An assessment of the current status and regeneration potential of the traditional conserved forests (*Ngitili*) in Kishapu district, Tanzania

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**Abstract:** The current study was carried out in the community forests conserved under the indigenous knowledge known as “*Ngitili*” in Kishapu district of Tanzania. The aim was to assess the current status and determines its regeneration potential in terms of plant species diversity, herbaceous productivity and tree stocking. A field survey was conducted for recording the current status while the phytosociological was carried to recognize vegetation composition and diversity. Regeneration potential was determined based on the population size of seedlings, saplings and adults. Disturbance index was used to calculate the level of disturbances while herbaceous productivity and tree stocking were estimated based on allometric models. Descriptive statistics for quantitative data was analysed using SPSS version 20. The study recorded a total of 10 *Ngitili* in Kishapu district, out of which, 9 still existing but highly threatened and disturbed, only 1 *Ngitili* was recorded to be dead (not existing). A total of 66 plant species were recorded of which 20 were grasses, 18 were forbs, and 28 species (17 genera and 13 families) were trees and shrubs. The dominant grass species were *Aristida funiculata* (28.9%) and *Cynodon dactylon*, while *Monechma cymosa* (4.6%) was the dominant forb. Similarly, *Acacia drepanolobium* (45.4) and *Balanites aegyptiaca* (42.9) trees dominated the area. The majority of tree species exhibited a “not regenerating” condition (51.8%) only a few (2.11%) showed a “good regeneration” condition while “newly regeneration” condition recorded 0.00%, with a diversity ranging from 1.86–2.44. Herbaceous and tree stocking potential was 1.23±0.05 t DM ha\(^{-1}\) and 5.66±0.21 t Cha\(^{-1}\) respectively, with a standing stem density (stems ha\(^{-1}\)) of 512.07±193.86. The study observed great degradation of the *Ngitili* characterized by low diversity and poor regeneration conditions. This signified that these community forests are currently threatened and its sustainability is highly at risk unless strong initiatives take place.

**Keywords:** Plant species diversity - Indigenous knowledge - Grazing pressure - Forest degradation - *Ngitili* - Kishapu.

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**INTRODUCTION**

Community conserved forests have been advocated as a proper means for forest management (Vipat & Bharucha 2014) and conservation of plant and animal species in different parts of the world (Kitalyi & Mlengi 2004, Khumbongmayum *et al.* 2005, Otsyina *et al.* 2008, Pala *et al.* 2013, Vipat & Bharucha 2014). The trend of recognizing the importance of community participation in forest management for protection of biodiversity, hydrological and nutrients cycles (Nyberg *et al.* 2015) as well as other forest-based resources which are
beneficial for the local inhabitants in terms of preventing soil erosion, control of flash flood and supply of food supplements, all over the globe are raising (Salunkhe et al. 2016). Conservation of nature and natural resources is an important part of the culture (Khumbongmayum et al. 2005, Konkane et al. 2018), associated with the indigenous communities inhabited around remote rural areas (Sala et al. 2000, Wade et al. 2003). Alteration of the ecosystem structure influence the respective ecosystem’s goods and services derived from forest to change over time (Sala et al. 2000, Zhu et al. 2004) therefore, the involvement of communities in the conservation paradigm is essential.

Many countries extending from Asia, Africa, Europe, and America have adopted this community based traditional vegetation conservation system in various socio-cultural practices of ethnicity groups (Agarwal 2016). For instance, in India, the system is known as “sacred groves” conserved by the local people intertwined with their social-cultural (Ray et al. 2015), and religious practice (Khumbongmayum et al. 2005, Sukumaran et al. 2018). In the northwestern and central parts of Tanzania, the system is traditionally known as “Ngitiili” and “Oliriri” among the Sukuma and the Maasai (Dery et al. 1999, Rubanza et al. 2006) respectively, the largest agro-pastoral and pastoral ethnic group in Tanzania.

The Ngitiili involve setting aside and retaining a patch of standing vegetation during the beginning of the rainy season and open up for grazing during the dry (Malcolm 1953, HASHI-ICRAF 1997, Issue 1997, Dery et al. 1999). It is an indigenous knowledge of the Sukuma people, mainly to carter for acute fodder shortage during the dry period (Malcolm 1953). The system existed as earlier as during the colonial era, and later considered as an important strategy for forest management and land restoration in northwestern semi-arid parts of Tanzania in the 1980s. The recognition of indigenous knowledge (Ngitiili) for land and forest restoration (Giliba et al. 2011), came into place after the declaration of the “The Desert of Tanzania” in 1984, by then the President Julius Nyerere, after touring Shinyanga region and shocked by the high extent of land degradation and deforestation resulted from several factors included; (i) vegetation clearing to eradicate tsetse flies program between 1925 to 1960s (ii) the villagization program of 1970s and (iii) expansion of cotton production for foreign markets (UNDP 2012, Selemani et al. 2012, Barrow 2016). Therefore, different strategies were taken to restore the situation, including the use of traditional indigenous knowledge.

Apart from its main roles Ngitiili, on the other hand, has contributed a significant and great potential on improving the ecological conditions of the region (Jama & Zain 2005), in terms of communities’ livelihoods, species diversity and soil erosion control (Barrow et al. 2002, UNFCC 2008). Others forest-based ecosystem goods and services such as climate change mitigation through enhanced carbon sequestration (Duguma et al. 2019), provisions of fuelwood, thatch grass, and diversification of nutrition options (fruits, vegetables, mushroom, edible insects, wild meat, ethnomedicinal) has been reported in the region (Malcolm 1953, Monela et al. 2005, Rubanza et al. 2006, Otsyina et al. 2008, Pye-Smith 2010, Chidumayo et al. 2011, Chirwa 2014). Furthermore, Ngitiili improves household economies that supplement the income from agriculture (Monela et al. 2005, Zahabu 2008, Duguma et al. 2013). In so doing, Ngitiili contributes to improving the ecological dynamics, provisions of ecosystem goods and services as well as act as the centre for biodiversity.

Unfortunately, information about the sustainable and traditional knowledge of the Sukuma people in conserving forest under Ngitiili system in Kishapu district of Shinyanga region, are highly neglected in the literature. Although several studies are describing the role of indigenous knowledge including Ngitiili, as one strategy for land and forest ecosystem restoration for biodiversity conservation and plant species biomass productivity as well as improvement of socio-economic wellbeing, for enhanced climate change mitigation in the region (Monela et al. 2005, Otsyina et al. 2008, Rubanza et al. 2006, Zahabu 2008, TaTEDO 2009, Pye-Smith 2010, Selemani et al. 2012, 2013, Chirwa 2014, Osei et al. 2015, Duguma et al. 2019), but information about the current status of Ngitiili, their performance on species diversity, herbaceous primary productivity and trees regeneration as well as stocking potential, at specific administration ecological sites such as Kishapu district, was rarely discussed and missing in the literature despite the presence of potential Ngitiili in the district. Therefore, the current study was carried out to bridge the prevailing gap by providing information about the current status of the available Ngitiili and their performance in Kishapu district of Shinyanga region.

**MATERIAL AND METHODS**

**Study area**

The study was conducted in the Kishapu district located in the northeast of the administrative region of Shinyanga, Tanzania (Fig. 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 (URT 2009). The district has a total area of 4,333 km², of which 101 km² is covered by forests. An area of about 47 km² is occupied by forests conserved under traditional knowledge (Ngiti) system.

The district is characterized by a dry tropical (semi-arid) climate with temperatures ranging from 22°C to 30°C and 15°C to 18.3°C for maximum and minimum, respectively. It is a semi-arid area that receives 450 mm to 990 mm of rainfall per annum (Tanzania National Bureau of Statistics (NBS 2012), rainfall start in late October/early November and end in April/May while the dry season begins in June and last in October. According to Katunzi et al. (2016), 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 (KDP 2013) 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, millets, sweet potatoes, and paddy, while cash crop is cotton (Katunzi et al. 2016) similarly, livestock kept are cattle, sheep, goats (sheep and goats) and poultry whereas, fishing is done during the rainy season.

Forest inventory and sampling design

In this study a systematic sampling was adopted, using concentric circular plots of 15 m radius along transects (comprised of sub-plots of 5, 10 and 15 m (Fig. 2A), modified from Malimbwi et al. (1994), Zahabu (2008), and Vesa et al. (2010). The enter plots and inter transects distances were maintained at 300 and 600 m, in between respectively. For studying and recording the current status of Ngiti in Kishapu district, a field survey was conducted. On the other hand, the phytosociological study was carried to recognize vegetation composition and plant species diversity using point sampling methods. 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 (Rubanza et al. 2006) using 0.25 m², metal quadrat (Crowder & Chheda 1982) (Fig. 2B).

While herbaceous biomass productivity was estimated based on (Pieper 1988), tree stocking potential based on (Philip 1994, Malimbwi et al. 1994, Zahabu 2008, Vesa et al. 2010) allometric models. The use of allometric provides proper estimate with less ecological disturbances (Chave et al. 2014). The model for tree bio-volume was given by Philip (1994) as,

\[ V = f \times g \times h \]

Where, \( g \) = Tree basal area at breast height (m²), \( h \) = Tree height and \( f \) = Form factor

The above-ground tree biomass (AGB) was computed based on the equation (Vesa et al. 2010),

\[ \text{AGB (t ha}^{-1}\text{)} = \frac{\text{Tree stem volume (m}^3\text{ha}^{-1}\text{)} \times \text{Tree wood density (kg m}^3\text{)}}{1000} \]
The belowground biomass was determined by multiplying the AGB by a factor of 0.25 (Kaonga & Bayliss-Smith 2009), the result was converted into carbon stock using the 'default carbon conversion factor' of 0.47 (Zahabu 2008, Pandya et al. 2013). Within the same sub-plot, seedling and sapling individuals species were identified for regeneration status [i.e., seedling species (≤20 cm height) and saplings (>20 cm, but <1 m height)], and their density were recorded.

Within 10 m radius, all plants with ≥1 but <5 cm diameter at breast height (dbh), were identified and recorded as shrub species. Furthermore, within 15 m radius all plant species (≥5 cm dbh), were recorded as tree species, (Fig. 2C). The tree dbh and heights were measured using the tree calliper and Suunto hypsometer respectively (Modified from Malimbwi et al. (1994) and Zahabu (2008).

Figure 2. A, Field plots layout; B, Assessment of herbaceous species using a 0.25 m$^2$ metal quadrat; C, Tree species identification and measurement of dbh using a calliper.

The regeneration status of plant species was determined based on the population size of seedlings, saplings and adults (modified from Good & Good 1972, Khumbongmayum et al. 2006, Iqbal et al. 2012). The 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 (Iqbal et al. 2012).

To quantify the level of disturbance, the disturbance score was calculated following Veblen et al. (1992) and Gillespie et al. (2000). The disturbance was qualitatively classified into four classes versus the degree of anthropogenic activities such as 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 only one or two anthropogenic activities evidenced; (3): for three evidence of anthropogenic activities; and (4): for more than three evidence of anthropogenic activities in the study sites (modified from Khumbongmayum et al. 2006). The sum of all ranks provided the overall ranking of the anthropogenic disturbance, such that the low rank represents a low level of disturbance. Similarly, the disturbance index (DI) was calculated based on the number of individual cut stumps.

Data collection and analysis

Data on the status of the Ngitili was collected using field survey approach, while the phytosociological approach was used to collect data on the herbaceous composition and tree diversity using point sampling (Crowder & Chhedha 1982, Rubanza et al. 2006). The collected data were computed using indices of diversity as per Shannon & Weaver (1949), Simpson (1949) and Pielou (1966). Meanwhile, species importance value index (IVI) was computed as the average of the relative basal area, density and frequency.

Data on herbaceous biomass productivity was computed following formulae given by Pieper (1988) and modified by Rubanza et al. (2006). Tree stocking parameters; basal area (m$^2$ ha$^{-1}$), standing bio-volume (m$^3$ ha$^{-1}$), above-ground and below-ground biomass were estimated based on allometric models (Philip et al. 1994, Malimbwi et al. 1994, Zahabu 2008, Vesa et al. 2010, Pandya et al. 2013). Descriptive statistics for quantitative data were analyzed using Statistical Package for Social Sciences (SPSS) software version 20.
Botanical field manual books and taxonomists were consulted for the identification of both herbaceous and tree species. However, plant species that were not easy to identify in the field, voucher specimens were taken for further identification at the college of natural and mathematical sciences, department of biological sciences, the University of Dodoma, Tanzania.

RESULTS AND DISCUSSION

Current status of Ngitili in Kishapu district of Shinyanga region

Results on the current status of Ngitili in Kishapu district is presented in table 1. The current study recorded ten (10) Ngitili in the district covering an area of 6,112.98 hectares. Out of 10, 9 (4569.34 ha), are existing while 1 Ngitili (1543.64 ha) is no longer existing (dead Ngitili). Similarly, out of the 9 existing Ngitili, 4 (2750.13 ha), are threatened and turning into a desert-like appearance whereas, the remaining five (5) are highly disturbed.

Table 1. The current status of Ngitili in Kishapu district of Shinyanga, Tanzania.

| Name of Ngitili | Village(s) | Size (ha) | Grazing | Charcoal | Agriculture | Wood fuel | Fire | Disturbance score | 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       |
| Shagihulu       | Shagihulu  | 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**|         |         |             |           |      |                   |     |         |

Note: P: Protected; T: Threatened; D: Disturbed; N: Not existing; DI: Disturbance Index.

The highest disturbance score was recorded in Lyabujije (20), followed by Bulima (15) (Table 1). Similarly, cut stumps were more recorded in Lyabujije, Bulima, and Mwamanota with relatively high disturbance index (DI) (Fig. 3). This suggests the survival of the Ngitili with its plant species is at risk. The study observed various factors affecting the status and the available vegetation species composition in the studied Ngitili. The most common observed factors include conflict of interest and ineffective improvement strategies, fewer emphases and absence of incentive from the government as compared to a few years back. Also, the introduction of agroforestry which mostly uses alien plant species (with extra care, not palatable by livestock, fail to adapt harsh condition), and unrecognition of the traditional police locally known as Sungusungu who had their ways of implementing the by-laws and protecting the communities against invaders are among of the factors.

Figure 3. Disturbance Index scores recorded in studied Ngitili of Kishapu district, Tanzania.

The reduced powers of the Elders and the Sungusungu has been attributed for the disappearance of Lyabujije Ngitili in Ng'wanima, due high level of human right consideration as it was reported by Minja & Machanya (2010) whereby, cases related to misuse of Ngitili related resources are now handled by government police.
usually discourage the action taken by Sungusungu, under the fact that is not legally recognized. Other recorded factors, included the ceasing of financial and technical support from supporting agents such as NORAD, cutting of trees for charcoal making to sustain livelihood and family economy, climate change, natural disturbance, grazing pressure, improper cultivation practices, deforestation, fires outbreak, extensive fuelwood collection and logs demand (Fig. 4). The same information has also reported by Gillespie et al. (2000) and Tefera et al. (2007) in Ethiopia.

Figure 4. A, Picture to show the observed agriculture activity taking place within Ngitili; B, Picture to show the observed cut stump in Ngitili; C, Picture to show the observed charcoal making within Ngitili; D, Picture to show the observed wood fuel collection within Ngitili.

Similar information was reported by (Kamwenda 2002, Rubanza et al. 2006, UNDP 2012) in Khama, Shinyanga rural and Meatu district respectively. On the other hand, Pye-Smith (2010) in Shinyanga region reported information on the human population and its threat to the existence of the ecosystem. Factors like the serious competition of land for human settlement, agriculture and livestock grazing (Chirwa 2014) have been attributing to high Ngitili degradation in Shinyanga.

An intense dependence on forest-related goods is attributed to poverty and few options for resource acquisition due to increased population. The World Agroforestry Centre highlighted the growing urban demand for charcoal, has accelerated the degradation of Ngitili. Furthermore, other observation that has been reported by other scholars in the Shinyanga region includes a tendency of the communities to shift from previously practised communal to private Ngitili (Selemani et al. 2012). The reasons for such movement is that the communal Ngitili provide low economic return mainly because of unequal sharing of benefits, poor land security, poor grazing management, and conflicts are unavoidable (Adams et al. 2003) as decisions are made by village government leaders on behalf of community members as compared to private Ngitili. Similarly, (Wilkie & Countries 2010) reported increased livestock and crop production threaten the existence of any ecosystem.

Plant species regeneration potential in conserved Ngitili of Kishapu

Regeneration status: The current study observed the majority of plant species (51.85%) in the studied Ngitili exhibited “Not regeneration” condition followed by “Poor regeneration” (25.41%), followed by “Fair regeneration” (20.74%) and lastly with lower percentage was “Good regeneration” (2.11%). While “Newly regeneration” was not recorded in the studied Ngitili (0.00%) (Table 2).

The study recorded a mean standing stem density of 512.07±193.86 stems ha⁻¹, for trees with greater than 5 cm diameter at breast height, similarly an average of 8.12 cm and 4.67 m, for diameter at breast height (dbh) and tree heights respectively. The findings of the current study observed a “Not regenerating” followed by a “Poor regeneration” status to dominate in the studied Ngitili. This portrayed a significant indicator of locally ecological extinction of some plant species soon. Apart from such observation, the findings of this study agree to Selemani et al. (2013) who reported 578.38±70.69 stems ha⁻¹ with an average height of 3.24 m, for tree stems density and heights respectively, in Shinyanga rural and Meatu districts.

However, the findings of the current study contradict the findings reported Monela et al. (2005) who reported the higher range of 1964 to 6553 stems ha⁻¹ and 6.7 to 27.2 cm, for tree stem density and diameter at breast height respectively, as compared to this study. Also, the findings contracted to a report by Otsyina et al. (2008) who observed a range of 1053 to 1360 stems ha⁻¹, in the districts of the Shinyanga region. Therefore, the sustainability of the Ngitili is questionable, as they are threatened by the illegal utilization of species by communities to sustain their livelihood. According to Barrow & Shah (2011), unstable climate
and edaphic variability provide an associated with poor regeneration of individual species. Similarly, Selemani et al. (2012) reported lower ecological carrying capacity due to scarcity of grazing land and low adaptability of some species to the degraded ecosystem contributed to the degradation of *Ngitili* in Shinyanga. On the other hand, the regeneration of species could have been affected by anthropogenic factors and natural phenomena (Iqbal et al. 2012).

**Table 2.** Plant species regeneration status of *Ngitili* in Kishapu district of Shinyanga, Tanzania.

| Botanical Name | Height (m) | dbh (cm) | No. of trees | No. of shrubs | No. of seedlings | No. of saplings | Regeneration status |
|----------------|------------|----------|--------------|--------------|-----------------|----------------|-------------------|
| *Acacia angustissima* (Mill.) Kuntze | 5.6 | 10.9 | 2 | 2 | 1 | 0 | NR |
| *Acacia concinna* (Willd.) DC. | 6.4 | 8.8 | 151 | 81 | 21 | 43 | GR |
| *Acacia drepanolobium* Harms ex Y.Sjöstedt | 4.4 | 5.5 | 315 | 135 | 326 | 432 | GR |
| *Acacia nilotica* (L.) Del. | 6.8 | 18.5 | 124 | 41 | 38 | 67 | FR |
| *Acacia polyacantha* Willd. | 7.4 | 16.8 | 15 | 15 | 3 | 11 | NR |
| *Acacia benthami* Meisn. | 4.3 | 9.5 | 15 | 3 | 4 | 6 | NR |
| *Acacia senegal* (L.) Willd. | 5.9 | 11.3 | 6 | 5 | 0 | 2 | PR |
| *Acacia tortilis* (Forssk.) Hayne | 7.1 | 15.8 | 102 | 28 | 9 | 16 | FR |
| *Adansonia digitata* L. | - | - | 23 | 2 | 0 | 0 | NR |
| *Albizia amara* (Roxb.) Boiv. | 2.6 | 5 | 1 | 10 | 13 | 6 | FR |
| *Azadirachta indica* A.Juss. | 4.6 | 6.7 | 2 | 1 | 1 | 2 | NR |
| *Balanites aegyptiaca* (L.) Delile | 6.1 | 8.8 | 142 | 40 | 21 | 18 | FR |
| *Capparis tomentosa* Lam. | 2.7 | 5 | 3 | 44 | 0 | 3 | NR |
| *Cassia abbreviata* Oliv. | 3.7 | 6.4 | 2 | 1 | 0 | 0 | NR |
| *Colotropis procera* (Aiton) W.T.Aiton | 1.6 | 3.6 | 1 | 7 | 13 | 24 | FR |
| *Combretum fraxigni* F. Hoffm | 5.4 | 5.8 | 1 | 14 | 0 | 0 | NR |
| *Combretum obovatum* F.Hoffm. | 3.9 | 5.1 | 1 | 5 | 0 | 0 | NR |
| *Dichrostachys cinerea* Wight et Arn. | 3.6 | 5.2 | 101 | 95 | 87 | 65 | GR |
| *Diospyros fischeri* Gürke | 3.2 | 6 | 6 | 5 | 1 | 3 | NR |
| *Euphorbia ingen* E.Mey. ex Boiss. | 4.2 | 6.2 | 1 | 12 | 7 | 9 | FR |
| *Euphorbia tirucalla* L. | 5.3 | 7.9 | 2 | 1 | 0 | 0 | NR |
| *Grewia bicolor* Juss. | 3.6 | 5.1 | 1 | 7 | 2 | 6 | NR |
| *Lannea humilis* (Oliv.) Engl. | 4.3 | 10.2 | 2 | 125 | 37 | 123 | GD |
| *Leucaena leucocephala* (Lam.) de Wit | 5.3 | 5.3 | 6 | 19 | 13 | 21 | FR |
| *Orrnocarpum kirikii* S. Moore | 2.8 | 6.5 | 7 | 21 | 6 | 19 | FR |
| *Senna siamea* (Lam.) de Wit | 5.7 | 8.7 | 1 | 1 | 17 | 5 | FR |
| *Senna singueana* (Delile) Lock | 3.1 | 5.8 | 1 | 6 | 0 | 0 | NR |
| *Tamarindus indica* L. | 6.5 | 13.6 | 2 | 1 | 0 | 6 | PR |

**Summary**

NR = 51.85; PR = 25.41; FR = 20.74; GR = 2.11
Standing stem density = 512.07±193.86 stems ha⁻¹
Average height = 4.67 m
Average dbh = 8.12 cm

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

Plant species composition and diversity status in conserved *Ngitili* of Kishapu: A total of 66 plant species were identified in the studied *Ngitili* of Kishapu district of the Shinyanga region in Tanzania. Of which, 20 species (19 genera and 3 families) were grasses, 18 species (18 genera and 11 families) were forbs, and 28 species (17 genera and 13 families) were trees and shrubs (Table 3). The findings from the current study observed few species as compared to 152 different plant species recorded by Monela et al. (2005) in the surveyed *Ngitili* forests of the Shinyanga region.

The result of grass and forb species composition as indicated in table 3 showed that the more dominant grass species were, *Aristida juniculata* Trin. & Rupr (28.93%) and *Cynodon dactylon* (L.) Pers. (12.9%). (Fig. 5). Other grass species with relatively high frequencies include *Dactylis glomerata* (L.) Willd. (6.1%) and *Eragrostis curvula* (Schrad.) Nees (4.2%), while dominant forb species were *Monechma debile* (Forssk.) Nees (4.6%), *Leucas martinicensis* (Jacq.) R.Br. and *Commelina benghalensis* L. (Fig. 6). Grass species were more diverse (58%) as compared to forb species (42%) in the study site. The reported dominant herbaceous species in the current study denote species that are native to a disturbed ecosystem, as it was observed by Pratt & Gwynne (1971), in semi-arid and disturbed landscapes of East Africa.
| Categories | Botanic Name | Composition (%) / IVI |
|------------|--------------|----------------------|
| **Category 1:** | | |
| Grass species | | |
| 1 | Aristida funiculata Trin. & Rupr | 28.9 |
| 2 | Brachiaria mutica (Forssk.) Stapf | 2.1 |
| 3 | Chenchus ciliaris L. | 3.2 |
| 4 | Chloris barbata Sw. | 1.5 |
| 5 | Chloris gayana Kunth | 0.6 |
| 6 | Cynodon dactylon (L.) Pers. | 12.9 |
| 7 | Cyperus esculentus L. | 2.7 |
| 8 | Dactyloctenium aegyptium (L.) Willd. | 6.1 |
| 9 | Digitaria scalarum (Schweinf.) Chiov. | 0.8 |
| 10 | Echinochloa colona (L.) Link | 0.1 |
| 11 | Eragrostis curvula (Schrad.) Nees | 4.2 |
| 12 | Heteropogon contortus (L.) P.Beauv | 0.4 |
| 13 | Urochloa panicoides P.Beauv. | 0.2 |
| 14 | Panicum trichocladum Hack. ex K. Schum. | 0.7 |
| 15 | Rhynchelytrum repens (Willd.) C.E.Hubb. | 1.7 |
| 16 | Monechma debile (Forssk.) Nees | 4.6 |
| **Category 2:** | | |
| Forb species | | |
| 21 | Leucas martinicensis (Jacq.) R.Br. | 3.5 |
| 22 | Commelina benghalensis L. | 3.3 |
| 23 | Ipomoea batatas (L.) Lam. | 2.8 |
| 24 | Tribulus terrestris var. inermis | 2.3 |
| 25 | Amaranthus spinosus L. | 2.2 |
| 26 | Oxygonum sinuatum (Hochst. & Steud.) | 2.2 |
| 27 | Lycopersicon lycopersicum (L.) H. Karst. | 1.8 |
| 28 | Sonchus luxurians (R. E. Fr.) C. Jeffrey | 1.5 |
| 29 | Corchorus capsularis L. | 1.1 |
| 30 | Solanum incanum L. | 0.8 |
| 31 | Sphaeranthus suaveolens (Forssk.) DC. | 0.7 |
| 32 | Acacia angustissima (Mill.) Kuntze | 6.77 |
| 33 | Acacia bethamii Meisn. | 6.09 |
| 34 | Acacia concinna (Willd.) DC. | 25.51 |
| 35 | Acacia drepanolobium Harms ex Y.Sjöstedt | 45.37 |
| 36 | Acacia nilotica (L.) Del. | 6.63 |
| 37 | Acacia polyacantha Willd. | 16.99 |
| 38 | Acacia seyal Delile | 13.74 |
| 39 | Acacia senegal (L.) Willd. | 15.53 |
| 40 | Acacia tortilis (Forssk.) Hayne | 33.2 |
| 41 | Albizia amara (Roxb.) Boiv. | 1.63 |
| 42 | Azadirachta indica A.Juss. | 5.53 |
| 43 | Balanites aegyptiaca (L.) Delile | 42.96 |
| 44 | Capparis tomentosa Lam. | 0.57 |
| 45 | Cassia abbreviata Oliv. | 1.79 |
| 46 | Colotropis procera (Aiton) W.T.Aiton | 0.98 |
| 47 | Combretum fraxigns F.Hoffm. | 1.84 |
| 48 | Combretum obovatum F.Hoffm. | 2.66 |
| 49 | Dichrostachys cinerea Wight et Arn. | 23.38 |
| 50 | Diospyros fischeri Gürke | 2.57 |
| 51 | Euphorbia ingens E.Mey. ex Boiss. | 1.43 |
| 52 | Euphorbia tirucalli. L | 8.32 |
| 53 | Grewia bicolor. Juss | 2.29 |
Figure 5. Grass species composition recorded in Ngitili of Kishapu district, Tanzania.

Figure 6. Forb species composition recorded in Ngitili of Kishapu district, Tanzania.
The presence of dominant forb species such as *Abelmoschus esculentus* (L.) Moench, *Convolvulus prostratus* Forssk., *Oxygonum sinuatum* (Hochst. & Steud. ex Meisn.) Dammer and *Sida spinosa* L., denote disturbed soil characteristics and could be attributed to certain forms of land degradation due to different factors including overgrazing and other anthropogenic activities. 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 conditions. 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. 2006, Rubanza et al. 2008, Selemani et al. 2012). A study by Rubanza et al. (2006) in Meatu reported the decline of some palatable herbage species “decreasers” as well as the emergence of less nutritious unpalatable species “increasers” that tend to dominate the place. The study observed the variation of soils, attributed to 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 Ilubu. Water-loving species like *Cynodon dactylon* (L.) Pers. were found dominant in heavy clay verisol soils (black cotton soil) characterized by high holding capacity and the associated water logging which favours water-loving grass species. Factors related to soil infertility as the cause of Ngitili degradation and distributions of species was also reported by Machanya et al. (2003).

Results on dominant tree and shrub species and their diversity are indicated in table 4. The dominant tree and shrub species recorded in the current study were from the genus Acacia. Other genera with relatively high dominant include, Dichrostachys, Lannea and Balanite. The study recorded dominant tree and shrub species such as *Acacia drepanolobium* Harms ex Y.Sjöstedt., *Acacia tortilis* (Forssk.) Hayne., *Acacia concinna* (Willd.) DC. *Acacia polyacantha* Willd. and *Acacia senegal* (L.) Willd. 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* Harms ex Y.Sjöstedt (45.37) and *Balanites aegyptiaca* (L.) Delile (42.96), with a diversity ranging from 1.9 to 2.5 and 0.07 to 0.12, for Shannon’s (H’) and Simpson’s (Ds) indices diversity respectively, in Kishapu district. There was a positive dominance relationship between tree and shrub species in the study as shown in figure 7. The domination of the observed species has been connected with their less valuable for timber markets and charcoal production as well as thorny nature that prevents them from frequently grazed by the domesticated animal.
Table 4. Dominant tree and shrub species and their diversity in Ngitili of Kishapu district, Shinyanga, Tanzania.

| Botanical Name                                | Important value index (IVI) |
|-----------------------------------------------|-----------------------------|
|                                | Tree | Shrub |
| Acacia angustissima (Mill.) Kuntze           | 6.77 | 1.62  |
| Acacia bethamii Meisn.                       | 6.09 | 2.33  |
| Acacia concinna (Willd.) DC.                 | 25.51| 6.12  |
| Acacia drepanolobium Harms ex Y.Sjöstedt     | 45.37| 10.08 |
| Acacia nilotica (L.) Del.                    | 6.63 | 1.82  |
| Acacia polyacantha Willd.                    | 16.99| 6.46  |
| Acacia senegal (L.) Willd.                   | 15.53| 2.15  |
| Acacia tortilis (Forssk.) Hayne              | 33.2 | 5.47  |
| Albizia amara (Roxb.) Boiv.                  | 1.63 | 1.44  |
| Azadirachta indica A.Juss.                   | 5.53 | 2.06  |
| Balanties aegyptiaca (L.) Delile             | 42.96| 7.29  |
| Capparis tomentosa Lam.                      | 0.57 | 8.26  |
| Cassia abbreviata Oliv.                      | 1.79 | 0.66  |
| Colotropis procera (Aiton) W.T.Aiton         | 0.98 | 0.71  |
| Combretum fraxgrans F.Hoffm.                 | 1.84 | 1.42  |
| Combretum obovatum F.Hoffm.                  | 2.66 | 1.24  |
| Dichrostachys cinerea Wight et Arn.          | 23.38| 0.71  |
| Diospyros fischeri Gürke                    | 2.57 | 0.91  |
| Euphorbia ingens E.Mey. ex Boiss.            | 1.43 | 1.13  |
| Euphorbia tirucalli. L.                      | 8.32 | 3.15  |
| Grewia bicolor. Juss.                        | 2.29 | 1.22  |
| Lannea humilis (Oliv.) Engl.                 | 33.57| 5.47  |
| Leucaena leucocephala (Lam.) de Wit          | 2.07 | 3.09  |
| Ormocarpum kirkii S. Moore                   | 3.86 | 2.75  |
| Senna siamea (Lam.) de Wit                   | 1.5  | 0.58  |
| Senna singueana (Delile) Lock                | 1.43 | 0.85  |
| Tamarindus indica L.                         | 5.53 | 2.06  |

Summary

Parameters | Value
---|---
Total 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

On the other hand, they 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. A study by Monela et al. (2005) highlighted the high regeneration potential of species like *Dichrostachys cinerea* Wight et Arn. and *Ormocarpum trichocarpum* (Taub.) Engl., indicates degraded areas. The recorded dominant tree and shrub species have similarly been reported in other parts of the (Monela et al. 2005, Rubanza et al. 2006, Otsyina et al. 2008, Selemani et al. 2013) in Shinyanga rural, Shinyanga urban, Meatu and Kahama districts, respectively. However, the current study has recorded fewer dominant tree species as compared to other districts in the region.

This might have been influenced by a high level of degradation and deforestation observed in the studied Ngitili. A study by Selemani et al. (2013) reported the predominant of plant species like *Acacia*, reflect an overgrazed land, as *Acacia* spp. can tolerate heavy grazing pressure and thrive well in degraded rangelands. According to Barbour et al. (1999) the larger the value of \( H' \) the greater the species diversity and vice versa in the scale of 1 to (Magurran 1988). While the lower the dominance index value (Ds), the lower the dominance of a single species (Giliba et al. 2011) 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 (Misra 1989). The recorded diversity (1.8 to 2.4) in the current study, portray low species diversity, characterized by the domination of a few species in the study area.

The lower 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, which may not offer sufficient time for vegetation recovery and transfer their trait to next-generation (Selemani et al. 2013). Instead of increases, the rate of species degradation and lowering their diversity (Zhu et al. 2004) observed on the forest fragmented forests in southern Yunnan. 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. The findings from the current work contradict the findings reported (Monela et al. 2005, Nyadzi et al. 2003) in different districts of Shinyanga region that showed relatively high values of both H’ and Ds.

Plant species biomass productivity potential: Results on herbaceous primary biomass productivity are given in table 5. The current study recorded a mean of 1.098±0.0306 t DM ha⁻¹, ranging from 0.00 to 3.68 t DM ha⁻¹ for minimum and maximum, respectively. The recorded biomass productivity concurs to the previous findings which were reported from other districts of the region ranged from 0.02 to 3.32 t DM ha⁻¹ (Rubanza et al. 2006) in the Meatu district and 0.92 to 3.87 t DM ha⁻¹ by Otsyina et al. (2008) in Shinyanga rural. However, the current study recorded a slightly lower average mean of biomass as compared to others (Issae 1997, Rubanza et al. 2006, Otsyina et al. 2008). The slight variations on herbaceous biomass productivity observed in the current study could be partly explained by constant grazing activities as well as differing in forest management aspects associated with overexploitation, 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; Fig. 8). Anthropogenic disturbances including resource exploitation, deforestation, and overgrazing, have altered the understory forest structure and species composition making a serious impact on future herbaceous diversity and productivity.

![Figure 8. A. Bare ground with no grass covers recorded in Bubinza Ngitili; B. Bare ground with no grass cover recorded in Shagihilu Ngitili of Kishapu district.](image)

Table 5. Herbaceous biomass productivity in Ngitili of Kishapu district, Shinyanga, Tanzania.

| Plots | FWT (g) | DWT (g) | DM (%) | Biomass (g DM⁻¹ ha⁻¹) | Biomass (t DM⁻¹ ha⁻¹) |
|-------|---------|---------|--------|-----------------------|-----------------------|
| 1     | 51.57   | 36.89   | 71.53  | 1475600               | 1.48                  |
| 2     | 105.92  | 57.16   | 53.97  | 2286400               | 2.29                  |
| 3     | 101.66  | 51.75   | 50.90  | 2070000               | 2.07                  |
| 4     | 43.2    | 21.92   | 50.74  | 876800                | 0.88                  |
| 5     | 12.48   | 8.38    | 67.15  | 335200                | 0.34                  |
| 6     | 19.82   | 11.7    | 59.03  | 468000                | 0.47                  |
| 7     | 37.94   | 21.92   | 57.78  | 876800                | 0.88                  |
| 8     | 39.79   | 22.94   | 57.65  | 917600                | 0.92                  |
| 9     | 52.86   | 28.16   | 53.27  | 1126400               | 1.13                  |
| 10    | 43.05   | 25.06   | 58.21  | 1002400               | 1.00                  |
| 11    | 24.98   | 16.94   | 67.81  | 677600                | 0.68                  |
| 12    | 28.18   | 18.87   | 66.96  | 754800                | 0.75                  |
| 13    | 55.94   | 22.34   | 39.94  | 893600                | 0.89                  |
| 14    | 112.67  | 55.87   | 49.59  | 2234800               | 2.23                  |
| 15    | 77.52   | 43.15   | 55.66  | 1726000               | 1.73                  |
| 16    | 28.8    | 19.43   | 67.47  | 777200                | 0.78                  |
| 17    | 54.17   | 21.55   | 39.78  | 862000                | 0.86                  |
|   |   |   |   |   |
|---|---|---|---|---|
| 18 | 49.2 | 19.98 | 40.61 | 792200 | 0.80 |
| 19 | 27.32 | 16.65 | 60.94 | 666000 | 0.67 |
| 20 | 34.16 | 20.01 | 58.58 | 804000 | 0.80 |
| 21 | 68.4 | 31.54 | 46.11 | 1261600 | 1.26 |
| 22 | 43.5 | 25.87 | 59.47 | 1034800 | 1.03 |
| 23 | 84.03 | 43.54 | 51.81 | 1741600 | 1.74 |
| 24 | 101.34 | 51.89 | 51.20 | 2075600 | 2.08 |
| 25 | 28.09 | 19.64 | 69.92 | 785600 | 0.79 |
| 26 | 54.1 | 21.35 | 39.46 | 854000 | 0.85 |
| 27 | 42.23 | 19.97 | 47.29 | 798800 | 0.80 |
| 28 | 92.01 | 47.23 | 51.33 | 1889200 | 1.89 |
| 29 | 49.2 | 19.98 | 40.61 | 792200 | 0.80 |
| 30 | 27.32 | 16.65 | 60.94 | 666000 | 0.67 |
| 31 | 34.16 | 20.01 | 58.58 | 804000 | 0.80 |
| 32 | 68.4 | 31.54 | 46.11 | 1261600 | 1.26 |
| 33 | 37.94 | 21.92 | 57.78 | 876800 | 0.88 |
| 34 | 39.79 | 22.94 | 57.65 | 917600 | 0.92 |
| 35 | 52.86 | 28.16 | 53.27 | 1126400 | 1.13 |
| 36 | 43.05 | 25.06 | 58.21 | 1002400 | 1.00 |
| 37 | 38.54 | 25.76 | 66.84 | 1030400 | 1.03 |
| 38 | 33.06 | 27.64 | 83.61 | 1105600 | 1.11 |
| 39 | 20.07 | 18.25 | 90.93 | 730000 | 0.73 |
| 40 | 40.69 | 24.53 | 60.29 | 981200 | 0.98 |
| 41 | 36.68 | 30.03 | 81.87 | 1201200 | 1.20 |
| 42 | 38.77 | 33.97 | 87.62 | 1358800 | 1.36 |
| 43 | 39.97 | 34.81 | 87.09 | 1394200 | 1.39 |
| 44 | 50.6 | 41.25 | 81.52 | 1650000 | 1.65 |
| 45 | 26.82 | 24.69 | 92.06 | 987600 | 0.99 |
| 46 | 25.03 | 22.43 | 89.61 | 897200 | 0.90 |
| 47 | 53.56 | 28.7 | 53.58 | 1148000 | 1.15 |
| 48 | 34.52 | 31.84 | 92.24 | 1273600 | 1.27 |
| 49 | 43.81 | 29.95 | 68.36 | 1198000 | 1.20 |
| 50 | 32.28 | 28.87 | 89.44 | 1154800 | 1.15 |
| 51 | 20.91 | 18.79 | 89.86 | 751600 | 0.75 |
| 52 | 34.18 | 31.13 | 91.08 | 1245200 | 1.25 |
| 53 | 38.46 | 27.76 | 72.18 | 1110400 | 1.11 |
| 54 | 119.78 | 54.62 | 45.60 | 2184800 | 2.18 |
| 55 | 30.43 | 26.27 | 86.33 | 1050800 | 1.05 |
| 56 | 33.25 | 26.9 | 80.90 | 1076000 | 1.08 |
| 57 | 27.01 | 25.19 | 93.26 | 1007600 | 1.01 |
| 58 | 27.09 | 24.58 | 90.73 | 983200 | 0.98 |
| 59 | 28.51 | 23.01 | 80.71 | 920400 | 0.92 |
| 60 | 20.14 | 17.65 | 87.64 | 706000 | 0.71 |
| 61 | 36.99 | 29.99 | 81.08 | 1199600 | 1.20 |
| 62 | 35.34 | 27.48 | 77.76 | 1099200 | 1.10 |
| 63 | 24.17 | 20.71 | 85.68 | 828400 | 0.83 |
| 64 | 31.9 | 26.21 | 82.16 | 1048400 | 1.05 |
| 65 | 17.12 | 15.29 | 89.31 | 611600 | 0.61 |
| 66 | 21.42 | 18.36 | 85.71 | 734400 | 0.73 |
| 67 | 14.91 | 12.58 | 84.37 | 503200 | 0.50 |
| 68 | 29.24 | 27.93 | 95.52 | 1117200 | 1.12 |
| 69 | 17.38 | 15.21 | 87.51 | 608400 | 0.61 |
| 70 | 17.01 | 15.01 | 88.24 | 600400 | 0.60 |
| 71 | 18.62 | 16.63 | 89.31 | 665200 | 0.67 |
| 72 | 21.32 | 19.35 | 90.76 | 774000 | 0.77 |
| 73 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 74 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 76 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 77 | 30.06 | 26.38 | 87.76 | 1055200 | 1.06 |
| 78 | 31.18 | 28.39 | 91.05 | 1135600 | 1.14 |
| 79 | 28.35 | 25.43 | 89.70 | 1017200 | 1.02 |
|   |     |     |     |     |     |
|---|-----|-----|-----|-----|-----|
| 80 | 31.24 | 28.26 | 90.46 | 1130400 | 1.13 |
| 81 | 31.81 | 26.04 | 81.86 | 1041600 | 1.04 |
| 82 | 30.91 | 27.75 | 89.78 | 1108000 | 1.11 |
| 83 | 26.24 | 22.79 | 86.85 | 911600 | 0.91 |
| 84 | 24.66 | 22.68 | 91.97 | 907200 | 0.91 |
| 85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 86 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 89 | 32.4 | 18.85 | 58.18 | 754000 | 0.75 |
| 90 | 26.97 | 21.08 | 78.16 | 843200 | 0.84 |
| 91 | 83.91 | 28.14 | 33.54 | 1125600 | 1.13 |
| 92 | 53.84 | 28.19 | 52.36 | 1127600 | 1.13 |
| 93 | 34.16 | 20.01 | 58.58 | 800400 | 0.80 |
| 94 | 68.4 | 31.54 | 46.11 | 1261600 | 1.26 |
| 95 | 37.94 | 21.92 | 57.78 | 876800 | 0.88 |
| 96 | 39.79 | 22.94 | 57.65 | 917600 | 0.92 |
| 97 | 24.17 | 20.71 | 85.68 | 828400 | 0.83 |
| 98 | 31.9 | 26.21 | 82.16 | 1048400 | 1.05 |
| 99 | 17.12 | 15.29 | 89.31 | 611600 | 0.61 |
| 100 | 21.42 | 18.36 | 85.71 | 734400 | 0.73 |
| 101 | 31.24 | 28.26 | 90.46 | 1130400 | 1.13 |
| 102 | 31.81 | 26.04 | 81.86 | 1041600 | 1.04 |
| 103 | 30.91 | 27.75 | 89.78 | 1108000 | 1.11 |
| 104 | 26.24 | 22.79 | 86.85 | 911600 | 0.91 |
| 105 | 24.98 | 16.94 | 67.81 | 677600 | 0.68 |
| 106 | 28.18 | 18.87 | 66.96 | 754800 | 0.75 |
| 107 | 55.94 | 22.34 | 39.94 | 893600 | 0.89 |
| 108 | 112.67 | 55.87 | 49.39 | 2234800 | 2.23 |
| 109 | 48.66 | 32.67 | 67.14 | 1306800 | 1.31 |
| 110 | 39.32 | 32.34 | 82.25 | 1293600 | 1.29 |
| 111 | 41.21 | 33.15 | 80.44 | 1326000 | 1.33 |
| 112 | 21.29 | 17.37 | 81.59 | 694800 | 0.69 |
| 113 | 27.51 | 24.79 | 90.11 | 991600 | 0.99 |
| 114 | 31.44 | 25.99 | 82.67 | 1039600 | 1.04 |
| 115 | 26.05 | 23.58 | 90.52 | 943200 | 0.94 |
| 116 | 23.58 | 17.88 | 75.83 | 715200 | 0.72 |
| 117 | 36.53 | 30.56 | 83.66 | 1222400 | 1.22 |
| 118 | 27.62 | 23.84 | 86.31 | 953600 | 0.95 |
| 119 | 32.42 | 26.69 | 82.33 | 1067600 | 1.07 |
| 120 | 27.61 | 24.11 | 87.32 | 964400 | 0.96 |
| 121 | 29.79 | 24.12 | 80.97 | 968400 | 0.96 |
| 122 | 67.2 | 34.85 | 51.86 | 1394000 | 1.39 |
| 123 | 43.5 | 31.92 | 73.38 | 1276800 | 1.28 |
| 124 | 64.7 | 26.25 | 40.57 | 1050000 | 1.05 |
| 125 | 26.01 | 18.94 | 72.82 | 757600 | 0.76 |
| 126 | 30.37 | 27.05 | 89.07 | 1082000 | 1.08 |
| 127 | 29.18 | 24.31 | 83.31 | 972400 | 0.97 |
| 128 | 33.16 | 20.87 | 62.94 | 834800 | 0.83 |
| 129 | 33.75 | 22.33 | 66.16 | 893200 | 0.89 |
| 130 | 33.42 | 20.52 | 61.40 | 820800 | 0.82 |
| 131 | 54.07 | 34.65 | 64.08 | 1386000 | 1.39 |
| 132 | 77.62 | 33.61 | 43.30 | 1344400 | 1.34 |
| 133 | 55.44 | 37.31 | 67.30 | 1492400 | 1.49 |
| 134 | 36.13 | 26.42 | 73.12 | 1056800 | 1.06 |
| 135 | 42.35 | 30.54 | 72.11 | 1221600 | 1.22 |
| 136 | 46.36 | 32.66 | 70.45 | 1306400 | 1.31 |
| 137 | 27.12 | 25.9 | 95.50 | 1036000 | 1.04 |
| 138 | 27.51 | 24.79 | 90.11 | 991600 | 0.99 |
| 139 | 31.44 | 25.99 | 82.67 | 1039600 | 1.04 |
| 140 | 26.05 | 23.58 | 90.52 | 943200 | 0.94 |
| 141 | 23.58 | 17.88 | 75.83 | 715200 | 0.72 |
|   | 142  | 143  | 144  | 145  | 146  | 147  | 148  | 149  | 150  | 151  | 152  | 153  | 154  | 155  | 156  | 157  | 158  | 159  | 160  | 161  | 162  | 163  | 164  | 165  | 166  | 167  | 168  | 169  | 170  | 171  | 172  | 173  | 174  | 175  | 176  | 177  | 178  | 179  | 180  | 181  | 182  | 183  | 184  | 185  | 186  | 187  | 188  | 189  | 190  | 191  | 192  | 193  | 194  | 195  | 196  | 197  | 198  | 199  | 200  | 201  | 202  | 203  |
|---|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|   | 22.88| 19.13| 83.61| 765200| 0.77 |
|   | 38.8 | 23.03| 59.36| 921200| 0.92 |
|   | 38.3 | 21.48| 56.08| 859200| 0.86 |
|   | 16.93| 14.57| 86.06| 582800| 0.58 |
|   | 20.54| 17.09| 83.20| 683600| 0.68 |
|   | 15.16| 13.07| 86.21| 522800| 0.52 |
|   | 33.56| 29.04| 86.53| 1161600| 1.16 |
|   | 24.94| 13.8 | 55.33| 552000| 0.55 |
|   | 18.33| 13.18| 71.90| 527200| 0.53 |
|   | 32.48| 20.88| 64.29| 835200| 0.84 |
|   | 21.03| 17.01| 80.88| 680400| 0.68 |
|   | 34.02| 27.49| 80.81| 1099600| 1.10 |
|   | 42.49| 30.32| 71.36| 1212800| 1.21 |
|   | 31.89| 23.08| 72.37| 923200| 0.92 |
|   | 59.83| 37.47| 62.63| 1498800| 1.50 |
|   | 62.79| 36.91| 58.78| 1476400| 1.48 |
|   | 63.33| 32.92| 51.98| 1316800| 1.32 |
|   | 28.93| 26.25| 90.74| 1050000| 1.05 |
|   | 68.39| 41.56| 60.77| 1662400| 1.66 |
|   | 35.13| 30.06| 85.57| 1202400| 1.20 |
|   | 37.87| 32.73| 86.43| 1309200| 1.31 |
|   | 22.03| 19.01| 86.29| 760400| 0.76 |
|   | 17.53| 16.02| 91.39| 640800| 0.64 |
|   | 89.4 | 61.18| 68.43| 2447200| 2.45 |
|   | 41.65| 30.43| 73.06| 1217200| 1.22 |
|   | 105.94| 43.11| 40.69| 1724400| 1.72 |
|   | 60.88| 42.41| 69.66| 1696400| 1.70 |
|   | 27.52| 21.3 | 77.40| 852000| 0.85 |
|   | 35.47| 30.42| 85.76| 1216800| 1.22 |
|   | 35.51| 28.18| 79.36| 1127200| 1.13 |
|   | 48.66| 32.67| 67.14| 1306800| 1.31 |
|   | 39.32| 32.34| 82.25| 1293600| 1.29 |
|   | 41.21| 33.15| 80.44| 1326000| 1.33 |
|   | 21.29| 17.37| 81.59| 694800| 0.69 |
|   | 54.39| 38.02| 69.90| 1520800| 1.52 |
|   | 30.4 | 25.26| 83.09| 1010400| 1.01 |
|   | 38.23| 30.02| 78.52| 1200800| 1.20 |
|   | 36.87| 31.22| 84.68| 1248800| 1.25 |
|   | 66.64| 33.38| 50.09| 1335200| 1.34 |
|   | 57 | 42.58| 74.70| 1703200| 1.70 |
|   | 63.59| 37.8 | 59.44| 1512000| 1.51 |
|   | 87.7 | 53.48| 60.98| 2139200| 2.14 |
|   | 45.05| 26.35| 58.49| 1054000| 1.05 |
|   | 129.26| 56.63| 43.81| 2265200| 2.27 |
|   | 32.46| 28.26| 87.06| 1130400| 1.13 |
|   | 55.67| 34.1 | 61.25| 1364000| 1.36 |
|   | 33.18| 28.89| 87.07| 1155600| 1.16 |
|   | 31.49| 22.71| 72.12| 908400| 0.91 |
|   | 80.11| 38.01| 47.45| 1520400| 1.52 |
|   | 126.89| 49.75| 39.21| 1990000| 1.99 |
|   | 28.48| 22.12| 77.67| 884800| 0.88 |
|   | 18.08| 16.52| 91.37| 660800| 0.66 |
|   | 22.04| 17.82| 80.85| 712800| 0.71 |
|   | 20.73| 17.71| 85.43| 708400| 0.71 |
|   | 31.6 | 17.59| 55.66| 703600| 0.70 |
|   | 25 | 19.97| 79.88| 798800| 0.80 |
|   | 24.62| 13.15| 53.41| 526000| 0.53 |
|   | 27 | 21.26| 78.74| 850400| 0.85 |
|   | 16.24| 13.08| 80.54| 523200| 0.52 |
|   | 104.87| 54.34| 51.82| 2173600| 2.17 |
|   | 36.18| 28.57| 78.97| 1142800| 1.14 |
|   | 70.68| 35.19| 49.79| 1407600| 1.41 |
|   |    |    |    |    |    |
|---|---|---|---|---|---|
| 204 | 40.35 | 24.98 | 61.91 | 999200 | 1.00 |
| 205 | 16.57 | 13.9 | 83.89 | 556000 | 0.56 |
| 206 | 29.75 | 21.23 | 71.36 | 849200 | 0.85 |
| 207 | 21.97 | 15.43 | 70.23 | 617200 | 0.62 |
| 208 | 19.03 | 18.91 | 99.37 | 756400 | 0.76 |
| 209 | 19.81 | 16.7 | 84.30 | 668000 | 0.67 |
| 210 | 25.6 | 21.97 | 85.82 | 878800 | 0.88 |
| 211 | 17.83 | 13.45 | 75.43 | 538000 | 0.54 |
| 212 | 26.9 | 20.6 | 76.58 | 824000 | 0.82 |
| 213 | 79.27 | 48.49 | 61.17 | 1939600 | 1.94 |
| 214 | 45.73 | 35.64 | 77.94 | 1425600 | 1.43 |
| 215 | 34.11 | 29.09 | 85.28 | 1163600 | 1.01 |
| 216 | 40.52 | 31.38 | 77.44 | 1255200 | 1.26 |
| 217 | 46.66 | 34.65 | 74.26 | 1386000 | 1.39 |
| 218 | 74.81 | 29.18 | 39.01 | 1167200 | 0.90 |
| 219 | 41.46 | 24.52 | 59.14 | 980800 | 0.98 |
| 220 | 56.56 | 21 | 37.13 | 840000 | 0.84 |
| 221 | 30.76 | 22.7 | 73.80 | 908000 | 0.91 |
| 222 | 38.9 | 28.57 | 73.44 | 1142800 | 1.14 |
| 223 | 29.01 | 26.77 | 92.28 | 1070800 | 1.07 |
| 224 | 41.46 | 29.81 | 71.90 | 1192400 | 1.19 |
| 225 | 51.11 | 30.78 | 60.22 | 1231200 | 1.23 |
| 226 | 24.37 | 22.64 | 92.90 | 905600 | 0.91 |
| 227 | 27.05 | 16.51 | 61.04 | 660400 | 0.66 |
| 228 | 57.31 | 37.11 | 64.75 | 1484400 | 1.48 |
| 229 | 40.76 | 27.51 | 67.49 | 1100400 | 1.10 |
| 230 | 26.94 | 23.28 | 86.41 | 931200 | 0.93 |
| 231 | 35.66 | 25.49 | 71.48 | 1019600 | 1.02 |
| 232 | 27.62 | 24.13 | 87.36 | 965200 | 0.97 |
| 233 | 28.57 | 20.57 | 72.00 | 822800 | 0.82 |
| 234 | 25.17 | 19.39 | 77.04 | 775600 | 0.78 |
| 235 | 18.06 | 14.4 | 79.73 | 576000 | 0.58 |
| 236 | 24.57 | 21.86 | 88.97 | 874400 | 0.87 |
| 237 | 16.88 | 14.11 | 83.59 | 564400 | 0.56 |
| 238 | 15.66 | 13.69 | 87.42 | 547600 | 0.55 |
| 239 | 18.97 | 15.73 | 82.92 | 629200 | 0.63 |
| 240 | 22.71 | 18.97 | 83.53 | 758800 | 0.76 |
| 241 | 43.35 | 21.58 | 49.78 | 863200 | 0.86 |
| 242 | 36.41 | 21.69 | 59.57 | 867600 | 0.87 |
| 243 | 17.52 | 15.51 | 88.53 | 620400 | 0.62 |
| 244 | 116.13 | 41.37 | 35.62 | 1654800 | 1.65 |
| 245 | 24.56 | 22.09 | 89.94 | 883600 | 0.88 |
| 246 | 26.81 | 23.6 | 88.03 | 944000 | 0.94 |
| 247 | 25.93 | 23.48 | 90.55 | 939200 | 0.94 |
| 248 | 39.68 | 27.65 | 69.68 | 1106000 | 1.11 |
| 249 | 26.66 | 21.24 | 79.67 | 849600 | 0.85 |
| 250 | 17.49 | 13.43 | 76.79 | 537200 | 0.54 |
| 251 | 20.9 | 18.6 | 89.00 | 744000 | 0.74 |
| 252 | 28.53 | 24.46 | 85.73 | 978400 | 0.98 |
| 253 | 64.01 | 54.34 | 84.89 | 2173600 | 2.17 |
| 254 | 32.4 | 30 | 92.59 | 1200000 | 1.20 |
| 255 | 28.6 | 25.4 | 88.81 | 1016000 | 1.02 |
| 256 | 29.49 | 26.89 | 91.18 | 1075600 | 1.08 |
| 257 | 60.4 | 56.2 | 93.05 | 2248000 | 2.25 |
| 258 | 54.6 | 50.2 | 91.94 | 2080000 | 2.01 |
| 259 | 39.76 | 35.88 | 90.24 | 1435200 | 1.44 |
| 260 | 42.4 | 39.03 | 92.05 | 1561200 | 1.56 |
| 261 | 24.76 | 20.99 | 84.77 | 839600 | 0.84 |
| 262 | 41.24 | 38.42 | 93.16 | 1536800 | 1.54 |
| 263 | 19.04 | 16.84 | 88.45 | 673600 | 0.67 |
| 264 | 21.33 | 17.04 | 79.89 | 681600 | 0.68 |
| 265 | 18.03 | 16.94 | 93.95 | 677600 | 0.68 |
On the other hand, the current study recorded a tree stocking potential of 5.657 tC ha\(^{-1}\), with an average mean of 0.209±0.047 tC ha\(^{-1}\) as shown in table 6. The study recorded low stocking potential, which describes how the Ngitili in the woodlands is characterized by a small-sized tree with low dbh and height that act as an important parameter for stocking. The high degree of disturbance particularly illegal tree cutting evidenced by the observed a larger number of stump cut trees and young regeneration potential might have influenced the recorded stocking. Plant species with relatively high stocking potential were *Acacia polyacantha* Willd. (0.99 tC ha\(^{-1}\)) and *Acacia tortilis* (Forssk.) Hayne (0.68 tC ha\(^{-1}\)). The reason behind the maximum carbon storage potential could be explained by the high dbh and height as well as wood density, associated with adaptation in the dry and degraded ecosystem. 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 highly low and impaired (Pandya et al. 2013).

The current study contradicts the findings given by Monela et al. (2005), Otsyina et al. (2008) and Zahabu (2008) who observed a relatively higher tree stocking potential in different districts of Shinyanga region. The low stocking observed in the current study could be due to the high level of forest degradation and deforestation observed in the study site. On top of that, the findings from the current study show similarity with the findings observed by Osei (2014), but with slight variations, probably because his study was so specific to certain plant species in private reserved Ngitili.
Table 6. Tree biomass stocking potential in Ngitili of Kishapu district, Tanzania.

| Botanical Name                        | Tree biomass stocking parameters |
|---------------------------------------|---------------------------------|
|                                       | AV (m³ ha⁻¹) | AGB | BGB | TB | C (tC⁻¹ ha⁻¹) |
| Acacia polyacantha Willd.             | 3.381        | 1.691 | 0.423 | 2.11 | 0.993 |
| Acacia tortilis (Forssk.) Hayne       | 2.331        | 1.166 | 0.291 | 1.46 | 0.685 |
| Balanites aegyptiaca (L.) Delile      | 2.122        | 1.061 | 0.265 | 1.33 | 0.623 |
| Albizia amara (Roxb.) Boiv.           | 1.374        | 0.687 | 0.172 | 0.86 | 0.404 |
| Euphorbia tirucalli, L.               | 1.317        | 0.658 | 0.165 | 0.82 | 0.387 |
| Acacia nilotica (L.) Del.             | 1.231        | 0.616 | 0.154 | 0.77 | 0.362 |
| Tamarindus indica L.                  | 1.041        | 0.52  | 0.13  | 0.65 | 0.306 |
| Acacia benthamii Meisn.               | 0.951        | 0.475 | 0.119 | 0.59 | 0.279 |
| Acacia angustissima (Mill.) Kuntze    | 0.897        | 0.448 | 0.112 | 0.56 | 0.263 |
| Azadirachta indica A.Juss.            | 0.737        | 0.368 | 0.092 | 0.46 | 0.216 |
| Acacia seyal Delile                   | 0.673        | 0.337 | 0.084 | 0.42 | 0.198 |
| Acacia concinna (Willd.) DC.          | 0.489        | 0.244 | 0.061 | 0.31 | 0.144 |
| Combretum fraxgrans F. Hoffm.         | 0.299        | 0.15  | 0.037 | 0.19 | 0.088 |
| Combretum fraxgrans F. Hoffm.         | 0.275        | 0.138 | 0.034 | 0.17 | 0.081 |
| Dichrostachys cinerea Wight et Arn.   | 0.254        | 0.127 | 0.032 | 0.16 | 0.075 |
| Grewia bicolor. Juss                  | 0.235        | 0.117 | 0.029 | 0.15 | 0.069 |
| Ormocarpum kirkii S. Moore            | 0.234        | 0.117 | 0.029 | 0.15 | 0.069 |
| Senna siamea (Lam.) de Wit             | 0.228        | 0.114 | 0.029 | 0.14 | 0.067 |
| Combretum obovatum F.Hoffm.           | 0.171        | 0.085 | 0.021 | 0.11 | 0.05  |
| Euphorbia ingens E.Mey. ex Boiss.     | 0.159        | 0.079 | 0.02  | 0.1  | 0.047 |
| Leucaena leucocephala (Lam.) de Wit    | 0.152        | 0.076 | 0.019 | 0.1  | 0.045 |
| Diospyros fischeri Gürke              | 0.148        | 0.074 | 0.018 | 0.09 | 0.043 |
| Acacia drepanolobium Harms ex Y.Sjostedt| 0.143    | 0.071 | 0.018 | 0.09 | 0.042 |
| Lannea humilis (Oliv.) Engl.          | 0.133        | 0.066 | 0.017 | 0.08 | 0.039 |
| Capparis tomentosa Lam.               | 0.129        | 0.065 | 0.016 | 0.08 | 0.038 |
| Senna singueana (Delile) Lock          | 0.118        | 0.059 | 0.015 | 0.07 | 0.035 |
| Colotropis procera (Aiton) W.T.Aiton   | 0.038        | 0.019 | 0.005 | 0.02 | 0.011 |

Total: 19.26  9.63  2.41  12  5.66

Tree parameters' summary

| Value |
|-------|
| Height (m) | 4.67 |
| Tree volume (m³) | 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 |

Note: AV: Average Volume; AGB: Aboveground biomass; BGB: Belowground biomass; TB: Total biomass; C: Carbon; tC: Tons of carbon.

CONCLUSION

From this study, it can be concluded that most of the available Ngitili in Kishapu district are threatened and being on the condition of disappearing shortly. An anthropogenic activity such as overexploitation of resources in the Ngitili, grazing pressure and deforestation has a direct impact on their existence. The observed degraded and threatened Ngitili due to overexploitation has accelerated the “Not regeneration condition” as well as poor biomass productivity and stocking potential which could reflect bad future upon the existence of the planned forest ecosystem for enhanced biodiversity and low value for atmospheric carbon dioxide mitigation. Therefore, effective’s measures such as government intervention, formulation of the task forces (special groups) for both financial and technical support to rescue these restorative ecosystems is inevitable.

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