crop cultivation into forests replaces natural vegetation with crops, consequently contributing to shrub invasion (Nkonya et al. 2013; Borrelli et al. 2017). All these factors are worsening the forest ecosystem's health along the coastal zone similar to many areas of Sub-Saharan Africa (Keenan et al. 2015; Temesgen et al. 2018).

In this view, farming activities affect forest land dynamics than other factors (Warinwa, Mwaura, and Kiringe 2016). To overcome the ongoing forest loss, alternative livelihood activities to replace crop-agriculture are needed. Otherwise, research on how agriculture can take place along the coastal zones without harming forests is needed. These efforts will help to overcome the impacts of crop agriculture on the already disturbed ecosystem like many other tropical ecosystems (Temesgen et al. 2018).

Ecosystem service values

Changes on each category of LCLU result in gains or losses of ESV and H-ESV accrued from each category (Zhang et al. 2015b; Scull et al. 2017). In this discussion of ESV and H-ESV, we have not included the ESV of artificial surface (built areas) because of lack of ecosystem service coefficients in the existing publications (Costanza et al. 1997; Zhang et al. 2015b; Temesgen et al. 2018). Therefore, ESV and H-ESV were computed only from forest, farmland, shrubland, waterbody, wetland, and grazing land.

The presented and discussed ESV and H-ESV data are expressed in monetary units to be understood by a broad audience and do not mean that ecosystem services should be treated as private commodities that can be traded in private markets (Costanza et al. 2014). This consideration is taken because ecosystem services are public goods or the product of common assets that cannot be privatized (De Groot et al. 2012; Costanza et al. 2014).

Because of changes on LCLU categories across 16 years, we found that the changes on ESV were higher on farmland, shrub land, and waterbody and forest categories than grazing land and wetlands. Gains on ESV were significantly higher on farmland and shrub land but not in waterbody. Loss in ESV was significantly higher on forest, followed by grazing land and wetlands.

The difference between gains and loss, gave a net loss of ESV across 2000, 2010, and 2016. This trend agrees with findings in Fujita et al. (2013) and Hu, Liu, and Cao (2008), but is different from Temesgen et al. (2018). The main factor for this difference could be that in our study, we found higher net loss of ESV on the forest land. It is apparent that changes in crop and grazing lands, as well as loss of forest cover, exacerbate the changes of coastal ESV (Temesgen et al. 2018). In relation to LCLU changes and ESV, the overall changes show that forest ESV ranked the highest net loss across the studied years supporting the documentations in Jew et al. (2016) and Chaudhary et al. (2017). The higher loss of forest overshadowed the total net gains on the ESV computed for shrub land, farmland and water, unlike in the exiting documents where land use gain or loss for each category were relatively more or less equal in values (see Temesgen et al. 2018). The decline on the total ESV along the coastal zone indicates that the magnitude of change on each LCLU category (but in most cases changes in forest) has significant implication on the net ESV (Fujita et al. 2013).

Changes on H-ESV

Changes on LCLU have impacts on the total human welfare obtained from the ecosystem services (Yirsaw et al. 2016). These changes have affected the total H-ESV too. Across 16 years, H-ESV declined subject to population growth. This decline implies that as human population grow, human activities increase and aggravate some changes on LCLU categories, ESV and finally lead to the decline of the H-ESV supporting the findings in Fujita et al. (2013). The loss in ESV and decline on H-ESV reported in this evaluation shows that if land use managements and the associated problems are not addressed properly, Tanzania will continue to lose benefits from ecosystem services, meaning that the current LCLU changes along the coastal zone need urgent attention. To address the current status of LCLU changes, ESV and H-ESV, efforts are required to slow down all processes that cause loss of each LCLU category, especially forest loss (Dale and Polasky 2007; Jantz and Manuel 2009; Han, Song, and Deng 2016). Indeed, we advise to allow natural regeneration processes to take place along the coastal zone because ecosystems have the resilient capacity to largely recover after disturbances (Rautiainen, Virtanen, and Kauppi 2016).

Community awareness on LCLU changes

Across the study sites, local community and leaders showed that they are aware about the transformation of LCLU classes in the coastal zone. This observation supports the work by Chaudhary et al. (2017) that local communities are aware about changes occurring in their environments and drivers for changes. While agricultural activities are frequently identified as the major drivers for LCLU changes, exploitation of forests resources for domestic bioenergy use is growing fast. This growth implies that overdependence on bioenergy is functioning as the current contributor of coastal forest loss, also globally reported in Jew et al. (2016) and Smith et al. (2014).

In recent years, urbanization is related to higher demand of land for settlements and establishments of local investments in the expenses of harvesting of woods/trees for construction materials. Moreover, livestock grazing is becoming the threat to the coastal zone and is increasing at alarming pace. These trends automatically compromises the capacity of coastal ecosystems to offer ecological services for human wellbeing. Therefore, the decline of land cover because of land use changes along the coastal zone threatens the life of local communities because the livelihoods of the people depend directly on ecosystems services (Chaudhary et al. 2017).

Interestingly, uncontrolled fire is not significantly affecting coastal ecosystems in recent years. This implies that efforts have been in place to address fire problems in this zone as supported by group discussions and individual interviews. In this case, there are some improvements on some drivers of the coastal zone disturbances. Thus, efforts are needed to address the remaining disconcerting factors, such as human population pressure, overdependence on natural coastal resources (because of lacking the alternative livelihood activities for income generation), and lack or poor implementation of land use plans supporting the findings of van Hoof and Kraan (2017). Indeed, it is important to consider that much work is needed to manage and address at large the interplays between socio-economic activities and ecosystems welfare along the coastal zone. Therefore, this study advises that there must be mechanisms that guide and give alternative livelihood activities, as well as application of land use plans that safeguard coastal ecosystems as supported by Quintas-Soriano et al. (2016) and Chaudhary et al. (2017).

Conclusions

This study has highlighted the important links between LCLU change and impacts on ESV and H-ESV in the tropical coastal forests. We conclude that land use changes in the coastal zone of Tanzania have transformed land cover to cultivated land, grazing lands, human settlements and other built area at the expense of natural vegetation mainly forest and grassland. The socioeconomic activities mainly crop farming, livestock grazing and harvesting of wood/trees as bioenergy sources all contribute to threaten the coastal ecosystems. These threats are aggravated by a rapid population growth and expansion of socio-economic activities along the coastal zone. Moreover, changes on LCLU have resulted into net loss of ESV and H-ESV. Given the ongoing population pressure and socioeconomic activities in the coastal zone, it is likely that an increasing demand for land use will place heavy pressure on these ecosystems. Consequently, the capacity of coastal ecosystems to offer ecological functions and services to sustain life of human beings will be further impaired. Therefore, it is important to regulate and balance population and socioeconomic activities so that all changes that give net loss on LCLU, ESV, and H-ESV are avoided.

Nevertheless, several limitations are acknowledged in this work. (1) Unlike in other existing studies (Chaudhary et al. 2017), in this work we assigned the coefficients values constantly across the community for all ecosystem settings under assumption that, other factors (e.g., access, priorities, and availability of ecosystems services) are kept constant thus the randomly sampled community were assumed to have equal access and priorities to ecosystems services. Indeed, this assumption should be treated with care because inclusion of these factors might have affected the results. (2) Most of the respondents interviewed based on recalls about human activities and trends of LCLU changes over the past 16 years. The recalls might have also affected the findings. However, to avoid biased responses, the interpretation of the results and conclusions, were generalized to present the general views after field revisits and triangulation workshop.

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Declaration of interest

No potential conflict of interest was reported by the author.

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References

Aighewi, I., A. Ishaque, and O. Nosakhare. 2014. "Geospatial Evaluation for Ecological Watershed Management II: Changes in Land Use-Land Cover Influence on Ecosystems Services." *Journal of Geographic Information System* 6: 246–257. doi:10.4236/jgis.2014.63023.

Baumgartner, P., and J. Cherlet. 2016. "Economics of Land Degradation and Improvement: An Introduction and Overview." In *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*, edited by E. Nkonya, A. Mirzabaev, and J. von Braun, 1–7. Heidelberg, New York, NY: Springer International Publishing AG Switzerland.

Bhagabati, N. K., T. Ricketts, T. B. S. Sulistyawan, M. Conte, D. Ennaanay, O. Hadian, and S. Wolny. 2014. "Ecosystem Services Reinforce Sumatran Tiger Conservation in Land Use Plans." *Biological Conservation* 169: 147–156. doi:10.1016/j.biocon.2013.11.010.

Bharathi, S., and A. G. D. Prasad. 2015. "Regeneration Status of Tree Composition in the Sacred Groves of Mercara, Central Western Ghats." *Euro Journal Experiments Bio* 5 (10): 29–40.

Blumstein, M., and J. R. Thompson. 2015. "Land-Use Impacts on the Quantity and Configuration of Ecosystem Service Provisioning in Massachusetts, USA." *Journal of Applied Ecology* 52 (4): 1009–1019. doi:10.1111/1365-2664.12444.

Borrelli, P., D. A. Robinson, L. R. Fleischer, E. Lugato, C. Ballabio, C. Alewell, and P. Panagos. 2017. "An Assessment of the Global Impact of 21st Century Land Use Change on Soil Erosion." *Nature Communications* 8 (1): 1–13. doi:10.1038/s41467-017-02142-7.

Bryceson, I. 2002. "Coastal Aquaculture Developments in Tanzania : Sustainable and Non-Sustainable Experiences." *Western Indian Ocean Journal of Marine Sciences* 1: 1–10.

Chapungu, L., and C. Hove. 2013. "Human Perceptions on Degradation of Wetland Ecosystems : The Case of Magwenzi Wetland in Chivi District; Zimbabwe." *Greener Journal of Geology and Earth Sciences* 1 (1): 13–22. doi:10.15580/GJGES.2013.1.071113716.

Chaudhary, S., T. Dago, P. Tshering, U. Kabir, S. Bandana, and C. Nakul. 2017. "Impacts Of Land Cover Change on a Mountain Ecosystem and Its Services: case Study from The Phobjikha Valley, Bhutan." *Ecosystem Health and Sustainability* 3: 1–12.

Chen, J., H. Wu, S. Li, A. Liao, C. He, and S. Peng. 2013b. "Temporal Logic and Operation Relations Based Knowledge Representation for Land Cover Change Web Services." *Journal of Photogrammetry and Remote Sensing* 83: 140–150. doi:10.1016/j.isprsjprs.2013.02.005.

Chen, J., M. Lu, X. Chen, J. Chen, and L. Chen. 2013a. "A Spectral Gradient Difference Based Approach For Land Cover Change Detection." *Journal of Photogrammetry and Remote Sensing* 85: 1–12. doi:10.1016/j.isprsjprs.2013.07.009.

Cork, S. J., and D. Shelton. 2000. The Nature and Value of Australia's Ecosystem Services : A Framework for Sustainable Environmental Solutions. In *Sustainable Environmental Solutions for Industry and Government' Proceedings of the 3rd Queensland Environmental Conference, Queensland*. http://www.ecosystemservicesproject.org/pdf: p.151–159 [accessed 15/05/2017].

Costanza, R., R. D'Arge, R. De Groot, S. Farber, M. Grasso, B. Hannon, and M. Van Den Belt. 1997. "The Value of the World's Ecosystem Services and Natural Capital." *Nature* 387: 253–260. doi:10.1038/387253a0.

Costanza, R., R. De Groot, P. Sutton, S. Van Der Ploeg, S. J. Anderson, I. Kubiszewski, S. Farber, and R. K. Turner. 2014. "Changes in the Global Value of Ecosystem Services." *Global Environmental Change* 26 (1): 152–158. doi:10.1016/j.gloenvcha.2014.04.002.

Dale, V. H., and S. Polasky. 2007. "Measures of the Effects of Agricultural Practices on Ecosystem Services." *Ecological Economics* 64 (2): 286–296. doi:10.1016/j.ecolecon.2007.05.009.

De Groot, R., L. Brander, S. Ploeg, D. Van, R. Costanza, and F. Bernard. 2012. "Global Estimates of the Value of Ecosystems and their Services in Monetary Units." *Ecosystem Services* 1 (1): 50–61. doi:10.1016/j.ecoser.2012.07.005.

Duku, H., H. Rathjens, S. J. Zwart, and L. Hein. 2015. "Towards Ecosystem Accounting: a Comprehensive Approach to Modelling Multiple Hydrological Ecosystem Services." *Hydrology and Earth System Sciences* 19 (10): 4377–4396.

Eva, H. D., A. Brink, and D. Simonetti. 2006. "Monitoring Land Cover Dynamics in Sub-Saharan Africa." *Institute for Environment and Sustainability, European Communities, Luxembourg*, 1–44. Accessed 18 May 2017. https://www.eldis.org/pdf

FAO. 2011. *The State of Food and Agriculture 2010-2011: Women in Agriculture*. Rome,Italy. Accessed 15 April 2017. http://www.fao.org/pfd.p.147

FAO. 2015. "Global Forest Resources Assessment 2015." *Desk Reference*. 244. Rome, Italy. Accessed 15 May 2017. http://www.fao.org/pfd

Fetene, A., T. Hilker, K. Yeshitela, R. Prasse, W. Cohen, and Z. Yang. 2015. "Detecting Trends in Landuse and Landcover Change of Nech Sar." *Environmental Management* 57 (1): 137–147. doi:10.1007/s00267-015-0603-0.

Foley, J. A., R. DeFries, G. P. Asner, C. Barford, G. Bonan, S. R. Carpenter…, and P. K. Snyder. 2005. "Global Consequences of Land Use." *Science* 309: 570–574. doi:10.1126/science.1116168.

Fujita, R., J. Lynham, F. Micheli, P. G. Feinberg, L. Bourillón, A. Sáenz-Arroyo, and A. C. Markham. 2013. "Ecomarkets for Conservation and Sustainable Development in the Coastal Zone." *Biological Reviews* 88 (2): 273–286. doi:10.1111/brv.2013.88.issue-2.

Guerry, A. D., S. Polasky, J. Lubchenco, R. Chaplin-Kramer, G. C. Daily, R. Griffin, and B. Vira. 2015. "Natural Capital and Ecosystem Services Informing Decisions: From Promise to Practice." *PNAS* 112 (24): 7348–7355. doi:10.1073/pnas.1503751112.

Han, G., J. Chen, C. He, S. Li, H. Wu, A. Liao, and S. Peng. 2015. "A Web-Based System for Supporting Global Land Cover Data Production." *Journal of Photogrammetry and Remote Sensing* 103: 66–80. doi:10.1016/j.isprsjprs.2014.07.012.

Han, Z., W. Song, and X. Deng. 2016. "Responses of Ecosystem Service to Land Use Change in Qinghai Province." *Energies* 9 (4): 1–16. doi:10.3390/en9040303.

Hu, H., W. Liu, and M. Cao. 2008. "Impact of Land Use and Land Cover Changes on Ecosystem Services in Menglun, Xishuangbanna, Southwest China." *Environmental Monitoring and Assessment* 146 (1–3): 147–156. doi:10.1007/s10661-007-0067-7.

IPCC. 2003. "Good Practice Guidance for Land Use, Land-Use Change and Forestry," edited by J. Penman, M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe, F. Wagner, 580. Hayama, Japan: IPCC/OECD/IEA/IGES. doi.org/citeulike-article-id:1260638

Jantz, D. C., and J. J. Manuel. 2009. "Estimating Impacts of Population Growth on Ecosystem Services for the Community of Albemarle County and Charlottesville, Virginia." Accessed 10 June 2017. http://cvilletomorrow.com/pdf.p.76

Jew, E. K. K., A. J. Dougill, S. M. Sallu, J. O'Connell, and T. G. Benton. 2016. "Miombo Woodland Under Threat: Consequences for Tree Diversity and Carbon Storage." *Forest Ecology and Management* 361: 144–153. doi:10.1016/j.foreco.2015.11.011.

Keenan, R. J., G. A. Reams, F. Achard, J. V. De Freitas, A. Grainger, and E. Lindquist. 2015. "Dynamics of Global Forest Area: Results from the FAO Global Forest Resources Assessment 2015." *Forest Ecology and Management* 352: 9–20. doi:10.1016/j.foreco.2015.06.014.

Kindu, M., T. Schneider, D. Teketay, and T. Knoke. 2016. "Changes of Ecosystem Service Values in Response to Land Use and Land Cover Dynamics in Munessa-Shashemene Landscape of the Ethiopian Highlands." *The Science of the Total Environment* 547: 137–147. doi:10.1016/j.scitotenv.2015.12.127.

Kubiszewski, I., R. Costanza, S. Anderson, and P. Sutton. 2017. "The Future Value of Ecosystem Services: Global Scenarios and National Implications." *Ecosystem Services* 26: 289–301. doi:10.1016/j.ecoser.2017.05.004.

Kuenzer, C., A. Bluemel, S. Gebhardt, T. V. Quoc, and S. Dech. 2011. "Remote Sensing of Mangrove Ecosystems." *Remote Sensing* 3 (12): 878–928. doi:10.3390/rs3050878.

Li, R. Q., M. Dong, J. Y. Cui, L. L. Zhang, Q. G. Cui, and W. M. He. 2007. "Quantification of the Impact of Land-Use Changes on Ecosystem Services: A Case Study in Pingbian County." *China. Environmental Monitoring and Assessment* 128 (1–3): 503–510. doi:10.1007/s10661-006-9344-0.

Ligate, E. J., S. Wu, and C. Chen. 2017. "The Status of Forest Ecosystem Services and their Management: The Case of Uzigua Forest Reserve in Tanzanian Coastal Forests." *Natural Resources and Conservation* 5 (2): 21–32.

Madriñán, M. J. M., M. Z. Al-Hamdan, D. L. Rickman, and J. Ye. 2012. "Relationship between Watershed Land-Cover and Land-Use Change and Water Turbidity Status of Tampa Bay Major Tributaries, Florida, USA." *Water Air Soil Pollution* 223 (5): 1–17.

Maitima, J. M., S. M. Mugatha, R. S. Reid, L. N. Gachimbi, A. Majule, H. Lyaruu…, and S. Mugisha. 2009. "The Linkages between Land Use Change, Land Degradation and Biodiversity across East Africa." *African Journal of Environmental Science and Technology* 3 (10): 310–325.

Marc, L., S. Babu, and K. Hamilton. 2005. "Ecosystem Conditions and Human Well-Being." In *Millenium Ecosystem Assessment*, edited by D. Rapport and L. Zhang, 123–164. Washington, DC: Ecosystems and Human Well-being: Current State and Trends.

NGCC. 2014. "30-Meter Global and Cover Dataset: GlobeLand30 Product Description." Beijing, China: National Geomatics Center of China. 25. Accessed 15 June 2016. http://www.globallandcover.com/home/Enbackground.aspx/pdf.

Nkonya, E., C. S. Jr, M. Shah, J. Braun, G. von-Galford, S. Park, and G. Nelson. 2012. *Sustainable Land Use for the 21st Century*, 82. Washington DC, USA: Division for Sustainable Development of the United Nations Department of Economic and Social Affairs.

Nkonya, E., J. Koo, E. Kato, and Z. Guo. 2013. "Trends and Patterns of Land Use Change and International Aid in Sub-Saharan Africa." *WIDER Working Paper, No. 2013/110, WIDER, Helsinki*. 33. Accessed 15 March 2017. http://wwwwider.unu.edu/pdf.

Otsuka, K., and F. Place. 2014. "Changes in Land Tenure and Agricultural Intensification in Sub-Saharan Africa. World Institute for Development Economics Research." Working Paper, Helsinki, Finland, 051: 18.

Pan, Y., J. M. Chen, R. Birdsey, K. McCullough, L. He, and F. Deng. 2011. "Age Structure and Disturbance Legacy of North American Forests." *Biogeosciences* 8 (3): 715–732. doi:10.5194/bg-8-715-2011.

Patra, B., S. K. Dey, and M. T. Das. 2015. "Forest Management Practices for Conservation of Biodiversity : An Indian Perspective." *International Journal of Environmental Biology* 5 (4): 93–98.

Quintas-Soriano, C., A. J. Castro, H. Castro, and M. García-Llorente. 2016. "Impacts of Land Use Change on Ecosystem Services and Implications for Human Well-Being in Spanish Drylands." *Land Use Policy* 54: 534–548. doi:10.1016/j.landusepol.2016.03.011.

Raburu, P. O., and F. Kwena. 2012. *Community-Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya*, 45. Nairobi, Kenya: McDowell Media Limited.

Rautiainen, A., T. Virtanen, and P. E. Kauppi. 2016. "Environmental Science and Policy Land Cover Change on the Isthmus of Karelia 1939 – 2005 : Agricultural Abandonment and Natural Succession." *Environmental Science and Policy* 55: 127–134. doi:10.1016/j.envsci.2015.09.011.

Reeves, P. N., and P. D. Champion. 2004. "Effects of Livestock Grazing on Wetlands: Literature Review. Environment Waikato Technical Report 2004/6." *Hamilton East: Volume 2. No. 928468*. 27. Accessed 15 March 2017. https://www.waikatoregion.govt.nz/pdf

Ryan, C. M., R. Pritchard, I. McNicol, M. Owen, J. A. Fisher, and C. Lehmann. 2016. "Ecosystem Services from Southern African Woodlands and their Future Under Global Change." *Phil Transactions R Social* 371: 1–16. doi:10.1098/rstb.2015.0312.

Santha, S. D. 2015. "Coastal Resources, Ecosystem Services and Disaster Risk Reduction; An Analysis of Social and Environmental Vulnerability along the Coast of India." *Global Assessment Report on Disaster Risk Reduction 2015*. 120. Accessed 27 May 2017. http://www.preventionweb.net/pdf

Schmidt, J. P., R. Moore, and M. Alber. 2014. "Integrating Ecosystem Services and Local Government Finances into Land Use Planning: A Case Study of Coastal Georgia." *Landscape and Urban Planning* 122: 56–67. doi:10.1016/j.landurbplan.2013.11.008.

Scull, P., C. L. Cardelus, P. Klepeis, C. L. Woods, A. Frankl, and J. Nyssen. 2017. "The Resilience of Ethiopian Church Forests: Interpreting Aerial Photographs, 1938-2015." *Land Degradation & Development* 28 (2): 450–458. doi:10.1002/ldr.2633.

Sloan, S., and J. A. Sayer. 2015. "Forest Resources Assessment of 2015 Shows Positive Global Trends but

Forest Loss and Degradation Persist in Poor Tropical Countries." *Forest Ecology and Management* 352: 134–145. doi:10.1016/j.foreco.2015.06.013.

Smail, R. A., and D. J. Lewis. 2009. "Forest-Land Conversion, Ecosystem Services, and Economic Issues for Policy: a Review." Portland, OR: U.S. Dept. of Agriculture, Forestry Services, Pacific Northwest Research Station-797, 40. Portland.

Smith, P., M. Bustamante, H. Ahammad, H. Clark, H. Dong, and E. A. Elsiddig. 2014. "Agriculture, Forestry and Other Land Use (AFOLU)." In *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the IPCC*, edited by O. Edenhofer, R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, and K. Seyboth, 811–922. United Kingdom and New York, NY, USA: Cambridge University Press, Cambridge.

Song, X. P., C. Huang, J. O. Sexton, S. Channan, and J. R. Townshend. 2014. "Annual Detection of Forest Cover Loss Using Time Series Satellite Measurements of Percent Tree Cover." *Remote Sensing* 6 (9): 8878–8903. doi:10.3390/rs6098878.

Sonneveld, B. G. J. S., M. A. Keyzer, and D. Ndiaye. 2016. "Quantifying the Impact of Land Degradation on Crop Production: The Case of Senegal." *Solid Earth* 7 (1): 93–103. doi:10.5194/se-7-93-2016.

Szuster, B. W., Q. Chen, and M. Borger. 2011. "A Comparison of Classification Techniques to Support Land Cover and Land Use Analysis in Tropical Coastal Zones." *Applied Geography* 31 (2): 525–532. doi:10.1016/j.apgeog.2010.11.007.

Tang, Z., C. Shi, and K. Bi. 2014. "Impacts of Land Use and Land Cover Change on Ecosystem Service Values in Maqu County." *Environmental Science and Management* 13 (10): 2697–2705.

Temesgen, H., and W. Wei. 2018. "Farmers ' Value Assessment of Sociocultural and Ecological Ecosystem Services in Agricultural Landscapes." *Sustainability* 10 (703): 1–18. doi:10.3390/su10030703.

Temesgen, H., W. Wu, X. Shi, and E. Yirsaw. 2018. "Variation in Ecosystem Service Values in an Agroforestry Dominated Landscape in Ethiopia : Implications for Land Use and Conservation Policy." *Sustainability* 10: 1–20. doi:10.3390/su10041126.

Thompson, J. R., K. F. Lambert, D. R. Foster, E. N. Broadbent, M. Blumstein, A. M. A. Zambrano, and Y. Fan. 2016. "Four Land-Use Scenarios and their Consequences for Forest Ecosystems and Services they Provide." *Ecosphere* 7: 1–22. doi:10.1002/ecs2.1469.

UNEP. 2015. "The Economics of Land Degradation in Africa, ELD Initiative." 155. Bonn, Germany, Accesed 17 May 2018. www.eld-initiative.org/pdf

URT. 2014. "The United Republic of Tanzania Basic Demographic and Socioeconomic Profile Report: Tanzania Mainland." *National Bureau of Statistics, Dar es Salaam, Tanzania*, 245. Accessed 15 June 2017. https://www.tanzania.go.tz/pdf

URT. 2015. "National Forest Resources Monitoring and Assessment of Tanzania Mainland; Ministry of Natural Resources and Tourism, Tanzania Forest Services Agency in Collaboration with the Government of Finland and Food and Agriculture Organization (FAO) of the United Nation." 37. Dar es Salaam, Tanzania, Accessed 15 July 2017. http://www.fao.org/forestry/pdf.

URT. 2016. Tanzania in Figures, National Bureau of Statistics, Dar es Salaam, Tanzania." 106. Accessed 15 January 2017. http://www.nbs.go.tz/pdf.

Van der Esch, S., B. T. Brink, E. Stehfest, M. Bakkenes, A. Sewell, and A. Bouwman. 2017. *Exploring Future Changes in Land Use and Land Condition and the Impacts on Food, Water, Climate Change and Biodiversity: Scenarios for the Global Land Outlook*, 116. The Hague: PBL Netherlands Environmental Assessment Agency. Accessed 15 March 2017. http://www.pbl.nl/pdf

Van der Ploeg, S., R. S. De Groot, and Y. Wang. 2010. *The TEEB Valuation Database: Overview of Structure, Data and Results*, 63. Wageningen, The Netherlands: Foundation for Sustainable Development.

van Hoof, L., and M. Kraan. 2017. "Mission Report Tanzania; Scoping Mission Marine Fisheries in Tanzania." 66. Wageningen. Accessed15 June 2017. http://wwwlibrary.wur.nl/WebQuery/wurpubs/516617/pdf.

Warinwa, F., F. Mwaura, and J. Kiringe. 2016. "Land Cover Dynamics in the Kirisia Forest Ecosystem, Samburu County, Kenya." *Advances in Remote Sensing*, (5): 168–182. doi:10.4236/ars.2016.53014.

Willcock, S., D. Hooftman, N. Sitas, P. O. Farrell, M. D. Hudson, B. Reyers, and J. M. Bullock. 2016. "Do Ecosystem Service Maps and Models Meet Stakeholders' Needs? A Preliminary Survey Across Sub-Saharan Africa." *Ecosystem Services* 18: 110–117. doi:10.1016/j.ecoser.2016.02.038.

Wu, K., X. Ye, Z. Qi, and H. Zhang. 2013. "Impacts of Land Use and Land Cover Change and Socioeconomic Development on Regional Ecosystem Services : The Case of Fast-growing Hangzhou Metropolitan Area, China." *Cities* 31: 276–284. doi:10.1016/j.cities.2012.08.003.

Xu, X., Y. Guishan, T. Yan, T. Xuguang, J. Hong, S. Xiaoxiang, Z. Qianlai, and L. Hengpeng. 2017. "Impacts of Land Use Changes on Net Ecosystem Production in the Taihu Lake Basin of China from 1985 to 2010." *Journal of Geophysical Research* 122 (3): 690–707.

Yirsaw, E., W. Wu, H. Temesgen, and B. Bekele. 2016. "Effect of Temporal Land Use and Land Cover Changes on Ecosystem Services Value in Coastal Area of China : The Case of Su-Xi-Chang Region." *Applied Ecology and Environmental Research* 14 (3): 409–422. doi:10.15666/aeer/1403_409422.

Yirsaw, E., W. Wu, X. Shi, H. Temesgen, and B. Bekele. 2017. "Land Use and Land Cover Change Modeling and the Prediction of Subsequent Changes in Ecosystem Service Values in the Coastal Area of China, the Su-Xi-Chang Region." *Sustainability* 9: 1–17. doi:10.3390/su9071204.

Zhang, W., A. Liao, S. Peng, X. Zheng, and M. Li. 2015a. "Check and Modification of GlobeLand30 with MODIS NDVI." In *SPIE 9675, AOPC: Image Processing and Analysis*, edited by H. L. C. Shen and W. Yang, 22. China: National Geomatics Center of Beijing.

Zhang, Y., L. Zhao, J. Liu, Y. Liu, and C. Li. 2015b. "The Impact of Land Cover Change on Ecosystem Service Values in Urban Agglomerations Along the Coast of the Bohai Rim, China." *Sustainability* 2015 (7): 10365–10387. doi:10.3390/su70810365.

Zhao, B., U. Kreuter, B. Li, Z. Ma, J. Chen, and N. Nakagoshi. 2004. "An Ecosystem Services Value Assessment of Land-Use Change on Chongming Island." *China. Land Use Policy* 21: 139–148. doi:10.1016/j.landusepol.2003.10.003.

Zhou, J., L. Sun, S. Y. Zang, K. Wang, J. Y. Zhao, Z. X. Li, and X. R. Liu. 2017. "Effects of the Land Use Change on Ecosystem Service Values." *Global Journal of Environmental Science and Management* 3 (2): 121–130.