Floristic Composition, Diversity And Abundance Of Woody Plant Species In Tulimani Hill Ecosystem- Makueni County, Kenya

Eunice Mutio Mule
Master of Science (Plant Ecology), School of Pure and Applied Sciences, Kenyatta University, P.O Box 43844-00100 Nairobi, Kenya

Dr. Emily Wabuyele, PhD
Department of Plant Sciences, School of Pure and Applied Sciences, Kenyatta University, P.O Box 43844-00100 Nairobi, Kenya

Dr. Paul K Muoria, PhD
Department of Plant Sciences, School of Pure and Applied Sciences, Kenyatta University, P.O Box 43844-00100 Nairobi, Kenya

ABSTACT

Tulimani Hill is a critical site for biodiversity conservation and was gazetted as a forest reserve in 2018. However, floristic composition and diversity of the ecosystem have not been documented. This study aimed at assessing diversity and abundance of woody species on the hill. Sampling was done in plots of 20m x 20m (400m^2) laid after every 100 m along 6 transects running from the base of the hill to the top. Distance between the transects was 200 m. In all plots, woody plants were identified and recorded. Their cover was visually estimated and recorded. Diameter at Breast Height (DBH) of trees >10cm was also measured. Voucher specimens were identified at the National Museum of Kenya Data from the plots was organized into three zones based on the altitudes (lower zone, middle zone and upper zone). Shannon –Wiener diversity index was used to calculate species diversity. ANOVA was used to test variation of species abundances with altitude. Fifty species belonging to 23 families were identified. Fabaceae was the most dominant family Diversity, basal area, frequency, density and cover increased with increase in altitude. This was attributed to disturbance from anthropogenic activities of neighboring communities in lower zone of the hill.

Key words: Density, Basal area, Cover, Frequency, Dryland hill forest

1. INTRODUCTION

Drylands have a scientific, economic and social value as they provide livelihood and habitat to about quarter of Earth's population (Bonkoungou, 2001). Many people and animals in drylands obtain goods and services they need for survival from these ecosystems (Kamotho *et al.*, 2008; Muller & Anderson 2018). These goods and services include food, water, fodder, shelter, fuel wood, medicinal plants and spring water (Bytebier, 2001) and globally important products such as gum arabic, and frankincense. Drylands are also valuable for carbon storage (Muller & Anderson, 2018) and provide opportunities for trade, tourism and migration (Hesse, 2020). These ecosystems have low and unpredictable rainfall and inter- annual climate changes (Hesse, 2020).

Tulimani Hill Forest is a gazetted forest located in Makueni County, Kenya. Like many other forests in drylands, this forest provides habitat for flora and fauna and products like timber, wood fuel and herbal medicine. It also provides forest nature functions like carbon sequestration, climatic stability, ground water recharge, control of erosion and flood, nutrient conservation and recycling. Indeed, Tulimani ecosystem is a critical unit that requires proper planning and implementation of conservation interventions to ensure continued benefits to humanity and nature at large.

Conservation of biodiversity is critically dependent on identifying its important components. In many cases, availability of basic biodiversity data determines efficiency of conservation action for a given ecosystem (Sousa-Baena *et al*., 2013). As noted by Haq *et al*., (2023) knowledge of floristic composition and distribution of species enhances rational utilization of resources. For Tulimani Hill however, no systematic studies have been undertaken to verify composition and diversity of both flora and fauna. This study aimed to bridge the gap on knowledge of the flora by assessing diversity and abundance of woody species on the Tulimani Hill.

2. MATERIALS AND METHODS

2.1 STUDY SITE

Tulimani Hill Forest is situated in Mbooni Sub County, Makueni County in Kenya (Figure 2.1). The forest is 325.8 hectares. It is situated between latitudes $01^0$51'07'' South, and $037^0$40'02" East. It has an elevation of 1153m above sea level. It has average annual temperatures of 17^oC and 27^oC with high temperatures during the dry seasons which occur in August, September and partly October. Average annual precipitation is 530mm to 625mm which is not distributed equally over the year. The main rainy season occurs in March to May. Short rains occur between October and December. The soils of the Hill are sandy clay.

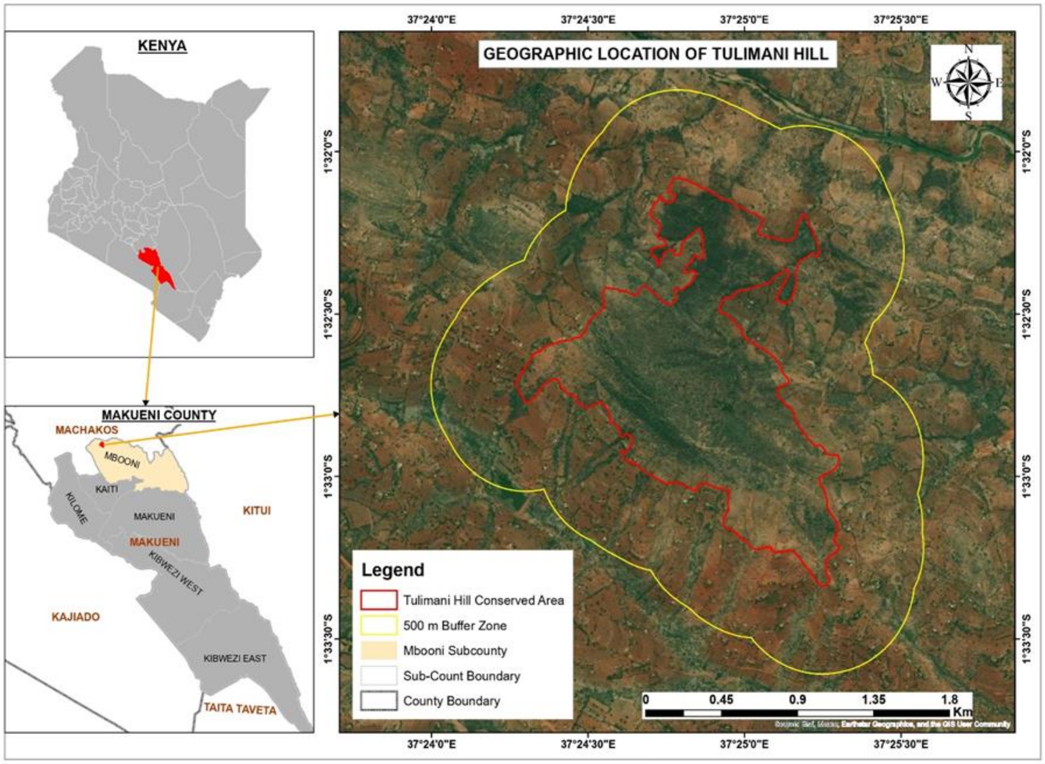

Figure 2.1: Map of Tulimani Hill.

Source. Author

2.2 DATA COLLECTION ON FLORISTIC DIVERSITY

Floristic data was collected using systematic sampling method in the month of November 2022, with permission from Kenya Forest Service (RESEA/KFS/VOL-V11/89). Six transect lines of approximately 1.7 Km each were used with 4 rectangular sampling plots of 20m x 20m ($400m^2$) laid at every 100m along the transect (Figure 2.2). The sampled zones were geo-referenced using GPS for future reference. Since elevation plays a significant function in community formation (Sakya & Bania, 1998) and Haq *et al.*, 2011, transects were laid from lowland to hilltop round the hill. The distance between two transect lines was 200m.

In each plot, the woody plant species were identified, tagged and recorded by botanical name and local names where available. The habit of the species was recorded (tree, shrub or tree/shrub). The numbers and DBH (for all trees above 10 cm in diameter) were measured using a caliper. Species identification was done with assistance of taxonomic and floristic experts and identification manuals (Agnew, 1974; Beentje *et al.*, 1994). Plant cover for each species was estimated visually and recorded. Altitude of each quadrant was recorded using GPS. For unknown species, voucher specimens were taken for identification at National Museums of Kenya.

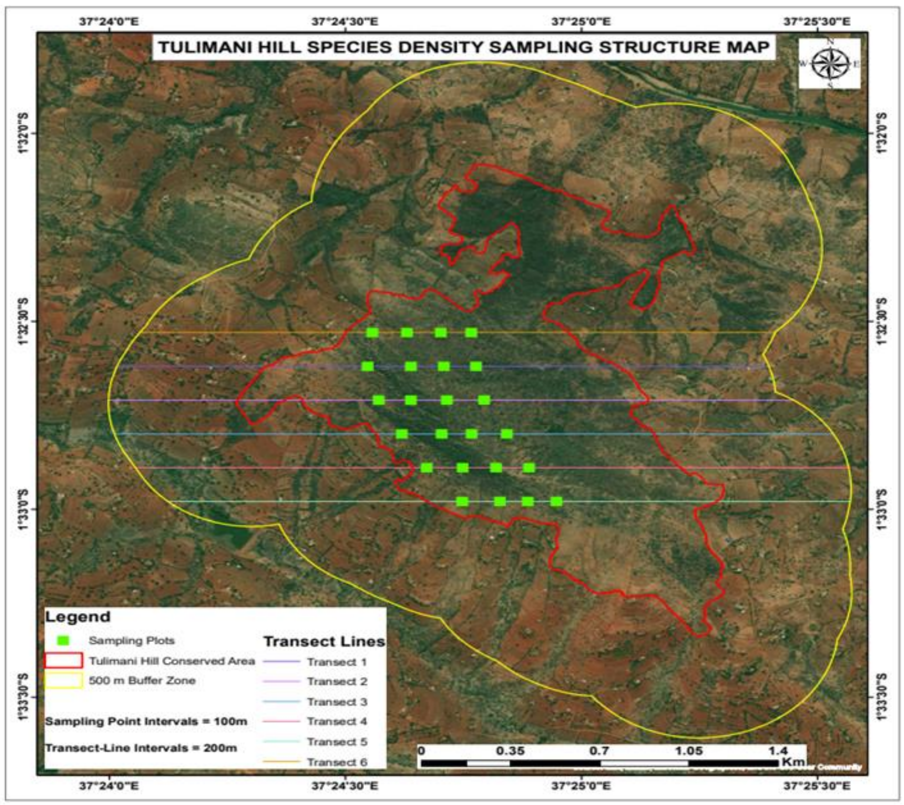

Figure 2.2: Tulimani Hill vegetation sampling map showing layout of transects from the base of the hill to the apex.

2.3 DATA ANALYSIS

Sampled plots were arranged and categorized into three zones based on the altitude values recorded i.e lower zone (4550-4700 ft), middle zone (4700-4850 ft) and upper zone (4850-5000 ft). Data on density, diversity, frequency, cover and tree basal area was compiled and analyzed using MS-Excel. Basal area for trees was calculated from the measured DBH values. Frequency was expressed in percentages. Density for each species was calculated in m^2.

Diversity was calculated using Shannon-Wiener diversity index (Mueller-Dombois & Ellenberg ,1974). Results were presented in tables and charts. The mean density, cover and basal area was calculated for the upper, middle and lower zones of the hill, respectively. ANOVA was used to test for variation in the mean density, tree mean basal area and mean cover with increase in altitude. Post hoc Tukey test was used to assess the difference in means.

3. RESULTS

3.1 FLORISTIC COMPOSITION

Fifty species (33 shrubs and 17 trees) belonging to 41 genera and 23 families were identified from the 24 plots sampled. The most common encountered families were Fabaceae with 14 species, Euphorbiaceae (4 species), Lamiaceae (4 species) and Rubiaceae (3 species). Asteraceae, Capparaceae, Combretaceae, Burseraceae, Malvaceae, and Solanaceae had two species. Acanthaceae, Anacardiaceae, Apiaceae, Asparagaceae, Balanitaceae, Boraginaceae, Celastraceae, Convolvulaceae, Labiatae, Phyllanthaceae, Sapindaceae, Thymelaceae and Verbenaceae were all represented by a single species.

Ten tree and fifteen shrub species were including *Commiphora indensis, Vachellia nilotica, Acalypha volkensii, Vachellia brevispica, Vachellia mellifera, Vachellia seyal, Vachellia tortilis, Lonchocarpus eriocalyx, Terminalia brownii* and *Tinnea aethiopica* were the tree species present in the three zones. *Asparagus africana, Croton dichogamus, Flueggea virosa, Gnidia latifolia, Hibiscus fuscus, Hoslundia opposita, Ipomoea fistulosa, Lantana camara, Maytenus heterophylla, Ocimum gratissimum, Pavetta abyssinica, Premna resinosa, Rhus natalensis, Solanum incanum* and *Senna senguena* were the shrub species present in the three zones.

3.2 SPECIES DIVERSITY

Higher species diversity was recorded at high altitudes than in lower and middle altitudes. Shannon- Wiener Index (H') in the lower zone was 2.3, middle zone 2.4 and upper zone 2.6 (Figure 3.1).

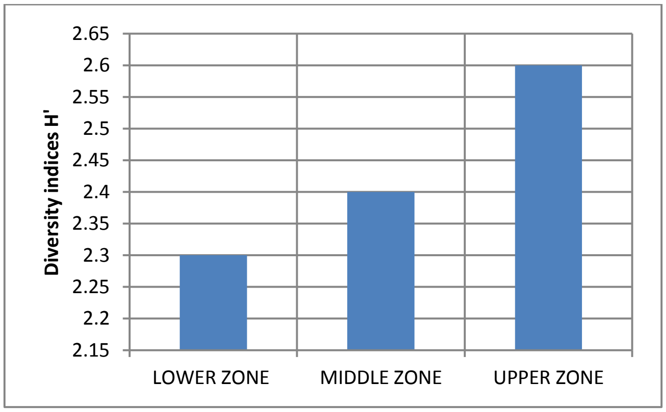

Figure 3.1: Variation of Diversity Indices with Altitudinal ranges.

3.3 FREQUENCY

The most frequent tree species was *Vachellia mellifera* (Family Fabaceae) at 54.5% in lower zone, 55.6% in middle zone and 75% in upper zone. Another species that was frequently encountered was *Commiphora indensis* (Family Burseraceae) (45.5%, 55.6% and 50% in lower, middle and upper zone respectively) and *Tinnea aethiopica* (Family Lamiaceae) (36.4%, 33.3% and 100% in lower, middle and upper zone respectively) (Figure 3.2).

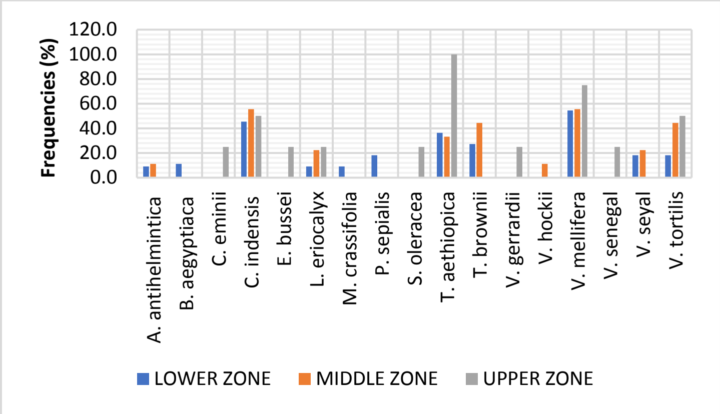

Figure 3.2: Tree species frequencies

The most frequent shrub species were *Gnidia latifolia* (Family Thymelaceae) (100.0% in lower zone, 100.0% in the middle zone and 100.0% in the upper zone), followed by *Lantana camara* (Family Verbenaceae) (100.0% in the lower zone, 88.0% in the middle zone and 100.0% in the upper zone). Other species that were frequently encountered included *Rhus natalensis* (Family Anacardiaceae) (100.0% in the lower zone, 77.8% in the middle zone and 100.0% in the upper zone) and *Croton dichogamus* (Family Euphorbiaceae) (90.9% in the lower zone, 77.8% in the middle zone and 100.0% in the upper zone).

The least frequent shrubs were *Capparis tomentosa* (Family Capparaceae) (0.0% in lower zone, 11.1% in the middle zone and 0.0% in the upper zone), *Combretum paniculatum* (Family Combretaceae) (0.0% in the lower zone, 11.1% in the middle zone and 0.0% in the upper zone), *Cordia monoica* (Family Boraginaceae) (0.0% in the lower zone , 0.0% in the middle zone, 25.0% in the upper zone) and *Maerua crassifolia* (Family Capparaceae) *(*9.1% in the lower zone , 0.0% in the middle zone and 0.0% in the upper zone).

Twenty species had their frequency values increasing with increase in altitude. i.e *V. gerardii, V. hockii, V. senegal, V. seyal, V. tortilis, A. volkensii, A. africana, A. mossambicensis, C. eminii, C. monoica, C. axillaris, E. bussei, G. similis, H. fuscus, H. opposita, L. eriocalyx, S. incanum, S. taitensis, S. oleraceae* and *T. brownii*.

Table 3.1: Shrub species frequencies (%)

SPECIES NAME	LOWER ZONE	MIDDLE ZONE	UPPER ZONE
Vachellia brevispica	72.7	44.4	75.0
Vachellia nilotica	27.3	22.2	0.0
Acalypha volkensii	81.8	66.7	75.0

Asparagus africana	9.1	33.3	75.0
Aspilia mosambicensis	0.0	0.0	50.0
Capparis tomentosa	0.0	11.1	0.0
Cathium keniense	18.2	11.1	0.0
Combretum paniculatum	0.0	11.1	0.0
Cordia monoica	0.0	0.0	25.0
Crotalaria axillaris	0.0	0.0	50.0
Croton dichogamus	90.9	77.8	100.0
Dyschoriste radicana	9.1	11.1	0.0
Entada abyssinica	0.0	11.1	0.0
Flueggea virosa	72.7	44.4	50.0
Gnidia latifolia	100.0	100.0	100.0
Grewia similis	0.0	0.0	0.0
Haplocoelum foliolosum	0.0	11.1	0.0
Hibiscus fuscus	36.4	66.7	100.0
Hoslundia opposita	9.1	22.2	25.0
Ipomoea fistulosa	27.3	11.1	50.0
Lantana camara	100.0	88.0	100.0
Maytenus heterophylla	90.9	66.7	100.0
Microglossa pyrifolia	18.2	0.0	50.0
Ocimum gratissimum	72.7	44.4	100.0
Pavetta abyssinica	27.3	33.3	25.0
Pentas lanceolata	27.3	22.2	0.0
Plectranthus barbetus	9.1	11.1	0.0
Premna resinosa	36.4	22.2	25.0
Rhus natalensis	100.0	77.8	75.0
Senna senguena	18.2	44.4	25.0
Solanum incanum	18.2	33.3	50.0
Solanum taitensis	0.0	11.1	25.0

3.4 SPECIES ABUNDANCE

3.4.1 DENSITY

A. volkensii, C. dichogamus, G. latifolia and L. camara had a high mean density in lower zone. In the middle zone, A. volkensii, C. dichogamus, L. camara, H. fuscus, O. gratissimum and T. aethiopica had high mean density. In the upper zone A. volkensii, C. dichogamus, L. camara, A. brevispica, O. gratissimum and T. aethiopica had high mean density (Table 3.2 and Table 3.3). L. camara was the most common exotic weed of the area. The species density values ranged between 25 to 2825 per hectare.

ANOVA revealed that the mean species density values differed significantly ($p<0.05$) with altitude for V. brevispica ($P =0.001$), V. mellifera ($P=0.038$), V. nilotica ($P=0.014$), V. senegal ($P=0.001$), V. seyal ($P= 0.027$), A. africana ($P=0.014$), E. bussei ($P=0.033$), S. oleracea ($P= 0.002$), T. brownii ($P = 0.033$) and T. aethiopica ($P= 0.014$) (Table 3.2)

However, mean density values of V. tortilis ($P= 0.548$), G. latifolia ($P= 0.7853$), H. opposita ($P= 0.6833$), L. camara ($P = 0.2687$), O. gratissimum ($P=0.4642$) and S. taitensis ($P= 0.3081$) did not vary significantly with altitude ($P>0.05$) (Table 3.3).

Table 3.2: Variation in mean tree densities in the three altitudinal bands of Tulimani Hill.

	LOWER ZONE		MIDDLE ZONE		UPPER ZONE			
SPECIES NAME	**MEAN DENSITY**	**STD ERROR**	**MEAN DENSITY**	**STD ERROR**	**MEAN DENSITY**	**STD ERRO**	**F**	**P**
Albizia anthelmintica	2.273	2.273	2.778	2.778	0.000	0.000	0.206	0.815
Balanites aegyptiaca	4.545	4.545	0.000	0.000	0.000	0.000	0.569	0.575
Commiphora indensis	0.000	0.000	0.000	3.675	6.250	0.000	8.750	**0.002**
Commpiphora eminii	47.727	0.000	30.556	0.000	12.500	7.217	0.872	0.433
Euphorbia bussei	0.000	0.000	0.000	2.778	106.250	0.000	4.033	**0.033**
Lonchocarpus eriocalyx	2.273	129.880	5.556	308.727	6.250	216.506	0.388	0.683
Maerua crassifolia	4.545	2.273	8.333	3.675	0.000	6.250	0.291	0.751
Phyllanthus sepialis	11.364	22.931	0.000	58.926	0.000	0.000	0.878	0.430
Steganotaenea oleracea	0.000	0.000	0.000	5.556	12.500	12.500	8.750	**0.002**
Terminalia brownii	18.182	0.000	58.333	0.000	168.750	6.250	4.034	**0.033**
Tinnea aethiopica	43.182	11.722	102.778	37.731	437.500	67.988	5.302	**0.014**
Vachellia gerrardii	0.000	0.000	0.000	0.000	6.250	6.250	3.080	0.066
Vachellia hockii	0.000	0.000	2.778	2.778	0.000	0.000	0.880	0.429
Vachellia mellifera	31.818	10.164	33.333	18.634	125.000	38.864	3.826	**0.038**
Vachellia senegal	0.000	0.000	0.000	0.000	6.250	6.250	9.240	**0.001**
Vachellia seyal	4.545	3.049	5.556	3.675	25.000	6.250	4.331	**0.027**
Vachellia tortilis	6.818	4.874	16.667	8.333	12.500	7.217	0.619	0.548

Table 3.3: Variation in mean shrub densities in the three altitudinal bands of Tulimani Hill.

	LOWER ZONE		MIDDLE ZONE		UPPER ZONE			P VALUE
SPECIES NAME	MEAN DENSITY	STD ERROR	MEAN DENSITY	STD ERROR	MEAN DENSITY	STD ERROR	F value	
Vachellia brevispica	38.636	10.852	52.778	25.154	437.500	119.678	23.449	0.001
Vachellia nilotica	6.818	3.521	5.556	3.675	25.000	11.968	5.303	0.014
Acalypha volkensii	889.545	269.807	819.444	311.018	1031.250	339.941	0.080	0.924
Asparagus Africana	9.091	9.091	13.889	7.349	68.750	21.348	5.267	0.014
Aspilia mosambicensis	0.000	0.000	0.000	0.000	50.000	35.355	5.833	0.010
Capparis tomentosa	0.000	0.000	2.778	2.778	0.000	0.000	0.820	0.454
Cathium keniense	9.091	6.098	5.556	5.556	0.000	0.000	0.415	0.666
Combretum paniculatum	0.000	0.000	5.556	0.000	0.000	0.000	1.875	0.178
Cordia monoica	0.000	21.704	0.000	12.345	12.500	6.250	8.750	0.002
Crotalaria axillaris	0.000	0.000	0.000	0.000	56.250	6.250	7.159	0.004
Croton dichogamus	218.182	0.000	202.778	0.000	562.500	35.904	4.235	0.028
Dyschoriste radicana	13.636	82.441	55.556	56.280	0.000	62.500	0.529	0.597
Entada abyssinica	0.000	13.636	2.778	55.556	0.000	0.000	0.820	0.454
Flueggea virosa	79.545	0.000	41.667	0.000	50.000	93.750	0.930	0.410
Gnidia latifolia	215.909	18.714	183.333	22.822	218.750	28.868	0.244	0.785
Grewia similis	0.000	32.904	0.000	38.415	43.750	60.703	4.331	0.027
Haplocoelum foliolosum	0.000	0.000	2.778	0.000	0.000	37.500	0.820	0.454

Hibiscus fuscus	79.545	0.000	219.444	2.778	368.750	0.000	3.533	0.048
Hoslundia opposite	6.818	47.771	16.667	70.683	18.750	126.398	0.388	0.683
Ipomoea fistulosa	18.182	6.818	5.556	11.024	25.000	18.750	0.927	0.411
Lantana camara	597.720	9.589	1091.667	5.556	843.750	14.434	1.400	0.269
Maytenus heterophylla	177.273	4.545	111.111	8.333	193.750	0.000	0.493	0.618
Microglossa pyrifolia	9.091	53.984	0.000	48.253	31.250	102.253	2.628	0.096
Ocimum gratissimum	245.455	6.098	494.444	0.000	506.250	23.662	0.796	0.464
Ormocarpum trichocarpum	4.545	72.834	0.000	223.870	0.000	262.674	1.264	0.303
Pavetta abyssinica	13.636	3.049	16.667	0.000	6.250	0.000	0.235	0.792
Pentas lanceolata	34.091	7.807	83.333	9.317	0.000	6.250	0.769	0.476
Plectranthus barbetus	4.545	9.148	5.556	0.000	0.000	0.000	0.206	0.815
Premna resinosa	36.364	4.545	25.000	5.556	18.750	0.000	0.127	0.881
Rhus natalensis	90.909	25.083	69.444	17.678	168.750	18.750	4.725	0.020
Senna senguena	13.636	10.265	41.667	15.466	6.250	52.416	0.981	0.392
Solanum incanum	75.000	9.148	86.111	25.345	81.250	6.250	0.007	0.993
Solanum taitensis	0.000	70.146	5.556	68.353	12.500	49.345	1.246	0.308

Species densities varied significantly with altitude with higher densities in the upper zone. Post hoc analyses revealed that densities in the upper zone for *A. mellifera* (*P*=0.011), *V. nilotica* (*P*=0.009), *V. senegal* (*P*=0.006), *C. eminii* (*P*=0.006), *C. monoica* (*P*=0.006), *S. oleracea* (*P*=0.006), *T. brownii* (*P*=0.004) and *T. aethiopica* (*P*=0.003) were significantly higher when compared with those in lower and middle zones. *V. gerardii*, *V. senegal*, *A. mossambicensis*, *C. eminii*, *C. monoica*, *C. axillaris*, *E. bussei*, *G. similis* and *S. oleracea* occurred in the upper zone only.

3.4.2 BASAL AREA

Tree basal area increased significantly with increasing altitude. The total basal area of trees was found to be 0.066 m^2 /ha in the lower zone, 0.071 m^2/ ha in the middle zone and 0.252 m^2/ ha in the upper zone. ($p<0.05$) for *V. mellifera*, *P. sepialis*, *V. seyal* and *T. brownii*. In the lower zone, *B. aegyptiaca* (0.0132 m^2/ha), *C. indensis* 0.018 m^2/ha. and *A. mellifera* 0.049 m^2/ha had the highest basal area. Mean basal area ranged between 0.003m^2 /ha to 0.050 m^2 /ha and was high in the middle zone and upper zone compared to lower zone.

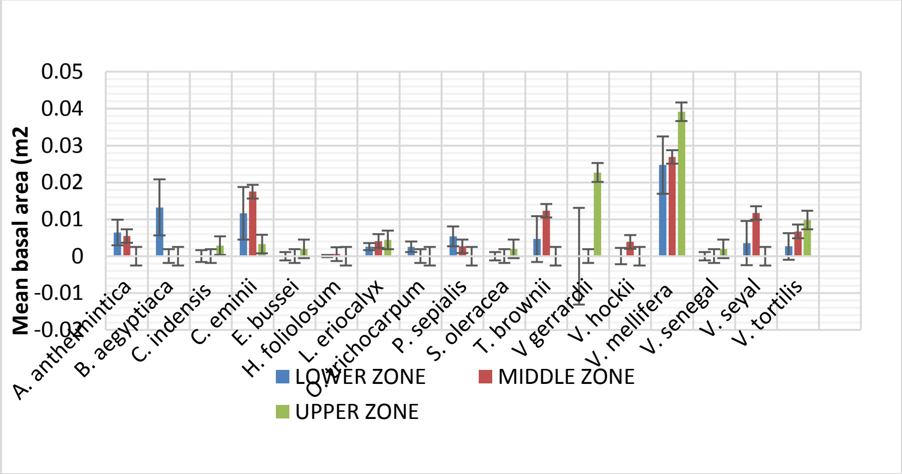

Figure 3.3: Mean tree basal area (+/-SE) variations with Altitude.

3.4.3 COVER

Mean woody species cover varied significantly with change in altitude for *A. africana* (*P*=0.015), *A. mosambicensis* (*P*=0.010), *C. monoica* (*P*=0.002), *C. dichogamus* (*P*=0.043), *E. bussei* (*P*=0.022), *G. similis* (*P*=0.022), *V.. senegal* (*P*=0.002), *C. eminii* (*P*=0.022), *C. axillaris* (*P*=0.008), *S. oleracea* (*P*=0.001) and *T. aethiopica* (*P*=0.016).

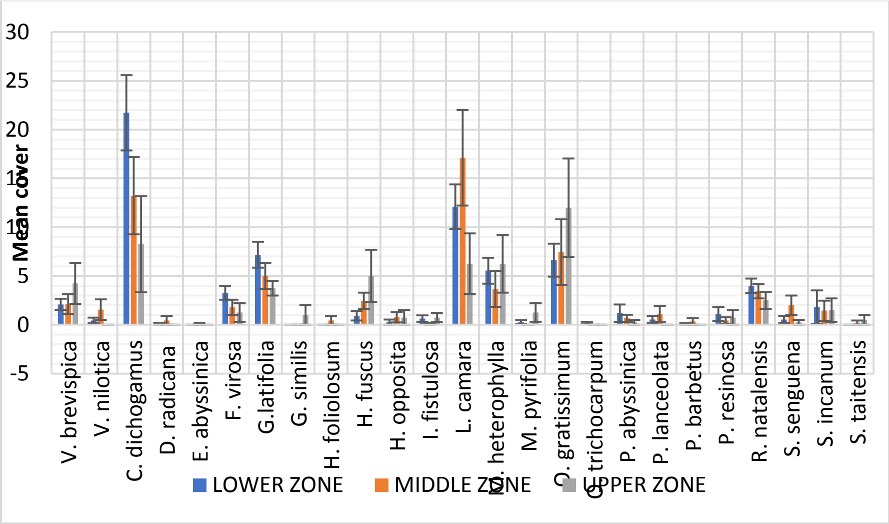

Figure 3.4 Mean cover (+/-SE) for shrubs

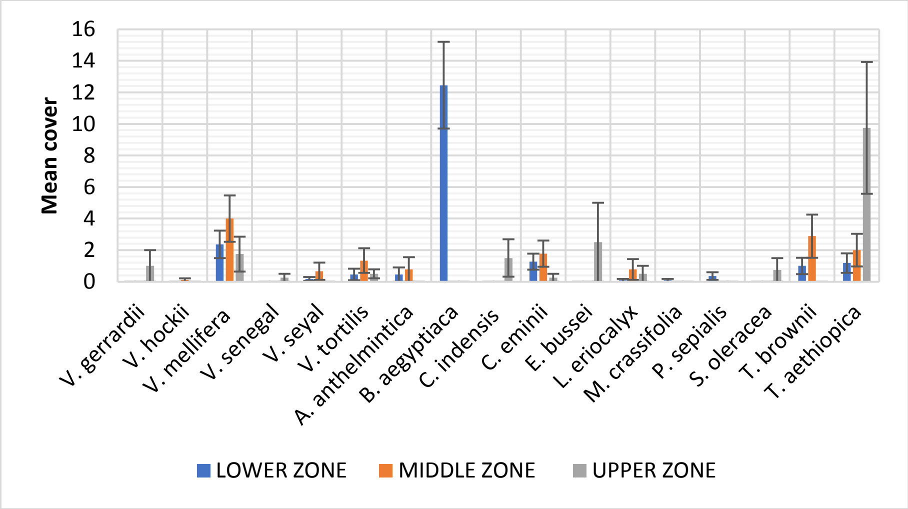

Figure 3.5: Mean cover (+/-SE) for trees

A Tukey post hoc test revealed that the upper and middle zones recorded a higher plant cover than lower zone for *A. senegal* (*P*=0.009), *S. Oleraceae* (*P*=0.006) and *T. Aethiopica* (*P*=0.012).

4. DISCUSSION

4.1 COMPOSITION OF WOODY PLANT SPECIES IN TULIMANI HILL

The dominance of Family Fabaceae, Euphorbiaceae and Lamiaceae in the study Tulimani Hill could be due to their effective dispersals and the ability to adapt to different ecological factors (Ensermu &Teshome, 2008) or this may imply that the environmental conditions in the study area are more favourable to these families.

The total number of woody plant species recorded in the lower, middle and upper altitudes of the hill were 33,36 and 36 respectively. The total woody species recorded in this study area were less than woody species reported in other forests in ASAL's like Nthangu Forest (292 species), Makongo (274 species), Makuli (264 species), Kitondo (196 species) (Malombe *et al*., 2012), Kibauni Hill forest 155 species (Mainga *et al*., 2012), Nthangu forest (77 species) Kathonzweni forest (69 species), Kibwezi forest (70 species) (Mengich *et al*.,2013).

These forests have higher number of woody species than Tulimani hill ecosystem probably due to different vegetation communities, their protection status, habitat heterogeneity. altitudinal range differences, climatic conditions, diverse environmental variables, lower disturbance levels and most of them are water catchment areas. The high intensity of human activities in the study area result to elimination of trees and shrubs through wood harvesting, fires, livestock grazing and agricultural activities. This is in agreement with studies done by Vuviya *et al*., 2014 on tree species richness and diversity in Kakamega Forest.

A higher number of woody species occurred in the middle and upper altitudes of Tulimani Hill. This could be due to anthropogenic disturbance in the lower altitudes or due to variations in altitudes. Another cause of low number of species could be associated with damage by wild animals that leads to loss of more susceptible tree and shrub species (Cheruto *et al*.,2016).

Tulimani Hill consists of higher number of shrubs than trees. This was same as of Kibauni Hill forest where shrub layer dominated (Mainga *et al*., 2011). This may be attributed to effects of elevational gradients and slope on species or due to cutting of the big trees intensively for construction poles and firewood or because soil of the area is at genesis and is full of rocks and murram and roots for huge trees cannot grow very deep.

4.2 DIVERSITY OF WOODY PLANT SPECIES IN TULIMANI HILL ECOSYSTEM

The highest species diversity was recorded in the upper altitudes (2.6), followed by middle (2.4) and lower altitudes of the hill (2.3). Diversity indices that are greater than 2, their species are said to be either medium or highly diverse (Giliba *et al*.,2011). The current study reflects an ecosystem with high species diversity and this calls for better strategies on conservation and management of the hill.

In this study, species diversity increased from lower to upper altitudes of the hill. This shows increased richness and evenness of species (Manuel & Cahill, 2007). Species richness and diversity depends on human disturbances and at low disturbance intensities the highest number of species are registered (Zegeye *et al*., 2006). According to Hughes, 2012; Dumbrell *et al*., 2008, the highly disturbed areas have low species diversity. However, Kayombo, 2020 reports that moderate disturbance in an area stimulates higher diversity. The variation in species diversity in the three zones of the study area were attributed to the effect of altitudinal gradients on the composition of woody species and impacts of minimal human disturbances to the vegetation in the plots in the upper zone. This stimulates growth of more woody plant species.

4.3 DENSITY OF WOODY PLANT SPECIES IN TULIMANI HILL

Density of plants predicts the health status of an ecosystem (Baker *et al*., 2004). Statistically significant difference was observed in the density of woody plant species among the three zones in the study area (Table 3.2 and Table 3.3). The overall mean density of woody plant species was 3064.54m^2/ha for lower zone, 3933.33m^2/ha for middle zone and 5762.5m^2/ha for upper zone. High density of woody species was recorded in the upper altitudes of the hill, showing that many species are found near the hilltop. This may be attributed to destructive anthropogenic activities (Fox, 2005) that lead to removal of trees and shrubs through intensive cutting, fire outbreaks, cattle grazing and introduction of invasive species in the lower zone as observed during the study, or natural phenomenon like frequent drought and wildlife damage.

Acalypha volkensii dominated the three zones of the hill. Most of the species with low density in the lower zone (Table 3.2) have medicinal uses, some are used to make charcoal and firewood *like A. mellifera, T. brownii, A. brevispica, R. natalensis, C. dichogamus, A. nilotica, A. seyal, M. heterophylla*. Most of the economically valuable trees are scarce, have low density and abundance due to higher degree and pattern of utilization (Aigbe & Omokhua (2015). *A. gerardii, A. senegal, A. mossambicensis, C. eminii, C. monoica, C. axillaris, E. bussei, G. similis* and *S. oleracea* were found in the upper zone only. This could be due to reduced human disturbances on the upper altitudes of the hill.

4.4 BASAL AREA OF TREES IN TULIMANI HILL

The overall mean basal area of trees recorded in Tulimani Hill was 0.0659m^2/ha in the lower zone, 0.0790m^2/ha in the middle zone and 0.2522 m^2/ha in the upper zone. Basal area increased with elevation. Trees in the lower zone could be affected by a variety of anthropogenic activities including wildfires, illegal cuttings and overgrazing leading to death of many trees in low and mid-altitudes due to the damage. Trees found in higher altitudes are not much affected (Coomes & Allen, 2007). Higher basal area values were recorded in higher altitudes due to availability of old aged and large sized trees with large diameters. This also indicates relatively little disturbance in the upper elevations of the hill.

In this study, *A. mellifera* had the highest basal area in the three zones of the hill. A species with the highest basal area is the highly significant and dominant woody species in an area. On the other hand, the lowest basal area was recorded for species like *A. hockii, E. bussei, H. foliolosum, O. trichocarpum* and *S. oleracea*. *T. brownii, C. indensis, A. seyal, A. senegal, A. nilotica* and *A. mellifera* were the most significant species of the area under study.

4.5 FREQUENCY OF WOODY PLANT SPECIES IN TULIMANI HILL

According to Santamaria, 2002 and Burnham & Santanna, 2015 a plant species with highest frequency is said to be the highly distributed in the study area. Among all the recorded woody species in Tulimani Hill, *G. latifolia* occurred frequently in the lower, middle and upper altitudes of the hill i.e 100%, 100% and 100% respectively. Some species such as *L. camara*, *R. natalensis*, *C. dichogamus* and *M. heterophylla* frequently occurred at the three zones of the hill. *A. hockii*, *B. aegyptiaca, C. tomentosa*, *C. paniculatum*, *E. abyssinica*, *H. foliolosum* and *M. crassifolia* were the least frequently occurring in the hill.

Differences in the frequencies of the woody species among the three zones could be due to species habitat preferences, effect of slope and altitude, adaptation of species, disturbance levels and availability of some factors necessary for regrowth.

4.6 COVER OF WOODY PLANT SPECIES IN TULIMANI HILL

The cover of some species increased upslope. Jiang *et al*., (2017) reported that cover is the most noticeable factor that is affected by many anthropogenic factors. Unsustainable fuel wood extraction for domestic purposes declines vegetation cover (Sahoo & Davidar ,2013). In this study, a high plant cover in middle and upper altitudes could be due to reduced human disturbance like charcoal burning which leads to reduced area occupied by plants, thus a sparse cover of the woody plants in the lower altitudes.

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Tulimani Hill is an important site with high woody plant species diversity, from a variety of families. These findings provide baseline information that will help in conservation strategies of these plants.

5.2 RECOMMENDATIONS

To reduce the anthropogenic pressures in the study area;

- Locals need to grow trees on their farms.
- There is a need for awareness and education among the locals on the importance of preserving plants, ecological consequences of vegetation loss and to change their attitudes towards the use of the ecosystem resources.
- Tulimani Hill management should help villagers to establish some local alternative livelihood projects and alternative sources of energy to reduce their dependence on the trees from the hill.
- A management plan for Tulimani Hill should be developed and implemented since there is need to control on-going illegal activities and immediate conservation action in order to ensure the suitable utilization and management of the ecosystem and to avoid vegetation degradation, species loss, and decline in plant richness, cover, abundance and diversity.

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