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Current Trend on Plant Species Diversity and Productivity Potential among Community Conserved *Ngitili* Subjected to Grazing Pressure in Kishapu District, Tanzania

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Abstract

Ngitili is the common practice among the *Sukuma* ethnic community in Tanzania, which involves retaining an area of standing vegetation during the rainy season and opening it up for grazing at the peak of the dry season. Exposure of *Ngitili* into extensive grazing has been associated with species alteration in terms of diversity and productivity. We conducted a field study to assess the trend of *Ngitili,* in Kishapu district of Tanzania. A phytosociological survey was carried to recognize vegetation composition using a point sampling technique. Regeneration potential was determined based on the population size of seedlings, saplings and adults. Herbaceous and tree species productivity potential was computed based on established allometric models. We recorded a total of 66 plant species, of which 20 were grasses, 18 were forbs, and 28 were trees. The dominant grass species were, *Aristida* spp. (28.9%) while *Monechma debile* (4.6%) was the dominant forb species. Importance Value Index recorded, *Acacia drepanolobium* (45.4) and *Balanite aegyptica* (42.9) as dominant trees species. The majority of the tree (51.8%) exhibiting a "*Not regenerating*" condition. A diversity of 1.8 to 2.4, with a stocking potential of 1.23±0.05 tDM ha^{-1} , 512.07±193.86 stems/ha, and 5.66±0.21 $tCha^{-1}$, for herbaceous and tree species was recorded, respectively. Therefore, the sustainability of *Ngitili* in Kishapu are highly threatened by ongoing grazing pressure.

***Keywords*:** Indigenous knowledge, extensive grazing, forest degradation, biodiversity conservation, anthropogenic activities.

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1.0 Introduction

Community conserved forests under indigenous traditionally known as *Ngitili* in the north-western parts of Tanzania, particularly in Shinyanga region, have been subjected to an extensive grazing pressure [1],[2]. The tendency resulting in a severe alteration of plant species diversity [3],[4]. Grazing pressure has resulted in substantial changes in species diversity and its productivity potential [5],[6] but such information is not well known in *Ngitili* of Kishapu district, Shinyanga region of Tanzania. Grazing management of any ecosystem may have a considerable influence on plant species diversity and their productivity potential [7]. Other factors like deforestation and forest degradation, agriculture and settlement, wildfires and overexploitation of forest-based resources for fuelwood collection and commercial purposes, has been documented as important forces affecting plant species diversity, composition and their productivity potential in community conserved *Ngitili* [1],[8–12]. Local communities are mainly key forest stakeholders and their involvement in decision-making and sustainable management of forest-based resources generates positive outcomes for livelihoods [13], as well as rural development, and forest conservation [14]. Countries in Latin America are advancing in the process of developing the concepts of community forestry as a collaborative governance approach to forest management. The same idea has been observed in Africa [15],[16]. For instance, some pastoralist communities, such as the *Himba* (Namibia) and the *Borana* (Ethiopia), *Masai* (Kenya and Tanzania) and the *Sukuma* (Tanzania) have traditional forestry conservation strategies [17] [12], in which some of their lands are temporally protected from any human-related influence during the rainy season (to regenerate and recovery) and open up for grazing during the dry season [18]. Such practice has been incorporated into governmental environmental conservation policies and laws. Despite the fact that the protected land, is mainly made for grazing, but also plays a significant contribution for vegetation species diversity and plant biomass productivity potential [19], hence climate mitigation through enhanced carbon sequestration. The Western part of Tanzania especially the Shinyanga region, which is dominated by the *Sukuma,* the largest agro-pastoral ethnic group is characterized by having forest resources conserved and managed under community traditional knowledge known as *Ngitili* [5],[10],[20].

Ngitili is one of the local and traditional vegetation conservation systems which involves retaining an area of standing vegetation from the beginning of the rainy season and opening it up for grazing at the peak of dry season

[21],[18],[10],[22]. It involves the exclusion of humans as well as livestock from openly accessing an area [23],[24].

The purposes of exclusion are to prevent further degradation of the ecosystems, advance re-vegetation, forest regeneration and restore the overall ecological conditions. The system existed as early as during the colonial era, around the 1920s, as an indigenous knowledge of the *Sukuma* people mainly to carter for acute fodder shortage [21],[25]. *Ngitili* acts as deferred pastures or enclosures in response to fodder shortage and usually remains un-disturbed from December to June and Open up for grazing in July to November. However, currently, *Ngitili* is frequently subjected to heavy grazing pressure [3],[2],[9] while information pertaining to the problem on species diversity and plant productivity is lacking in works of literature.

Local communities in Kishapu district of Shinyanga region, have been practising the *Ngitili* vegetation conservation system even during the colonial era [25],[20]. The management of the system is under the Council of village Elders or *Dagashida*, [8] whose main role is decision making to ensure sustainable use of the resources as well as the welfare of the people in *Ngitili*. On top of that, the traditional police locally known as *Sungusungu* are the implementers of the by-laws in protecting the communities against invaders [26],[14],[21],[18]. Heavy fines (such as live cow, which is then slaughtered or/and 40,000 Tanzanian shillings, approximately 20 USD) are to be paid for by-laws breakers [24],[27]. Different *Ngitilis'* ownership exists in the district and region in general includes; communal ownership, private ownership (individual ownership, household, and group ownership) and Institutional ownership [2],[13],[8]. The incorporation and implementation of this indigenous knowledge (*Ngitili)* into environmental related policies, were made more effective after a declaration of the "*Desert of Tanzania"* by then, the late President Julius Nyerere. Who was shocked by the high extent of deforestation and soil degradation in the year 1984, after touring the Shinyanga region [5],[25],[20]. The main causes of such degradation were; tsetse flies eradication program (1925-1960s); the villagization programme (the 1970s) and expansion of cotton production for foreign markets [22],[5],[12].

Apart from its main roles, *Ngitili* in Shinyanga region has shown great potential for improving the ecological conditions of a given ecosystem [28]. *Ngitili* acts as a centre for biodiversity and soil erosion control in the region [25]. It provides forest-based ecosystem goods and services such as climate change mitigation [29]. It provides fuelwood, thatch grass, water catchment, scenic beauty and diversification of nutrition options e.g. fruits, vegetables, mushroom, edible insects, wild meat, and medication [21],[3],[8], [30]. On the other hand, *Ngitili* improves household's economies that supplement the income from agriculture [19],[13],[27]. The

system has received an international recognition not only as a means of restoring degraded lands but also for their contribution to forestry restoration, environmental conservation and atmospheric optimal as carbon stocking and hence carbon dioxide mediator [31].

These characteristics observed in *Ngitili*, made them be considered as an important strategy for forestry management and rehabilitation in the north-western semi-arid part of Tanzania [32],[20]. The system was incorporated and recognized in several environmental policies and laws, where local communities were encouraged to participate in the forest management on the basis of community-based forest management (PFM), joint forest management (JFM) [33],[34],[35]. Furthermore, the system was well-articulated in Tanzania Village Land Act of 1999 [16], the National Environmental Policy of 1997, the Environmental Management Act of 2004, Forest Act 2002 and its regulations of 2004 that promote participatory forest resource conservation and management as well as sustainable use of biodiversity [36]. The strong commitment by the local communities and the government attracted attention to the different organization both international, national and private that worked under the umbrella of the traditional knowledge for land and forest restoration [37]. For instance, the Norwegian Agency for Development Cooperation (NORAD) become the main donor of the programme for promoting *Ngitili* in Shinyanga from 1989 to 2004 [29]. The Nairobi-based International Centre for Research in Agroforestry (*World Agroforestry Centre, ICRAF)* works in developing and implementing agroforestry practices complementary to *Ngitili* since 2002 [30],[38],[27], the Tanzania Natural Forest Resources and Agroforestry Management Centre (NAFRAC), that takes responsibility of NORAD [20], the Tanzania Traditional Energy Development and Environmental Organization (TaTEDO) that promotes energy-efficient technologies to reduce GHG emissions, from 2010 to 2013 [39],[40], the Development Associates Ltd (DASS), which conducts carbon monitoring and accounting in *Ngitili* systems. All these increased the potentiality of *Ngitili* for ecosystem health. Nevertheless, studies have recognizes the variety of tree species, grasses herbs, and their productivity in different districts of the region [8] [26],[31],[9],[2],[26]. For instance [32], estimated biomass production of 25.43 tons ha^{-1} from trees, 3.6 tons ha^{-1} from grasses and forbs, 2.32 tons ha^{-1} from litter and 8.61 tons ha^{-1} of soil carbon. A diversity of 2.0 to 3.8 with respect to Shannon's index was reported by [8], with a total of 152 plant species. A variable range of standing tree density of 922 to 6553 stem/ha at a volume of 48.9 m^3/ha [32],[8] had been documented in different studied *Ngitili* of the former Shinyanga region. On the other hand, a survey made in 1986, recorded a total of 600 ha, of *Ngitili* and 18,607 ha in

the 1990s. Similarly, a total of 250,000 to 500,000 ha, were recorded between 2001 and 2005, being restored to regenerate naturally in different districts of Shinyanga region [8], [10], [20].

However, the recognition of the available *Ngitili* of Kishapu district, in accordance to plant species diversity and carbon stocking potential is left behind in literature. The available information remains to other districts of the Shinyanga region [8],[26],[31],[9],[12],[2] with less attention in Kishapu district. The available data are limited to larger area coverage of the former Shinyanga region, and maximally excludes Kishapu district, which was formed as a separate district from Shinyanga rural in 2002/2003. This tendency increased the abandonment of potential *Ngitili* representing the district, leaving the district (Kishapu) with insufficient specific ecological information pertaining to the current status of *Ngitili*, in terms of plant species diversity, regeneration and productivity potential. As the results of imposing difficultness in determining the true value of the ecosystem. Therefore, we conducted a study in order to bridge the prevailing gap of knowledge.

2.0 Material and Methods

2.1 *Study Area*

The study was conducted in Kishapu district located in the northeast of the administrative region of Shinyanga, Tanzania (Figure 1). The district lies between 3° 15" and 4° 05" south of the equator and longitudes 31° 30"E and 34°15" E east of the Greenwich meridian [41]. The district has a total area of 4,333 sq. kilometres, where 101 sq km area is covered by forests. Of which about 47 sq km area is occupied by *Ngitili* natural regeneration woodland conserved under the traditional system. 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, respectively. It is a semi-arid area that receives 450 mm to 990 mm of rainfall per annum [42]. Rainfall starts in late October/early November and ends in April/May while the dry season begins in June and last in October. According to [43], the rainfall amount and distribution patterns are generally neither even nor expectable, meanwhile, there is decreasing of rainfall such that the district experiences a gap of rainfall between January and February. The district is characterized by flat and gently undulating plains covered with low and sparse vegetation, soil varies along with relief features such that on hilltops soils are moderately well drained greyish brown and sandy [44] whereas, low-lying valley bottom soils are moderately deep well-drained and greyish brown sand. Most population in the district is engaged in crops and livestock production, major food crops grown includes maize, sorghum, bulrush millets, sweet potatoes, paddy, and pulses while cash crop is cotton [43]. Livestock kept are cattle, shoats (sheep and goats) and

poultry, but fishing is done during the rainy season. The district was selected because of its community participation in *Ngitili* system [44], without being well assessed and published in the literature.

Keys

Other districts in Shinyanga region of Tanzania

Kishapu district in Shinyanga region of Tanzania

Fig 1: The Map of the Shinyanga region to show the distribution of its different districts

2.2 ***Sampling design***

For studying the current trend in communities conserved forest under indigenous knowledge known as *Ngitili*, a systematic sampling design was adopted, using a concentric circular plot of 15 m radius, along transects, modified from [45],[33]. The inter plots and inter transects distances were maintained at 300 and 600 m, in between respectively. In each plot data were collected in the following manner; within 5 m radius, all herbaceous species were assessed based on frequencies of the individual species [9],[46]. Within 10 m radius, all plants with ≥ 1 but <5 cm diameter at breast height (dbh, of 1.37 m), were identified and recorded as shrub species while, within 15 m radius all plant species (≥5 cm dbh), were recorded as tree species, and their heights were measured using Suunto hypsometer (Modified from [33] and it's detailed in [19].

The regeneration status of plant species was determined based on the population size of seedlings, saplings and adults (modified from [47], such that

regeneration status was considered as '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). While, if the species is recorded only in adult form it was considered as 'not regenerating', similar species with individuals only in seedlings or saplings without any adult was considered as 'newly regenerating' species. Furthermore, within 5 m radius, seedling (≤ 20 cm height) and saplings (>20 cm, but < 1 m height) species were identified and their density of all the individuals were recorded.

2.3 ***Data collection and analysis***

Field survey and the phytosociological study was carried to record and recognize herbaceous vegetation composition based on frequencies of the individual species using a point sampling technique (0.25 m^2) metal quadrat [46],[9]. Shrub and tree species diversity were determined based on tree tally [48],[19]. The regeneration status of plant species was determined based on the population size of seedlings, saplings and adults [47]. To determine herbaceous biomass productivity, herbaceous species were cut at 1.5 cm above the ground using hand sickles and immediately transferred to a pre-weighed labelled paper bags. The cut herbages were instantly weighted in the field for the fresh weight determination using a sensitive weighing balance [9]. Sub-samples from each quadrat were re-weighed into a separate paper bags and taken into the laboratory for a forced air oven dry at 60°C for 48 h to constant weight. Data on herbaceous biomass productivity was computed following formulae given by [49],[9]. Tree stocking parameters (basal area (m^2 ha^{-1}), standing biovolume (m^3 ha^{-1}) above-ground and below-ground were estimated based on allometric models [50],[51],[33],[45]. Shrub and tree species diversity in terms of richness, dominance and evenness were computed using Shannon's, and Simpson's diversity indices as well as Evenness index [52],[53][54].

Species Importance Value Index (IVI) was computed as the average of the relative basal area, density and frequency. Descriptive statistical analysis was used to analyse quantitative data by Statistical Package for Social Sciences (SPSS) version 20. Botanical field manual book and taxonomist were consulted for the identification of both herbaceous, shrub and tree species. Plant species that were not easy to identify in the field, they were taken for further identification at the department of biological sciences, the University of Dodoma, Tanzania.

3.0 Results and Discussion

3.1 ***Plant Species Diversity***

3.1.1 Herbaceous Species Composition

A total of 38 herbaceous species were identified in the studied *Ngitili* of Kishapu district in Shinyanga region, of which 20 species (19 genera and 3 families) were grasses (Figure 1) and 18 species (18 genera and 11 families) were forb (Figure 2). The dominant grass species includes *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%) as compared to forb species (42%) in the study site. The presence of dominant species such as *Aristida* sp., *Monechma* sp., and *Sida* spp. clearly denote disturbed soil characteristics and could be attributed to certain forms of land degradation due to different factors including overgrazing and other anthropogenic activities. Grass species such as *Aristida* spp. and *Cenchrus* spp. are good indicators of disturbed, aridity and semi-aridity zones [9], [8], [12].

The recorded dominant herbaceous species in the current study denote species that are native to the disturbed ecosystem in a semi-arid area with great regeneration potential under harsh condition. Species such as *Aristida funiculate* characterises the disturbed landscapes of semi-arid areas in East Africa [55]. However, the findings from the current study observed few species as compared to [8], who recorded a relatively higher number of species in *Ngitili* forests of Shinyanga Region.

Various factors ranging from extrinsic and intrinsic that affect the re-growth and recovery of herbaceous species composition in the studied *Ngitili* include overgrazing as well as the introduction of alien plant species that tend to dominate the woodland. Heavy grazing pressure could have resulted in the disappearance of other herbaceous species and leads to the domination of the recorded species due to their great tolerate and regeneration potential under harsh condition. According to [9] the decline of some palatable herbage species "*decreasers"* as well as the emergence of less nutritious unpalatable species "*increasers*" tend to dominate among *Ngitili* in Meatu district, that in turn affect diversity.

Variation of soils has attributed the presence of a particular dominant grass species. For instance, species such as *Sorghum* spp., *Digitaria* spp., and *Rhynchelytrum* spp. were found to be 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 water logging which favours water-loving grass species.

3.1.2 *Shrub and Tree Species Diversity*

Results on shrub and tree species diversity are indicated in Tables 1. The current study recorded a total of 28 shrub and tree species (belonging to 17 genera and 13 families). The dominant tree and shrub species recorded in the current study are from the genus *Acacia*. Another genus with relatively high dominance in the studied area includes; *Dichrostachys, Lannea,* and *Balanite*. The study recorded dominant tree and shrub species such as *Acacia nilotica., A. tortilis., A. drepanolobium., A. delile., A. polyacantha,* and *A. senegal* as well as other species such as *Balanites* spp. (desert plum). In order of Importance Value Index (IVI), the dominant tree and shrub species were; *Acacia drepanolobium* (45.37), *Balanite aegyptica* (42.96) and *Acacia tortilis* (33.57) while *Dichrostachys cinerea*, recorded the highest domination for seedling and sapling. The current study recorded a diversity index ranging from 1.9 to 2.5 and 0.07 to 0.12, for Shannon's index of diversity (H′) and Simpson's index of dominance (Ds) respectively. This index tells about species richness, evenness and number of dominance species in the studied *Ngitili* [56]**.** According to [57] the larger the value of H′ the greater the species diversity and vice versa, while the lower the dominance index value (Ds), the lower the dominance of a single species and the greater the value of the index of dominance the lower the species diversity and vice versa in the scale of 0 to 1.

The findings from the study portray low species diversity, characterized by the domination of a few species in the study area. The low species diversity and regeneration in most of the *Ngitili* in the study area have been attributed by a short period of protection of *Ngitili* before grazing season that may not offer sufficient time for vegetation recovery and regeneration. The predominant of species of the genus *Acacia* in the study areas may reflect an overgrazed land, which should perhaps not be expected to demonstrate high species diversity [2]**.** The findings from the current work show low values of both H′ and Ds which contradicts the findings reported by others [8],[32] in different districts of Shinyanga.

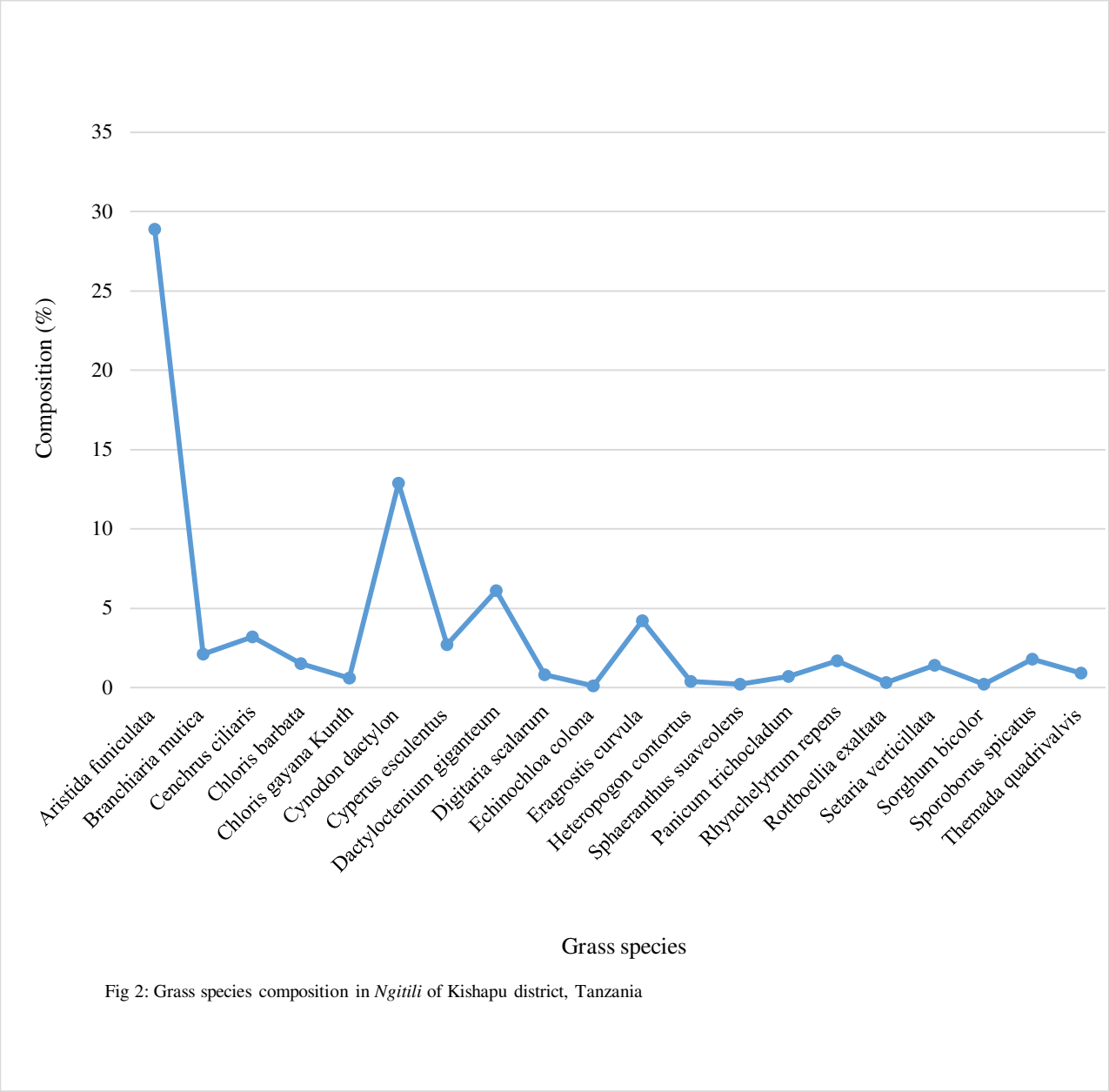

Fig 2: Grass species composition in *Ngitili* of Kishapu district, Tanzania

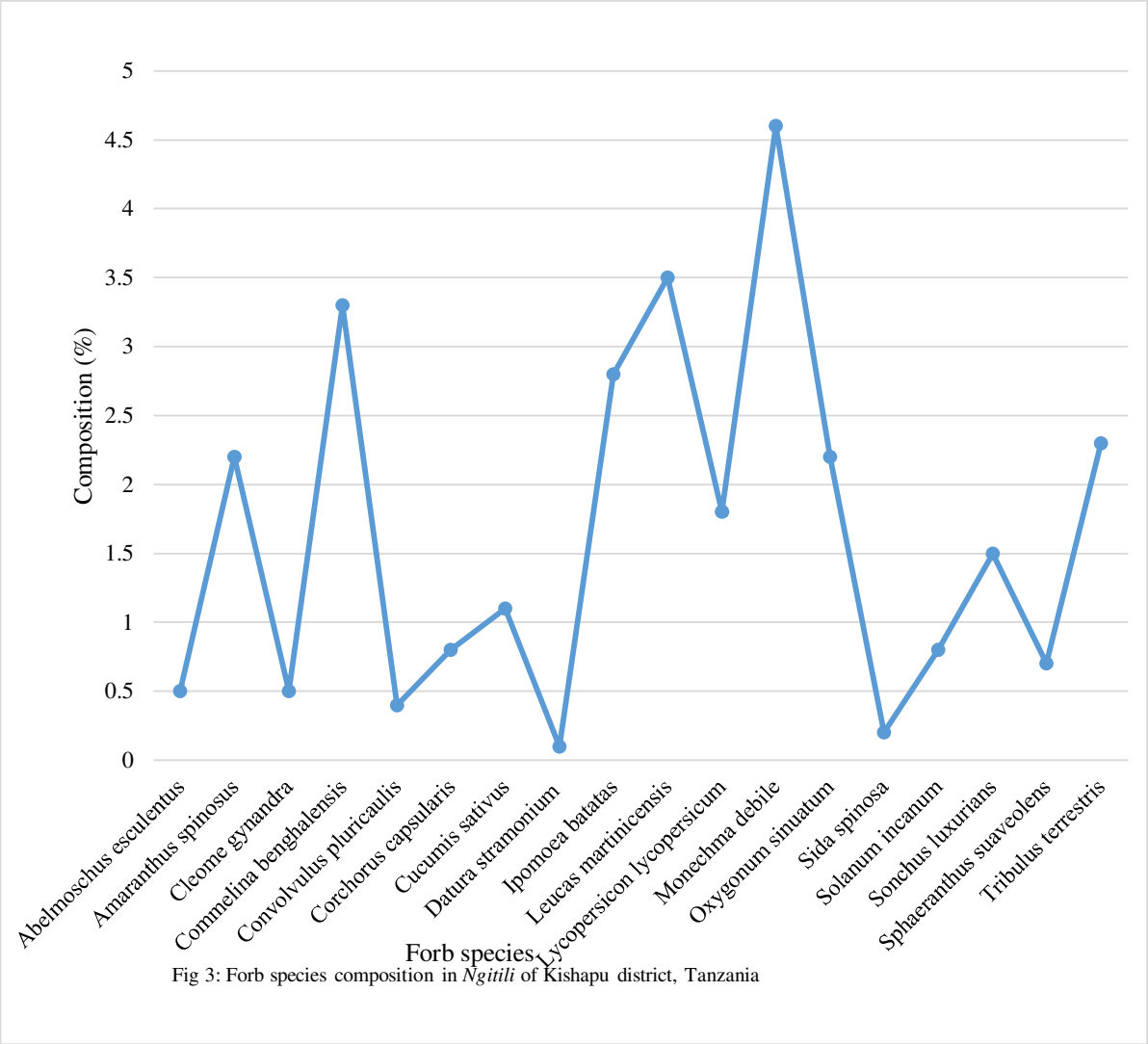

Fig 3: Forb species composition in *Ngitili* of Kishapu district, Tanzania

This has been connected to frequently grazing pressure in the studied sites. *Ngitili* is protected during the rainy season and grazed during the peak of the dry season [9],[18] when feed is scarce, as the result the re-occurring species get grazed on their sapling stage such that never transfer their generation to next [3]. The domination of the stated species has been connected with the thorny nature that prevents them from frequently attack by the domesticated animal under grazing pressure. They also possess less valuable market for timber and charcoal production. On the other hand, the high regeneration potential of species like *Dichrostachys cinerea* indicates degraded areas [8], and have great adaptation and thereby represent tree species that are well adapted to arid and semi-arid regions with annual rainfall ranging from about 400 to 800 mm.

The recorded tree and shrub species have similarly been reported in other parts of the region [8],[9],[2],[5] in Shinyanga rural, Shinyanga urban, Meatu and Kahama districts, respectively. However, the current study has recorded a few dominant tree species as compared to others. This might have been influenced by a high level of forest degradation due to overgrazing and deforestation observed in the studied *Ngitili.* Dominant species under the genus *Acacia*, may reflect an overgrazed land, as *Acacia* spp. have the ability to tolerate heavy grazing pressure and thrive well in degraded rangelands [2]. Similarly, [23] reported a high density of *Acacia* species indicates over-utilized rangeland.

Table 1: Shrub and tree species diversity in *Ngitili* of Kishapu district

Common tree and shrub species			IVI for plant species	
Botanical name	**Genus**	**Family**	**Tree**	**Shrub**
Acacia angustissima	Acacia	Fabaceae	6.77	1.62
Acacia bethamii	Acacia	Fabaceae	6.09	2.33
Acacia delile	Acacia	Fabaceae	25.51	6.12
Acacia drepanolobium	Acacia	Fabaceae	45.37	10.08
Acacia nilotica	Acacia	Fabaceae	6.63	1.82
Acacia polyacantha	Acacia	Fabaceae	16.99	6.46
Acacia senegal	Acacia	Fabaceae	15.53	2.15
Acacia tortilis	Acacia	Fabaceae	33.2	5.47
Albizia amara	Albizia	Fabaceae	1.63	1.44
Azadirachta indica	Azadirachta	Meliaceae	5.53	2.06
Balanites aegyptiaca	Balanites	Zygophyllaceae	42.96	7.29
Capparis tomentosa	Capparis	Capparaceae	0.57	8.26
Cassia abbreviata	Cassia	Caesalpiniaceae	1.79	0.66
Colotropis procera	Colotropis	Apocynaceae,	0.98	0.71
Combretum fraxgrans	Combretum	Combretaceae	1.84	1.42
Combretum obovatum	Combretum	Combretaceae	2.66	1.24
Dichrostachys cinerea	Dichrostachys	Fabaceae	23.38	0.71
Diospyrus fischeri	Diospyrus	Ebenaceae	2.57	0.91
Euphorbia ingens	Euphorbia	Euphorbiaceae	1.43	1.13
Euphorbia tirucalli	Euphorbia	Euphorbiaceae	8.32	3.15
Grewia bicolor. Juss	Grewia	Tiliaceae	2.29	1.22
Lannea humilis	Lannea	Anacardiaceae	33.57	5.47
Leucaena leucocephala	Leucaena	Fabaceae	2.07	3.09
Ormocarpum ulata	Ormocarpium	Fabaceae	3.86	2.75
Senna siamea	Senna	Fabaceae	1.5	0.58
Senna singueana	Senna	Fabaceae	1.43	0.85
Tamarindus indica L.	Tamarindus	Fabaceae	5.53	2.06

Parameters	**Value**
Total plant species richness	66
Tree and shrub species richness	28
Grass species richness	20

Forb species richness	18
Shannon's index	1.96-2.45
Simpson's index	0.07-0.12
Pielou's evenness index	0.6
Effectiveness number of species	6

IVI: Importance Value Index

3.1.3 ***Shrub and Tree Species Regeneration Potential***

The current study observed that majority of plant species (51.85 %) exhibited "*Not regeneration*" condition followed by "*Poor regeneration*" (25.4 %), " *Fair regeneration*" (20.7 %) and lastly "*Good regeneration*" (2.1 %) as in Table 2. No newly regenerating species was recorded. This portrays that *Ngitili* in Kishapu is on critical condition. A study also recorded a mean for standing stem density of 512.07±193.86 stems/ha, for trees having a diameter greater than 5 cm at breast height. Similarly, an average of 8.12 cm and 4.67 m, for diameter at breast height (Dbh) and heights (h) were recorded, respectively in the studied area. The findings of the current study observed a bad regeneration potential which portrayed an indicator of extinction of some species in the near future.

The findings of this study agree with those of [2] who reported an average of 578.38±70.69 stems/ha and height of 3.24 m, for tree stems density and heights respectively in Shinyanga rural and Meatu district. However, the findings of the current study contradict the findings reported by [8] and [32], who reported a range of 1964 to 6553 stems/ha and 1053 to 1360 stems/ha, as well as 6.7 to 27.2 cm, for tree stem density and diameter at breast height (Dbh) in Shinyanga rural and Meatu districts respectively. Anthropogenic activities including grazing pressure have been reported to play a great role in these conditions. For instance, [12] reported lower ecological carrying capacity due to scarcity of grazing land and low adaptability of some species to frequent exposure to grazing contributed to the degradation of plant species among *Ngitili* in Shinyanga.

Other recorded factors such as the ceasing of supporting agents like NORAD, cutting of tree for charcoal to sustain livelihood and family economy, climate change, natural disturbance, improper cultivation practices, fires outbreak, extensive fuelwood collection and logs demand required for house construction, has contributed for the reduction of tree and shrubs regeneration potential [20], [9], [30], [58], [14], [59]. Therefore, the sustainability of the *Ngitili* is threatened by an extensive grazing and illegal utilization of species by communities to sustain their livelihood.

Table 2: Plant species regeneration potential in *Ngitili* of Kishapu district

Scientific name	Tree		Number of individuals (m^2)				Regeneration status
	Height (m)	Dbh (cm)	Shrubs	Trees	Seedlings	Saplings	
Acacia nilotica	6.8	18.5	41	124	38	67	FR
Acacia drepanolobium	4.4	5.5	135	315	326	432	GR
Acacia angustissima	5.6	10.9	2	2	1	0	NR
Acacia polyacantha	7.4	16.8	15	15	3	11	NR
Acacia senegal	4.3	9.5	3	15	4	6	NR
Acacia bethamii	5.9	11.3	5	6	0	2	PR
Acacia tortilis	7.1	15.8	28	102	9	16	FR
Azadirachta indica	4.6	6.7	1	2	1	2	NR
Balanites aegyptiaca	6.1	8.8	40	142	21	18	FR
Capparis tomentosa Lam.	2.7	5	44	3	0	3	NR
Cassia abbreviata	3.7	6.4	1	2	0	0	NR
Colotropis procera	1.6	3.6	7	1	13	24	FR
Combretum obovatum	3.9	5.1	5	1	0	0	NR
Dichrostachys cinerea	3.6	5.2	95	101	87	65	GR
Euphorbia tirucalli. L	5.3	7.9	1	2	0	0	NR
Euphorbia ingens.	4.2	6.2	12	1	7	9	FR
Grewia bicolor. Juss	3.6	5.1	7	1	2	6	NR
Leucaena leucocephala	5.3	5.3	19	6	13	21	FR
Senna siamea	5.7	8.7	1	1	17	5	FR
Senna singueana	3.1	5.8	6	1	0	0	NR
Tamarindus indica	6.5	13.6	1	2	0	6	PR
Ormocarpum ulata	2.8	6.5	21	7	6	19	FR
Acacia delile	6.4	8.8	81	151	21	43	GR
Combretum fraxgrans	5.4	5.8	14	1	0	0	NR
Diospyrus fischeri	3.2	6	5	6	1	3	NR
Albizia amara	2.6	5	10	1	13	6	Fair
Lannea humilis	4.3	10.2	125	2	37	123	GD

Adasonia digitata	-	-	2	23	NR

Summary.
Standing trees and shrubs stem density = 512.07±193.86 stems/ha
Standing regenerant density = 32.85±16.54 per ha
Average height =4.67 m
Average Dbh = 8.12 cm

NR: no regeneration; **PR**: poor regeneration; **FR**: fair regeneration; **GR**: good regeneration; **Dbh:** diameter at breast height

3.2 Plant Species Productivity Potential

3.2.1 *Herbaceous Biomass Productivity*

The current study recorded herbaceous primary biomass productivity ranging from 0.16 to 44.94 t DM ha-1, with an average mean of 2.31±0.031 t DM ha^{-1}, for grass species (Figure 3). Grass species with relative high stocking potential were *Aristida* sp., (44.94) and *Cynadon* sp. (12.73). On the other side, a range from 0.15 to 3.39 t DM ha^{-1} with an average mean of 0.37±0.023 t DM ha^{-1}, was recorded for forb species (Figure 4). Forb species like *Monechma debile* recorded the highest among forbs (3.4 t DM ha^{-1}). The results observed in this research indicates poor stocking and productivity potential of herbaceous species. This could be attributed by the observed high degradation in the *Ngitili*, turning them into a desert with no record of species (Plate 1a). The findings from the current study concur to the previous findings which were reported from other districts of the Shinyanga region. For instance, [9] recorded herbaceous biomass ranging from 0.02 to 3.32 t DM ha^{-1} in the Meatu district. Similarly, [32] recorded a range of 0.92 to 3.87 t DM ha^{-1} in Shinyanga rural. However, the current study recorded slightly low average mean as compared to others [9][32].

The slight variation observed on herbaceous biomass productivity in the current study could be partly explained by constant grazing activities as well as differing in forest management aspects associated with overexploitation and heavy grazing pressure, which influenced herbaceous species composition and stocking potential to lower their recovery and productivity potential. The study observed some parts of the *Ngitili* were highly degraded such that, there were no herbaceous species to be recorded on it (bare ground) as shown in Plate 1b. Anthropogenic disturbances including resource exploitation, deforestation and overgrazing have altered the forest structure and species composition making a serious impact on future herbaceous biomass productivity. Factors like the serious competition of land for human settlement and agriculture has been attributing to high *Ngitili* degradation in Shinyanga region and Kishapu district as well. An intensive dependence on forest-related goods and services is attributed to poverty and few options for resource acquisition [3].

Plate 1: (a) Bubinza *Ngitili* of Kishapu district turning into a desert-like, (b) bare ground cover observed in Shagihilu *Ngitili* of Kishapu district

3.2.2 *Tree Biomass Productivity*

The current study recorded a total of tree biomass stocking potential of 12. 04 t/ha^{-1} (5.657 tC ha^{-1}), with an average mean of 0.37±0.109 tC ha^{-1} (Table 3).

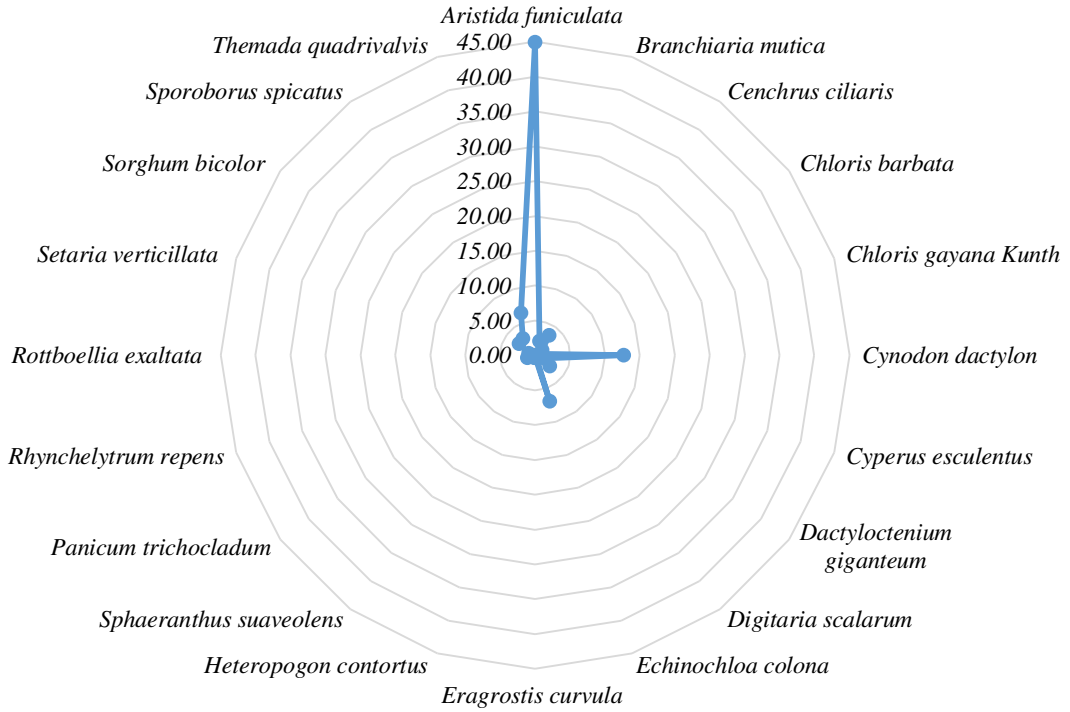

Fig 4: Grass species biomass productivity in *Ngitili* of Kishapu district, Shinyanga

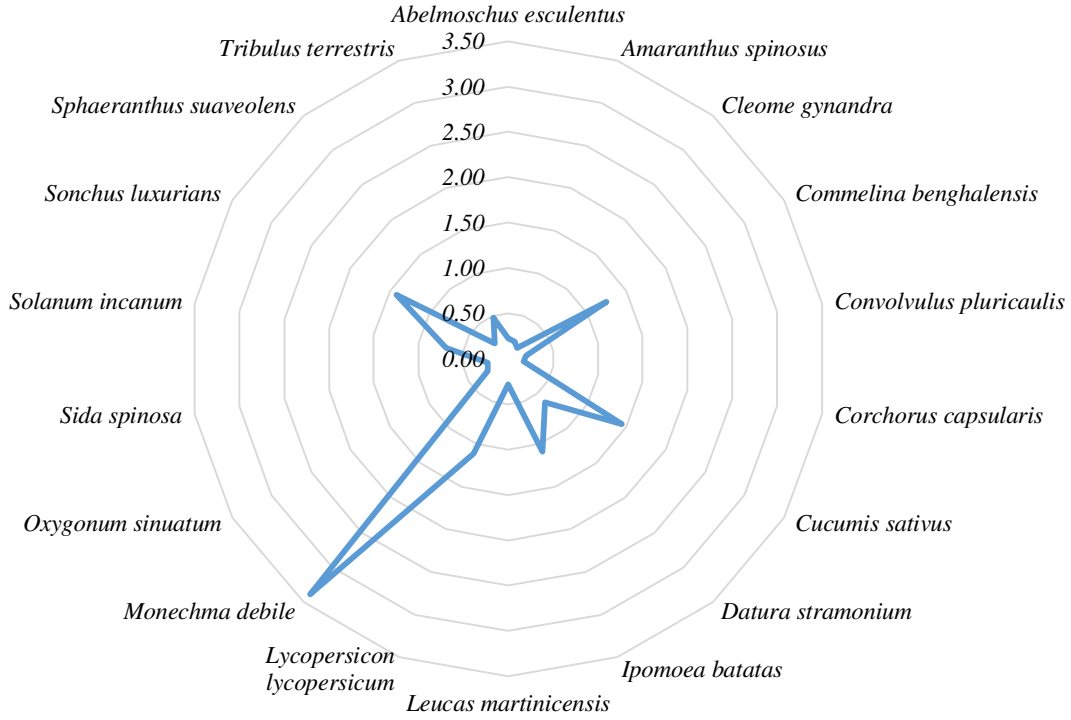

Fig 5: Forb species biomass productivity in *Ngitili* of Kishapu district, Shinyanga

Plant species such as *Acacia polyacantha* (2.11 t/ha^{-1}) and *Acacia tortilis* (t/ha^{-1}) had recorded the highest stocking potential as compared to other tree species. But the generally *Ngitili* has recorded a low tree stocking potential. The observed low stocking potential signifies the high degree of disturbance particularly illegal tree cutting in the studied *Ngitili,* which were characterized by the presence of charcoal kilns and a large number of cut stumps. Other reasons behind low tree stocking potential could be explained by the absence of large-sized tree with sufficiency dbh and height which are important parameters on assessing tree stocking, as most of the large-sized tree was cut for charcoal making to sustain livelihood and family economy. Similar information was reported by [20],[58]. The recorded data portrayed a poor value of the current *Ngitili* for enhanced climate change mitigation and carbon dioxide (CO_2) offset through carbon sequestration. Thereby, its role to reduce the effects of global warming is impaired.

The findings from the current study show similarity with the findings observed by [31] but with slight variations, probably because his study was so specific to certain plant species in private reserved *Ngitili*. On the other hand, the current study contradicts the findings given by [8], [32],[19] whose observations indicated a relatively higher tree stocking potential in different *Ngitili* of Shinyanga region.

Such changes could be due to the high level of forest degradation and deforestation observed in the study site. According to the report given by the World Agroforestry Centre [38], highlighted the growing urban demand for charcoal, has accelerated the degradation of *Ngitli*. Furthermore, a tendency of the communities to shift from previously practised communal to private *Ngitili* in Shinyanga region is among the reason for the great degradation of community *Ngitili* [12]. On top of that, the unrecognition of the *Sungusungu* or traditional police, who had their own ways of implementing the by-laws and protecting the community *Ngitili* against invaders has been reported to accelerate the degradation, as no one is taking care off. The reduced powers of the Elders and the *Sungusungu* has been attributed for the disappearance of some community *Ngitili* in the district (such as Lyabujije *Ngitili* in Ng'wanima village). Cases related to misuse of *Ngitili* related resources are now handled by government police, who usually discourage the action taken in hand by the *Sungusungu*, under the fact that is not legally recognized. Conflict of interest and ineffective improvement strategies,

fewer emphases and absence of incentive from both the government and non-government organization are factors to a great degradation of the studied *Ngitili* of Kishapu district.

Table 3. Tree carbon stocking potential in *Ngitili* of Kishapu district, Shinyanga, Tanzania

	Average tree parameters			Average tree biomass (t/ha)			
Botanical name	**Tree (stem/ha)**	**Height (m)**	**dbh (cm)**	**Volume (m^3/ha)**	**AGB**	**BGB**	**TB**
Acacia nilotica	1753.36	6.8	18.5	1.231	0.616	0.154	0.770
Acacia drepanolobium	4454.1	4.4	5.5	0.143	0.071	0.018	0.089
Acacia angustissima texensis	28.28	5.6	10.9	0.897	0.448	0.112	0.560
Acacia polyacantha	212.1	7.4	16.8	3.381	1.691	0.423	2.113
Acacia senegal	212.1	4.3	9.5	0.489	0.244	0.061	0.306
Acacia bethamii	84.84	5.9	11.3	0.951	0.475	0.119	0.594
Acacia tortilis	1442.28	7.1	15.8	2.331	1.166	0.291	1.457
Azadirachta indica	28.28	4.6	6.7	0.737	0.368	0.092	0.460
Balanites aegyptiaca	2007.88	6.1	8.8	2.122	1.061	0.265	1.326
Capparis tomentosa	42.42	2.7	4.7	0.129	0.065	0.016	0.081
Cassia abbreviata	28.28	3.7	6.4	0.171	0.085	0.021	0.107
Colotropis procera	14.14	1.6	3.6	0.038	0.019	0.005	0.024
Combretum obovatum	14.14	3.9	4.2	0.299	0.150	0.037	0.187
Dichrostachys cinerea	1428.14	3.6	5.2	0.254	0.127	0.032	0.159
Euphorbia tirucalli.	28.28	5.3	7.9	1.317	0.658	0.165	0.823
Euphorbia ingens	14.14	4.2	6.2	0.159	0.079	0.020	0.099
Grewia bicolor	14.14	3.6	3.4	0.235	0.117	0.029	0.147
Leucaena leucocephala	84.84	5.3	5.3	0.152	0.076	0.019	0.095
Senna siamea	14.14	5.7	8.7	0.228	0.114	0.029	0.143
Senna singueana	14.14	3.1	5.8	0.118	0.059	0.015	0.074
Tamarindus indica	28.28	6.5	13.6	1.041	0.520	0.130	0.650
Ormocarpum ulata	98.98	2.8	6.5	0.234	0.117	0.029	0.146
Acacia delile	2135.14	6.4	8.8	0.673	0.337	0.084	0.421
Combretum fraxgrans	14.14	5.4	5.8	0.275	0.138	0.034	0.172
Diospyrus fischeri	84.84	3.2	6	0.148	0.074	0.018	0.092
Albizia amara	14.14	2.6	3.2	1.374	0.687	0.172	0.859
Lannea humilis	28.28	4.3	10.2	0.133	0.066	0.017	0.083
Total	14323.82	126.10	219.30	19.26	9.63	2.41	12.04

Standing tree parameters	**Summary**
Height (m)	4.67
Tree volume (m^3)	19.26
AGB (t B ha^{-1})	9.63
BGB (t B ha^{-1})	2.41

Total biomass (t B ha^{-1})	12.04
Carbon stocking (t C ha^{-1})	5.66

AGB: Aboveground biomass; **BGB:** Belowground biomass; **C**: Carbon; **Dbh**: diameter at breast height; **TB:** Total biomass

4.0 Conclusion

This study concluded that grazing pressure and other anthropogenic activities (i.e., cultivation, deforestation, overutilization etc.,) in *Ngitili* have attributed their current threatened status in Kishapu district of Shinyanga. On the other hand, un-recognition of the local guard (*Sungusungu*), lack of incentives (in terms of awareness, monetary and technical support) and unequal sharing of resources from communal owned *Ngitili* have played a great role on the low plant species diversity and stocking potential among the studied *Ngitili*.

Furthermore, unpredictable rainfall, inadequate management capacity, poor institutional coordination, and low level of awareness among people have attributed to the poor regeneration potential recorded by the current study. The recorded dominant species in this study site represent plant species that indicates a highly degraded ecosystem, and those adapted to arid and semi-arid zones. Therefore, there is a need for formulation an effective and appropriate management interventions strategies as well as the provision of awareness workshop among the *Sukuma* people regarding sustainable harvest and utilization of *Ngitili* resources so as to enhance *Ngitili* sustainability.

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