Chapter

[9]

Indigenous knowledge in forest conservation, species diversity and stocking potential: A historical perspectives of northwest Tanzania

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Abstract

The study evaluated the current status (i.e., species diversity, regeneration, and productivity) of the community forests conserved under indigenous knowledge known as Ngitili of northwest Tanzania. We conducted a field study in 10 community forests using phytosociological approaches. Quantitative data were statistically analyzed using ANOVA, while the differences between mean was checked by LSD at $p < 0.05$ using SPSS software. Results indicated that, out of 10 surveyed community forests, 4 were highly threatened (40 %), 5 were highly disturbed (51 %), while 1 (9 %) was converted to other land use. A total of 66 plant species belonging to 54 genera and 27 families were recorded. Biomass production varied significantly between plants ($p < 0.001$). Lack of environmental education and anthropogenic activities pose a great challenge among community forests. Therefore, appropriate management interventions are highly required to rectify the situation for the sustainability of these forests.

Keywords   Biodiversity, Deforestation, Traditional Ngitili, Kishapu-Tanzania

Introduction

The use of indigenous and traditional knowledge in forest conservation and management among communities, particularly the northwest regions of Tanzania, has been practicing even before the colonial era (Malcolm, 1953; Dery *et al.,* 1999; Barrow and Mlenge, 2003). Some pastoralist communities, such as the Sukuma, the largest ethnic group in northwest Tanzania, set aside and retaining an area of standing vegetation from the beginning of the rainy season and opening it up for grazing at the peak of the dry season (Selemani *et al.,* 2012; Cazzolla-Gatti *et al.,* 2014). Other communities practicing vegetation conservation systems include the Himba (Namibia) and the Borana (Ethiopia), and Masai (Kenya) (Selemani *et al.,* 2012; Duguma *et al.,* 2013). The community forest and vegetation conservation system in the northwest of Tanzania is locally known as "*Ngitili*" (Malcolm, 1953; Dery *et al.,* 1999; UNDP, 2012). It is one of the local and traditional vegetation conservation systems among the agro-pastoral ethnic group in the Shinyanga region of Tanzania (Otsyina *et al.,* 2008; Buckingham and Hanson, 2015). The system existed as early as even before the colonial era (Duguma *et al.,* 2019). The indigenous knowledge aims to carter acute fodder shortage by providing a good time for vegetation recovery (Barrow and Mlenge, 2003; Treue *et al.,* 2014). Apart from its prominent roles, *Ngitili* contributes to improving a given environment's ecological conditions (Jama and Zeila, 2005). The system contributes more to species diversity and ecosystem services in the region, such as climate change mitigation through enhanced carbon sequestration (Duguma *et al.,* 2019). It also provides a fundamental source of fuelwood, thatch grass, water catchment, scenic beauty, and diversification of nutrition options (e.g., fruits, vegetables, mushroom, edible insects, wild meat, medication) (Monela *et al.,* 2005; Barrow, 2014; Chirwa, 2014). Apart from forest-based ecosystem services, the system improves households' economies that supplement agriculture income (Zahabu, 2008; Duguma *et al.,* 2013).

Therefore, *Ngitili* is considered an essential traditional strategy for forestry management, rehabilitation, and restoration in Tanzania. The recognition and incorporation of *Ngitili* in forest management came into existence in the early 1980s. The government revised its forest policy, emphasizing community participation in forestry management (Zahabu *et al.,* 2009; Treue *et al.,* 2014). It was subsequently reinforced in the Forest Act No.14 of 2002 (URT, 2002). Following the recognition of *Ngitili* as a traditional vegetation conservation system by the government in the 1980s. The sizes and number of *Ngitili* increased spontaneously from 600 to 18,607 ha from 1986 to the 1990s (UNDP, 2012). From 250,000 to about 500,000 ha in 2001-2004 (Monela *et al.,* 2005; Buckingham and Hanson, 2015). The system received international recognition as a means of restoring degraded lands and its contribution to forestry restoration, environmental conservation, and atmospheric carbon stocking (Monela *et al.,* 2005; Barrow, 2016; Osei *et al.,* 2018).

Historical perspective about *Ngitili* and conservation

Shinyanga region was initially being dominated by dense woodland and bushland with different tree

species of the genus *Acacia, Brachystegia, Jubernardia, Albizia, Commiphora,* and *Dalbergia* (Monela *et al.,* 2005; Otsyina *et al.,* 2008; UNDP, 2012). Other common plants were *Grewia, Balanites, Pterocarpus*, and *Afzelia* (Kamwenda, 2002). Dominant tree species were; *Acacia tanganyikensis, Acacia polyacantha, Afzilia quanzensis, Brachystegia species, Commiphora africana, Combretum zayeri,* and *Dalbrgia melanoxylon* (Kamwenda, 2002; Barrow, 2014). The forested woodlands provided fodder for livestock and basic needs such as food and fuel for the agro-pastoralists ethnic group in the region. Despite that, the dense forest was also a reservoir for the tsetse flies, transmitting a parasitic disease known as *trypanosomiasis* to both humans and livestock (Barrow and Mlenge, 2003; Duguma *et al.,* 2019). Therefore, in the 1920s, the colonial authorities instituted a program through which local people were paid to cut down large woodland areas to eradicate the tsetse flies. The Sukuma people were happy with the order, not only for eradicating tsetse flies but also for opening up new grazing and agricultural land (Selemani *et al.,* 2012; Buckingham and Hanson, 2015). Apart from the tsetse flies eradicating program of 1925 to 1960s, other programs that accelerated massive deforestation and land degradation includes; the villagization program of the 1970s (Barrow, 2016) and expansion of cotton production for foreign markets (Otsyina *et al.,* 1992; Selemani *et al.,* 2012; Barrow, 2014). These programs created severe threats to existing forests and ecosystems-based resources (Barrow, 2016). Further, these programs also abandoned the previous traditional practices, including *Ngitili*, and brought about threats to the ecological system. With the extreme land degradation and deforestation, the region was badly turned into treeless. The late President Nyerere was shocked by what he observed during his visit to the area in 1984. He thereby declared the area as "The Desert of Tanzania" (UNDP, 2012; Barrow, 2016). In response to this calamity, in 1986, the government initiated the land rehabilitation project called the Shinyanga Soil Conservation Programme, better known by its "Swahili acronym HASHI *(Hifadhi Ardhi Shinyanga)*, (UNDP, 2012). The primary function is to promote sound land-use technologies' adoption through awareness-raising with tree planting from hand-outs of exotic tree species seedlings from central nurseries on severely degraded land (Selemani *et al.,* 2012; Barrow, 2016). This approach failed because of the harsh weather, termite attack, low acceptance by the community, and poor management (UNDP, 2012).

Observing the failure in the establishment of the HASHI program in the region, project members made a self-reflection and reformation to involve the community (UNDP, 2012) by making people feel that they are responsible for both destruction and restoration of the landscape (Barrow *et al.,* 2002; Minja and Machanya, 2010). Adopting local and traditional knowledge as one of the strategies for forest restoration was thought and taken in place (Otsyina *et al.,* 2008; UNDP, 2012). Thus, the revival and use of indigenous knowledge, attitudes, and practices, such as *Ngitili,* based on indigenous knowledge, were given more priority and became more applicable (Akida and Blomley, 2006; Burgess *et al.,* 2010). Local communities were encouraged to participate in forest management by setting aside forest areas to be sustainably managed. Thus, different environmental policies were associated with the system. For instance, Tanzania introduced so-called participatory forest management (PFM), joint forest management (JFM), and Wildlife Management program (URT, 2006; Zahabu *et al.,* 2009; Treue *et al.,* 2014). Other related laws and policies such as; the Village Land Act of 1999 and Land Act of 1999, Tanzania Wildlife Policy of 1998 (Akida and Blomley, 2006), the National Environmental Policy of 1997,

the Environmental Management Act of 2004, Forest Act 2002, and its regulations of 2004 (URT, 2006) were also enacted. All of these policies and regulations promoted participatory forest resource conservation and management for sustainable use.

Furthermore, the government recognized the decentralization of power to the local community and the traditional guard (Kamwenda, 2002; Monela *et al.,* 2005; Duguma *et al.,* 2013). The Council of Elders, locally known as "*Dagashida,*" is involved in decision-making to ensure sustainable use of the resources and the welfare of the people in *Ngitili* (Monela *et al.,* 2005). At the same time, the traditional guard (police) locally known as *Sungusungu* were given power and became the implementers of the by-laws and protecting the communities against invaders. Heavy fines (e.g., a live cow or 40,000 Tanzanian shillings, approximately to 20 USD) were paid by those who break the by-laws (Minja and Machanya, 2010; Duguma *et al.,* 2013). Different kind of *Ngitili* ownership exists, communal ownership, private ownership (individual ownership, household, and group ownership) and institutional ownership (school and religious organizations), (Kitalyi and Mlenge, 2004; Selemani *et al.,* 2013).

The strong commitment by the local communities and the government attracted attention to the different organizations both within and outside (international, government and privates) that worked under the umbrella of traditional knowledge for land and forest restoration (Nyadzi *et al.,* 2003). For instance, the Norwegian Agency for Development Cooperation (NORAD) became the primary donor of the program to promote *Ngitili* in Shinyanga from 1989 to 2004 (Duguma *et al.,* 2019). The International Centre for Research in Agroforestry (ICRAF) has developed and implemented agroforestry practices complementary to *Ngitili* since 2002 (Duguma *et al.,* 2013). The Tanzania Natural Forest Resources and Agroforestry Management Centre (NAFRAC), that takes responsibility of NORAD (UNDP, 2012), the Tanzania Traditional Energy Development and Environmental Organization (TaTEDO) that promotes energy-efficient technologies to reduce GHG emissions, from 2010 to 2013 (TaTEDO, 2009; TaTEDO, 2012). The Development Associates Ltd (DASS) conducts carbon monitoring and accounting in *Ngitili* systems. The programs resulted in outstanding successes. In 2004 more than 152 different trees, shrubs, and herbaceous were recorded in the region (Monela *et al.,* 2005; Selemani *et al.,* 2013). Plant species diversity values ranged from 2.0 to 3.8 concerning Shannon's index (Monela *et al.,* 2005, Zahabu, 2008). A variable range of standing density and tree standing volume was from 922 to 6553 stem ha^{-1} and 5.1 to 48.9 m^3 ha^{-1}, respectively (Monela *et al.,* 2005; Otsyina *et al.,* 2008).

Ceasing of the donors (NORAD) in 2004, most of the programs in *Ngitili* ceased as well (Chirwa, 2014). More ever, the entire situation about the current status of *Ngitili* in terms of conservation, plant diversity, and stocking potentials remains unreported. A few available pieces of works of literature focus on the performances of the pre-existing *Ngitili* and highlight the challenges. For instance, Chirwa (2014) reported that; conflict of interests, ineffective improvement strategies, and lack of recognition of the local institutions and their arrangements had converted the *Ngitili* into other land use. Similarly, Pye-Smith (2010) highlighted the lack of financial incentives and technical support provided by NORAD had accelerated the convention of *Ngitili* to other land use.

On the other hand, agroforestry, which mostly uses alien plant species due to their fast-growing ability, is not palatable to livestock and is characterized by high soil-water consumption (Cazzolla -Gatti *et al.,*

2014). Other noted factors include negative impacts of climate change, natural disturbance, high grazing pressure, bush fires, extensive wood collection, human population, and land competition for human settlement and agriculture (Pye-Smith, 2010; Chirwa, 2014). For instance, poor land preparation practices further threaten the sustainability of *Ngitili* conservation systems, the traditional 'slash and burn', and its typical shifting cultivation. Thus, most of the areas that were used to be *Ngitili* are no longer the same in the Shinyanga region. Unfortunately, the detailed information about these traditional practices (*Ngitili*) on forest management, sustainability, and conservation are highly neglected in the literature. Therefore, we carried out a detailed ecological study in Kishapu district of Shinyanga, northwest Tanzania in order: (i) to assess and document the current status of *Ngitili*, (ii) to determine the diversity of plant species, (iii) to evaluate the regeneration potential of plant species, and (iv) to quantify biomass stocking potential within *Ngitili.*

Description of the study area

The study was conducted in Kishapu district located in the northeast of the administrative region of Shinyanga (Figure 1). The district lies between 3º 15'' and 4º 05'' south of the equator and longitudes 31º 30''E and 34º15'' E east of the Greenwich meridian (URT, 2009). The district has a total area of 4,333 sq. km. About 101 sq. km area is covered by forests, of which 47 sq km is occupied by community conserved forests (*Ngitili*). The district is characterized by a dry tropical climate with temperatures ranging from 22^0C to 30^0C and 15^0C to 18.3^0C for maximum and minimum. A semi-arid area receives 450 mm to 990 mm of rainfall per annum (NBS, 2012). Precipitation starts in late October/early November and ends in April/May, while the dry season begins in June and lasts in October. The rainfall amount and distribution patterns are neither even nor expectable (Bushesha and Katunzi, 2017); there is a decrease in rainfall, experiencing a gap between January and February.

 The district is characterized by flat and gently undulating plains covered with low and sparse vegetation; soil varies with relief features (KDP, 2013). People in the district are engaging themselves in crops and livestock production. The principal food crops grown include maize, sorghum, bulrush millets, sweet potatoes, paddy, and pulses, while the cash crop is cotton (Katunzi *et al.,* 2016). Livestock kept are cattle, shoats (sheep and goats), and poultry, but fishing is done during the rainy season (KDP, 2013).

Forest inventory design and field layout

Ten (10) community conserved forests, namely, Ikonda A, Mwamanota, Bubinza, Shagihilu, Busongo, Mihama, Bulima, Lyabujije, Ndoleleji, and Nyasamba found in the Kishapu district were selected for the purpose of study. For studying the current status and ecological attributes of Ngitili, ground-based forest inventory techniques (Brand *et al.*, 1991) were employed. Permanent circular plots of 15 m radius (with inner sub-plots of 5 and 10 m) were systematically laid along transects (Zahabu, 2008). The inter
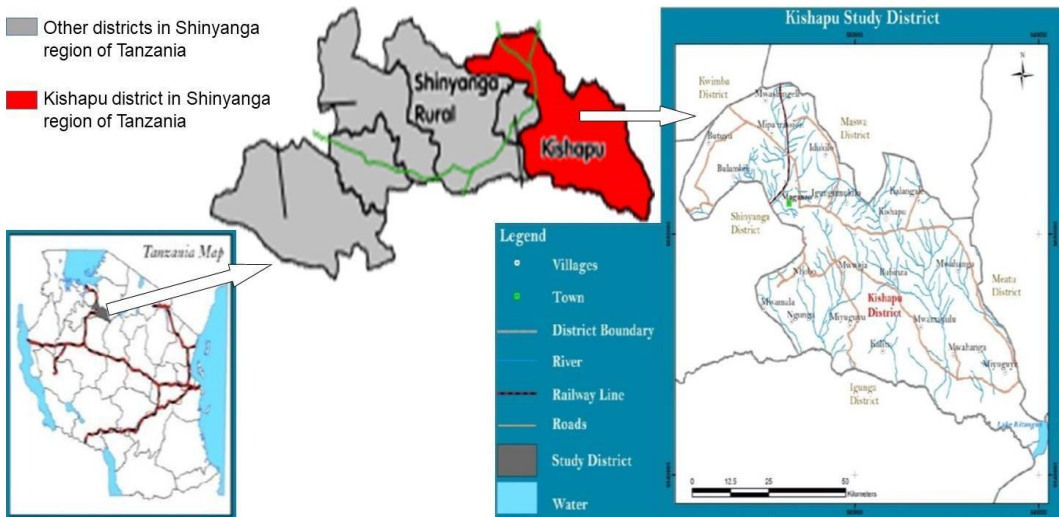
Figure 1. The Map of Shinyanga region to show studied community forests in Kishapu districts, northwest Tanzania.

plots and inter transects distances were maintained at 300 and 600 m, in between, respectively. In each plot, plant phytosociological attributes (number of individual species, frequency, height and diameter at breast height) were recorded in the following manner:

- Within a 5 m radius: the frequencies of the individual herbaceous species were recorded. Seedling (≤ 20 cm height) and saplings (>20 cm, but < 1 m height) were identified and recorded (Rubanza *et al*., 2006).

- Within a 10 m radius: all standing woody plant species with a diameter at breast height (dbh) < 5 cm were identified and recorded as shrubs.

- Within a 15 m radius: all plants with dbh ≥ 5 cm were identified and recorded as trees. In the forked trees, stems were numbered differently, and each stem were measured for dbh at 1.37 m and height. The measuring caliper was used to determine tree dbh (cm), while Suunto clinometer (PM-5/360 PC) was used to determine the tree heights (m) (Modified from Zahabu, 2008).

Data collection

Status of community reserved forests

A field survey was conducted to record the current status of community conserved forests (*Ngitili*). The disturbance score was calculated as per Veblen *et al.* (1992) and Gillespie *et al.* (2000). The disturbance was qualitatively classified into four classes versus the degree of anthropogenic activities (i.e., grazing pressure, wood fuel collection, agriculture, charcoal making, and fire outbreak). The anthropogenic activities were ranked as (1) for no evidence of anthropogenic activity; (2) for one or only two

anthropogenic activities evidence; (3) for three shreds of evidence of anthropogenic activities; and (4) for more than three evidence of anthropogenic activities. The sum of all ranks provided the overall ranking of the anthropogenic disturbances (i.e., the low grade represents a low level of disturbance and vice versa). The disturbance index (DI) was calculated based on the number of individual cut stumps observed and recorded in the study site (Kanzaki and Yoda, 1986).

Determination of floristic composition and ecological attributes

The phytosociological study was carried out to recognize vegetation composition and plant species diversity using point sampling methods (Rubanza *et al.,* 2006; Zahabu, 2008). The important plant community attributes such as frequency and abundance were quantitatively computed following Curtis and McIntosh (1950) and basal area following Phillips (1959). The relative frequencies, relative density, and relative dominance were calculated as per Curtis and McIntosh (Curtis and McIntosh, 1950), while the importance value index (IVI) of the individual plant species were determined by summing up the relative frequency, relative density, and relative dominance (Misra, 1989). Plant species diversity, richness, and evenness were computed using indices of diversity as per Shannon and Weaver (1949); Simpson (1949) and Pielou (1966), for Shannon's diversity index (H'), Simpson's dominance index (C), and Evenness index (J'), respectively.

Determination of plant regeneration potential

The regeneration status of plant species was determined based on the population size of seedlings, saplings and adults (modified from (Khumbongmayum *et al.,* 2006). Regeneration status was considered '*good*' regeneration, if seedling > sapling > adults; '*fair*' regeneration, if seedlings > or < saplings <adults; and '*poor*' regeneration, if the species survives only in sapling stage, but no seedling (saplings may be <, > or = adults), (Khumbongmayum *et al.,* 2006). While, if the species is recorded only in adult form, it was considered 'not regenerating', similar species with individuals only in seedlings or saplings without any adult was considered '*newly regenerating*' species.

Plant biomass stocking potential

Herbaceous biomass was determined by the harvest method (Chambers, 1983), a destructive technique that involves clipping off the herbaceous species in a thrown quadrat (Rubanza *et al.,* 2006). The clipped herbaceous species were immediately transferred to pre-weighed labeled bags, and instantly fresh weighted was recorded. The samples were taken into the laboratory for a forced-air oven at 60°C for 48 hours to obtain dry matter (DM). The dry matter contents were used to estimate the biomass production (Chambers, 1983) Eq 1.

$$(1)\ B\ (t\ DM\ ha^{-1}) = \frac{TDM}{TQs}\ x\ QA$$

where; B- biomass, TDM- total dry matter contents, TQs- total quadrats, QA- quadrat area.

While, tree biomass stock was estimated by a non-destructive method (Chave *et al.*, 2014; Chave *et al.*, 2005). The method employs allometric equations, which considers measurable parameters like dbh, tree

height, basal area, and wood density (Nath *et al*., 2019): Eqs. 2-4. Above-ground tree biomass (AGB) was computed as per (Vesa *et al*., 2010) Eq 2.

(1) AGB (kg tree^{-1}) = $\dfrac{g^* \, h^* \, \delta}{1000}$

Where; g- basal area (m²), h- height (m), δ- wood density.
The BGB was estimated by multiplying the AGB to 0.26 (root to shoot ratio) as per Sheikh *et al*. (2011) and Suryawanshi *et al*. (2014): Eq 3.

(3) BGB (kg tree^{-1}) =AGB*0.26

The total tree biomass (TB) was determined as the sum of the AGB and BGB: Eq 4.

(4) TB (kg tree^{-1}) =ABG +BGB

Statistical analysis
All data were normalized to fit parametric tests. Normality and homogeneity were verified using the Shapiro-Wilk and Levene tests, respectively. Descriptive statistics on plant species biomass stocking potential were analyzed statistically using analysis of variance (ANOVA). Fisher's Least Significant Difference Test (LSD) was carried out to test whether the differences between means were statistically significant at $p < 0.05$. All statistical analysis was performed using the SPSS Software package (ver. 20.0; SPSS, Chicago, IL) at a significance level of $\alpha = 0.05$.

Status of community conserved forests

Different forms of fragmentation and the nature of community conserved forests have been observed in the present study. The results on the current status of community conserved forests of the Kishapu district are presented in Table 1. The present study surveyed to record the status in ten (10) community conserved forests in the district covering 6,112.98 ha. Nine conserved community forests contributed 4569.34 ha, while one forest recorded 1543.64 ha converted into other land use. Furthermore, out of the nine community conserved forests, four (2750.13 ha) are threatened (40 %) and turning into a desert-like appearance (Figure 2), while the remaining (five) are highly disturbed (51 %).
The present study observed various ongoing human activities such as forest encroachment, agriculture, and other forms of human-induced disturbances such as burning, overgrazing, fuelwood extraction, which might be attributed to the degradation of the study sites. The factors such as conflict of interest and ineffective improvement strategies could have attributed as well. Other factors include introducing agroforestry, which mainly uses alien plant species due to their fast-growing nature, but in contrast, they require extra care, not palatable by livestock, and fail to adapt to harsh conditions. The reduced powers of the *Dagashida* (Group of elders) and the *Sungusungu* have been deliberated to the disappearance of most community forests.

Table 1. Status of the community conserved forests of Kishapu district, northwest Tanzania.

| Name of *Ngitili*	Village (s)	Size (ha)	Factors of disturbance					Disturbance score	Measurement of disturbance	
			Grazing	Charcoal	Agriculture	Wood fuel	Fire		DI	Status
Ikonda A	Ikonda	55	3	1	1	1	1	7	5.51	D
Mwamanota	Mwamanota	100.13	4	3	1	4	1	13	9.47	T
Bubinza	Bubinza	385	2	2	1	2	1	8	5.95	D
Shagihilu	Shagihilu	1168	2	2	2	2	1	9	4.59	D
Busongo	Busongo	475	3	2	2	4	2	13	6.49	T
Mihama	Mihama	500	4	2	2	3	2	13	9.19	T
Bulima	Bulima	1675	4	4	2	3	2	15	12.17	T
Lyabujije	Ng'wanima	1543.6	4	4	4	4	4	20	35.1	N
Ndoleleji	Ndoleleji	345	3	1	1	2	1	8	5.76	D
Nyasamba	Nyasamba	190.3	3	2	2	2	1	10	5.68	D
	Total	6437.1								
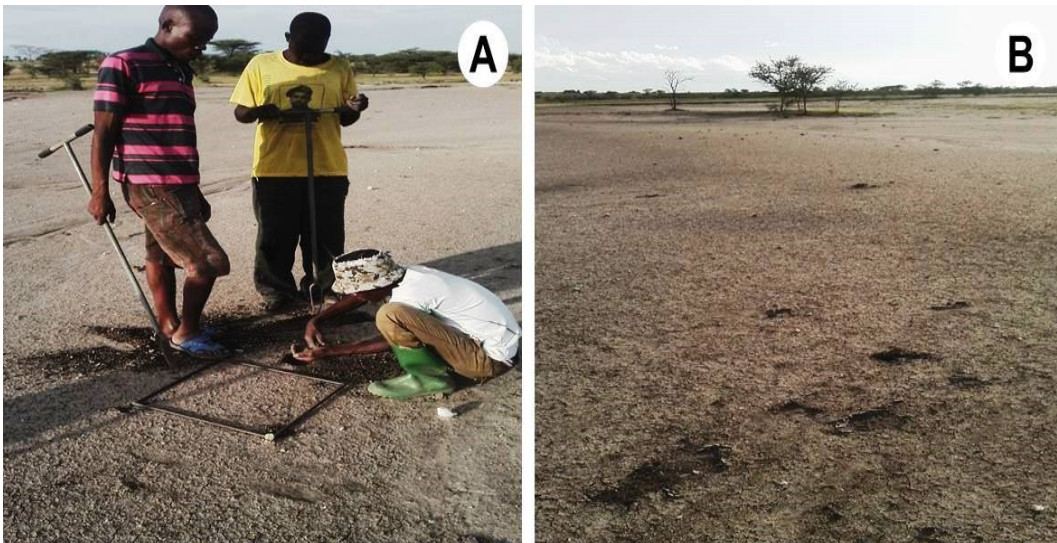
Figure 2. Threatened *Ngitili* showing bare ground with no grass covers turning into a desert-like appearance in Bubinza (A) and Shagihilu (B) community forests Kishapu, Tanzania.

The high level of civilization and the human population has resulted in a great conflict of interest, forcing people to opt for private forest conservation instead of community consideration. Minja and Machanya (2010) reported the exact reasons for declining community conserved forests in Tanzania. Cases related to misuse of forest-related resources are now handled by government police, who usually discourage the action that was taken by the local police *Sungusungu*. Therefore, the unrecognition of the *Sungusungu* in implementing the by-laws and protecting the communities against invaders has increased over exploitation of forest.

The demand for land for human settlement, agriculture, and livestock stocking was attributed significantly to high degradation in the region. Chirwa (2014) reported that much dependence on forest goods and services due to poverty has resulted in forest degradation. Similarly, the ceasing of supports from agents such as NORAD, charcoal making to sustain a livelihood, climate change, natural disturbance, grazing pressure, improper cultivation practices, deforestation, fires outbreak, and extensive fuelwood collection are some of the reasons for degradation in the region (Kamwenda, 2002; Rubanza *et al.*, 2008; UNDP, 2012; Malunguja *et al.*, 2020). On the other hand, Pye-Smith (2010) reported information on the human population and its threat to the community forest ecosystem. According to the report given by the World Agroforestry Centre (ICRAF) (Selemani *et al.*, 2012), the growth of urban demand for charcoal and shift from previously practiced communal to private *Ngitili* has augmented the degradation of community conserved forests in the region. The reasons for such movement include low economic return, mainly due to unequal sharing of benefits, poor land security, poor grazing management, and unavoidable conflicts (Adams *et al.*, 2003). Village government leaders make the

decisions in communal forests on behalf of community members compared to private *Ngitili* (Machanya *et al.,* 2003; Treue *et al.,* 2014).

Floristic composition and ecological attributes

Herbaceous composition

38 herbaceous species (37 genera and 14 families) were identified in the studied *Ngitili* of Kishapu district in the Shinyanga region (Table 2). 20 species (19 genera and 3 families) were grasses, and 18 species (18 genera and 11 families) were forb and climber species. The dominant grass species include *Aristida* spp. (28.93%), and *Cynodon s*pp. (12.9%). Other grass species with relatively high frequencies were *Dactylectenium giganteum* (6.1%) and *Eragrostis curvula* (4.2%), while dominant forb species were *Monechma debile* (4.6%), *Commelina* spp., and *Leucas* spp. Grass species were more diverse (58%) than forb species (42%) in the study sites. The reported dominant herbaceous species in the current study denote that the species are native to the disturbed ecosystem. Grass species such as *Aristida* spp. and *Cenchrus* spp. are good indicators of disturbed aridity and semi-aridity zones (Monela *et al.,* 2005; Otsyina *et al.,* 2008; Selemani *et al.,* 2012). However, the findings from the current work observed few species compared to Monela *et al.* (2005) in the surveyed *Ngitili* forests of Shinyanga. Heavy grazing pressure could have resulted in the disappearance of some native herbaceous species and leads to the domination of the recorded species due to their great tolerate and regeneration potential under harsh conditions. Rubanza *et al.* (2008) reported the decline of some edible herbage species "*decreasers*" as well as the emergence of less nutritious unpalatable species "*increasers*" that tend to dominate the place. The study observed that variation of soils is attributed to the presence of a particular dominant grass species. For instance, species such as *Sorghum* spp., *Digitaria* spp., and *Rhynchelytrum* spp. were found dominant in black clay soil locally known as *Mbuga*. Other grass species such as *Aristida* spp., *Cenchrus* spp., *Heteropogon* spp., *Chloris* spp., and *Branchiaria* spp. were localized in clay loam soil locally known as *Ibushi*. Water-loving species like *Cynodon dactylon* were found dominant in heavy clay vertisol soils (black cotton soil) characterized by high holding capacity and the associated waterlogging, which favors water-loving grass species. The dominant forb species include *Cassia occidentalis, Convolvulus* spp., *Indigofera* spp., *Oxygonum sinuatum,* and *Sida* spp., which indicates disturbed soil characteristics and could be associated with certain forms of land degradation. Pratt and Gwyne (1971) reported the same species in the semi-arid and disturbed landscapes of East Africa. High anthropogenic pressure and the absence of incentive from the government have contributed significantly to the present situation of degraded habitat.

Tree species composition

The present study recorded 28 tree species belonging to 17 genera and 13 families **(**Table 3). The dominant tree species recorded in the present study is from the genus *Acacia*. Another genus with relatively high dominance in the survey includes *Dichrostachys, Lannea,* and *Balanites*. The study recorded dominant tree and shrub species such as *Acacia. nilotica, A. tortilis., A. drepanolobium., A. delile.,*

Table 2. Herbaceous composition in community forests of Kishapu district, northwest Tanzania.

Botanical name	Family	Composition (%)
Grass species		
Aristida funiculata Trin. & Rupr	Poaceae	28.9
Branchiaria mutica (Forssk.) Stapf	Poaceae	2.1
Cenchrus ciliaris L.	Poaceae	3.2
Chloris barbata Sw.	Poaceae	1.5
Chloris gayana Kunth	Poaceae	0.6
Cynodon dactylon (L.) Pers.	Poaceae	12.9
Cyperus esculentus L.	Cyperaceae	2.7
Dactyloctenium aegyptium (L.) Willd.	Poaceae	6.1
Digitaria scalarum (Schweinf.) Chiov.	Poaceae	0.8
Echinochloa colona (L.) Link	Poaceae	0.1
Eragrostis curvula (Schrad.) Nees	Poaceae	4.2
Heteropogon contortus (L.) P.Beauv	Poaceae	0.4
Urochloa panicoides P.Beauv.	Poaceae	0.2
Panicum trichocladum Hack. ex K. Schum.	Poaceae	0.7
Rhynchelytrum repens (Willd.) C.E.Hubb.	Poaceae	1.7
Rottboellia exaltata L. f.	Poaceae	0.3
Setaria verticillata (L.) P.Beauv.	Poaceae	1.4
Sorghum bicolor (L.) Moench	Poaceae	0.2
Sporoborus spicatus Kunth	Poaceae	1.8
Themada quadrivalvis (L.) Kuntze	Poaceae	0.9
Forb and climber		
Monechma debile (Forssk.) Nees	Acanthaceae	4.6
Leucas martinicensis (Jacq.) R.Br.	Lamiaceae	3.5
Commelina benghalensis L.	Commelinaceae	3.3
Ipomoea batatas (L.) Lam.	Convolvulaceae	2.8
Tribulus terrestris var. inermis	Zygophyllacea	2.3
Amaranthus spinosus L.	Amaranthaceae	2.2
Oxygonum sinuatum (Hochst. & Steud.)	Polygonaceae	2.2
Lycopersicon lycopersicum (L.) H. Karst.	Solanaceae	1.8
Sonchus luxurians (R. E. Fr.) C. Jeffrey	Asteraceae	1.5
Cucumis anguria L.	Cucurbitaceae	1.1
Corchorus capsularis L.	Malvaceae	0.8
Solanum incanum L.	Solanaceae	0.8
Sphaeranthus suaveolens (Forssk.) DC.	Asteraceae	0.7
Abelmoschus esculentus (L.) Moench	Malvaceae	0.5
Cleome gynandra L.	Cleomaceae	0.5
Convolvulus prostratus Forssk.	Convolvulaceae	0.4
Sida spinosa L.	Malvaceae	0.2
Datura stramonium L.	Solanaceae	0.1

A. polyacantha, and *A. Senegal*. Other species such as *Balanites* spp. (desert plum) dominate the study sites. In order of importance value index (IVI), the dominant species under trees are; *Acacia*

Table 3. Tree species composition community forests of Kishapu district, northwest Tanzania.

Botanical name	Family	IVI
Acacia angustissima (Mill.) Kuntze	Fabaceae	6.77
Acacia bethamii Meisn.	Fabaceae	6.09
Acacia concinna (Willd.) DC.	Fabaceae	25.51
Acacia drepanolobium Harms ex Y.Sjöstedt	Fabaceae	45.37
Acacia nilotica (L.) Del.	Fabaceae	6.63
Acacia polyacantha Willd.	Fabaceae	16.99
Acacia seyal Delile	Fabaceae	15.53
Acacia senegal (L.) Willd.	Fabaceae	33.2
Acacia tortilis (Forssk.) Hayne	Fabaceae	6.63
Albizia amara (Roxb.) Boiv.	Fabaceae	1.63
Azadirachta indica A. Juss.	Meliaceae	5.53
Balanites aegyptiaca (L.) Delile	Zygophyllaceae	42.96
Capparis tomentosa Lam.	Capparaceae	0.57
Cassia abbreviata Oliv.	Caesalpiniaceae	1.79
Colotropis procera (Aiton) W.T.Aiton	Apocynaceae,	0.98
Combretum fraxgrans F.Hoffm.	Combretaceae	1.84
Combretum obovatum F.Hoffm.	Combretaceae	2.66
Dichrostachys cinerea Wight et Arn.	Fabaceae	28.38
Diospyros fischeri Gürke	Ebenaceae	2.57
Euphorbia ingens E.Mey. ex Boiss.	Euphorbiaceae	1.43
Euphorbia tirucalli L.	Euphorbiaceae	8.32
Grewia bicolor. Juss	Tiliaceae	2.29
Lannea humilis (Oliv.) Engl.	Anacardiaceae	33.57
Leucaena leucocephala (Lam.) de Wit	Fabaceae	2.07
Ormocarpum kirkii S. Moore	Fabaceae	3.86
Senna siamea (Lam.) de Wit	Fabaceae	1.5
Senna singueana (Delile) Lock	Fabaceae	1.43
Tamarindus indica L.	Fabaceae	5.53

drepanolobium (45.37), *Balanites aegyptiaca* (42.96), and *Acacia tortilis* (33.57), while *Dichrostachys cinerea*, recorded the highest domination for seedling and sapling.

Species diversity

Analysis of variance (ANOVA) indicated that there was no significant difference ($p > 0.05$) in plant species diversity. Diversity (H') in the present study ranges from 1.02 to 2.42. Grass species recorded the highest diversity (H' = 2.34), while the lowest value was observed in tree species (H' = 2.05) (Table 4). The findings from the present study portray relatively low species diversity, characterizing a few species that dominate the study sites. The predominant species of the genus Acacia in the study area reflects an overgrazed and disturbed land, which should perhaps not be expected to demonstrate high

species diversity. The present study observed poor vegetation recovery because of over-grazing, which does not offer sufficient vegetation to recover from one season to another.

Rubanza *et al.* (2008) pointed out that individuals of re-occurring species in *Ngitili* get grazed on their sapling stage; thereby, they never attain the adult stage to produce their next generation. *Ngitili* is only protected during the rainy season and grazed during the peak of the dry season when fodder for livestock is scarce. Thus, the low species diversity observed in the present study is associated with this grazing pressure. The findings from the present study show lower values of diversity (H') which contradicts the data reported in different districts of the region (Monela *et al.,* 2005; Otsyina *et al.,* 2008). Domesticated animals avoid consuming Acacia species due to the presence of thorns; thus, the species is less affected and dominates *Ngitili*.

Moreover, the species have a less valuable market for timber and charcoal production. According to Monela *et al.* (2005), excellent regeneration potential species like *Dichrostachys cinerea* and *Omorcapum trichocarpum* indicate degraded ecosystems. They have great adaptation to arid and semi-arid regions with low annual rainfall (400 to 800 mm). These recorded tree and shrub species have similarly been reported in other parts of the region (Monela *et al.,* 2005; Rubanza *et al.,* 2006; Otsyina *et al.,* 2008; Selemani *et al.,* 2013). The high level of forest degradation and deforestation observed in the studied *Ngitili* might have been influenced by fewer plant species. Furthermore, Tefera *et al.* (2007) reported that plant species like Acacia might reflect an overgrazed land.

Table 4. Dominant species, diversity of plant species recorded in community reserved forests of Kishapu district, northwest Tanzania.

Plant category	Dominant plant species based on calculated composition (%) and IVI	SR	H'	C	J'	EF	WI	NF	NG
Grasses	*Aristida* spp. (28.93 %), *Cynodon* spp. (12.9 %), *Dactyloctenium giganteum* (6.1 %), *Eragrostis curvula* (4.2 %) and *Cenchrus ciliaris* (3.20 %).	20	1.02-2.34	0.08-0.11	0.91	9	0.06	3	19
Forbs and climbers	*Monechma debile* (4.6 %), *Leucas martinicensis* (3.5 %), *Commelina benghalensis* (3.3 %), *Ipomoea batatas* (2.8 %) and *Tribulus terrestris* (2.3 %).	18	1.13-2.42	0.09-0.04	0.9	13	0.09	11	18
Trees	*Acacia drepanolobium* (45.37), *Balanites aegyptiaca* (42.96), *Lannea humilis* (33.57), *Acacia tortilis* (33.20) and *Dichrostachys cinerea* (28.38).	28	1.90-2.05	0.07-0.12	0.93	6	0.06	13	17

Note: SR -species richness; H' -Shannon-Wiener diversity index; C -Simpson's index (1/D); J' -Pielou's index of evenness; EF -effective number of species; WI -Whitford index; NF -Number of the family; NG -Number of the genus.

Regeneration potential status

The present study observed a high percentage (51.85 %) of plant species exhibits a "*Not regeneration*" condition followed by "*Poor regeneration*" (25.4 %), "*Fair regeneration*" (20.7 %), and "*Good regeneration*" recorded the lowest value (2.1 %). The present study doesn't observe any newly regenerated species (Table 5). The absence of new regeneration in the study area indicates that the prevailing environmental conditions are either unsuitable for new species to colonize or there is high pressure of grazing and other anthropogenic activities that fail to establish new upcoming species. The present study's findings portray a destructive regeneration potential, an indicator of threat to the native species leading to local extinction. Illegal utilization of species by communities to sustain their livelihood for charcoal making, medicinal, unstable climate, and edaphic variability attributes to poor regeneration of individual species. Both anthropogenic and natural phenomena affect regeneration potential (Iqbal *et al*., 2012). Scarcity of grazing land and lower ecological carrying capacity resulted from poor adaptability of some species to degraded ecosystem contributed to the degradation of plant species among *Ngitili* in Shinyanga (Selemani *et al.,* 2012). Therefore, the sustainability of the *Ngitili* is threatened by extensive grazing and overexploitation of species by communities to meet their daily livelihood requirements.

Tree biomass stocking

The total tree stocking is 12. 04 tB ha^{-1} and results of tree biomass stocking potential are presented in Table 7. Plant species that have relatively high stocking potential are; *Acacia polyacantha* (2.11 tB ha^{-1}), *Acacia tortilis* (1.46 tB ha^{-1}) and *Balanites aegyptiaca* (1.33 tB ha^{-1}). The community forests recorded relatively low biomass stocking potential compared to other reports in the region (Zahabu, 2008). The observed low stocking potential signifies the high degree of disturbance, particularly illegal tree cutting for charcoal making. This is evidenced by the presence of charcoal kilns and a large number of cut stumps. Other reasons could be explained by the absence of large-sized tree individuals with sufficient girth and height, which are essential parameters for assessing tree stocking. The present study observed that most large-sized trees are cut for charcoal making to sustain livelihood and family economy. The low biomass in community reserved forests of the region signifies poor carbon dioxide (CO_2) contribution offset through carbon sequestration for enhanced climate change mitigation. The present study recorded a range of 14 to 4454 stems ha^{-1}, an average of 8.12 cm, and 4.67 m for tree diameter at breast height (dbh), and heights (h), respectively. The findings of this study concur with Selemani *et al.* (2013), who reported an average of 578±70 tree stems ha^{-1} and a height of 3.24 m in Shinyanga rural of Meatu districts. However, the findings from the present study are lower than the data reported by Monela *et al.* (2005) of 1964 to 6553 stems ha^{-1}, and 6.7 to 27.2 cm, for tree stem density and diameter at breast height (dbh), respectively. The estimated values are similarly contrasted to Otsyina *et al.* (2008) of 1053 to 1360 stems ha^{-1}. The high level of forest degradation and deforestation observed during the present study is directly related to the low biomass stocking. The growing urban demand for charcoal has accelerated the degradation of *Ngitli*. Furthermore, a great shift from community-owned to private *Ngitili* in the region is among the main reasons for the degradation and low biomass stocking.

Table 5. Tree species composition community forests of Kishapu district, northwest Tanzania.

Botanical name	Number of individual adult plants				Regener-ation status
	Shrubs	Trees	Seedlings	Saplings	
Acacia nilotica (L.) Del.	41	124	38	67	FR
Acacia drepanolobium Harms ex Y.Sjöstedt	135	315	326	432	GR
Acacia angustissima (Mill.) Kuntze	2	2	1	0	NR
Acacia polyacantha Willd.	15	15	3	11	NR
Acacia senegal (L.) Willd.	3	15	4	6	NR
Acacia bethamii Meisn	5	6	0	2	PR
Acacia tortilis (Forssk.) Hayne	28	102	9	16	FR
Azadirachta indica A. Juss.	1	2	1	2	NR
Balanites aegyptiaca (L.) Delile	40	142	21	18	FR
Capparis tomentosa Lam.	44	3	0	3	NR
Cassia abbreviata Oliv.	1	2	0	0	NR
Colotropis procera (Aiton) W.T.Aiton	7	1	13	24	FR
Combretum obovatum F.Hoffm	5	1	0	0	NR
Dichrostachys cinerea Wight et Arn.	95	101	87	65	GR
Euphorbia tirucalli L.	1	2	0	0	NR
Euphorbia ingens E.Mey. ex Boiss.	12	1	7	9	FR
Grewia bicolor. Juss	7	1	2	6	NR
Leucaena leucocephala (Lam.) de Wit	19	6	13	21	FR
Senna siamea (Lam.) de Wit	1	1	17	5	FR
Senna singueana (Delile) Lock	6	1	0	0	NR
Tamarindus indica L.	1	2	0	6	PR
Ormocarpum kirkii S. Moore	21	7	6	19	FR
Acacia concinna (Willd.) DC	81	151	21	43	GR
Combretum fraxgrans F.Hoffm.	14	1	0	0	NR
Diospyros fischeri Gürke	5	6	1	3	NR
Albizia amara (Roxb.) Boiv.	10	1	13	6	FR
Lannea humilis (Oliv.) Engl.	125	2	37	123	GD

Conclusion

From the present study, anthropogenic activities (i.e., cultivation, deforestation, overutilization, overgrazing etc.) attributed to the observed threatened status in community reserved forests (*Ngitili*) of Kishapu district, northwest Tanzania. Lack of incentives regarding awareness, monetary and technical

Table 6. Herbaceous productivity (ANOVA, LSD and descriptive statistics for minimum, maximum, and Mean±SD) in community forests of Kishapu district, northwest Tanzania.

ANOVA				LSD					Descriptive statistics				
	df	F	Sig.	(I) Herb's category	(J) Herb's category	Mean Difference (I-J)	Std. Error	Sig.		N	Min	Max	Mean ±SD
Between Groups	2	168.681	0.000	Grasses	Forbs	-1.46732*	0.35196	0.000	Grasses	120	0.17	3.68	2.31± 0.03
					Climbers	-0.18604*	0.35196	0.000					
Within Groups	357			Forbs	Grasses	2.46732*	0.35196	0.000	Forbs	120	0.15	3.35	0.37± 0.02
Total	359				Climbers	-1.71872*	0.35196	0.000					
				Climbers	Grasses	0.18604*	0.35196	0.000	Climbers	120	0.07	1.63	0.08± 0.06
					Forbs	1.71872*	0.35196	0.000	Total	360	0.07	3.68	1.09± 0.03

* The mean difference is significant at the 0.05 level.

Table 7. Tree-wise biomass stocking potential in community forests of Kishapu district, northwest Tanzania.

Botanical name	Stems ha⁻¹	Height (m)	dbh (cm)	Volume (m³ ha⁻¹)	AGB t ha⁻¹	BGB t ha⁻¹	TB t ha⁻¹
Acacia nilotica (L.) Del.	1753	6.8	18.5	1.231	0.616	0.154	0.770
Acacia drepanolobium Harms ex Y.S.	4454	4.4	5.5	0.143	0.071	0.018	0.089
Acacia angustissima (Mill.) Kuntze	28	5.6	10.9	0.897	0.448	0.112	0.560
Acacia polyacantha Willd.	212	7.4	16.8	3.381	1.691	0.423	2.113
Acacia senegal (L.) Willd.	212	4.3	9.5	0.489	0.244	0.061	0.306
Acacia bethamii Meisn	84	5.9	11.3	0.951	0.475	0.119	0.594
Acacia tortilis (Forssk.) Hayne	1442	7.1	15.8	2.331	1.166	0.291	1.457
Azadirachta indica A. Juss.	28	4.6	6.7	0.737	0.368	0.092	0.460
Balanites aegyptiaca (L.) Delile	2007	6.1	8.8	2.122	1.061	0.265	1.326
Capparis tomentosa Lam.	42	2.7	4.7	0.129	0.065	0.016	0.081
Cassia abbreviata Oliv.	28	3.7	6.4	0.171	0.085	0.021	0.107
Colotropis procera (Aiton) W.T.Aiton	14	1.6	3.6	0.038	0.019	0.005	0.024
Combretum obovatum F.Hoffm	14	3.9	4.2	0.299	0.150	0.037	0.187
Dichrostachys cinerea Wight et Arn.	1428	3.6	5.2	0.254	0.127	0.032	0.159
Euphorbia tirucalli L.	28	5.3	7.9	1.317	0.658	0.165	0.823
Euphorbia ingens E.Mey. ex Boiss.	14	4.2	6.2	0.159	0.079	0.020	0.099
Grewia bicolor. Juss	14	3.6	3.4	0.235	0.117	0.029	0.147
Leucaena leucocephala (Lam.) de Wit	84	5.3	5.3	0.152	0.076	0.019	0.095
Senna siamea (Lam.) de Wit	14	5.7	8.7	0.228	0.114	0.029	0.143
Senna singueana (Delile) Lock	14	3.1	5.8	0.118	0.059	0.015	0.074
Tamarindus indica L.	28	6.5	13.6	1.041	0.520	0.130	0.650
Ormocarpum kirkii S. Moore	98	2.8	6.5	0.234	0.117	0.029	0.146
Acacia concinna (Willd.) DC	2135	6.4	8.8	0.673	0.337	0.084	0.421
Combretum fraxgrans F.Hoffm.	14	5.4	5.8	0.275	0.138	0.034	0.172
Diospyros fischeri Gürke	84	3.2	6	0.148	0.074	0.018	0.092
Albizia amara (Roxb.) Boiv.	14	2.6	3.2	1.374	0.687	0.172	0.859
Lannea humilis (Oliv.) Engl.	28	4.3	10.2	0.133	0.066	0.017	0.083
Total	**14323**	**126.10**	**219.30**	**19.26**	**9.63**	**2.41**	**12.04**

support, and unequal sharing of resources from communal-owned *Ngitili* have played a significant role in low plant species diversity among *Ngitili*. Similarly, the Elders' Council reduced authority power, locally known as "*Dagashida*," and the unrecognition of the local guard (police) known as *Sungusungu* in implementing the by-laws and protecting the communities against invaders has increased forest overexploitation. Low levels of environmental education, poverty, and more demand for land expansion for agriculture due to increasing population have accelerated deforestation and land degradation. On the other hand, the high level of forest degradation and deforestation observed in the present study is directly related to the low plant species diversity, primary biomass production, and stocking. Therefore, effective and appropriate management interventions such as environmental education to raise awareness are of utmost importance. Re-establishment and strengthening community participation in conservation and management practices for sustainable harvest and resource utilization are required with practical action to enhance forests and land sustainability.

Acknowledgments

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