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Assessment of Forest Cover Change under Different Forest Tenure Regimes in *Ngitili* Management Systems in Meatu District, Tanzania

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ABSTRACT

Deforestation and forest degradation are tied to a complex array of socioeconomic and political factors. Quantifying the amount of amount of forest is key to ensure that appropriate management practices and policies are in place to combat deforestation and forest degradation. Despite the fact that forestland tenure changes from private and communal to state ownership occurred in *Ngitili* management systems in Meatu district Tanzania, little has been done to evaluate its impacts on forest cover. The objective of this study was to assess the forest cover changes under different tenure regimes in *Ngitili* management system. Landsat imagery of 1986 and 2000 were used in this study and data were analyzed using QGIS software. Results show that open land, grassland, bushland and open forest were the dominant forest classes under private and communal tenure regime while semi closed forest dominated most of the *Ngitili* area under the state tenure regime. The study concludes by supporting the alternative hypothesis that, forest land tenure changes have significant impacts on forest cover. The study recommends that, a study is needed to assess the impact of devolution which occurred in 2002 on forest cover change.

Key words: *Ngitili* - private and state tenure – deforestation - HASHI.

INTRODUCTION

Forests support the flow of essential ecosystem services such as animal fodder, fibre, energy, recreation, biodiversity, carbon storage and flux and water (Mauya *et al.* 2019, Manyanda *et al.* 2021). Efforts to maintain and/or enhance ecosystem services must start with a clear understanding of the forest land base that provides these services and how that land base is changing. Quantifying forest extent and change in forest extent that are caused by deforestation and forest degradation are important in environmental research, monitoring and designing appropriate responses that would reduce anthropogenic impacts on the environment (Estoque and Murayama 2015, Briassoulis 2019, Agyemang-Duah *et al.* 2021).

Remote sensing (RS) and Geographical Information System (GIS) technologies are useful for providing land change information in forest landscape to inform policymakers about the pattern of forest change (Kusimi 2015, Oduro Appiah and Agyemang-Duah 2021). RS and GIS have been successfully used in many locations in Tanzania and elsewhere to measure land change (Singh 1999, Kashaigili and Majaliwa 2010, Kusimi 2015, Kpienbaareh and Oduro Appiah 2019, Oduro Appiah *et al.* 2021).

Tanzania mainland is endowed with vast forest resources with an estimated total forest area of 48.1 million hectares (ha) representing 54.4% of the total land area of 88.3million ha. Miombo woodlands occupy most of the forest area, which cover 93% of the total forest area (URT 2015). The rest are lowland, humid montane, mangrove and plantation forest which cover 3.4%, 2.1%, 0.3% and 1.2% of total forest area respectively (URT 2015). However, forest

and woodlands in Tanzania are threatened by deforestation and forest degradation (Mauya *et al.* 2019, Manyanda *et al.* 2021). The extent of deforestation and or forest degradation depend much on the tenure regimes underlying a forest (Manyanda *et al.* 2021). Tenure rights encompasses operational level property rights that include access rights and withdrawal right (Zahabu *et al.* 2009). Access right means the right to go into a defined physical property for example forestland and make non-subtractive uses and withdrawal rights that are called use rights i.e., the right to obtain the "products" of a resource. Collective choice property rights include management rights (i.e., rights to transform resource and/or regulate its uses) among others (Zahabu *et al.* 2009, Kaniki *et al.* 2012). Forests and woodlands in Tanzania fall under five main categories of tenure namely Central Government, Local Government Authority, Village Government, Private and general land. Forest conditions differs significantly in each tenure type (URT 2015, Manyanda *et al.* 2020). By tenure we broadly mean who has the right to benefit from forests and who has duties to protect them (Zahabu *et al.* 2009, Kaniki *et al.* 2012, Mongo *et al.* 2014).

Of interest to this study is *Ngitili* system (dry season fodder reserves) in Meatu, a northeastern district in Simiyu region of the United Republic of Tanzania. The system involves retaining an area of standing vegetation (grasses, trees, shrubs and forbs) from the onset to the end of the rainy season. *Ngitili* area remains closed to livestock at the beginning of the wet season and is opened up for grazing at the peak of dry season. It consisted of Miombo and Acacia woodlands (Malcolm 1953). Before 1970, ownership and access rights of most *Ngitili* were governed under customary law (Otysina 1994, Kilahama 1994). However, after the introduction of villagisation programme in 1970s most *Ngitili* fell into the management of village governments. Most of the private *Ngitili* collapsed in some villages in Meatu district because of the socialism notion of "*land is a common property*" (Monela *et al.* 2004). This institutional failure resulted into serious environmental degradation forcing many people to leave the region in search of better grazing land for their livestock.

The Government of Tanzania through the Ministry of Natural Resources and Tourism (MNRT) introduced a soil conservation project known as Hifadhi Ardhi Shinyanga (HASHI) in 1986 to combat massive deforestation and forest degradation in the region. HASHI was introduced mainly to restore forest cover in the land area which had been so degraded including the area under communal and private *Ngitili* in Meatu District Simiyu region. It is estimated that between 350 000 and 500 000 ha of woodlands were restored in the period from 1986 to 2001 (Kaale *et al.* 2002). Despite the intervention by the state through HASHI programme in combating deforestation and forest degradation in *Ngitili* management systems, no study has been done to assess forest cover under different tenure regime. Available studies (Barrow and Mlenge 2003; Barrow and Shah 2011 and Schuman et al. 2002) revealed on the contribution of restored trees in *Ngitili* in risk management for the pastoralist and carbon potential. Others (Kamwenda 2002; Selemani 2015) have assessed the contribution of restored *Ngitili* to the livelihood and soil characteristics. This study aimed at assessing forest cover changes underlying *Ngitili* management system under different tenure regimes. With this objective, we answer the following research questions. By how much is the quantity of forest cover increase or decrease in HASHI and non-HASHI Ngitili? Understanding forest cover change is an important component when addressing sustainability concerns. The information would contribute in filling the existing knowledge gap on the changes in forest cover brought by the forestland tenure changes in *Ngitili* management systems under different tenure regimes i.e., under HASHI and without HASHI. Furthermore, to gain analytical traction for our study we provide the null hypothesis as "there is no forest cover recovery in *Ngitili* under HASHI

and without HASHI *Ngitili* while the alternatives hypothesis is also true.

METHODS AND MATERIALS

Study area

The study was conducted in *Ngitili* of Meatu District, Simiyu Region Tanzania (Fig. 2). Meatu District covers a total of 8,871 km^2 (URT 1996) and is located within a semi-arid zone between latitude 3^o and 4^o south and longtude34^{o}8' and 34^o 49' east. Between October and May the district have high, erratic, unpredictable rainfall, with two minor seasonal peaks in December and March to April (URT 1996, Otysina and Asenga 1993). The major soil types found in the district include: *ferric luvisols*, *Acrisols* and chromic *cambisols*. In low lying areas often referred as "mbugas", black grey clays or *vertisols* are found. The native vegetation of Simiyu is composed of shrubs (4 to 6 m high), often thorny and usually deciduous, and trees reaching up to 10 to 15m. The herbaceous layer that occupies the open spaces suffers severe livestock grazing pressure. Important species found in the district are *Brachystegia, Julbenardia, Isoberlinia, Combretum collinum, Baikea spp., Lonchocarpuscapasa, Azanza garkeana, Albizia spp. and Dalbergia melanoxylon*. Acacia wood-lands consist mostly of *Acacia tortilis, A.nilotica and A. polyacantha,* while other important species in this agropastoral land include *Adansonia digitata and Tamarindus indica* (Kamwenda 1999).The population of Meatu is dominated by the Wasukuma tribe, who are traditionally agropastoralists. Economic activities in the area include cultivation of food and cash crops, cattle rearing and mining Maro 1995).

Figure 1: Map of Simiyu region showing location of Meatu district (*Source*: https://meatudc.go.tz>district- profile)

The district has high evapotranspiration rates with erratic rainfalls (URT 1996). It receives uni-modal rainfall of 600-800 mm per annum and is mainly in mid-November through mid-May (MNTE 1995). Minimum and maximum temperatures are 26.8 and 33.6^{o}C respectively. Altitude varies between 1000 and 1500m above sea level with detached hill and grassy "mbuga" (URT 1996). The natural vegetation of Meatu district was originally woodlands on unreserved land (Mlenge 2002). However, it gradually reverted to an open bush savanna characterized by short grasses with scattered shrubs (4-6m high) and trees that are dominated by *Acacia* species mainly *Acacia tortilis, polycantha, nilotica, drepanolobium and Senegal* (Otysina 1994, Otysina and Asenga 1993, Otysina and Ng'atigwa 2003).

Data collection

Landsat images were collected from the website of United States Geological Survey (USGS) Earth Explorer. We considered one period i.e., the period from 1986 to 2000. For this period two data sets were derived from Low Resolution Landsat Thematic Mapper (TM) imagery for 1986 and High-Resolution Thematic Mapper (TM) imagery for 2000 both provides 30 by 30 m spatial resolution images (Table 1). Landsat image of 1986 was collected to aid the determination of the forest cover of the "*Ngitili*" under the private and communal in the absence of HASHI. Likewise, Landsat image of 2000 was selected to determine the forest cover of the *Ngitili* under the state with HASHI. Even though images higher in spatial resolution than 30 by 30 m could have been used in this study, the Landsat images are still suitable for a study to assess forest cover changes in the forest ecosystem and have been used in several studies in more complicated landscapes than the *Ngitili* management system (Basommi *et al.* 2015; Acheampong *et al.* 2018). Using the Global positioning system (GPS) receiver, 98 waypoints of different places were recorded for serving as training sites during image analysis. Moreover, topographical sheet of 1972 was collected to supplement the evaluation of forest cover in *Ngitili* management systems before HASHI tenure change (Table1).

Table 1: Spatial data collected for forest cover changes detection

S/No.	Data type	Path/row	Acquisition date	Spatial resolution
1.	Landsat TM	169/63	1986	30 x 30 m
2.	Landsat ETM^{+}	169/63	2000	30 x 30 m
3	Topographic sheets	-	1972	-

Data analysis

The images were pre-processed and then analyzed using QGIS 3.22.4 software. The analysis followed two steps: satellite imagery interpretation which involved image processing and image classification and second, change detection analysis was done involving assessment of the rate of change. Image processing involved image pre-processing, image rectification/geo-referencing and image enhancement. The images were geo-referenced to be as close as to the real-world coordinate system. Enhancement usually reinforces the visual interpretation of the images. False colors composites were created by combining images (bands) captured at different wavelengths to enable better visualization of vegetation, soil, water bodies and settlement in the landscape (Kashaigili 2006). Image classification followed in which it involved both visual and digital image classification approaches.

We classified the Landsat images into five classes i.e., open land, grass land, bushland, open forest and semi closed forest based on field observation in the *Ngitili* landscape and visual inspection of the Landsat and Google Earth Pro-images.

The contrast stretch, spatial filtering, and colour composite image enhancement techniques were used for visual image interpretation. Through visual interpretation, features showing change in vegetation were extracted. Supervised image classification using maximum likelihood classifier was performed in QGIS software. Training fields were identified by inspecting enhanced colour composite bands 4, 5 and 3.

On top of that, change detection analysis involved the ability to quantify temporal effects using multi temporal data sets (Singh 1999). This study used post classification change detection approach where two images from different dates were classified and labeled and the area of change extracted through the direct comparison of the classification results (Mbilinyi 2000, Kashaigili *et al.* 2006). The imageries of 1986 and 2000 were analyzed and the

detection of forest cover was carried. Moreover, forest cover maps for 1986 and 2000 were developed containing the identified forest cover classes. Finally, the estimation for the rate of change for the different covers was computed based on the formulae (Kashaigili 2006):

$$\%\ Cover\ change\ = \frac{Cover\ area_t - Cover\ area_{t+1}}{Cover\ area_t}\ x\ 100\% \quad [1]$$

$$Annual rate\ of\ area change = \frac{Cover\ area_t - Cover\ area_{t+1}}{t_{years}} \quad [2]$$

$$\%\ Annual rate of\ area change = \frac{Cover\ area_t - Cover\ area_{t+1}}{Cover\ area_t * t_{years}}\ x\ 100\% \quad [3]$$

Where:

$Cover\ area_t$ = area of cover at the first date,
$Cover\ area_{t+1}$ = area of cover at the second date, and
t_{years} = the difference in years between the first and second scene acquisition dates
.

RESULTS

Impacts of forestland tenure changes from private to state under HASHI on forest cover

In this category two *Ngitili* i.e., Mwamishali and Peri urban 1 were analyzed to provide an understanding of the forest cover changes pathways. Forest cover classification discriminated five classes i.e., open land, grassland, bushland, open forest and semi closed forest (Table 2, Fig. 2) for both Landsat imagery of 1986 and 2000 in the Mwamishali and Peri urban 1 *Ngitili*. Results shows that, during private tenure regime in 1986 in the *Ngitili* of Mwamishali, the open forest classes dominated the area by covering 45.43 ha (43.68%) followed by grassland 33.27 ha (31.99%), open land 18.45 (17.74) % and bushland 6.85 (6.59%) while semi closed forest was completely lacking. In 2000 when Mwamishali *Ngitili* was under state tenure regime i.e., HASHI programme, a reverse trend was observed in which tremendous spatial expansion in semi closed forest area was observed. The trend of this forest cover was from none existence 0.00 ha (0%) in 1986 to 65.63 ha (63.11%) in 2000 under state tenure regime (Table 2). Grassland decreased from 33.27 ha (31.99%) under private tenure regime in 1986 to 2.99 ha (21.47%) under state tenure regime in 2000. Also, open forest decreased from 45.43 ha (43.68%) under private tenure regime in 1986 to 22.33 ha (21.47%) under state in 2000. While bush land on the other hand, increased from 6.85 ha (6.59%) under private tenure regime in 1986 to 11.39 ha (10.96%) under state tenure regime in 2000 equivalent to 66.36% percentage increase. On the other hand, the forest cover map appeared to have been occupied by semi closed forest cover classes in the Mwamishali *Ngitili* under state indicating more forest cover recovery (Fig 2).

On the other hand, similar trend was observed in the *Ngitili* of Peri urban 1 where open land, grassland, bushland, open forest decreased in favour of semi closed forest class during state tenure regime. The detail on how these forest classes changed during private and state tenure regime are shown in Table 2.

Impacts of forestland tenure changes from communal to state tenure regime under HASHI on forest cover

In this category two *Ngitili* (Bulyanaga and Mwambegwa *Ngitili*) were analyzed to determine forest cover changes. Table 3 show results of areas, percentage area underlying the Bulyanaga "*Ngitili*" in 1986 and 2000 when the "*Ngitili*" was under the communal and state tenure regime

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Table 2: Cover area and the percentage change between 1986 and 2000 for Mwamishali "*Ngitili*"

Ngitili name	Forest cover classes	Private tenure regime in 1986		State tenure regime in 2000		Change area 1986-2000 (ha)	% Change	Annual rate of area change (ha/yr)	% Annual rate of change
		Area (ha)	% Coverage	Area (ha)	% Coverage				
Peri urban 1	Open land	13.72	21.89	0.31	0.49	-13.41	-97.74	-0.96	-6.72
	Grass land	11.05	17.69	0.56	0.90	-10.49	-94.93	-0.75	-6.78
	Bush land	12.83	20.47	3.09	4.93	-9.74	-75.92	-0.70	-5.42
	Open forest	25.07	40.00	8.89	14.19	-16.18	-64.54	-1.16	-4.61
	Semi closed forest	0.00	0.00	49.82	79.49	49.82	infinity*	3.56	infinity *
Mwamishali	Open land	18.45	17.74	1.65	1.59	-16.80	-91.06	-1.20	-6.50
	Grass land	33.27	31.99	2.99	2.88	-30.28	-91.01	-2.16	-6.50
	Bush land	6.85	6.59	11.39	10.96	4.54	66.28	0.32	4.73
	Open forest	45.43	43.68	22.33	21.47	-23.10	-50.85	-1.65	-3.63
	Semi closed forest	0.00	0.00	65.63	63.11	65.63	infinity*	4.69	infinity*

* division by zero

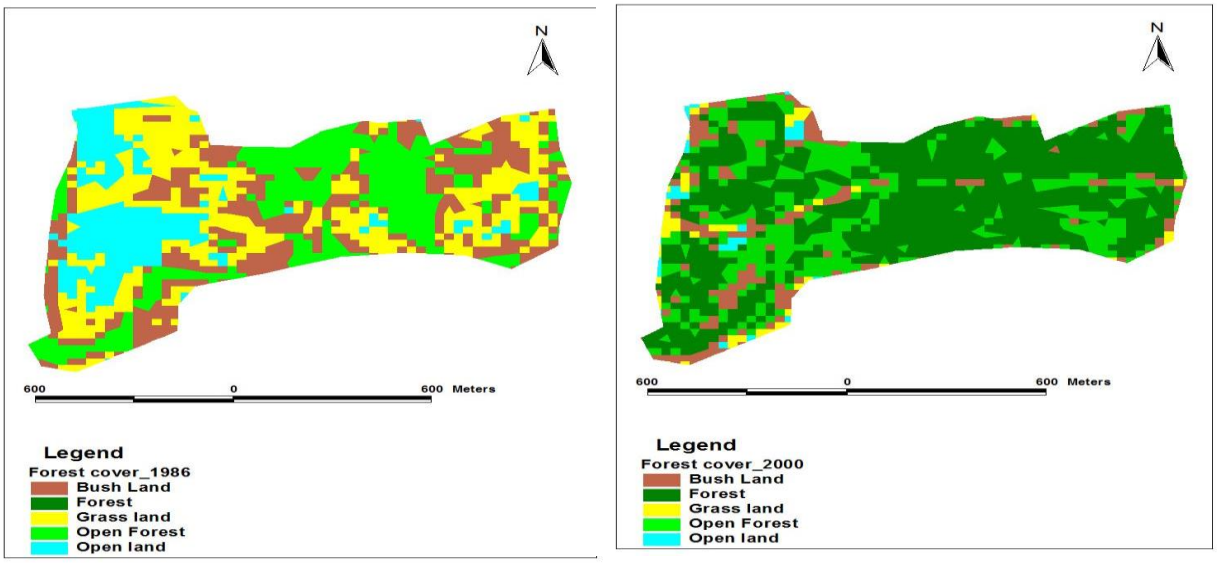

Figure 2: Forest cover change maps of Mwamishali *Ngitili* in 1986 and 2000

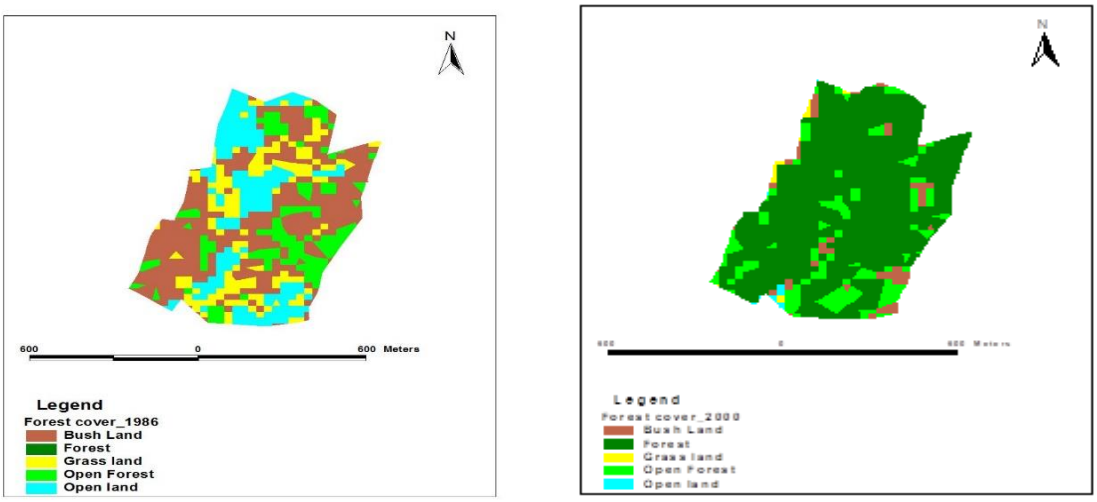

Figure 3: Forest cover maps of Peri urban 1 *Ngitili* in 1986 and 2000

respectively. Results indicate that the open land dominated the area by covering 16.33 ha (32.36%) of the total "*Ngitili*" area followed by grassland 12.21 ha (24.19%), open forest 11.45 ha (22.69%) and bushland 10.48 ha (20.76%) under communal tenure regime. However, semi closed forest dominated the area by covering 27.07Ha equivalent to 53.64% of the total area. The trend of other forest classes is also shown (Table 3).

On the other hand, Table 3 and Fig. 5 show, the results of forest cover changes and forest cover maps for Mwambegwa *Ngitili* in 1986 and 2000 when was under communal and state (HASHI) respectively. Under communal tenure regime the open forest dominated the area by 10.00ha which is equivalent to 31.25% of the total area. Other classes are indicated in the Table 3 and figure 5. Furthermore, a reverse trend was seen in 2000 when the *Ngitili* was under state (HASHI) in which semi closed forest class occupied most of the area by covering 27.25 ha equivalent to 85.16% of the total area of the *Ngitili*. Additionally, other forest classes occupied different degree of forest cover (Table 3).

Table 3: Cover area and the percentage change between 1986 and 2000 for Bulyanaga and Mwambegwa *Ngitili*

***Ngitili* name**	**Forest cover classes**	**Communal tenure regime in 1986**		**State tenure regime in 2000**		**Change area 1986-2000 (ha)**	**% Cover change**	**Annual rate of change (ha/yr)**	**% annual rate of change**
		Area (ha)	**% Coverage**	**Area (ha)**	**% Coverage**				
Bulyanaga	Open land	16.33	32.36	1.03	2.04	-15.3	-0.94	-1.09	-6.69
	Grass land	12.21	24.19	2.46	4.87	-9.75	-0.80	-0.70	-5.69
	Bush land	10.48	20.76	6.83	13.53	-3.65	-0.35	-0.26	-2.49
	Open forest	11.45	22.69	13.08	25.92	1.63	0.14	0.12	1.02
	Semi closed forest	0.00	0.00	27.07	53.64	27.07	infinity*	1.93	infinity*
Mwambegwa	Open land	6.22	19.44	0.40	1.25	-5.82	-93.57	-0.42	-6.68
	Grass land	6.59	20.59	0.29	0.91	-6.3	-95.59	-0.45	-6.83
	Bush land	9.19	28.72	1.87	5.84	-7.32	-79.65	-0.52	-5.69
	Open forest	10.00	31.25	2.19	6.84	-7.81	-78.10	-0.56	-5.58
	Semi closed forest	0.00	0.00	27.25	85.16	27.25	infinity*	1.95	infinity*

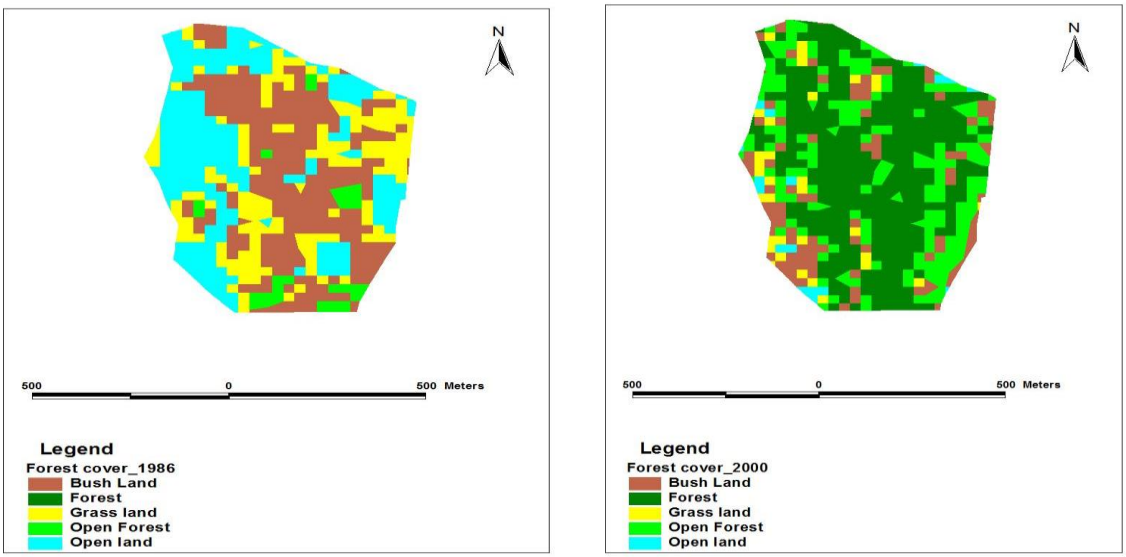

Figure 4: Forest cover maps of Bulyanaga *Ngitili* in 1986 and 2000

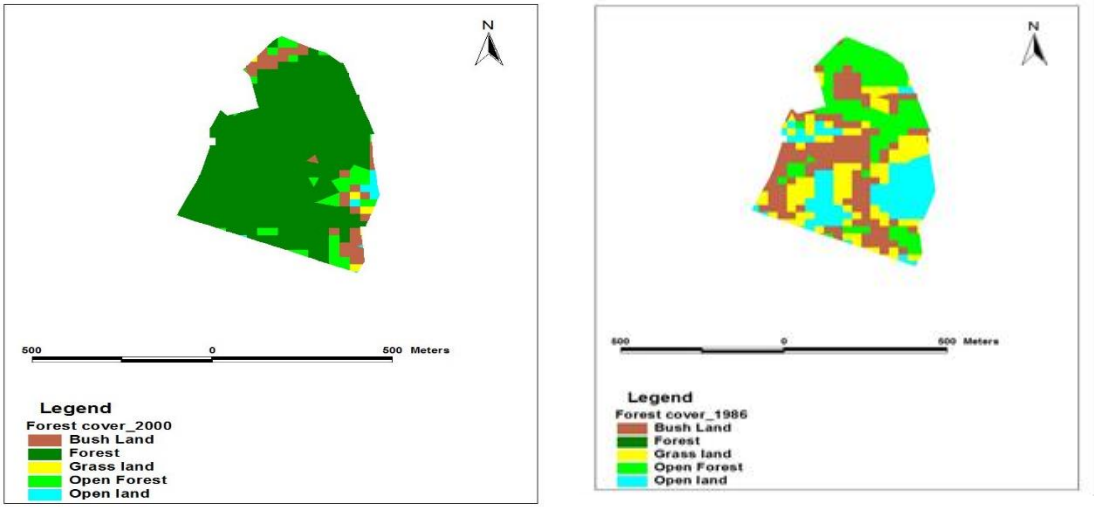

Figure 5: Forest cover maps of Mwambegwa *Ngitili* in 2000 and 11986

DISCUSSION

Forest tenure regimes in *Ngitili* management systems was mainly brought about by the introduction of HASHI project. The HASHI project was launched by the Government of Tanzania to reverse severe and alarming land degradation that faced Shinyanga region and which made the first president of the united republic of Tanzania, the late President J.K Nyerere to nickname the region as the desert of Tanzania. Four *Ngitili* namely: Mwamishali, Peri urban 1, Mwambegwa and Bulyanaga were analyzed to determine the change of forest cover in *Ngitili* before HASHI and after HASHI. Two *Ngitili* (Mwamishali and Peri urban 1) were selected to determine changes in forest cover in *Ngitili* under the private and state regime before and after HASHI while Bulyanaga and Mwambegwa *Ngitili* were selected to determine forest cover changes under communal and state before and after HASHI. The selection was done to provide an understanding of which tenure regime could provide a better forest cover condition.

Impacts of forestland tenure changes from private to state under HASHI on forest cover. Forest cover classification discriminated five classes for the year 1986 and 2000 in *Ngitili* of Mwamishali and Peri urban 1. For the year 1986 the identified forest covers were: open land, grassland, bushland, open forest and semi closed forest (forest). The same classes were used for 2000. During private tenure regime in 1986, the open forest dominated the area, and bushland followed while semi closed forest was completely lacking in the *Ngitili* of Mwamishali and Peri urban 1. This suggest massive forest degradation happed when *Ngitili* were under the private management regime. Shifting cultivation, tsetse flies and *Quellea quellea* control campaigns and extensive grazing, have been cited as direct drivers to the forests in the *Ngitili* ecosystems (MNRE 1995, Kamwenda 1999). Until recently, athropogenic activities are the main drivers of forest degradation in most forest and woodlands in most of the countries in the tropic (Kusimi 2015, Snapir *et al*. 2017, Lambini and Nguyen 2014, Sobeng et al. 2018, Manyanda *et al*. 2021).

In 2000 when Mwamishali and Peri urban 1 *Ngitili* were under state tenure regime a reverse trend was observed in which spatial expansion in semi closed forest area was observed. The trend of this forest cover was from none existence in 1986 to the noticeable higher increase in semi closed forest in 2000 under state tenure regime. Assuming a constant increase in semi closed forest cover, the annual rate of change was estimated at 4.69ha per year. This indicates that semi closed forest increased significantly in the state tenure regime under HASHI. Furthermore, the increase in the semi closed

forest cover suggests that there was no disturbance in the *Ngitili* after the tenure change. Interestingly, there was a rapid decrease of open land during state tenure regime which was almost 11 times less of what was observed in 1986 under private tenure regime. Grassland and open forest decreased while bushland increased suggesting forest cover recovery under state tenure regime in 2000. The decrease of open land, grassland and open forest favored semi closed forest cover in the *Ngitili* area. The state interventions through HASHI programme could explain the forest cover recovery that was observed in the *Ngitili* management systems in 2000. The interventions could have confronted drivers for deforestation and forest degradation in *Ngitili* that was previously taking out forest products. Robinson et al (2011) and Mpanda *et al* (2011) found similar findings by suggesting that state-owned protected forests are associated with more positive forest outcomes relative to private and communal land. Additionally, Manyanda *et al* (2020) reported low level of volume removals in the state-owned woodlands compared to private and communal ownership suggesting better management.

Impacts of forestland tenure changes from communal to state tenure regime under HASHI on forest cover.

In this category two *Ngitili* i.e., Bulyanaga and Mwambegwa were analyzed to determine forest cover changes. In 1986 when Bulyanaga and Mwambegwa *Ngitili* were under the communal tenure regime, forest cover changes detection indicated that, open land dominated the area followed by grassland, open forest and bushland while semi closed forest did not exist. The dominance of open land cover class indicates that huge deforestation and or forest degradation characterized the area under *Ngitili*. The explanations are supported by the forest cover map of the *Ngitili* as at 1986. However, huge forest cover recovery was observed where semi closed forest cover classes dominated the area in 2000 when Bulyanaga and Mwambegwa *Ngitili* were under the state tenure regime. The substantial increases in semi closed forest cover class definitely answer the question why other cover classes i.e., open land, grassland and bushland decreased. This suggest that activities that were contributing to the degradation of the forest in the *Ngitili* were better combatted during the state regime (Kamwenda 1999).

CONCLUSION

The change in forest tenure i.e., from private and communal to state under HASHI in *Ngitili* management systems had positive impact in term of forest cover recovery. The study found that forest cover changed tremendously from open land, grass land, open forest and bushland forest classes that were seen in the private and communal tenure regime to semi closed forest which occupied most of the *Ngitili* areas under state tenure. This indicate that state (HASHI) had a better strategy in managing *Ngitili* compared to when *Ngitili* were under the management of the community and private. In order to ensure sustainable harvesting from these well restored *Ngitili* therefore, the search for livelihoods should be done more sustainably to prevent the future cost of reclaiming degraded forests in *Ngitili* ecosystem. Moreover, since various products are being accrued from *Ngitili* as the results of tenure changes, economic analysis of the products need to be addressed. Moreover, Participatory Forest Management (Community based forest management in particular) should be applied in *Ngitili* management in order to control deforestation and forest degradation while observing livelihood of the people.

REFERENCES

Acheampong, M., Yu, Q., Enomah, L.D., Anchang, J. & Eduful, M. 2018. Land use/cover change in Ghana's oil city: assessing the impact of neoliberal

economic policies and implications for sustainable development goal number one-a remote sensing and GIS approach. Land Policy 73: 373–384.

Barrow, E. & Shah, A. 2011. Restoring Woodlands, Sequestering Carbon and Benefiting Livelihoods in Shinyanga, Tanzania. Economic of ecosystem and biodiversity. [http://www.teebweb.org] accessed on 11th September, 2022.

Barrow, E. & Mlenge, W. 2003. Trees as key to pastoralist risk management in semi-arid landscapes in Shinyanga, Tanzania and Turkana, Kenya. The International Conference on Rural Livelihoods, Forests and Biodiversity, Bonn, Germany. 15p.

Basommi, P.L., Guan, Q. & Cheng, D. 2015. Exploring land use and land cover change in the mining areas of Wa East District, Ghana using satellite imagery, Op. Geosci, 7 (1): 618–626.

Estoque, R.C. & Murayama, Y. 2015. Intensity and spatial pattern of urban land changes in the megacities of Southeast Asia. Land policy 48: 213–222.

Kaale, B., Mlenge, W. & Barrow, E. 2002. The potential of *Ngitili* for forest landscape restoration in Shinyanga Region – a Tanzania case study. Paper for the International Expert Meeting on Forest Landscape Restoration, San José, Costa Rica, 27-28 February 2002.

Kamwenda, G.J. 2002. *Ngitili* agrosilvipastoral systems in the United Republic of Tanzania. Unasylva 53, 46-50.

Kamwenda, G.J. 1999. Analysis of *Ngitili* as a traditional silvopastoral technology among the Agropastoralists of Meatu, Shinyanga Tanzania. Dissertation for Award of Master of Science Degree at Sokoine University of Agriculture, Morogoro, Tanzania.

Kaniki, H.N., Kajembe, G.C., Zahabu, E., Katani, J.Z. & Eid, T. 2012. Role of communal and private forestland tenure regimes in regulating forest ecosystem goods and services in Rombo District, Tanzania. Tanzania Journal of Forestry and Nature Conservation, 82 (1): 650-662.

Kashaigili, J.J. & Majaliwa, A.M. 2010. Integrated assessment of land use and cover changes in the Malagarasi river catchment in Tanzania. Physics and Chemistry of the Earth 35, 730–741.

Kashaigili, J.J. 2006. Land covers dynamics and hydrological functioning of wetlands in the Usangu Plains, Tanzania. PhD Thesis, Sokoine University of Agriculture, Morogoro.

Kilahama, F.B. 1994. Trees and indigenous Ecological knowledge about Agroforestry practices in the rangelands of the Shinyanga region, Tanzania, Unpublished PhD Thesis, University of Wales, Bangor pp-178.

Kpienbaareh, D. & Oduro Appiah, J. 2019. A geospatial approach to assessing land change in the built-up landscape of Wa Municipality of Ghana. Geogr. Tidsskr. Dan. J. Geogr, 119 (2): 121–135.

Kusimi, J.M. 2015. Characterizing land disturbance in Atewa range forest reserve and buffer zone. Land Policy 49, 471–482.

Lambini, C.K. & Nguyen, T.T. 2014. A comparative analysis of the effects of institutional property rights on forest livelihoods and forest conditions: evidence from Ghana and Vietnam. For. Policy Econ. 38, 178–190.

Malcolm, D.W. 1953. Sukumaland, an African people and their Country: A study on land use in Tanzania. OUP, London.

Manyanda, B.J., Nzunda, E.F., Mugasha, W.A. & Malimbwi, R.E. 2020a. Estimates of volume, and carbon removals in Miombo woodlands of

mainland Tanzania. International Journal of Forest Research, 4043965, 1–10.

Manyanda, B.J., Nzunda, E.F., Mugasha, W.A. & Malimbwi, R.E. 2021. Effects of drivers and their variations on the number of stems and aboveground carbon removals in miombo woodlands of mainland Tanzania. Carbon Balance and Management 16, 16.

Maro, R.S. 1995. In-situ Conservation of Natural Vegetation for sustainable production in Agropastoral system. A case study of Shinyanga, Tanzania. MSc Thesis submitted at the Norway Agricultural University. pp.119.

Mauya, E.W., Mugasha, W.E., Njana, M. A., Zahabu, E. & Malimbwi, R.E. 2019. Carbon stocks for different land cover types in Mainland Tanzania. Carbon Balance and Management, 14, 4–12.

Mbilinyi, B.P. 2000. Assessment of land degradation and its consequences: Use of Remote sensing and Geographical Information System techniques. A case study of Ismani Division, Iringa Region, Tanzania. A PhD Thesis, Berlin Technical University, Berlin.156p.

Meatu District Council. "LGA". [https://meatudc.go.tz>district-profile-maps] Accessed on 12 March 2022.

Mlenge, W. 2002. Revival of customary landscape in Shinyanga Region, Tanzania. Forests, Trees and People 45: 21-28.

MNTE. 1995. HASHI phase II Programme report 1996/1997. Ministry of Tourism, Natural resource and Environment, Forest and Beekeeping department Dar –es-salaam Tanzania p 95.

Monela, G.C., Chamshama, S.A.O., Mwaipopo, R. & Gamassa, D.M. 2004. A Study on the Social, Economic and Environmental Impacts of Forest Landscape Restoration in Shinyanga Region, Tanzania.

Mongo, C., Eid, T., Kashaigili, J.J., Malimbwi, R.E., Kajembe, G.C. & Katani J. 2014. Forest cover changes, stocking and removals under different decentralised forest management regimes in Tanzania. Journal of Tropical Forest Science, 26(4): 484–494.

Mpanda, M.M., Luoga, E.J., Kajembe, G.C. & Eid, T. 2011. Impact of forestland tenure changes on forest cover, stocking and tree species diversity in Amani Nature Reserve, Tanzania. Forests, Trees and Livelihoods 20, 215-230.

Oduro Appiah, J. & Agyemang-Duah, W. 2021. Identifying spatially-explicit land use factors associated with forest patch sizes in a forest reserve in Ghana. Land Use Policy 101, 1–10.

Oduro Appiah, J., Kpienbaareh, D. & Adomako, J.A.A. 2021. Built-up area expansion in the Wa Municipality of Ghana: implications for vegetation cover loss and fragmentation. African Geog. Rev. 1–10.

Otsyina, R. 1994. Traditional natural resource management and Agroforestry in Sukumaland. Paper presented to ICE course on Natural Resource Management 23 Feb.-30 May 1994, SUA, Morogoro, Tanzania. 14 p.

Otysina, P. & Ng'atigwa, C. 2003. *Ngitili* Fodder Banks for the dry season: Arid Lands Information Network for International Centre for Agroforestry Research, Nairobi. 3p.

Otysina, R. & Asenga, D. 1994. Potential of *Ngitili* as a traditional Agroforestry system among the Sukuma of Tanzania. ICRAF Agroforestry research project, Shinyanga (Unpublished) 20p.

Robinson, B.E., Holland, M.B. & Naughton-Treves, L. 2011. Does secure land tenure save forests? A review of the relationship between land tenure and tropical deforestation. CCAFS Working Paper no. 7. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark.

Schuman, G.E., Janzen, H.H. & Herrick, J.E. 2002. Soil carbon dynamics and potential carbon sequestration by rangelands. Environmental Pollution, 116 (3): 391-396.

Selemani, I.S. 2015. Influence of *Ngitili* management on vegetation and soil characteristics in semi-arid Sukumaland, Tanzania. Livestock Research for Rural Development, 27(37): 213-225.

Singh, A. 1999. Digital Change Detection Techniques Using Remotely Sensed Data. International Journal of Remote Sensing, 10(6):989-999.

Snapir, B., Simms, D.M. & Waine, T.W. 2017. Mapping the expansion of galamsey gold mines in the cocoa growing area of Ghana using optical remote sensing. Int. J. Appl. Earth Obs. Geoinf, 58, 225–233.

Sobeng, A.K., Agyemang-Duah, W., Thomas, A. & Oduro Appiah, J. 2018. An assessment of the effects of forest reserve management on the livelihoods of forest fringe communities in the Atwima Mponua district of Ghana. For. Tr. Livelihoods, 27 (3): 158–174.

URT. 1996. Hifadhi Ardhi Shinyanga (HASHI)/ICRAF Agroforestry Research Project Evaluation Report, MNRT, Dar es Salaam.

URT. 2015. National Forest Resources Monitoring and Assessment of Tanzania mainland (NAFORMA). Main results. 106p.

Zahabu, E., Eid, T., Kajembe, G.C., Mbwambo, L., Mongo, C., Sangeda, A.Z., Malimbwi, R.E., Katani, J.Z., Kashaigili, J.J. & Luoga, E.J.2009. Forestland tenure systems in Tanzania: Overview of policy changes in relation to forest management. INA-Fagrapport No. 14, Department of Ecology and Natural Resource Management, Norwegian University of Life Sciences. 24p..