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Original Article

The Determination of Floristic Diversity within Image Forest Reserve (IFR) Land Cover Types, Kilolo District, Tanzania

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ABSTRACT

Image Forest Reserve (IFR) in the Eastern Arc Mountains of Tanzania is known for its high floristic diversity within the various land cover types. The study was conducted from August to October 2019 to determine the floristic diversity in IFR. A total of 170, 20m x 40m were systematically set at an inter-plot interval of 250 m within the land cover types. Plants were identified for their botanical names, determined for A, and herbarium specimens were collected and identified later at the DSM herbarium and NHT in Arusha. Also, 2m x 5m nested subplots were set to determine shrubs and saplings, while 1m x 1m were laid for non-woody plants and tree seedlings. The Shannon index of diversity (H') and index of dominance (ID) were calculated using the H' and ID indices; plant species evenness (J') was also calculated. ANOVA was used to compare species composition parameters among the different land cover types. A total of 502 plant species were identified in IFR. Woodland had the largest number of plant species (38.0%) followed by trees (31.0%), shrubland and grassland (21.9%) and bare land and rocks (9.1%). The forest had the largest number of trees (115) followed by woodland (93), shrubland and grassland, and bare land and rocks had the least species diversity. The woodland had the largest relative abundance (50.3%), trailed by forest (38.9%), shrubland and grassland (8.8%), and bare land and rocks (1.9%). The H', A, ID and J' showed a significant difference within the forest, woodland, shrubland and grassland, and bare land and rocks. The largest plant species diversity group had an H' < 0.0195 (230 - plant species). The medium group H' ranged from ≥ 0.0195 - ≤ 0.0504 (55-plant species), and the largest H' group ranged from ≥ 0.0649 - ≤ 0.3358 with only 10 plant species. The plant species with the largest abundance had also the largest

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H', and D, and hence were suggested to be the most abundant. The A, number of species (S), H', and ID were suggested to differ significantly within the land cover types. The floristic diversity findings establish their presence and create awareness towards the conservation strategy priorities for Tanzania Forest Agency. The survey team recommends further research on biological species of IFR, participatory forest management to stimulate the sense of ownership responsibility, implementation of laws and bylaws, land cover types gaps restoration, introduction of non-woody income-generating projects, provision of regular education to the community, awareness creation on forest resources conservation, ensure permanent boundaries beacons.

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INTRODUCTION

Image Forest Reserve (IFR) is a part of the Eastern Arc Mountains in the Udzungwa Mountains, Tanzania with relatively high plant species diversity due to different vegetation types it contains (Frontier, 2001). The upper montane at the high altitudes is covered by forest patches as well as extensive areas of grassland, wooded grasslands and bush grasslands (Minja, 1991). The woodland exists on the western slopes giving away to grassland patches at 2200 m and moist forest on the wetter eastern slopes and rivers draining eastwards into the Ruaha (Lovett and Congdon, 1990). Despite the high plant species diversity in the Mountains, little is known about their existence.

Plant species diversity is the number of species found in a plant community (Primack, 2002; Rahul and Jain, 2015). It is the plant richness and the most occurring species stems reflect the most dominant (Eranso et al., 2014). Studies conducted in Madagascar (Brown et al., 2015) found a large-scale land cover type change was driving changes in plant biodiversity across the whole country. Plant species diversity is an issue of public concern because of the increase in extinction rates (Burgess et al., 2000). Image Forest Reserve plant species are under threat due to the continuous land cover types changed due to human activities. Despite the observed threats, little has been done to determine the plant species diversity of the area.

Globally, land cover types are known for their floristic diversity (Achard et al., 2002). The

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tropical forests are potential in terms of plant species diversity found in the forests, woodlands, shrublands (Assefa et al., 2013). The tropical land cover types cover face high risk of declining in plant species diversity as a result of uncontrolled human activities like agriculture, settlement, livestock grazing, wildfires and mining. For instance, the mining areas of Tanzania face severe loss of plant species diversity due to the removal of vegetation and the spilling of toxic materials from mining industries (Mganga, 2010). Many tropical forests offer natural resources such as firewood, charcoal, timber, livestock pastures, poles and wild foods (Munishi et al., 2010). In addition, plant species diversity significantly enhances carbon sequestration (Asrat and Tesfaye, 2013). East Africa, apart from being deforested and degraded is still known to have relatively high plant species diversity existing in the natural ecosystems (Lung and Schaab, 2010).

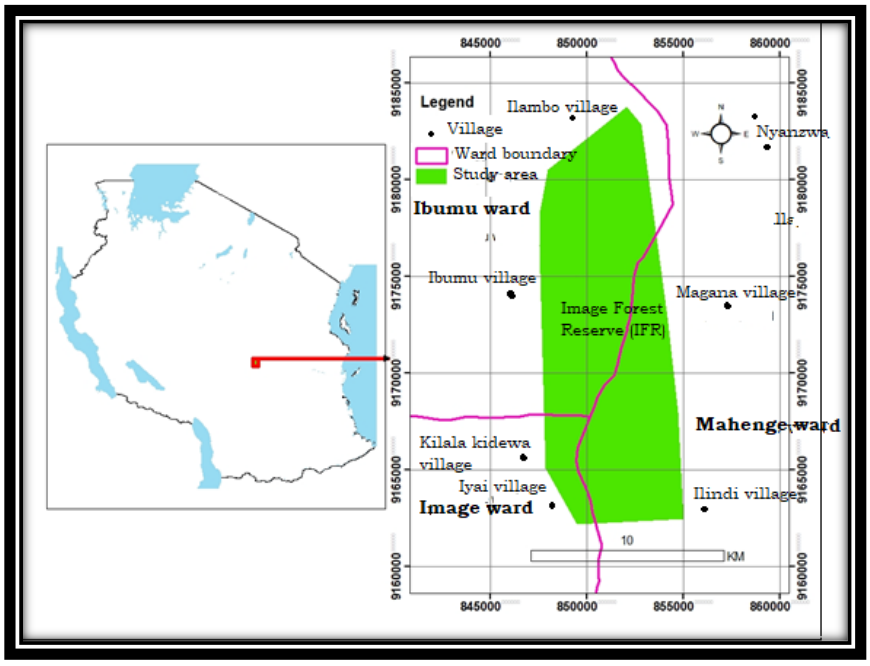
In Tanzania, forests support the life of the people bordering them even though forest degradation and deforestation threaten the forest products (Halpern, 1995). IFR is a part and parcel of the Eastern Arc Mountains of Tanzania with high plant species diversity (Frontier, 2001). According to Mligo, (2015) IFR is among important catchment forests declared as a forest reserve in 1954. It covers 8,920 hectares across three wards, which are all in Kilolo District, Iringa Region (URT, 2013). The three wards have a high human population that depends on the natural resources from the protected land vegetation. However, the floristic diversity within the land cover types remains inadequately studied and thus, a need for a thorough determination. In this study, floristic diversity was determined in IFR. It was hypothesized that floristic diversity varied among different land cover types. The evaluation of plant species diversity adds up to the national and global plant diversity and carbon capturing plan.

MATERIAL AND METHODS

Study Area

The study was conducted at Image Forest Reserve, which is situated in Kilolo District, Iringa region. IFR falls under the Image ward that lies on the south and southwest, Ibumu on the west and northern western side, while on the east the IFR lies on the Mahenge ward (*Figure 1*). It is located at 07°22'15" - 07°33'15" South and 36°08'15" - 36°12'25" East (Lovett and Congdon, 1990) in Iringa Region. The study area was selected because of its' high plant species diversity in the Eastern Arc Mountains of Tanzania, an inadequately studied land cover type.

Figure 1: Map showing Image Forest Reserve



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Vegetation Types and Topography

The IFR consists of the forest, woodland, shrubland, and grassland. The tallest woody plants in the forest exceed 35 m with a canopy cover reaching ≥ 95%. The dominant tree species included *Ilex mitis, Polysias fulva, Craibia brevicaudata, Rapanea melanophloesa, Nuxia congesta, Dombeya torrida, Podocarpus latifolius, Hagenia abyssinica, Vepris simplicifolia,* and *Zanthoxylum deremense.* It is mostly dominated by miombo woodland *Brachystegia spiciformis, B. utilis, B. boehmii, Julbernardia globiflora, Albizia antunesiana* mixed with *Uapaca kirkiana.* The shrubland and grassland included the lower slender multi-stemmed woody plant species and grasses (grassland plains) forming distinct patches within the woodland, forest, and mountain ridge tops. The shrub and grass species with very scattered trees also extended on the known bare land and rock sheets. The identified plant species on bare land and rocks included *Hymenodictyon floribunda* and *Dissotis melleri*), shrubs (*Myrothamnus flabelifolius*), sedges and grasses.IFR lies in the zone characterized by rolling scenery and plateau at an altitude range of 1640 to 2440 m a.s.l. (Ruffo, 1991).

IFR experiences oceanic rainfall with continental temperatures (Minja, 1991). The area experiences one season of rain from November to April with an annual rainfall of 1500 mm (Lovett and Congdon, 1990). The annual temperature ranges between 15 ^{0}C and 20 ^{0}C (URT, 2013).

Human Population Bordering Image Forest Reserve

IFR borders three wards with a high population. According to URT (2013), Ibumu ward had a total population of 6,681, Image ward had 9,180 and Mahenge ward had 10,039 people. This makes an overall total of 25,900 (URT, 2013). The villages bordering IFR include Iyai and Kilalakidewa (Image ward), Ibumu and Ilambo (Ibumu ward), Magana, Ilindi and Nyanzwa in Mahenge ward. The communities adjacent to Image Forest Reserve practice both pastoralism and agriculture. Irrigation farming is prominent during the dry season and mostly practiced very close to IFR boundary, especially for the Image ward, while for Ibumu and Mahenge, cultivation is done very close to the buffer zone. The various livestock kept in the three wards include cows, goats, and donkeys allowed to move freely within the public land and illegally in IFR. It has been stated that suitable climatic condition supports the farming of maize, beans, and sugarcane (URT, 2013).

DATA COLLECTION

In this study, rectangular plots of 20 m x 40 m (800 m^2) as per FAO (2007) and Shirima et al. (2015) were established to survey the floristic diversity within the land cover types (forest, woodland, shrubland and grassland, and bare land and rocks). Rectangular plots were preferred to circular plots due to being widely applied in natural vegetation surveys and suitable for apprehending variations in heterogeneous land cover (Stohlgren et al., 1995; Mathur, 2015). A pilot inventory survey was conducted to estimate the variance of trees in each land cover type. Stand basal area was determined using point sampling instead of sample plots to save time and reduce costs. The tree stand was taken using a relascope from more than 20 randomly selected points in each land cover type. The data collected from point sampling was used to determine the means and standard deviations. Then the number of sample plots (n) required in each land cover type for the tree inventory was determined using the below formula. 170 rectangular sample plots were set within IFR at 250 m inter-plot distance (*Table 1*). The sample size was obtained as per formula:

$$n = \frac{t^2 CV^2}{E^2}$$

Where: CV = Coefficient of variation n = standard deviation/mean, t = the value of t obtained from the student's distribution table at n-1 degree of freedom of the pilot study plots at 5% probability, E = Sampling error.

According to Zahabu (2008), a sampling error (E) of 10% is recommended for tree inventory and can be used to reduce costs while maintaining estimates within the precision of ±10% of the mean with a 95% confidence level. The plant species were identified for their botanical names in the field where possible and counted for their number of stems (abundance); herbarium specimens were

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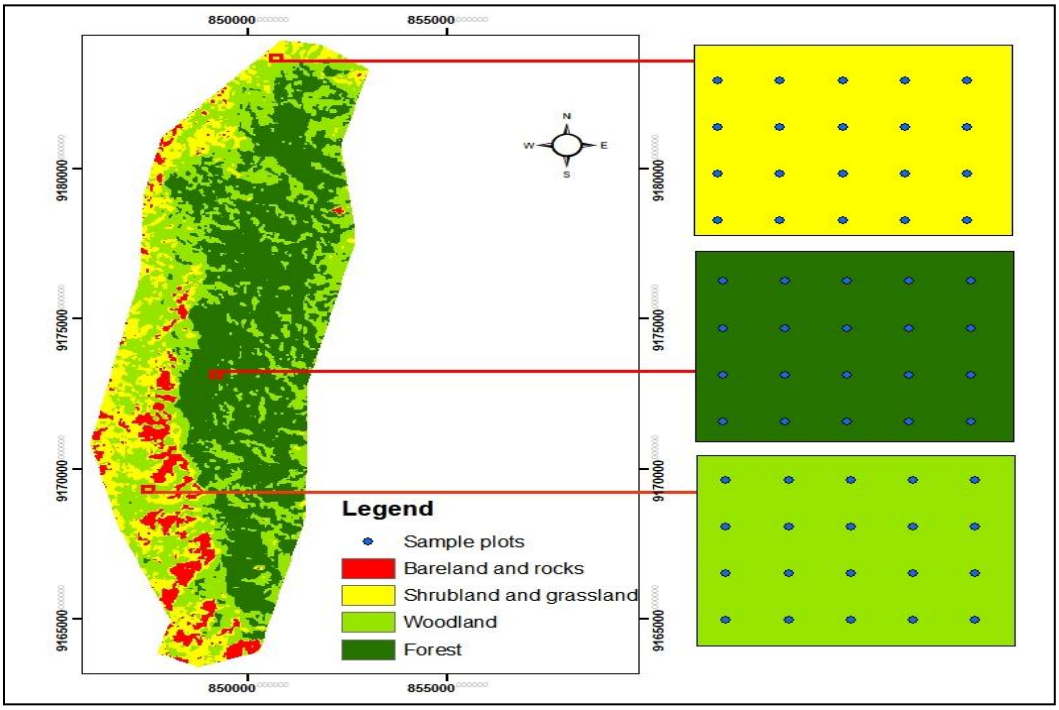
collected and identified later at the DSM herbarium in Dar es Salaam and NHT in Arusha.

Table 1: Number of sample plots per land cover type

Land cover type	Area (Ha)	No. of plots	Actual no. of plots
Forest	3,868.11	72	67
Woodland	3,325.95	62	64
Shrubland and grassland	1,379.88	26	28
Bare land and rocks	544.14	10	11
Total	**9,118.08**	**170**	**170**

The plots were set systematically within each land cover type (forest, woodland, shrubland, and grassland, bare land and rocks) (*Figure 2*) at an interval of 250 m. The nested subplots 10 m x 10 m were established to avoid repetitive measurement and recording tree species. Also, 2 m x 5 m (10 m^2) nested subplots were established to determine shrubs and saplings, while 1 m x 1 m (1 m^2) subplots were laid for herbs, grasses, sedges, and tree seedlings. The geographical coordinates were recorded using Global Positioning System (GPS) receiver in the middle of the main plots. All plants encountered in the sample plots were recorded for their richness, abundance, frequency, and species identity to species level in the field in every plot and where this was not possible, plant samples were collected, pressed, dried and taken to the NHT and the DSM for identification. The plants found outside the sample plots along the consecutive plot intervals not recorded before were recorded to enrich the plant species list of IFR.

Figure 2: Sampled area at Image Forest Reserve



Source: (Field data coordinates, 2019)

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DATA ANALYSIS

The total species richness was calculated as the total number of species across all land covers. Plant species diversity and dominance were computed using Shannon Wiener Diversity's (H') and Simpson's Dominance Indices (ID) (Kent and Cover, 1992); plant species evenness (J′) was calculated. The Shannon index considers species richness (number of species) and evenness (species distribution) (*equation 1*). The species diversity index increases with the number of species in the community but in practice, for biological communities H' does not exceed 5.0 (Krebs, 1989). The index of dominance is a measure of the distribution of individuals among the species in a community (*equation 2*); the value of ID ranges between 0 and 1. The value '0' represents infinity diversity and '1' represents no diversity (Krebs, 1989). Analysis of Variance (ANOVA) was used to compare species composition parameters among the different land cover types.

Shannon (H') equation

$$H' = -\sum_i^s (p_i \ln p_i) \ldots\ldots (1)$$

Where; H' = the Shannon index of diversity; S = the number of species; p_i = the proportional of individual or abundance of species in the sample; $\log_a$ = the logarithm to base a (any base of logarithm may be taken)

Index of Dominance equation

$$ID = \sum_i^s \left(\frac{n_{i-1}}{N-1}\right)^2 \ldots\ldots (2)$$

Where; ID = the index of dominance; n_i = the number of individuals of species in the sample; N = the total number of individuals all species) in the sample; s = the number of species

Plant species evenness (J equation)

$J' = \frac{H'}{\ln(S)}$ Where J'= Plant species evenness; ln = natural logarithm and S = plant species richness.

RESULTS

The identified land cover types were grouped into four major groups (forest, woodland, shrubland and grassland, and bare land and rocks). Forest is a vegetation type comprising of many trees closed together, with a closed canopy cover. It encompasses very tall trees. These were along riverine between the mountain spurs within the woodland, on slopes, valleys at a higher altitude, and plateaus on IFR. This is Afromontane vegetation at an altitude range of 1500 – 2400m *a.s.l.* The montane forest was common above 1700 m a.s.l while below that was along rivers. The following forest plant species were identified: *Hagenia abyssinica, Podocarpus latifolius, Aphloia theiformis, Galiniera saxifrage, Dombeya torrida, Polysias fulva, Macaranga kilimandscharica, Canthium oligocarpum, Brucea antidysenterica, Casearia battiscombei, Cassipourea malosana, Cyathea manniana, Croton macrostachyus, Bersama abyssinica, Bridelia micrantha, Bridelia bridelifolia, Lasianthus kilimandschricus, Cussonia zimmermannii, Phoenix reclinata, Pauridiantha paucinervis* and *Neoboutonia macrocalyx.*

Woodland land cover is composed of lower and open canopy trees than the forest. Woodland of Image Forest Reserve consisted the following species of *Brachystegia boehmii, Brachystegia microphylla, B. spiciformis, B. bussei, Julbernardia globiflora, Uapaca kirkiana, Protea welwitschii, Pittosporum viridiflorum, Faurea rochetiana, Faurea saligna, Osyris lanceolate, Acacia sieberiana, Schrebera alata, Psorospermumm febriguga, Protea gaguedii, Rourea orientalis,* and *Vitex doniana.*

Shrubland and grassland were defined vegetation types made up of grasses and slender lower woody plants mixed with herbs, sedges, and very scattered trees. This vegetation appears as small to large vegetation patches within the woodland, bare land and rocks, forest, and Image Forest Reserve plateaus. The identified plants were: *Bidens magnifolia, Leonotis ocymifolia, Leonotis nepetifolia, Anthospermum usambarense, Artemisia afra, Anthrixia rosimalifolia, Andropogon gayanus, Aneilema aequinoctiale, Lantana trifoliata, Plectranthus* sp., *Helichryssum*

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spp., *Commelina africana, Helichryssum* spp., *Bothriocline tomentose, Pteridium aquillinum, Acalypha volkensii, Kotschya recurvifolia, Indigpfera rynchocarpa, Spermannia ricinocarpa, Kniphofia thomsonii*. They were mixed with scattered trees of *Protea welwitschii, Brachystegia spiciformis, Euclea divinorum, Vernonia myriantha, Solanecio mannii, Rhus natalensis,* and *Acacia sieberiana, Pittosporum viridiflorum,* and *Lannea schimperi.*

Bare land and rocks consist of over 90% without plants. The bare land is an area with soil not covered with plants (vegetation), while rocks are the areas with very large rock sheets. Apart from being bare lands and rocks, they are characterized by very scattered plant species such as the lithophytes (rock loving plants). The found plant species on bare land and rocks include: Orchidaceae, *Dodonaea angustifolia, Ansellia* sp., *Streptocarpus* sp., *Aloe chabaudii, Aloe congdonii, Bidens magnifolia, Achyranthes aspera, Aeollanthus subacaulis, Andropogon gayanus, Exothecca abyssinica, Kotschya recurvifolia, Pteridium aquillinum, Myrothamnus flabbelifolius, Clutia abyssinica, Leonitis acymifolia* and *Wahlenbergia virgata.*

Floristic Diversity for Different Land Covers

An overall total of 502 plant species was identified in Image Forest Reserve land cover types. The woodland had the largest number of plant species (38.0%) followed by trees (31.0%), shrubland and grassland (21.9%), bareland and rocks (9.1%). Of all identified land cover types, the forest had the largest number of trees (115) followed by woodland (93), shrubland and grassland, and bare land and rocks had the least species diversity. Shrub richness was the highest in woodland (32) followed by forest (31), shrubland and grassland (28), and bare land and rocks (10) (*Table 2*). This trend continued for herbaceous plant richness (see *Table 2*). There were more grass species in woodland than in all other land cover types (31), followed by shrubland and grassland (15), and bare land and rocks. Sedges were the growth form with the least species diversity varying within the land cover types where woodland had the highest number of species (3) while forest hand the least (1). In this study, many ferns were identified in the forest (12) and least in the shrubland (10) (*Table 3*). Generally, the largest group of plant species were herbs (41.1%) followed trees (34.4%), shrubs (3.1), grasses (7.8%), ferns (2.6), and sedges (1.0%).

Table 2: Floristic composition for different land cover types

Variable	Forest (n=67)	Woodland (n=64)	Shrubland and grassland (n=28)	Bareland and rocks (n=11)	Total (n=170)	Percentage
Trees	115	93	37	21	266	**34.4**
Shrubs	31	32	28	10	101	**13.1**
Herbs	76	130	86	26	318	**41.1**
Grass	5	31	15	9	60	**7.8**
Sedges	1	3	2	2	8	**1.0**
Ferns	12	5	1	2	20	**2.6**
Total	**240**	**294**	**169**	**70**	**773**	**100**
Percentage	**31.0**	**38.0**	**21.9**	**9.1**	**100**	

The woodland had the largest abundance (3192), followed by forest (2466), shrubland and grassland (559), and bareland and rocks (123). The relative abundance was highest for woodland land cover (50.3%) and least for bareland and rocks (1.9%). The plant species richness, abundance, Shannon of diversity index, and evenness showed a significant difference within the forest, woodland, shrubland and grassland, and bareland and rocks (*Table 3*). On the other hand, there was no significant difference

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in plant species dominance within the four land cover types (see *Table 3).* There was a significant difference plant species abundance (S) (P<0.05), richness (S) (P<0.05), abundance (A) (P<), and H' (P<0.05) and evenness (J) (P<0.05) in the forest, woodland, shrubland and grassland, and bareland and rocks land covers (*Table 3*). The study revealed no significant difference in the plant species dominance (D) (P > 0.05) within the land cover types in Image Forest Reserve (*Table 3*).

Table 3: Plant species richness, abundance, evenness, dominance and Shannon wiener diversity index per land cover

Variable	Land cover type						
	Forest	Woodland	Shrubland and grassland	Bareland and rock	$F_{3,167}$	p-value	Total
Richness (S)	240	294	169	70	19.24	0.000*	558
Abundance (A)	2466	3192	559	123	30.24	0.000*	6340
Relative abundance (RA)	38.9%	50.3%	8.8%	1.9%	3.00	0.092*	2.68
Evenness (J)	0.828	0.722	0.935	0.851	53.32	0.000*	0.82
Dominance(D)	0.0004	0.063	0.010	0.020	3.65	0.140	0.020
Shannon (H')	4.618	4.261	4.883	4.095	4.26	0.006*	5.17

*The difference is significant at the 0.05 level.

Study findings showed a significant difference mean species H′ within the woodland, shrubland, and grassland, while there was no significant difference in the mean H′ within the forest, and bareland and rocks (*Table 4*).

Table 4: Mean difference significance per land cover type in Image Forest Reserve

	(I) Landcover	(J) Landcover	Mean Difference (I-J)	Std. Error	Sig.
Shannon (H)	Forest	Woodland	-0.11	0.08	0.57
		Shurbland and Grassland	-0.25	0.11	0.10
		Rocks and bareland	0.32	0.16	0.18
	Woodland	Forest	0.11	0.08	0.57
		Shurbland and Grassland	-0.14	0.11	0.57
		Rocks and bareland	0.42	0.16	0.04
	Shurbland and Grassland	Forest	0.25	0.11	0.10
		Woodland	0.14	0.11	0.57
		Rocks and bareland	0.56*	0.17	0.01
	Rocks and bareland	Forest	-0.32	0.16	0.18
		Woodland	-0.42*	0.16	0.04
		Shurbland and Grassland	-0.56*	0.17	0.01

*. The mean difference is significant at the 0.05 level.

Most of the plant species identified from the land cover types belonged to the group of the lowest abundance and H' per individual species, followed by medium-sized and the least (*Table 5*). The diverse group of lowest plant species had an H' < 0.0195 (230 - plant species); the medium group H' ranged from ≥ 0.0195 - ≤ 0.0504 (55-plant species); and the largest H' group ranged from ≥ 0.0649 - ≤ 0.3358 with only 10 plant species in woodland cover. Bareland and rocks land cover had the highest species richness in the H' medium group ranging from ≥ 0.0669 - ≤ 0.0905 with 31 plant

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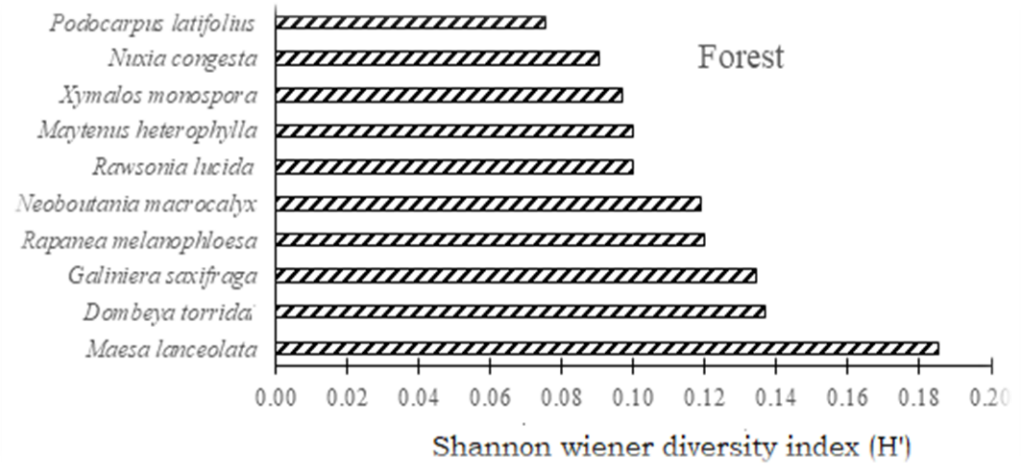
species while the largest H' group ranging from ≥ 0.0905 – ≤ 0.2379 had the least number of plant species (*Table 5*).

Table 5: Plant species richness per Shannon classes (H′-class)

Land Cover		
Forest	**Shannon (H')**	**Richness**
Largest	≥0.0844 - ≤ 0.1908	10
Medium	≥0.0251 - ≤0.0745	44
Lowest	<0.0251	187
Total		**241**
Woodland	**Shannon (H')**	**Richness**
Largest	≥0.0649 - ≤0.3358	10
Medium	≥0.0195 - ≤0.0504	55
Lowest	<0.0195	230
Total		**295**
Shrubland and grassland	**Shannon (H')**	**Richness**
Largest	≥0.0905 - ≤0.2379	12
Medium	≥0.02805 - ≤0.04218	62
Lowest	<0.02805	95
Total		**169**
Bareland and rocks	**Shannon (H')**	**Richness**
Largest	≥0.0905 - ≤0.2379	11
Medium	≥0.0669- ≤0.0905	31
Lowest	<0.0669	27
Total		**69**

In the forest, the forest plant species with the largest H′ ranged from 0.0844 to 0.1908. This comprised 10 plant species to include *Podocarpus latifolius* (0.0844), *Nuxia congesta* (0.0937), *Xymalos monospora* (.1005), *Maytenus heterophylla* (0.1037), *Rawsonia lucida* (0.1037), *Neoboutonia macrocalyx* (0.12315), *Rapanea melanophloesa* (0.1241), *Galiniera saxifraga* (0.1390) *and Maesa lanceolata* (0.1908). Those with medium ranged from ≥ 0.0000018 to ≤ 0.0844, while the least got H'< 0.0000018. The plant species with the highest H', were also the largest in terms of D and abundance (*Figure 3*).

Figure 3: Forest plant species with the largest H'



In addition, 10 plant species from woodland revealed to be the largest of all others in terms of abundance, H' and D. The H' ranged from ≥ 0.06499 to 0.33581 which included *Protea gaguedii, Combretum mole, Rhus natalensis, Ormocarpum kirkii, Erica mannii, Faurea saligna, Julbernardia globiflora, Brachystegia utilis, Uapaca kirkiana,* and *Brachystegia spiciformis* (*Figure 4*).

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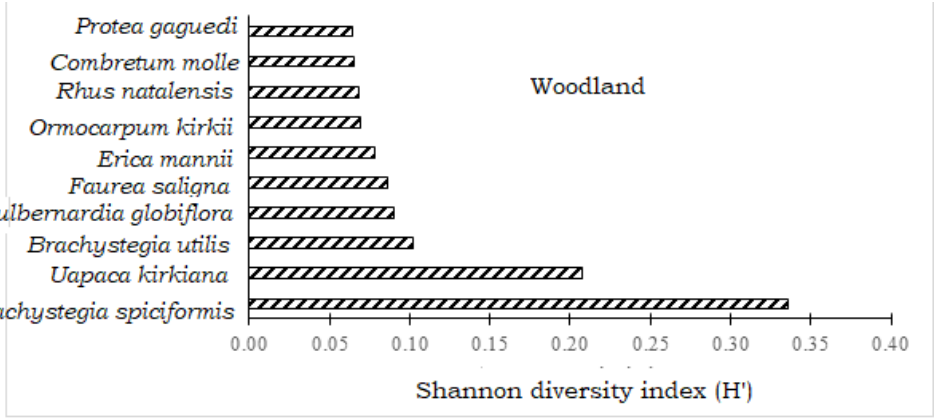
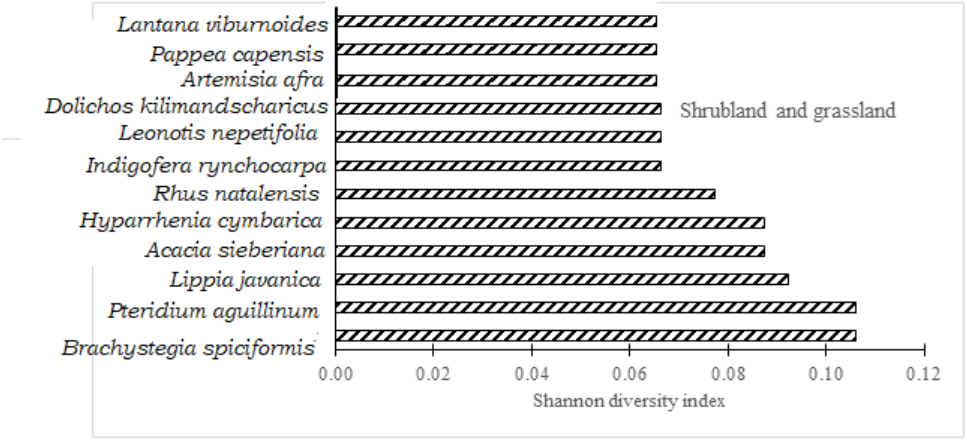
Figure 4: Woodland plant species with the largest H'



The following plant species had the largest H' in the shrubland and grassland; *Lantana viburnoides, Pappea capensis, Artemisia afra, Dolichos kilimandscharicus, Leonotis nepetifolia, Indigofera rynchocarpa, Rhus natalensis, Hyparrhenia cymbarica, Pteridium aquillinum*, and *Brachystegia spiciformis*. (*Figure 5*). Their H' ranged from Shrbland ≥ 0.09057 and ≤ 0.23791.

Figure 5: Plant species with the highest H' in shrubland and grassland



Eleven plant species were ranked as the highest in terms of H' for the bareland and rocks ranging from ≥ 0.09057 to ≤ 0.2379 (*Figure 6*). The associated plant species were *Melinis minutiflora, Myrothamnus flabellifolius, Scleria* sp., *Aloe congdonii, Anthospermum usambarense, Rhamnus staddo, Ficus thonningii, Apodytes dimidiata, Crassula globularioides, Rhus natalensis, and Crassocephallum sarcobasis*.

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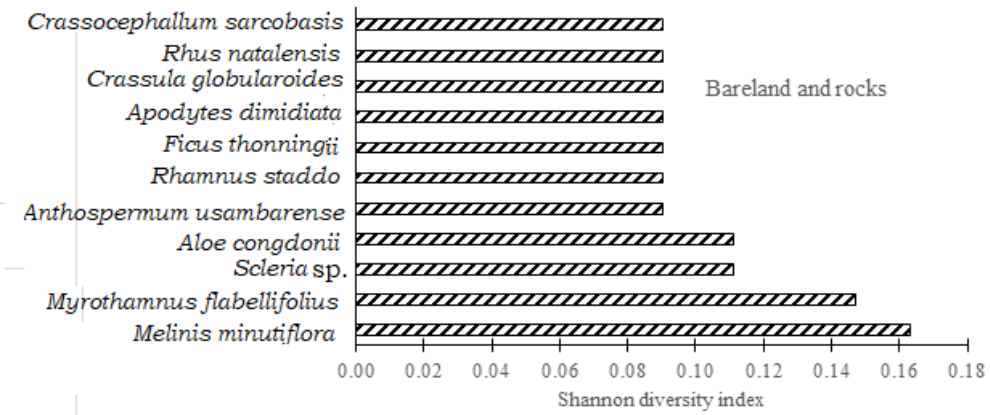
Figure 6: Plant species with the largest H' in bareland and rocks



Plant Species Richness per Land Cover

The results of plant species richness per land cover divided by the number of plots within each land cover type revealed differences. Bareland and rocks (6.4) (31%) had the largest mean richness, followed by shrubland and grassland (6.0) mean plant species richness (29%); woodland (4.6) with (22%), and forest was ranked the least (3.6) in terms of the mean plant species richness (17%) (*Table 6*). As opposed to the results above (*Table 3*), the land cover type with the largest richness (woodland) was the third in terms of mean species richness; forest land cover which was the second was ranked fourth (*Table 6*) while shrubland and grassland was ranked the second while bareland and rocks was ranked the first (*Table 6*).

Table 6: Mean plant species richness (S) per land cover

Land cover	Richness (S)	Rank	Mean richness (Mean-S)	Rank
Woodland	294	1	4.60	3
Forest	240	2	3.60	4
Shrubland and grassland	169	3	6.00	2
Bare land and rocks	70	4	6.40	1

Plant Species Richness per Growth Form per Land Cover

Tree species had the largest mean richness (S) (1.7) followed by woodland (1.4), shrubland and grassland (1.3), while bareland and rocks were the least (0.8). Shrubland and grassland had the largest mean S (1.0) followed by bareland and grassland (0.9), and forest and woodland had the same mean S (0.5 each). Most of the herbs were identified from the shrubland and grassland (3.1), followed by bareland and rocks (2.4), woodland (2.0) and forest had the least mean herb species richness (1.1). The least mean richness (S) for grasses was revealed on forest (0.1), while woodland and shrubland and grassland had a bit larger mean richness (0.5), and bareland and rocks had a mean richness of 0.8. The larges mean richness sedges were revealed on shrubland and grassland (2.0), proceeded by barelend and rocks (0.2), forest and woodland (0.04). In this study, the largest mean richness for ferns was observed on shrubland and grassland (1), shadowed by bareland and rocks (0.2), woodland and grassland (0.08), and forest (0.02) (*Table 7*).

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Table 7: Mean plant species richness per growth form per land cover type

Growth form	Forest (67-plots)	Mean-S	Woodland (64-plots)	Mean -S	Shrub land and grassland (28-plots)	Mean -S	Bareland and rocks (11-plots)	Mean -S
	Richness (S)		Richness (S)		Richness (S)		Richness (S)	
Tree	115	1.7	93	1.4	37	1.3	21	0.8
Shrub	31	0.5	32	0.5	28	1	10	0.9
Herb	76	1.1	130	2	86	3.1	26	2.4
Grass	5	0.1	31	0.5	15	0.5	9	0.8
Sedge	1	0.04	3	0.04	2	0.1	2	0.2
Fern	12	0.02	5	0.08	1	0.02	2	0.2
Total	**240**	**3.4**	**294**	**4.5**	**169**	**6**	**70**	**5.2**

Image Forest Reserve Plant species IUCN status

Image Forest Reserve in the Eastern Arc Mountains of Tanzania has a potential in plant species diversity of which some of the species are well known for their endemism. Endemism was assessed as vulnerable (V) and near threatened (NT) (*Table 8*). According to the World Conservation Centre (1998), Lovett and Clarke (1998) and IUCN Red List (2013) some plant species depending on their distribution, population and the human disturbances are treated as either endangered, threatened, near threatened, vulnerable and or less concern. *Podocarpus latifolius* as a timber tree is also declared as a Near Threatened tree species (Farjon and Potter, 2013) (*Table 8*).

Table 8: IUCN status of some of Trees Species in IFR

Botanical name	Author	Family	IUCN Status
Agelanthus uhehensis	(Engl.) Danser	Loranthaceae	T
Aloe congdonii	S. Carter	Aloaceae	VU
Aloe volkensii	Engl.	Asphodalaceae	T
Monodora globifolius	Couvereu	Annonaceae	NT
Osyris lanceolata	Hochst. & Steud	Santalaceae	T
Podocarpus latifolius	C.Peter	Podocarpaceae	NT
Prunus africana	(Hook.f) Kalkman	Rosaceae	T
Streptocarpus compressus	B.L. Burtt	Gesneriaceae	VU
Streptocarpus inflatus	B.L. Burtt	Gesneriaceae	NT
Warburgia ugandensis	Sprague	Canellaceae	VU

DISCUSSION

There was a relationship between the land cover type and the plant species richness. Other scholars such as Dupuy et al. (2002) noted that a high diversity of plant species is supported by a remarkably broad range of habitats and that the diversity of habitats decreases with a consequent reduction in species diversity with some species becoming extinct throughout the whole range of biological diversity. The land cover type with the largest woody plants had low species richness, which suggests that the largest wood plants inhibit the growth of lower plants. For the bare land rocks, low species richness is obvious that few plants could grow on rocks. There is a great relationship between plant species diversity and habitat heterogeneity (Zhou et al., 2018). In this study, it

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was found that there was a relationship between the plant species abundance and richness (Table 3 and 5), inferring that the higher the number of stems the more the chances of many different plant species occupying a certain locality. The significant difference in the H' and D suggested inequality in the plant species diversity within the forest, woodland, shrubland and grassland, and bare land and rocks. The size of the RA depended on the abundance (A). The highest H' class range hat the lowest plant species richness, while the medium H class range had medium, and the least H' class had the largest plant species richness. This suggested that the largest H' class had the largest number of stems belonging to few species, while the lowest in H' range was occupied by many stumps belonging to different many plant species. This implied that the most common plants always have many stems but fewer species than the less common plants. Wasof et al. (2018) supported that the area with dominant plant species tends to have more stems of fewer species than the area with rare individuals, but with lower diversity, while the rare many individuals contain a high diversity of plants each of them occupying a small space. The plant species with the largest H' had the largest number of stems of all others, while the medium had a medium number of stems, and the lowest had the least number of stems. The plant species with the largest H' in each land cover imply that they are the most abundant within such land cover types.

During this study, some plant species were known to be treated as threatened (T), vulnerable (VU), and near threatened (NT) (*Table 8*), implying the potential biological resources of the IFR. The plant species can be treated as threatened. Near threatened, vulnerable or endangered depending on its distribution limit, population and or location (IUCN, 2001).

CONCLUSION AND RECOMMENDATIONS

IFR is such a potential locality in terms of biological plant species diversity. Of the four identified land cover types, woodland was the richest in plant species (294), followed by forest (240), shrubland and grassland (169) and bare land and rocks (70). The largest number of plants was from the herbaceous plants, followed by trees, shrubs, grasses, ferns, and sedges were the least. The plant species diversity (richness) varied among the land cover types. The relationship between plant species diversity and habitat heterogeneity showed a difference in plant form richness in the ecosystem. Also, the plant species abundance reflects the richness, that there are the chances of higher richness in the land cover with more abundance than the one with low abundance. The plant species with the largest abundance had also the largest H' and D, hence they were suggested to be the most abundant. The forest, woodland, shrubland and grassland, and bare land and rocks were suggested to be significantly different in terms of plant species abundance (A) richness, H'. The largest H'class had the lowest plant species richness, whereas the medium class range had medium, and the least H' class had the largest plant species richness, signifying that the largest H' class had the largest number of stems belonging to few species, while the lowest in H' range was occupied by many stumps belonging to different many plant species. IFR being a part parcel of Eastern Arc Mountains is internationally known for its potential in plant species diversity, and among them are treated as threatened (T), near threatened (NT) and vulnerable (V). The floristic survey for IFR establishes their presence and create awareness towards the conservation strategy priorities by the Tanzania Forest Agency in collaboration with the local community and national and international research organizations.

IFR ecosystem with high biological diversity, but being inadequately studied, further study is required to determine all biological species existing in IFR, as in this study dealt with floristic diversity only. Participatory forest management is vital to create a sense of local people's ownership and responsibility for natural resources conservation. Funds should be made available by the Tanzania Forest Agency (TFA) and non-governmental organizations to support patrol teams regularly. Natural resource benefit sharing among TFA and the local community should be enhanced as this would create the local community's trust and ownership. Restoration efforts of deforested and degraded forest reserve areas should also be enhanced because the formerly burnt patches within the woodland and forest are being replaced by shrub and grass species rapidly. Awareness creation to the local community on the negative effect of natural

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resources damage such as climate change as a result of the removal of vegetation cover should be promoted. Education of the local community on the existing biological species and conservation potential for sustainable environment and development for the present and future generations should be promoted. Beekeeping and ecotourism as a non-woody income generating projects should be established as a source of income and employment to the local community, while the natural vegetation as a commodity is reserved. Beacons as permanent boundary signs should be made clear in collaboration with the local people to avoid unnecessary conflicts between government, conservation agents and the local community.

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