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Full Length Research Paper

Floral diversity of the littoral vegetation of Southeastern Nigeria

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An investigation of the floral diversity of the littoral vegetation of Akwa-Ibom State coastline of South eastern Nigeria was carried out using quadrat and transects techniques. The results revealed three (3) vegetation types viz: coastal/shoreline, mangrove and secondary forest vegetation. Although, the most encountered ecosystem was the mangrove yet, coastal vegetation had the highest flora diversity of 100 (47%) as compared to mangrove and secondary forest with 87 (41%) and 27 (12%) species, respectively. A total of 147 taxa belonging to 134 genera and 58 families were recorded from the study area. The dominant family was Fabaceae with 17 species (29.3%), while the dominant genus was *Ipomoea* with 5 species (3.73%). Of these taxa, 59 occurred in more than one vegetation type while 11 were present in all the three (3) vegetation types. Phanerophytes are the dominant life form covering 36% (53 species) of the encountered species. Similarly, diversity index revealed the highest diversity of species in the coastal ecosystem with Shannon-wiener's, Simpson's and Margalef values of 0.99, 4.61 and 21.67, respectively. Correlation matrix and Jaccard similarity coefficient value (0.35) was high between the coastal and mangrove pairs; however, it depicts a minimal significant difference in the species composition within the three ecosystems at 0.05% probability level. Also, PCA scatter plot established less variation between the coastal and mangrove vegetation. Also, 16 economic plants were encountered during the study with uses ranging from edible fruits, spices, vegetables, root crop, and medicine, to palm wine. Factors affecting species distribution are introduction of alien species (*Nypa fruticans*), canalization, dredging, over exploitation of mangrove and pollution. Conservation status of these taxa according to IUCN 2014-2 showed that no endangered species was encountered during the study. However, conservation of this littoral vegetation is highly imperative in other to stabilize the ecosystem dynamics, protect the biodiversity, prevent or reduce potential effects of ecological disasters such as flooding and erosion.

Key words: Littoral vegetation, flora, diversity, ecosystem, conservation.

INTRODUCTION

Nigeria's vegetation belts reflect a very close link between vegetation and climate. Vegetation belts are

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demarcated on west-to-east zonation pattern characterized by transitional zones from one belt to another hence, resulting into different types of vegetation including the littoral vegetation that occurs along the shorelines of water bodies. The study area is part of the Niger Delta Region (NDR) which is characterized by rich biodiversity, highly diverse and productive ecosystems, good agricultural land and excellent fisheries. The ecological significance of the region is underlined by some important characteristics (NDES, 1997). The NDR is home to the last remaining intact vestiges of lowland rainforest area in Nigeria which have now been placed under protection as Cross River (Oban and Okwangwo Divisions) and Okomu National Parks. Mangrove ecozone of the region is the most important mangrove ecosystem in Africa and the third largest in the world. For rural communities that make up much of the NDR, the dependence on biodiversity constitutes the sole means of livelihood. The constant and growing threat to which biodiversity is exposed in the region as a direct consequence of various anthropogenic activities, including oil exploitation, necessitates that constant evaluation of bio-resources status of the region should be undertaken as a tool for constant updating and improvement in conservation strategies. The littoral vegetation is the portion of the aquatic shore that is inhabited by diverse autotrophic plants, that is, areas with water that is shallow enough to admit sufficient light to support rooted vegetation. The littoral zone comprises the zone of fluctuating water levels (that is, the intertidal zone, which is between high/low water marks), wave action at the actual land/water interface and also the deeper inshore areas that support aquatic vegetation. The boundary between vegetation types is sometimes attributable to sharp changes of topography (Kikkawa et al., 1981; Webb and Tracey, 1981; Bowman and Wightman, 1985). The littoral zone may form a narrow or broad fringing wetland, with extensive areas of aquatic plants sorted by their tolerance to different water depths and adaptability (Keddy, 2010).

The ecosystem varies from littoral, brackish, freshwater to lowland rainforest ecosystems. Although, natural climate variation and non-climatic factors such as land transformation may also be responsible for some of these trends, human-induced climate and atmospheric changes are the most identified reasons (Hughes, 2000; Parmesan, 1996). In coastal environments, the littoral zone extends from the high water mark, which is rarely inundated, to shoreline areas that are permanently submerged. The plant species of the open coast are referred to as halophytes because they receive large amounts of salt spray (Calder and Taylor, 1968). However, the number of species found in this habitat largely depends on the level of salinity, ability to withstand excessive wave action, fluctuation in water level and tolerance of the species. Depletion of natural resources and the attendant insecurity of rural livelihoods contribute to the social conflicts which plague the Niger Delta Region.

The main objective of this study was to provide a checklist and diversity of accurately identified plant species of the south-eastern zone including the creeks, estuaries and shoreline before their habitats are obliterated by raging waves, aggressive incursion of *Nypa fruticans* and human activities which will assist in future conservation programmes.

Study area

The study was carried out along the coastal zone of Akwa-Ibom state on Latitudes 4° 39'N and Longitudes 7° 56'E between the shoreline and the estuaries of the Cross river to Imo river and banks of Qua-Iboe, Imo, Oron and Mbo rivers in Ibeno, Local government area, Eket, Akwa Ibom State, Nigeria (Figure 1), while the details of each points are shown in Table 1. The three (3) ethnic groups in the study area are Ibibio, Annang and Oron. Of these three, the Ibibio remain the majority. The main occupations of the inhabitants of the coastal vegetation include fishing, subsistence farming, water transportation business, trading, and a few are government workers. The Nigerian coastline covers a total length of approximately 859 km and it is divided into four geomorphic plain zones (from east to west) namely the strand coast/estuary, Niger-Delta, Transgressive mahin mud coast and the Barrier beach on the lagoon coast complex (Udo, 1970). It stretches Inland for a distance of about 15 km in Lagos to about 100 km in the Niger Delta and about 25 km east of the Niger Delta. The tidal range increases progressively eastwards to about 3 km at the Calabar estuary. The area is contingent on the movement of the Inter Tropical Discontinuity (ITD) and characterized by very high rainfall (annual total > 4,000mm), temperature values of about 27°C, and relative humidity with mean value of 80.3%. The Niger Delta is one of the major features of the West African coastline which projects into the Gulf of Guinea and is characterized by vast sedimentary basin with a complex river network, and a fragile ecology in which fresh and saline water ecosystems maintain a dynamic equilibrium. The sandy shoreline is backed by extensive mangrove and fresh water swamps. However, mangrove dominates the coast while freshwater swamp forests are dominated with palms and trees (Flyod, 1969); moreso, the Delta contains large natural gas and oil deposits.

The coastline is sandy, heavily incised by numerous creeks, shallow streams and rivers, and drained by a number of rivers including the Cross River, and the Qua Iboe River. Apart from the shoreline and tidal mudflats which are in most areas covered by the invasion of *Nypa friutcans*, all other areas depict highly disturbed vegetation following persistent and increasing anthropogenic pressure.

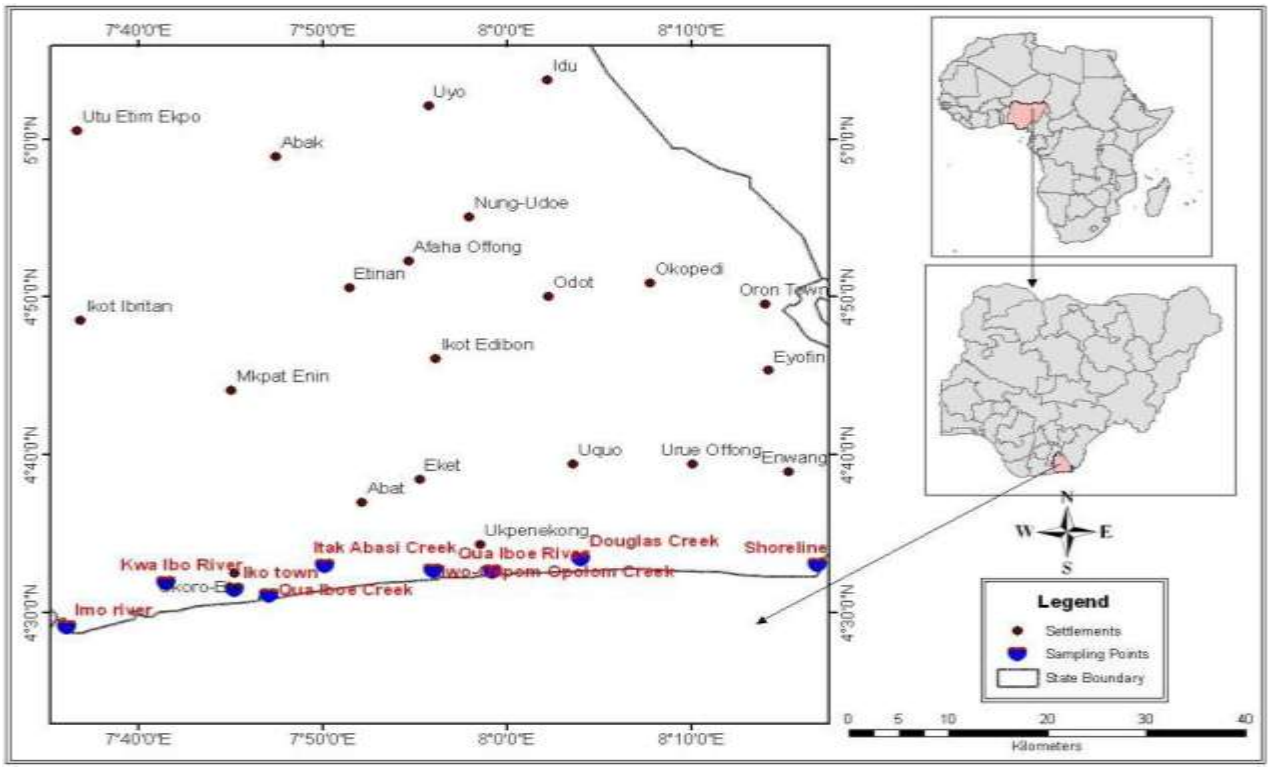

Figure 1. Map of Akwa Ibom State Coastal region showing the study area.

Table 1. Details of the sampling points within the studied area.

S/N	Location	Coordinates		Remarks
		Latitude	Longitude	
1	Shoreline	04° 33' 0.549"	08° 16' 52.396"	Strand vegetation along the coastline characterized by loose soils dominated by *Ipomoea pes-caprae*, *Ipomoea aquatica*, *Dalbergia ecastaphyllum*, *Canavalia rosea, Rhizophora racemosa, Cocos nucifera, Laguncularia racemosa Nypa fruticans*, *Sphagneticola trilobata*, *Paspalum vaginatum*, *Hydrocotyle bonariensis.*
2	Imo river	04° 29' 4.66"	07° 36' 3.497"	Mosaic forest comprising of the mangrove and secondary regrowth vegetation. Common species are *Rhizophora racemosa, Nypa fruticans, Lonchocarpus sericeus, Artocarpus altilis, Drepanocarpus lunatus.*
3	Itak Abasi Creek	04° 32' 58.619"	07° 50" 5.559"	Mangrove vegetation dominated by *Acrostichum aureum, Nypa fruticans, Conocarpus erectus, Laguncularia racemosa, Avicennia germinans, Phoenix reclinata*, *Rhizophora racemosa*
4	Iwuo-Okpom Opolom Creek	04° 32' 40.708"	07° 55' 58.85"	Densely populated Mangrove vegetation dominated by *Acrostichum aureum, Nypa fruticans, Conocarpus erectus, Laguncularia racemosa, Avicennia germinans, Phoenix reclinata*.
5	Kwa Ibo River	04° 31' 52.622"	07° 41' 28.655"	Mangrove vegetation dominated by *Acrostichum aureum, Nypa fruticans, Conocarpus erectus, Laguncularia racemosa, Avicennia germinans, Phoenix reclinata.*
6	Douglas Creek	04° 33' 23.486"	08° 4' 2.279"	Mangrove vegetation dominated by Rhizophora racemosa, *Acrostichum aureum, Nypa fruticans, Conocarpus erectus, Laguncularia racemosa, Avicennia germinans, Phoenix reclinata.*
7	Qua Iboe Creek	04° 31' 5.057"	07° 47' 4.427"	Mangrove vegetation dominated by *Acrostichum aureum, Nypa fruticans, Conocarpus erectus, Laguncularia racemosa, Avicennia germinans, Phoenix reclinata*.
8	Qua Iboe River	04° 32' 36. 7"	07° 59' 12.298"	Mangrove vegetation dominated by *Rhizophora racemosa, Acrostichum aureum, Drepanocarpus lunatus, Nypa fruticans, Conocarpus erectus, Laguncularia racemosa, Avicennia germinans*

METHODOLOGY

A combination of sampling and study techniques was adopted for the extensive and intensive assessment of the vegetation types. These include line transects and Quadrats. The survey was carried out in the months of November and December 2014 and facilitated by the use of Four-Wheel-Driver vehicles and motorized boats.

Sampling techniques

Line transects

Twenty line transects were cut across the vegetation formations at two-kilometer-intervals along the coastline, starting from the Cross river estuary and terminating at Imo river estuary for rapid and extensive assessment of ecosystem types.

Quadrats

Twenty quadrats with 5 and 10 m^2 in dimension were established within the ecosystems for intensive and detailed evaluation of various plant species occurrences.

Floristic composition and conservation status

All plant specimens encountered along the transects and within the quadrats were identified to species level either in the field or herbarium, using appropriate Floras, Manuals and Monographs Life form classification was carried out according to Kershaw (1973) and Raunkiaer (1934) and the conservation status of each species was evaluated using the IUCN Redlist v.2014-2.

Life form classification according to Kershaw (1973) and Raunkiaer (1934)

1. Phanerophytes (Trees & Shrubs)
(a) Megaphanerophytes > 30 m in height
(b) Mesophanerophytes 8 – 30 m
(c) Microphamerophytes 2 – 8m
(d) Nanophanerophytes < 2m
2. Chamaephytes (buds borne close to the ground)
3. Hemi cryptophyes (buds borne at or in the soil surface)
4. Cryptophytes (buds borne below ground or below water)
(a) Geophytes (with rhizomes, bulbs or underground tuber)
(b) Helophytes (perennating organ in soil or mud below water level)
(c) Hydrophytes (water plants, perennating buds from submerged rhizome)
5. Therophytes (no perennating buds, annual or ephermeral plants)
6. Epiphytes (air plants, no roots in the soil)

Data Analyses

The frequency and habitat richness were calculated while species indices were carried out with PAST version 2.3 with probability set at the 0.05% level of significance.

Herbarium Specimens

Representative samples of the species were collected, pressed, dried and prepared as herbarium specimens using standard techniques (Radford et al., 1974). The preserved specimens would serve as permanent records of the vegetation and floristic composition of this region. Each specimen would always be available for study or quick reference in connection with future operations in the study area and for future conservation programmes. All representative specimens are deposited in the Herbarium of the University of Lagos, Akoka, Yaba, Lagos, Nigeria (LUH).

RESULTS

The survey revealed that coastal/littoral/shoreline, mangrove and degraded secondary forest are the dominant vegetation types within the studied area (Table 1) and the highest species diversity was observed along the shoreline vegetation where it covers 47% followed by mangrove that covers 41%, and secondary forest vegetation 31% of the species, respectively. Notably, eleven (11) species were present in all the habitat types (Table 3). Similarly, the diversity index revealed that the coastal ecosystem had the highest Shannon-wiener, Simpson and Margalef values of 0.99, 4.61 and 21.67, respectively as shown in Figure 2 while the highest correlation value was recorded between the coastal and mangrove vegetation (0.35), followed by the value 0.16 for the mangrove and secondary forest vegetation while coastal and secondary forest had the least correlation value of 0.14 at p=0.05% as presented in Table 2. Furthermore, Jaccard similarity index represented with a dendrogram (Figure 4) also confirmed the high correlation between the coastal and mangrove vegetation because they are sisters joining together at the same point on similarity index scale (0.35). Figure 3 presented the principal component analysis (PCA) scatter plot of minimal spanning tree showing less variation between the coastal and mangrove ecosystems.

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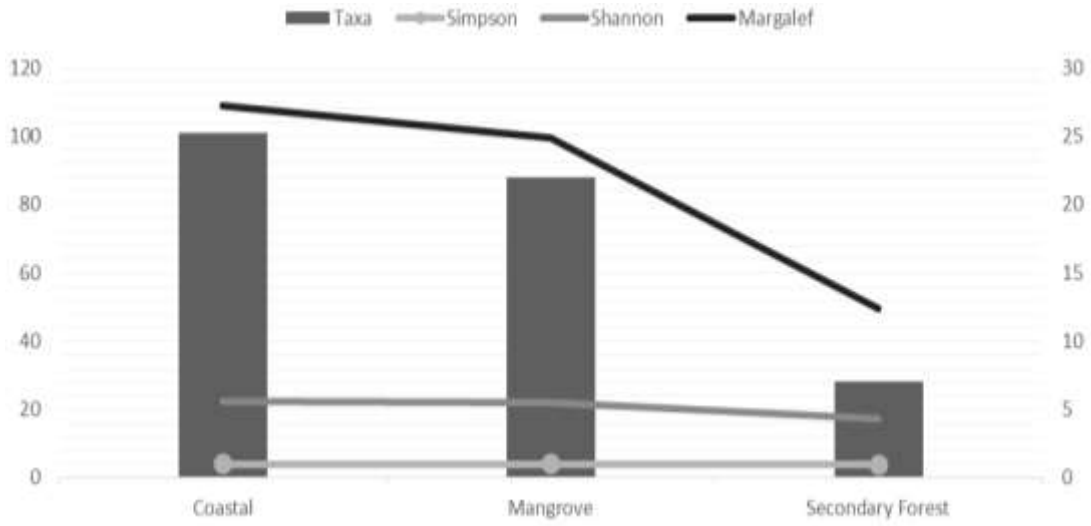

Figure 2. Species indices across the studied area.

Table 2. Cross correlation tabulation for the encountered ecosystem.

	Coastal	Mangrove	Secondary forest
Coastal	1	0.35	0.14159
Mangrove	-	1	0.16
Secondary Forest	-	-	1

Summarily, a total of 147 taxa belonging to 134 genera and 58 families were encountered and identified during the study (Table 3). The dominant families encountered include Fabaceae and Poaceae with 17 and 16 species, respectively (Figure 5) while genus *Ipomoea* had the highest diversity of five (5) species as shown in Table 3. The dominant life form was Phanerophytes as it covers 36% followed by Chamaephytes (31%), while Geophytes and Cryptophytes cover 17 and 16%, respectively (Figure 6). Moreover, 16 economic species were recorded with the study area as presented in Table 4. In accordance with the International Union for Conservation of Nature (IUCN) Redlist of threatened species, 15 species fall within the category of least concern (LC), 2 are in Data Deficient (DD) while others are yet to be assessed (NA).

DISCUSSION

The vegetation composition varies because of the transitions from one ecosystem to the other as a result of the abrupt changes in the physical conditions, notably the soil. The similar ecosystems had similar species composition as observed in Imo River, Itak Abasi creek, Iwuo Okpom Opolom creek, Douglas creek, Qua Iboe creek and river sampling points which are of similar mangrove ecosystem dominated by Mangrove species such as *Rhizophora racemosa, Avicennia germinans, Nypa fruticans* and *Dalbergia ecastaphyllum as* compared to the shoreline vegetation. However, the three (3) vegetation types encountered during the study are the coastal, mangrove and secondary forest vegetation.

Coastal/shoreline vegetation

This vegetation is the nearest to the Atlantic Ocean and is usually inundated at high tide. It is the most extensive plant formation in the study area extending from the western banks of the Cross River to the shores of Imo River (Plate 1). From the study,100species were identified and the most prominent of these species include *Ipomoea* spp.,*Canavalia rosea,Phoenix reclinata, Cocos nucifera, Tetracera alnifolia, Remirea maritima, Tragus bertorianus, Sphagneticola trilobata* with other associated species such as *Dalbergia ecastaphyllum,Rhizophora,Alchornea,cordifolia,Drepanocarpus lunatus, Terminalia catappa, Hibiscus tiliaceous, Portulaca pilosa, Philoxerus vermiculare, Elaeis guineensis* and *Diodia rubricosa.* The vegetation structure/composition are controlled by lateral changes

Table 3. Checklist of the flora diversity encountered across the studied area.

S/N	Botanical name	Taxonomic family	Ecosystem			IUCN Status
			Coastal	Mangrove	Secondary forest	
1.	*Acrostichum aureum* L.	Adianthaceae	*	*		LC
2.	*Adenia cissampeloides* (Planch. ex Hook.) Harms	Menispermaceae		*	*	NA
3.	*Aeschynomene sensitiva* Sw.	Fabaceae	*			NA
4.	*Aframomum melegueta* K.Schum.	Zingiberaceae	*	*		NA
5.	*Ageratum conyzoides* L.	Asteraceae		*		NA
6.	*Alchornea cordifolia* (Schumach. & Thonn.) Müll.Arg.	Euphorbiaceae	*	*	*	NA
7.	*Alstonia boonei* De Wild.	Apocynaceae	*	*		NA
8.	*Alternanthera sessilis* L.	Amaranthaceae	*			LC
9.	*Amaranthus viridis* L.	Amaranthaceae	*			NA
10.	*Andropogon gayanus Kunth* var. *tridentatus*	Poaceae		*		
11.	*Anthocleista vogelii* Planch.	Loganiaceae		*		NA
12.	*Antigonom leptopus* Hook. & Arn.	Polygonaceae	*			NA
13.	*Artocarpus altilis* (Parkinson) Fosberg	Moraceae		*		NA
14.	*Asystasia gangetica* (L.) T.Anderson	Acanthaceae	*	*		NA
15.	*Avicennia germinans* (L.) L.	Avicenniaceae	*	*	*	LC
16.	*Boerhavia diffusa* L.	Nyctaginaceae	*			NA
17.	Borreria scabra (Schumach. & Thonn.) K.Schum.	Rubiaceae	*	*		NA
18.	*Caesalpinia bonduc* (L.) Roxb.	Fabaceae	*			NA
19.	*Calophyllum inophyllum* L.	Gutifferae	*	*		LC
20.	*Calopogonium mucunoides* Desv.	Fabaceae		*		LC
21.	*Canavalia rosea* (Sw.) DC.	Fabaceae	*			NA
22.	*Canna indica* L.	Cannaceae	*			NA
23.	*Caperonia palustris* (L.) A.St. Hil.	Euphorbiaceae		*		NA
24.	*Carica papaya* L.	Caricaceae	*	*		NA
25.	*Cassipourea barteri* (Hook.f.) N.E.Br.	Rhizophoraceae		*		NA
26.	*Cassytha filiformis* L.	Lauraceae	*			NA
27.	*Ceiba pentandra* (L.) Gaertn.	Bombacaceae	*			NA
28.	*Centrosema pubescens* Benth.	Fabaceae		*		NA
29.	*Chromolaena odorata* (L.) R.M.King & H.Rob.	Asteraceae	*	*	*	NA
30.	*Chrysobalanus icaco* L.	Chrysobalanaceae	*			NA
31.	*Chrysopogon aciculatus* (Retz.) Trin.	Poaceae		*		NA
32.	*Cleome ciliata* Schum. & Thonn.	Capparidaceae	*			NA
33.	*Clerodendrum paniculatum* L.	Verbenaceae			*	NA
34.	*Cnestis ferruginea* DC.	Connaraceae	*			NA
35.	*Cocos nucifera* L.	Arecaceae	*	*		NA
36.	Colocasia esculenta (L.) Schott	Araceae	*		*	NA
37.	*Commelina diffusa* Burm. F.	Commelinaceae	*	*		LC
38.	*Conocarpus erectus* L.	Combretaceae	*	*		LC
39.	*Costus afer* Ker Gawl.	Zingiberaceae		*	*	NA
40.	*Cuscuta australis* R. Br.	Convolvulaceae	*			NA
41.	*Cyathula prostrata* (L.) Blume	Amaranthaceae	*	*		NA
42.	*Cyperus distans* L. f.	Cyperaceae		*		LC
43.	*Cyperus esculentus* L.	Cyperaceae		*		LC
44.	*Cyrtosperma senegalensis* (Schott) Engl.	Araceae	*	*		NA
45.	*Dalbergia ecastaphyllum* (L.)Taub.	Papilionoideae	*	*	*	NA
46.	*Desmodium ramosissimum* G. Don	Papilionoideae		*		NA

Table 3. Contd.

47.	*Desmodium triflorum* (L.) DC	Papilionoideae		*		NA
48.	*Diodia rubricosa* Hiern	Rubiaceae	*			NA
49.	*Dissotis rotundifolia* (Smith) Triana	Melastomataceae	*	*		NA
50.	*Dracaena arborea* (Willd.) Link	Agavaceae	*		*	NA
51.	*Drepanocarpus lunatus* (L.f.) G.Mey.	Fabaceae	*	*		NA
52.	*Echinocloa colona* Link.	Poaceae	*	*		NA
53.	*Elaeis guineensis* Jacq.	Arecaceae	*	*		NA
54.	*Eleusine indica* (L.) Gaertn	Poaceae	*	*		LC
55.	*Eleutheranthera ruderalis* Pirotta ex Bose	Asteraceae			*	NA
56.	*Emilia coccinea* (Sims) G.Don	Asteraceae	*	*	*	NA
57.	*Ficus erybotryoides* Kunth & Bouch	Moraceae		*		NA
58.	*Ficus exasperata* Vahl	Moraceae			*	NA
59.	*Ficus trichopoda* Baker	Moraceae	*			
60.	*Fimbristylis ferruginea* (L.) Vahl	Cyperaceae	*			NA
61.	*Hallea ledermannii* (Krause) Verdc.	Rubiaceae		*		NA
62.	*Harungana madagascariensis* Poir	Guttiferae		*		NA
63.	*Heliotropium indicum* L.	Boraginaceae	*			NA
64.	*Heteropteris leona* (Cav.) Exell	Malpighiaceae		*		NA
65.	*Hibiscus surattensis* L.	Malvaceae	*			NA
66.	*Hibiscus tiliaceus* L.	Malvaceae	*	*		NA
67.	*Hydrocotyle bonariensis* Commerson ex Lam.	Umbelliferae	*	*		NA
68.	*Imperata cylindrica* (L.) Raeusch.	Poaceae		*		NA
69.	*Ipomoea aquatic* Forssk.	Convolvulaceae	*			LC
70.	*Ipomoea cairica* (L.) Sweet	Convolvulaceae	*	*	*	NA
71.	*Ipomoea carnea* Jacq.	Convolvulaceae	*			NA
72.	*Ipomoea involucrata* Beauv.	Covolvulaceae	*	*	*	NA
73.	*Ipomoea pes-caprae* (L.) R.Br.	Convolvulaceae	*			NA
74.	*Ixora coccinea* L.	Rubiaceae		*		NA
75.	*Justicia brasiliana* Roth	Acanthaceae		*		NA
76.	*Kyllinga erecta* Schumach.	Cyperaceae	*	*		NA
77.	*Lagenaria breviflora* (Benth.) Roberty	Cucurbitaceae	*			NA
78.	*Laguncularia racemosa* (L.) C. F. Gaertn.	Combretaceae	*	*		LC
79.	*Lantana camara* L.	Verbenaceae	*	*		NA
80.	*Lonchocarpus sericeus* (Poir.)DC.	Fabaceae	*	*		NA
81.	*Ludwigia erecta* (L.) Hara	Onagraceae	*			NA
82.	*Luffa cylindrica* (L.) Roem.	Cucurbitaceae	*			NA
83.	*Maesobotrya sp.*	Euphorbiaceae			*	
84.	*Mangifera indica* L.	Anacardaceae		*	*	DD
85.	*Manihot esculenta* Crantz	Euphorbiaceae	*	*	*	NA
86.	*Mariscus alternifolius* Vahl	Cyperaceae	*			NA
87.	*Mariscus ligularis* (L.) Urb.	Cyperaceae	*		*	NA
88.	*Millettia arboreus* P. Beauv	Fabaceae		*		NA
89.	*Mucuna pruriens* (L.)DC.	Fabaceae		*		NA
90.	*Musa paradisiaca* L.	Musaceae	*		*	NA
91.	*Musa sapientum* L.	Musaceae	*	*		NA
92.	*Musanga cecropioides* R. Br. apud Tedlie	Moraceae	*	*		NA
93.	*Nephrolepis bisserata* (SW.) Schott	Davalliaceae	*	*		NA
94.	*Nephrolepis undulata* (Afzel. ex Sw.) J. Sm.	Davalliaceae	*			NA
95.	*Nypa fruticans* Wurmb	Arecaceae	*	*	*	LC
96.	*Oplismenus burmannii* (Retz.) P. Beauv	Poaceae	*		*	NA
97.	*Opuntia aciculata* Griffths	Cactaceae	*			DD
98.	*Ormocarpum verrucosum* P.Beauv.	Fabaceae	*	*		NA

Table 3. Contd.

99.	*Pandanus candelabrum* P.Beauv.	Pandaceae	*	*		NA
100.	*Panicum maximum* Jacq.	Poaceae		*		NA
101.	*Paspalum vaginatum* Sw.	Poaceae	*	*		LC
102.	*Passiflora foetida* L.	Passifloraceae	*			NA
103.	*Paullinia pinnata* L.	Sapindaceae		*		NA
104.	*Pennisetum hordeoides* (Lam.) Steud	Poaceae		*		NA
105.	*Pennisetum purpureum* Schumach.	Poaceae	*	*	*	NA
106.	*Persea americana* Mill.	Lauraceae		*		NA
107.	*Phaulopsis falcisepala* C. B. Cl.	Acanthaceae		*	*	NA
108.	*Philoxerus vermiculare* (L.).P. Beauv	Amaranthaceae	*			NA
109.	*Phoenix reclinata* Jacq.	Arecaceae	*	*		NA
110.	*Phragmites australis* Trin. ex Steud	Poaceae	*			LC
111.	*Physalis angulata* L.	Solanaceae	*			NA
112.	*Piper umbellatum* L.	Piperaceae			*	NA
113.	*Portulaca pilosa* L.	Portulacaceae	*			NA
114.	*Psidium guajava* L.	Myrtaceae		*		NA
115.	*Psychotria cf. marginata*	Rubiaceae	*			
116.	*Pterocarpus santalinoides* DC.	Fabaceae	*			LC
117.	*Quisqualis indica* Blanco	Combretaceae		*		NA
118.	*Raphia farinifera* (Gaertn.) Hyl.	Arecaceae	*	*		NA
119.	*Rauvolfia vomitoria* Afzel.	Apocynaceae		*		NA
120.	*Remirea maritima* Aubl.	Cyperaceae	*			NA
121.	*Rhizophora racemosa* L.	Rhizophoraceae	*	*	*	LC
122.	*Saccharum officinarum* L.	Poaceae		*		NA
123.	*Sacciolepis africana* C.E.Hubb. & Snowden	Poaceae	*			NA
124.	*Scleria depressa* (C.B.Clarke) Nelmes	Cyperaceae	*	*		NA
125.	*Scoparia dulcis* L.	Scrophulariaceae		*		NA
126.	*Sesamum indicum* L.	Pedaliaceae	*			NA
127.	*Sida acuta* Burm. f.	Malvaceae		*	*	NA
128.	*Solanum nigrum* L.	Solanaceae	*	*		NA
129.	*Sphagneticola trilobata* (L.) Pruski	Asteraceae	*			NA
130.	*Spigelia anthelmia* L.	Loganiaceae		*		NA
131.	*Spilanthes filicaulis* (Schumach. & Thonn.) C. D. Adams	Asteraceae	*			NA
132.	*Sporobolus pyramidalis* P. Beauv	Poaceae		*		NA
133.	*Stachytarpheta jamaicensis* (L.) Vahl	Verbenaceae	*	*		NA
134.	*Sterculia tragacantha* Lindl.	Sterculiaceae			*	NA
135.	*Terminalia catappa* L.	Combretaceae	*			NA
136.	*Tetracera alnifolia* L.	Dileniaceae	*	*		NA
137.	*Tragus berteronianus* Schult.	Poaceae	*			NA
138.	*Tristema hirtum* P. Beauv	Melastomataceae	*	*		NA
139.	*Triumfetta cordifolia* A. Rich	Tiliaceae	*	*		NA
140.	*Uapaca cf. paludosa*	Euphorbiaceae		*		
141.	*Urena lobata* L.	Malvaceae	*			NA
142.	*Vetiveria zizanioides* (L.) Nash	Poaceae			*	NA
143.	*Vigna marina* (Burm.) Merr	Fabaceae	*	*		NA
144.	*Vigna unguiculata* (L.) Walp.	Fabaceae	*			NA
145.	*Ximenia americana* L.	Olacaceae	*			NA
146.	*Xyris anceps* Lam.	Xyridaceae	*			NA
147.	*Zornia glochidiata* DC.	Fabaceae	*			NA

*- Present, NA- not assessed, DD- data deficient, & LC- least concern.

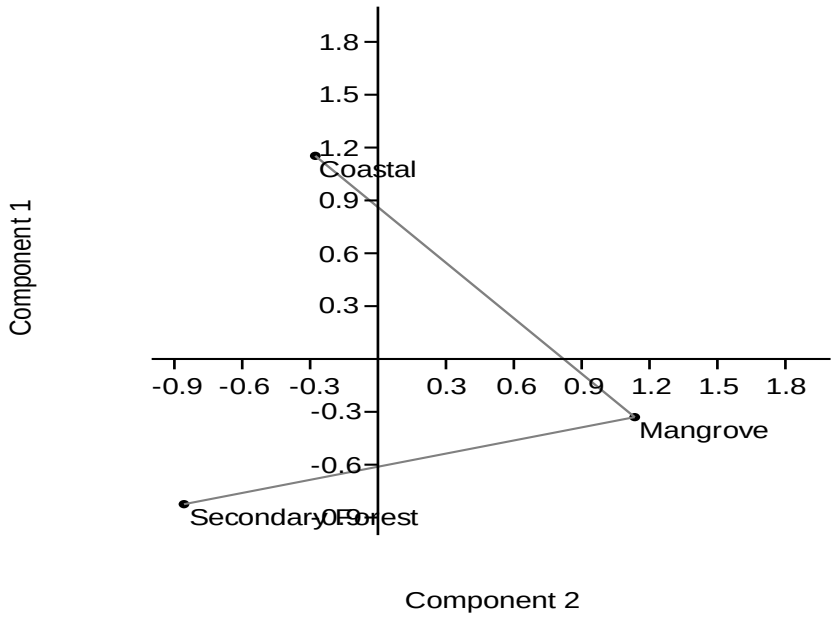

Figure 3. Principal component analysis of the studied area.

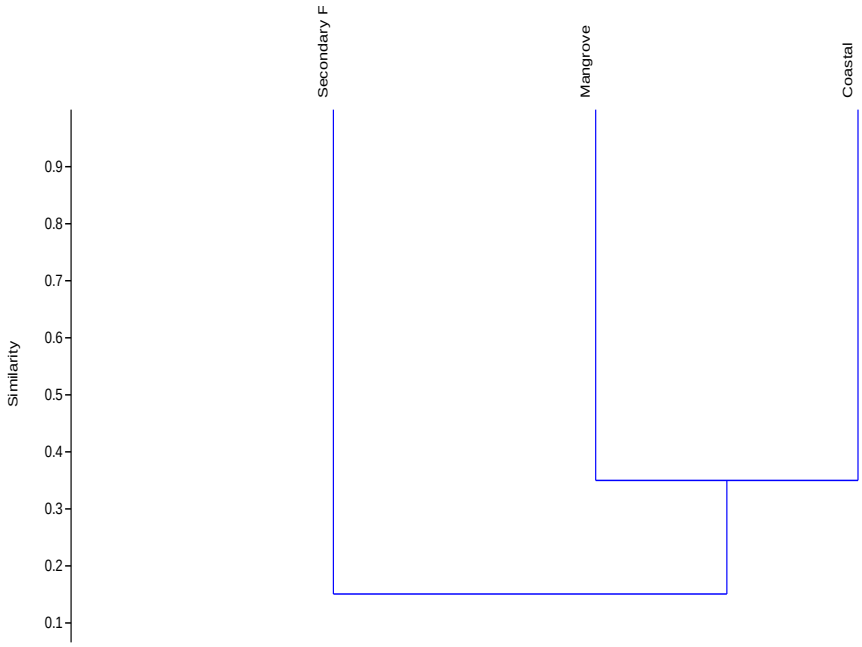

Figure 4. Dendogram showing the similarity coefficient among the vegetation (Jaccard similarity index).

in sediment character and nutrients deposition, salinity level which is consequent of the topography of the islands. The coastline and sandy beaches constitute extreme environment for plant life because of the combined effect of factors such as wind, wave, saline water, loose substratum with little water retention capacity which renders the soil very harsh to plant life. However, some species have to migrate to another ecosystem because they require the terrain that can enhance their growth in order to promote development. Notably, as the distance from the shore increases, the distinct adaptations of plants to tolerate coastal

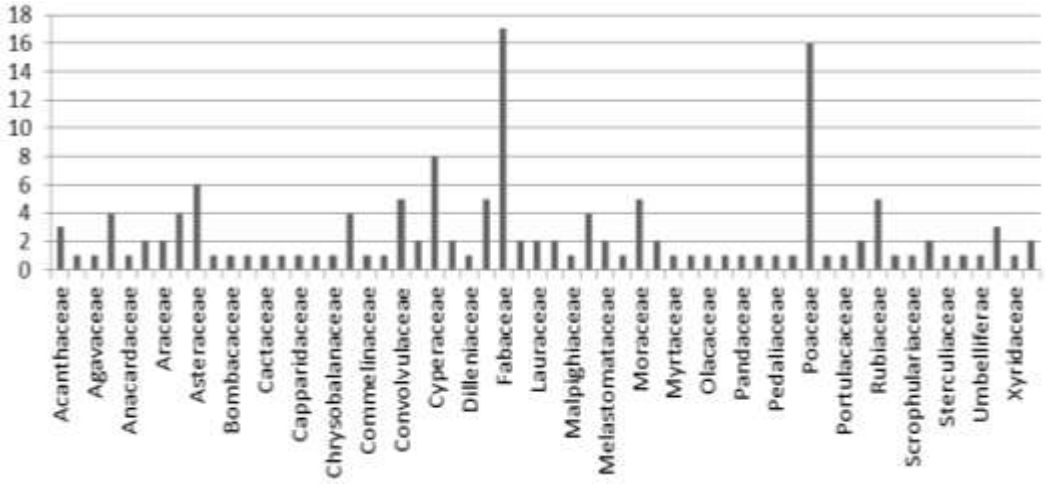

Figure 5. Family distribution across the studied area.

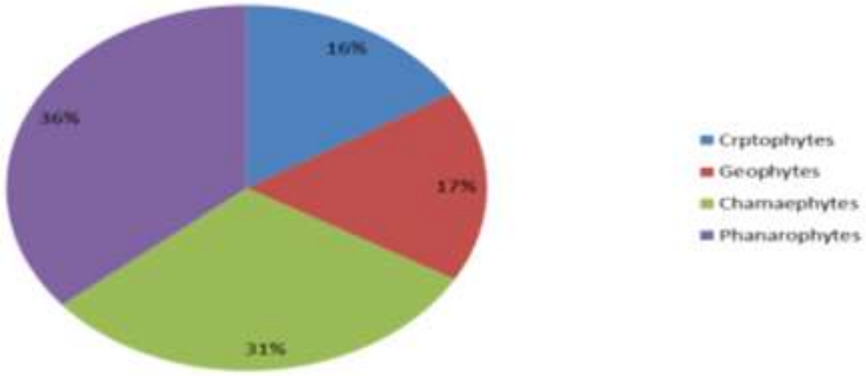

Figure 6. Life form distribution across the study area.

Table 4. Checklist of the encountered economic plants.

S/N	Botanical Name	Common name	Uses
1	*Musa sapientum* L.	Banana	Fruit
2	*Musa parasidiaca* L.	Plantain	Fruit
3	*Cocos nucifera* L.	Coconut	Fruit
4	*Ananas comosus* (L.) Merr.	Pineapple	Fruit
5	*Mangifera indica* L.	Mango	Fruit
6	*Carica papaya* L.	Pawpaw	Fruit
7	*Terminalia catappa* L.	Indian almond	Fruit tree
9	*Aframomum melegueta* K. Schum	Grains of paradise	Spice
10	*Alstonia boonei* De Wild	Pattern wood	Medicinal
11	*Ageratum conyzoides* L.	Goat weed	Medicinal
12	*Elaeis guineensis* Jacq	Oil palm tree	Oil & Wine
13	*Raphia hookeri*	Raffia palm	Palm wine
14	*Talinum triangulare* (L.) Juss	Water leaf	Vegetable
15	*Amaranthus viridis* L.	Spinach	Vegetable
16	*Manihot esculenta* Crantz	Cassava	Root crop

Plate 1. Littoral vegetation with diverse species e.g. *Calophyllum inophyllum*, *Terminalia catappa* and *Paspalum vaginatum*.

conditions decrease; although, many plants have adapted and flourished in this harsh coastal environment because of the:

1. Increased thickness of their leaves to protect the plant from dehydration, exposure to sun and salt spray e.g. *R. racemosa, Calophyllum inophyllum,* etc.
2. Ability to delay germination in response to excessive salt spray, dehydration or other environmentally harsh conditions e.g. *Nypa fruticans, Phoenix reclinata*
3. Ability to produce large seeds to increase the viability and vigour of seedlings e.g. *P. reclinata*
4. Dependence on the sea for the dispersal of their seeds e.g *Nypa fruticans, Pterocarpus santalinoides*
5. Ability to roll the leaves, in response to heat, salt and lack of water e.g. *Rhizophora* spp., *Sphagneticola trilobata*
4. Occurrence of hairs on the leaves, which helps to avoid heat stress, common in plants found close to the shore as in *Diodia rubricosa*.
5. Wiry stiff leaves and stems which enable the plants to tolerate abrasion by salt-laden winds and sands e.g. *Dissotis rotundifolia*.

Mangrove vegetation

Mangrove swamp forests are fully developed in the estuaries of the Cross River, Qua Iboe River, Imo River, Douglas, Itak Abasi and Iwuo-Okpom Opolom Creeks and on the banksof Oron and Mbo Rivers (Plate 2). Mangroves also occur either as large stretches or pockets of vegetation throughout the study area. Mangroves are the characteristic littoral plant formations of sheltered tropical and subtropical coastlines. Saenger et al.(1983) have divided the mangroves into two broad groups;exclusive species(only found in mangrove) and non-exclusive species (commonly associated with mangrove).Most of the dominant and important species are *Rhizophora* spp. *Conocarpus erectus,Nypa fruticans,A.germinans.*Mangrove vegetation is not generally rich in plant species because of the complexities and rigours of the habitat. These plants are generally referred to as halophytes, adapted to anaerobic conditions of both salt and fresh water in muddy and dark coloured soil with high organic content through the development of stilt roots and pneumatophores which project above the mud and water in order to absorb oxygen. Moreso, mangroves have the ability to grow where no other tree can, thereby making significant contributions that benefit the environment. They protect the coast from erosion, buffer adjacent marine ecosystems (often coral reefs) from terrestrial inputs, and form the primary habitat for a high diversity of fish and invertebrates, some of which are commercially important (Rützler and Feller 1996; Mumby et al., 2004; Layman et al., 2004). Their coverage of coastal shorelines and wetlands provides many diverse species of birds, mammals, crustacean, and fish a unique, irreplaceable habitat. Mangroves preserve water quality and reduce pollution by filtering suspended material and assimilating dissolved nutrients. The presence of some non-mangrove plant species in this zone shows that the habitat has been altered by human activities. Mangrove is the preferred wood for several purposes including fish drying and the

Plate 2. Mangrove vegetation dominated *Rhizophora racemosa, Avicennia germinans* and young *Nypa fruticans*.

construction of temporary shelters used by fishermen. Human interference which involves cutting down of the mangrove provides the foothold for *Nypa* invasion which subsequently gains advantage and then displaces the mangrove. Large areas within the study sites, e.g. Ibeno, Ikot Abasi and Imo River estuary, have been decimated by the aggression of this invasive species. *Nypa* palm has a superficial fibrous root system which lacks the holding ability to maintain coastline integrity.

Degraded secondary forest vegetation

The forest encompasses three vegetation types: the swamp forest, tropical rain forest and secondary regrowth. The swamp forest is found along the coastal and deltaic regions of Nigeria as observed within the study area. It harbors a wide variety of tree species such *as R. racemosa*, *A. germinans, Sterculia tragacantha* and *Laguncularia racemosa*. Structurally, secondary forest can be grouped into three: tree layers, shrub layer and the undergrowth that are of great economic values. The forests are supposed to be dominated by trees, shrubs, woody climbers (*lianas*) and abundance of epiphytes. The rate of forest degradation is on the high side because of intense anthropogenic factors such as indiscriminate bush burning, conversion of forest land for other uses e.g. Oil palms plantation, introduction of alien species e.g. *Nypa fruticans*, farming and replacement of forest species with fruits trees and arable crops and pollution, etc. All these determine the vegetation structure/floristic composition of this vegetation.

Generally, species distribution takes the form of a mosaic of local populations of greater or less degree of isolation, and therefore it is to be expected that most will show a degree of micro-geographical variation, with correlatable differences.

Avicennia and *Rhizophora* are some of the dominant plants species of mangrove communities in the Niger Delta genera with several closely related species, this is similar to the report of Ellison (1991) in the study of pacific paleogeography of *Rhizophora mangle* L. Moreso, plants develop adaptive features to survive the ecosystem conditions. *Nypa fruticans* is an invasive species (Plate 3) that has posed significant threat to the mangrove ecosystem. Invasion of *N. fruticans* in the mangrove swamps was observed to be consequent on human activities; *N. fruticans* is a strong competitor and lack utilization by the local people. The impacts include the reduction in primary and secondary productivity, disruption of food chain and erosion ofriverbanks. The biological diversity in the mangrove can be enhanced if *Nypa* palm is replaced with red and white mangroves in the mangrove ecosystem. Fruits and seeds of some non-coastal species are dispersed by water and were deposited along the shoreline as a result of tidal movement.These species include:*Pentaclethra macrophylla*,*Dioclea reflexa* and *Pterocarpus santalinoides*. The coastal vegetation, which is the most extensive and the nearest to the Atlantic Ocean had the highest floral diversity than the other vegetation types/ecosystems. The links between forest structure and environmental conditions have been studied by McKee (1993) and Fromard et al. (1998) who suggested that the wide variation in tree height and

Plate 3. Young *Acrostichum aureum* and dense thickets of *Nypa fruticans* which pose serious threat to the health of the mangrove ecosystem.

productivity are in response to temporal and spatial variation of environmental factors across the intertidal zone, such as soil salinity, soil waterlogging and nutrient availability (Koch, 1997; Feller et al., 2002, 2003). There is a significant difference in the species composition of three ecosystems at probability level of 0.05 even though they are positively correlated. This is as a result of some species adapting to the changing environment e.g. *A. cordifolia, A. germinans, Chromolaena odorata, Emilia coccinea, Dalbergia ecastaphyllum, N. fruticans, Pennisetum* sp., *Ipomoea pes-caprae* and *Ipomoea cairica* were recorded across the three dominant ecosystems within the study area while others are found in one or two of the vegetation types. The coastal and mangrove vegetation are similar because there are no clear margins between the habitats, they are both halophytic, mangrove protects the coastal area and are usually parallel to the coastline hence leading to occurrence of same species as compared to the secondary forest which are majorly fallow and farm land. The economic species were mostly found around the communities in some parts of the study area, where they are used as food and medicine. Jessica and Dianna (2004) stated that the introduction and spread of non-native species has become a global ecological and conservation crisis as invasive organisms are increasingly altering terrestrial and aquatic communities worldwide. The loss of biodiversity and species extinction are, likewise, major ongoing crises. Native species decline often occur simultaneously and in the same place as invasion by non-native species, leading many conservationists and researchers to believe that invasions and extinctions are closely linked. The identified anthropogenic factors are farming, dredging, drilling and laying of oil pipes, improper waste disposal, introduction of alien species and over- exploitation of the resources e.g. *R. racemosa* are used as fuelwood. As the world's biodiversity faces incessant threats from environmental and human induced factors, it is imperative to know the conservation status of the flora and fauna in any ecosystem. In accordance with the International Union for Conservation of Nature (IUCN) Red list of threatened species, 15 species fall within the category of Least Concern (LC), 2 are in Data Deficient (DD) while others are yet to be assessed (NA).

Conclusion

The study has provided the checklist of the floral diversity and the various vegetation types across the littoral zones of eastern part of Nigeria. The change in vegetation structure was attributed to the fierce action of strong waves and active coastal erosion which are quite evident in several locations; fishing activities, overexploitation of plant resources, invasion of alien species e.g. *N. fruticans*, and replacement of original plant communities by tree crops, such as coconut, oil palms, mango, plantain and vegetables. Dredging, pollution and canalization remain constant industrial activities which promote mangrove clearing constitute a threat to the well-being of the ecosystems. Species conservation in these ecosystems is highly imperative in

order to maintain the ecosystem dynamics, and the benefits that can be derived from these natural resources in perpetuity. Conservation efforts are often hampered by dearth of basic botanical information such as taxonomic identification and nomenclature of plant taxa. Therefore, information provided in this study is expected to fill such gaps.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

Diversity complex of plant species spread in Nasarawa State, Nigeria

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This research was carried out to assess the plant species diversity in Nasarawa State, Nigeria with a view to obtain an accurate database and inventory of the naturally occurring plant species in the state for reference and research purposes. This preliminary report covers a total of nine local government areas in the state. The work involved intensive survey and visits to the sample sites for this exercise. The diversity status of each plant and the distribution across the state were also determined using standard method. A total of number of 244 plant species belonging to 57 plant families were identified out of which the families, *Asteraceae, Poaceae, Combretaceae, Euphorbiaceae, Moraceae* and *Papilionaceae* were the most highly distributed across the entire study area. There was great extent of diversity in the distribution of plants across all the areas sampled with the highest in Wamba LGA. The most predominant food crop across the state was *Sorgum* spp. followed by *Sesame indica* and then *Zea mays.* The total percentage occurrence of herbs, shrubs and trees in the study area are 31.19, 16.29 and 47.91%, respectively. This preliminary work has provided a baseline data and reference point for future taxonomical stratagem in Nasarawa State.

Key words: Herbarium, conservation, Nasarawa, plant diversity.

INTRODUCTION

Biological diversity or biodiversity refers to the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. It encompasses the variety of all forms of life on earth, which provides the building blocks for human existence and ability to adapt to environmental changes in the future (FEPA, 2003). Biological diversity involves genetic, species and ecosystem diversity. Estimates of the total number of species range from 5 million to 100 million globally; though less than 1.7 million have actually been described (FEPA, 2003). Species diversity remains central to the evaluation of diversity at other levels, and is a constant point of reference in biodiversity conservation. Conservation is the planned management of natural resources, to retain the natural balance, diversity and evolutionary change in the environment. It is a protective measure taken; to prevent the loss of genetic diversity of a species; to save a species from becoming extinct and to protect an ecosystem from damage so as to promote

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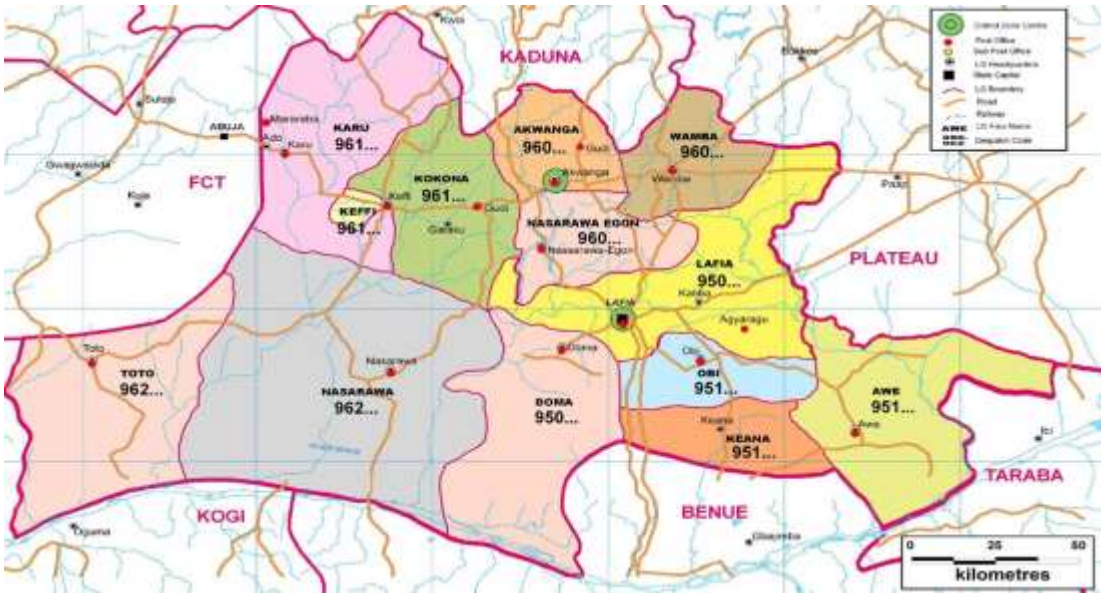

Figure 1. Showing the map of Nasarawa state as it borders with other states (source: www.google.com)

its sustained utilization. Plant germplasm is a non-renewable natural resource indispensable for the sustenance of human life on this earth (Borokini et al., 2010).

Nigeria is one of the most populous countries in Africa and has a landmass of over 923,768 squ km including about 13,000 sq km of water (NBS, 2007). There is an array of flora and fauna species associated with the varied ecological zones in Nigeria. There are 7,895 plant species from 338 families and 2,215 genera that have been identified in Nigeria (FGN, 2006). According to the FAO Forest Resources Assessment Report, Nigeria has the highest rate of deforestation of primary forests between 2000 and 2005 (FAO, 2005). The great diversity of plant species found in Nigeria cannot be unconnected with the diversity of ecosystems and habitats as well as the tropical climate in the country (FEPA, 1992). Nasarawa State is one of the states in the North-Central geo-political zones in Nigeria. It is bounded in the north by Kaduna State, in the west by the Abuja Federal Capital Territory, in the south by Kogi and Benue States and in the east by Taraba and Plateau States. It has a total land area of 27,137.8 sqkm (NPC, 2006). Nasarawa's main economic activity is agriculture. Production of minerals such as salt is also another major economic activity in the state. It lies within the guinea Savannah region and has tropical climate with moderate rainfall (annual mean rainfall of 1311:75 cm) (Nyagba, 1995). The state is made up of plain lands and hills and has some of the most beautiful sites and landscapes in the country.

There is still a lack of quantitative information on naturalized plants for major regions of the world, especially for those of Asia and Africa. Floras of these regions are either not existent or are incomplete, making it difficult to assess the native plant diversity populations. It is very true that many of our valuable plant generic resources are fast disappearing due to afore mentioned reasons and there is a careful need to document current plant diversity status so as to guide in the conservation plans to salvage the residual diversity. This study provides specific and comprehensive information on the species enumeration, diversity and conservation status of the plants in Nasarawa State, Nigeria.

MATERIALS AND METHODS

Sampling areas

Nine out of thirteen local government areas of Nasarawa State were selected at random and sampled for this study namely: Akwanga, Awe, Keffi, Kokona, Nasarawa, Nasarawa Eggon, Toto, Obi and Wamba (Figure 1).

Sample collection

This study involved intensive survey and several visits to the sample sites for plant identification and enumeration exercise.
Surveys and direct field observation were carried out as done in previous works (Lipp, 1989; Kayode et al., 1997). In each of the selected local government area, two rural communities, with plant richness and still far from urban influence were sampled. The Origin, life form and habitats colonized by each species were identified as far as possible. Life samples were collected and preserved using plant presses. The identification of the plants was done on the spot and with the aid of published floral and taxonomic books (NNMDA, 2006; 2008). A few unidentified plants were sent to standard herbaria for proper identification.

Table 1. Diversity status of plants in all the nine local governments.

S/N	Name of plant	Common name	Presence in local government areas									Overall diversity status
			Akwanga	Awe	Keffi	Kokona	Nasarawa	Nasarawa eggon	Obi	Toto	Wamba	
1	*Uvaria chamae* Vahl ex DC.	Hausa: rukuti	√	X	X	√	√	√	X	X	√	Very abundant
2	*Crossopteryx febrifuga* (Afzel. Ex G. Don) Benth.	Hausa: kashin akuya	√	X	√	√	X	X	X	√	√	Abundant
3	*Holarrhena floribunda* (G. Don) Schinz.	Conessi	√	X	X	X	X	√	X	X	√	Occasional
4	*Lophira lanceolata* Tiegh. Ex. Keay		√	X	X	X	√	X	X	√	√	Abundant
5	*Parkia biglobosa* (Jacq) G. Don	African locust beans	√	X	√	√	√	√	√	√	√	Abundant
6	*Vitellaria paradoxa* C.F. Gaertn.	Shea butter tree	√	X	√	√	√	√	√	√	√	Abundant
7	*Pericopsis laxiflora* (Baker) Hams.	African Teak	√	X	√	√	√	X	X	X	√	Frequent
8	*Detarium microcarpum* (Guill.) Perr.	Detar	X	√	√	X	X	X	√	√	√	Frequent
9	*Gmelina arborea* Roxb.	Gmelina	√	√	√	√	√	√	√	√	√	Abundant
10	*Sarcocephalus latifolius* (Sm.) Bruce	African Peach	√	X	√	√	X	√	√	√	√	Abundant
11	*Prosopis africana* (Guill.) Perr.	Iron wood	√	√	X	√	√	X	X	√	√	Frequent
12	*Bridelia ferruginea* Benth.		√	X	X	√	√	√	√	√	√	Abundant
13	*Hymenocardia acida* Tul.		√	√	X	√	√	√	X	X	√	Frequent
14	*Viscum album* Linn.	Mistletoe	X	X	X	√	X	X	X	X	√	Occasional
15	*Cissus populnea* (Guill.) Perr.		X	X	X	X	√	√	√	X	√	Frequent
16	*Vernonia perrottetii* Sch. Bip.		X	X	√	√	X	X	√	X	√	Frequent
17	*Eriosema griseum* Baker		√	X	√	X	X	√	√	√	√	Abundant
18	*Pavetta crassipes* K. Schum		X	X	√	√	√	X	√	X	√	Abundant
19	*Dioscorea esculenta* (Lour.) Burkill.		√	√	√	√	√	X	√	√	√	Abundant
20	*Dioscorea bulbifera* Linn.	Air potatoe	√	X	X	√	√	√	√	√	√	Abundant
21	*Dioscorea rotundata* Poir.	Guinea white yam	√	X	√	√	√	√	√	√	√	Abundant

Table 1, contd.

22	*Panicum baumannii* K. Schum.		√	√	√	√	√	√	√	√	√	Very abundant
23	*Chromolaena odorata* (L.) R.M. King	Siam weed	√	√	√	√	√	√	√	√	√	Abundant
24	*Mangifera indica* Linn.	Mangoe	√	√	√	√	√	√	√	√	√	Abundant
25	*Andropogon gayanus* (Hochst.) Hack.		√	X	X	X	√	√	√	√	√	Frequent
26	*Uacapa togoensis* Pax	Togo Uacapa	X	X	X	X	X	√	√	√	√	Occasional
27	*Pennisetum pedicellatum* Trin.	Desho grass	√	√	√	√	√	√	√	√	√	Very abundant
28	*Piliostigma thonningii* (Schum.) Milne-Redh.	Camel's foot	√	√	√	√	√	√	√	√	√	Very abundant
29	*Parinari curatellifolia* Planch. Ex Benth	Cork tree, Hissing tree	√	X	√	√	√	√	√	√	√	Very abundant
30	*Musa paradisiaca* Linn.	Plantain	√	X	√	√	√	√	√	√	√	Abundant
31	*Elaeis guineensis* Jacq.	Oil palm tree	√	√	√	√	√	√	√	√	√	Abundant
32	*Zingiber officinales* Rosc.	Ginger	√	X	X	X	X	√	√	√	√	Frequent
33	*Abelmoschus esculentus* (L.) Moench.	Okro	√	√	√	X	X	√	√	√	√	Abundant
34	*Achyranthes aspera* Linn.		√	X	X	√	√	√	X	X	√	Frequent
35	*Synedrella nodiflora* (L.) Gaertn.		√	X	X	√	X	X	√	X	X	Frequent
36	*Ipomoea batatas* Linn.	sweet potatoe	X	√	X	√	√	X	X	√	√	Frequent
37	*Ipomea involucrata* P. Beauv.	potatoe	√	X	√	X	√	√	√	X	√	Frequent
38	*Echiopta spp*		√	X	X	X	X	√	X	√	√	Frequent
39	*Ageratum conyzoides* Linn.	Billy goat weed	X	√	X	√	√	√	X	X	√	Frequent
40	*Achyranthes atollensis* H.St. John.		√	X	X	X	√	√	√	X	√	Frequent
41	*Sida acuta* Burm. F.	Wire weed	√	√	√	√	√	√	√	√	√	Very abundant
42	*Cissampelos mucronata* A. Rich		√	X	X	X	√	X	√	X	√	Frequent
43	*Vernonia amygdalina* Del.		√	X	√	√	√	X	√	X	√	Frequent
44	*Ocimum gratissimum* Linn.	Scent tree	√	√	√	√	√	√	√	√	√	Abundant
45	*Eragrostis cilianensis* (All.) Vignolo ex J.	Love grasses	X	√	X	X	X	√	√	√	√	Frequent

Table 1, Contd.

46	*Chloris pilosa* Schum		√	√	X	X	X	X	√	√	√	Frequent
47	*Eleusine indica* (L.) Gaertn.	Fowl-foot grass Hausa: Tuji	√	√	X	X	X	X	X	X	√	Occasional
48	*Psidum guajava* Linn.	Guava	√	X	X	X	√	X	√	√	√	Frequent
49	*Colocasia esculenta* (L.) Schott.	Cocoyam	X	X	X	X	X	√	√	√	√	Frequent
50	*Citrus sinensis* (L.) Osbeck	Sweet orange	√	√	√	√	√	√	√	√	√	Abundant
51	*Thevetia neriifolia* (Linn.) Lippolt		√	X	√	√	X	√	√	√	√	Frequent
52	*Solanum tuberosum* L.		√	√	√	√	√	√	√	√	√	Frequent
53	*Phyllanthus floribunda* Lam.		X	√	√	X	X	X	X	X	√	Occasional
54	*Anogeissus leiocarpus* (DC.) Guill. And Perr.	Chew stick	X	X	√	√	√	√	X	√	√	Occasional
55	*Manihot esculenta* Crantz	Cassava	√	X	X	√	X	√	√	√	√	Frequent
56	*Andropogon tectorum* Schum.	Blue stem	√	X	√	√	√	X	√	√	√	Frequent
57	*Pennisetum polystachion* Linn.		√	√	√	√	√	√	√	√	Very abundant	Very abundant
58	*Tephrosia linearis* (Willd.) Pers.		√	√	√	X	√	X	X	√	√	Frequent
59	*Acacia seya* (Linn.) Willd.	Hausa: Farin kaya	X	X	X	X	X	√	X	X	√	Occasional
60	*Cajanus cajan* (L.) Millsp.	Pigeon pea	X	X	√	√	X	√	X	√	√	Frequent
61	*Lippia javanica* (Burm. F.) Spreng.		X	√	√	√	X	X	X	X	√	Frequent
62	*Gardenia aqualla* Stapf and Hutch.	Hausa: Gaude	√	X	√	√	√	√	√	√	√	Frequent
63	*Grewia mollis* Juss.		√	√	√	√	√	X	X	X	√	Frequent
64	*Sorghum bicolor* (L.) Moench	Guinea corn	√	√	√	√	√	√	√	√	√	Very abundant
65	*Annona senegalensis* Pers.	Wild custard apple	√	X	X	X	X	X	X	X	√	Occasional
66	*Combretum indicum* (L.) DeFilipps		√	X	√	X	X	√	√	√	√	Frequent
67	*Mitracarpus villosus* (Swartz) Cham. and Schltdl		√	√	√	√	√	√	√	√	√	Abundant

Table 1. Contd.

68	*Terminalia avicennoides* Guill and Perr.		√	X	√	√	√	√	X	X	√	Frequent
69	*Trichilia emetica* (Forsskal) Vahl.		X	X	X	√	X	√	√	√	√	Occasional
70	*Calopogonium mucunoides* (Bentham) Hem.	Calopo	√	√	√	√	√	√	√	√	√	Frequent
71	*Brachiaria jubata* Stapf.		√	X	X	√	√	X	√	√	√	Occasional
72	*Justicia schimperi* (Hochst.) Dandy.		X	X	√	√	X	√	√	X	√	Occasional
73	*Panicum maximum* Jacq.	Forage grass	√	√	√	√	√	√	√	√	√	Frequent
74	*Rottboellia cochinchinensis* (Lour.) Clayton	Itch grass	X	X	√	√	√	√	√	√	√	Frequent
75	*Cleistopholis patens* (Benth.) Engl. and Diels.	none	X	X	X	√	X	X	X	X	√	Occasional
76	*Ficus carica* Linn.		X	X	X	X	√	√	X	√	√	Occasional
77	*Alchornea cordifolia* (Schum. and Thonn.) Mull.	Chrismas bush	√	√	√	√	√	√	√	√	√	Frequent
78	*Erythrophleum suaveolens* Guill. and Perr.	Red water tree	√	X	X	√	X	X	X	√	√	Occasional
79	*Hyperrhenia rufa* (Nees) Stapf.	Zebra grass, Hausa: Chiyawan zana	X	√	√	√	√	√	√	√	√	Frequent
80	*Dioscorea alata* Linn.	Cultivated water yam	√	X	√	√	√	X	X	√	√	Occasional
81	*Aspilia africana* Perrs.	Haemorrhage plant	√	X	√	√	X	√	√	√	√	Frequent
82	*Tamarindus indica* Linn.	Tamarind, Indian date	X	X	√	√	√	X	√	X	√	Occasional
83	*Desmodium velutinum* (Willd.) DC.		√	X	√	X	√	√	X	√	√	Occasional
84	*Dachrostachys cinerea* (Linn.) Wight and Arn.		√	X	√	√	√	√	√	√	√	Frequent
85	*Urena lobata* Linn.	Ramarama	√	√	√	√	√	√	√	√	√	Very abundant
86	*Borreria radiata* DC.		X	X	X	X	√	√	√	X	√	Occasional
87	*Combretum molle* R.Br. ex G. Don.		X	X	X	X	√	√	X	√	√	Occasional
88	*Combretu collinum* (SIDA) Storrs AEG.		X	X	X	√	√	√	X	√	√	Occasional

Table 1. Contd.

89	*Entada africana* Guill.	Entada, Monkey's sandal	√	√	X	X	X	√	√	X	√	Frequent
90	*Indigofera pulchra* Willd.		√	X	√	√	√	X	X	X	√	Frequent
91	*Syzygium guineense* Willd.		X	√	X	√	√	√	√	√	√	Frequent
92	*Waltheria americana* Linn.		√	X	√	√	√	√	X	X	√	Frequent
93	*Phyllanthus muellerianus* Schum. and Thonn.	Hausa: Dandami	√	X	√	X	X	√	X	√	√	Frequent
94	*Crotalaria ledermannii* Baker F.		√	X	X	√	√	X	√	√	√	Occasional
95	*Tephrosia candida* (Roxb.) DC.		√	X	√	√	√	X	√	X	√	Frequent
96	*Mucuna sloanei* Fawc. and Rendle	Horse eye bean	√	X	√	√	√	√	X	X	√	Frequent
97	*Emilia praetermissa* Milne-Redh		X	X	X	X	X	X	X	X	√	Rare
98	*Cissus petiolata* Hook. F.		√	X	√	X	√	√	X	√	√	Frequent
99	*Hyptis suaveolens* (L,) Poit.	Bush tea-bush	√	√	√	√	√	√	√	√	√	Very abundant
100	*Cassia tora* L.	Foetid cassia	√	√	√	√	X	√	√	√	√	Frequent
101	*Costus afer* Ker. Gawl.	Common ginger lily	√	X	√	√	X	√	X	√	√	Occasional
102	*Zea mays* L.	Maize	√	√	√	√	√	√	√	√	√	Frequent
103	*Vitex doniana* Sw.	Black plum	√	X	X	√	√	√	X	√	√	Frequent
104	*Isoberlinia doka* Craib and Stapf.		√	X	X	√	√	√	X	√	√	Frequent
105	*Adenodolichos paniculata* (Hua) Hutch.		X	√	√	√	√	X	X	X	√	Occasional
106	*Daniella oliveri* (Rolfe) Hutch.	African Copuba balsam	√	X	√	√	√	√	√	√	√	Frequent
107	*Nelsonia canescens* (Lam.) Spreng	Blue pussyleaf	√	X	√	X	X	X	X	X	√	Occasional
108	*Hyperrhenia hirta* (Linn.) Stapf		√	X	√	√	√	√	√	√	√	Frequent
109	*Mimosa pigra* Linn.		√	X	√	X	√	X	√	√	√	Occasional
110	*Paullinia pinnata* Linn.		X	X	√	X	X	X	X	√	√	Occasional
111	*Vigna unguiculata* (L.) Walp.	Cowpea, bean	√	√	√	√	X	√	√	√	√	Frequent

Table 1, Contd.

112	*Newbouldia laevis* (P. Beauv.) Seem.	Fertility plant, tree of life	√	X	√	√	√	√	√	√	√	Frequent
113	*Oryza sativa* Linn.	Rice	√	X	√	√	√	√	√	√	√	Abundant
114	*Adansonian digitata* Linn.	Baobab	X	X	√	√	√	√	X	X	√	Occasional
115	*Euphorbia hirta* Linn.	Asthma plant, hairy spurge	√	X	√	X	√	√	√	X	√	Occasional
116	*Cassia sieberiana* DC.		√	√	√	√	√	√	√	√	√	Abundant
117	*Gardenia erubenscens* Stapf and Hutch.		√	X	√	√	√	X	√	X	√	Frequent
118	*Sterculia setigera* Delile.		X	√	√	√	X	√	√	√	√	Occasional
119	*Byrsocarpus coccineus* Schum. and Thonn.		√	X	√	√	X	√	√	√	√	Frequent
120	*Tephrosia bracteolata* Guill. and Perr.		√	X	√	X	√	√	X	√	√	Frequent
121	*Ipomoea involucrata* P. Beauv.		√	X	√	X	√	√	X	√	√	Frequent
122	*Cochlospermum tinctorium* Perr.		√	X	√	√	√	√	√	√	√	Frequent
123	*Dialium guineense* Willd.	Black or Velvet Lamarind	√	√	√	√	X	√	√	√	√	Frequent
124	*Allophyllus africanus* P. Beauv.		√	X	√	√	X	√	√	X	√	Frequent
125	*Anchomanes difformis* (Blume) Engl.	Aroids	√	X	√	√	X	√	X	√	√	Occasional
126	*Bidens pilosa* Linn.	Black jack, Bur marigold	√	X	√	X	√	√	X	√	√	Occasional
127	*Smilax kraussiana* Meisn.	West African sarsaparilla	√	X	√	√	√	√	X	√	√	Occasional
128	*Desmodium canadense* (Linn.) DC.		√	√	√	X	√	X	√	√	√	Frequent
129	*Landolphia owariensis* P. Beauv.	White rubber vine	√	X	√	√	√	√	√	X	√	Frequent
130	*Cissus doeringii* Gilg and Brandt.		√	X	√	√	√	√	X	√	√	Frequent
131	*Borassius aethiopium* Mart.	Fan palm	√	X	√	√	X	√	X	√	√	Occasional
132	*Ficus exasperata* Vahl	Sand paper tree	√	X	√	X	X	√	X	√	√	Occasional

Table 1, Contd.

133	*Stereospermum kunthianum* Cham.		√	X	√	√	X	√	X	√	√	Frequent
134	*Stylosanthes hamata* (L.) Taub.		√	√	X	√	√	X	√	X	√	Frequent
135	*Cassia rotundifolia* (SIDA) Kiepe		√	X	√	√	X	√	X	√	√	Frequent
136	*Cassia nigricans* Vahl		√	X	√	√	√	√	X	√	√	Frequent
137	*Anacardium occidentalis* Linn.	cashew	√	√	√	√	√	√	√	√	√	Abundant
138	*Hibiscus asper* Hook.		√	X	√	X	√	X	√	X	√	Occasional
139	*Desmodium spirale* (Sw.) DC.		√	X	√	√	√	√	X	√	√	Frequent
140	*Imperata cylindrica* (Linn.) Beauv.	Cogon grass	√	√	√	√	√	√	√	√	√	Abundant
141	*Asparagus africanus* (Lam.) Oberm.		√	X	√	X	X	√	X	√	X	Occasional
142	*Strychnos spinosa* Lam.		√	X	√	X	X	√	X	√	X	Occasional
144	*Scleria verrucosa* Willd.	Suswam (tiv)	X	X	√	X	X	√	√	√	X	Occasional
145	*Tephrosia densiflora* Hook.		√	X	√	X	√	√	X	√	√	Frequent
146	*Paspalum orbiculare* Linn.		X	X	√	X	X	√	√	√	X	Occasional
147	*Biophytum petersianum* Klotz.	Sensitive leg	X	X	√	X	X	√	√	√	X	Occasional
148	*Alysicarpus vaginalis* (L.) DC.		X	X	√	X	X	√	√	√	X	Occasional
149	*Cissus ivorens* L.	Yaluyaka Tiv	√	√	√	X	√	√	X	√	√	Frequent
150	*Sporobolus pyramidalis* (Beauv.) R. Br.		X	X	√	X	X	√	√	√	X	Occasional
151	*Securidaca longepedunculata* SIDA	Violet tree	X	X	√	X	X	√	√	√	X	Occasional
152	*Kigelia africana* (Lam.) Benth.		√	√	√	X	√	√	X	√	√	Frequent
153	*Tecoma stans* (Linn.) Juss.	Yellow trumpet tree	X	X	X	√	X	X	X	X	X	Rare
154	*Solanum nigrum* Linn.	Black nightshade	√	√	√	X	√	√	X	√	√	Frequent
155	*Cyperus rotundus* Linn.		√	X	√	√	√	√	√	X	√	Frequent
156	*Panicum effusum* R. Br.		X	X	√	√	√	√	X	√	√	Frequent
157	*Cussonia barteri* Seemann.		√	X	√	√	√	√	√	√	√	Abundant

Table 1,Contd

158	*Ficus capensis* Thunb.		√	X	√	√	X	√	√	√	√	Frequent
159	*Boswellia dalzielii* Hutch.	Frankincense tree	√	X	√	√	X	√	√	√	√	Frequent
160	*Lannea kerstingii* Engl. and Krause.		√	X	√	√	X	√	X	√	√	Occasional
161	*Monechma ciliatum* (Jacq.) Mil.		√	X	√	√	X	√	√	√	√	Frequent
162	*Trema orientalis* (Linn.) Blume.		√	X	√	√	X	√	X	X	√	Occasional
163	*Euphorbia poissonii* Fax.	Tiv - Icheu	√	√	√	√	√	X	√	√	√	Frequent
164	*Sida cordifolia* L.		√	√	√	√	√	√	√	√	√	Very abundant
165	*Gynandropsis gynandra* (L.) Briq.	Cat whiskers	√	X	√	√	X	√	X	√	√	Frequent
166	*Petrocarpus erinaceus* Poir.	African Kino	√	√	√	√	X	√	X	√	√	Frequent
167	*Setaria pallidefusca* Stapf and Hubb.		X	X	√	√	X	√	X	X	√	Occasional
168	*Dactyloctenium aegyptium* (Linn.) Willd.	Egyptian grass	√	X	√	√	√	X	√	√	√	Frequent
169	*Celosia argentea* Linn.		√	√	√	√	√	√	√	√	√	Abundant
170	*Brachiaria decumbens* Stapf.		X	X	√	√	√	X	X	√	√	Occasional
171	*Azadiractha indica* A. Juss.	Neem tree	√	√	√	√	√	√	√	√	√	Very abundant
172	*Eragrostis gangetica* (Roxb.) Steud.		√	√	√	√	√	√	√	√	√	Abundant
173	*Citrullus vulgaris* Schrad.	Melon, Agusi	√	X	√	√	√	√	X	√	√	Frequent
174	*Hygrophila spinosa* T. Ander.		√	X	√	√	X	√	X	√	√	Frequent
175	*Desmodium salicifolium* (Poir.) DC.		X	X	√	√	√	√	X	√	√	Frequent
176	*Panicum antidotale* Retz.		√	√	√	√	√	√	√	√	X	Abundant
177	*Amaranthus spinosus* Linn.	Pricky amaranth	√	X	√	√	√	√	√	√	√	Frequent
178	*Sanseviera liberica* Ger. and Labr.		√	X	√	√	√	√	√	√	√	Abundant
179	*Lycopersicon esculentum* Mill.	Tomatoe	X	√	X	√	X	√	√	X	√	Occasional
180	*Pennisetum typhoides* (Burm. F.) Stapf.	Millet	√	√	√	X	X	√	√	X	X	Occasional

Table 1, Contd.

181	*Physalis angulata* Linn.	Tiv - Tampue	√	√	√	X	X	√	√	X	√	Occasional
182	*Eclipta alba* (L.) Hassk.		√	√	√	X	X	√	√	X	X	Occasional
183	*Boerhavia diffusa* Linn.		√	√	√	X	X	√	√	X	X	Occasional
184	*Cassia occidentalis* Linn.	Negro coffee	√	√	√	X	X	√	√	X	√	Frequent
185	*Cynodon dactylon* (Linn.) Pers.	Carpet grass	X	√	√	X	X	√	√	X	√	Frequent
186	*Luffa cylindrical* Linn.	Smooth loafah	X	√	√	X	X	√	√	X	√	Occasional
187	*Ocimum basilicum* Linn.		X	√	√	X	X	√	√	X	X	Occasional
188	*Momordica charantia* Linn.	African cucumber, balsam peer	X	√	√	X	X	√	X	X	√	Occasional
189	*Mitragyna inermis* Linn.		√	√	√	X	X	√	X	X	√	Occasional
190	*Khaya seneganlensis* (Desr.) Juss.	Dry zone mahogamy	√	√	√	X	X	√	√	X	√	Frequent
191	*Trianthema portulacastrum* Linn.		X	√	√	X	X	√	X	X	√	Occasional
192	*Combretum platypterus* Szys.		√	√	√	X	X	√	X	X	√	Frequent
193	*Eucalyptus globulus* Labill.	Eucalyptus leaf	√	√	√	√	X	√	√	X	√	Abundant
194	*Burkea africana* Hook.		√	√	√	X	X	√	√	X	X	Frequent
195	*Striga hermonthica* (Del.) Benth.	Purple witchweed	X	√	√	√	X	√	√	√	√	Frequent
196	*Sesamum indicum* Linn.	Beni seed	X	√	√	√	X	√	√	√	√	Frequent
197	*Ricinus communis* Linn.	Castor oil plant	X	√	√	√	X	√	√	X	√	Frequent
198	*Hibiscus sabdariffa* Linn.	Red roselle, Zobo	√	√	√	√	X	√	√	√	√	Abundant
199	*Calotropis procera* (L.) Dryand.	Giant milkweed, Sodom apple	√	√	√	√	√	√	√	√	√	Abundant
200	*Commelina benghalensis* Linn.		X	√	X	√	X	√	X	√	√	Occasional
201	*Boerrhavia repens* Linn.	Hog weed	X	√	X	√	X	√	X	√	X	Occasional
202	*Acanthospermum hispidum* (DC.) Kuntze.	Star bur	√	√	X	√	X	√	X	√	√	Frequent

Table 1,Contd.

203	*Indigofera hirsuta* Linn.		X	√	X	√	X	√	X	√	√	Occasional
204	*Altenanthera sessilis* (Linn.) R. Br.		√	√	√	√	X	√	X	√	√	Frequent
205	*Corchorus tridens* Mut.	Bush okra	X	√	X	√	X	√	X	√	√	Occasional
206	*Ficus thonningi* Blume		√	√	√	√	X	√	√	√	√	Abundant
207	*Dracaena smithii* (Baker) Hook.		X	√	X	√	X	√	X	√	√	Occasional
208	*Tridax procumbens* Linn.		√	√	√	√	X	√	X	√	√	Frequent
209	*Ficus trichopoda* Baker	Tiv – Po	√	√	√	√	√	X	X	√	√	Frequent
210	*Berlinia grandifolia* (Vahl) Hutch.	Berlinia tree	√	√	√	√	√	X	X	√	√	Abundant
211	*Senna alata* (Linn.) Roxb.	Ringworm bush	X	√	X	√	X	√	X	√	X	Occasional
212	*Crotalaria juncea* Linn.		X	√	X	√	X	√	X	√	X	Occasional
213	*Terminalia glaucescens* Planch.		√	X	√	√	X	√	√	√	√	Frequent
214	*Andropogon verticilatus* Schum.		√	X	√	√	√	√	√	√	√	Frequent
215	*Ficus polita* Vahl		√	√	√	√	√	X	√	√	√	Abundant
216	*Bambusa vulgaris* Schrad	Bamboo	X	X	X	√	X	√	X	√	X	Occasional
217	*Plumeria rubra* Linn.	Red frangipani	X	√	X	√	X	X	X	√	X	Occasional
218	*Datura stramonium* Linn.	Jimson weed	X	X	X	√	X	√	X	√	X	Occasional
219	*Lagenaria siceraria* (Molina) Standl.	Calabash tree	X	√	X	X	X	√	X	√	X	Occasional
220	*Gossypium barbadense* Linn.	Cotton	X	√	X	X	X	√	X	√	X	Occasional
221	*Terminalia catappa* Linn.	Almond tree	√	√	X	X	X	√	X	√	X	Occasional
222	*Spondias monbin* Linn.	Hog plum	X	X	X	X	X	√	X	√	X	Occasional
223	*Delonix regia* (Hook.) Raf.	Flame of forest	X	X	X	X	X	√	√	√	X	Occasional
224	*Indigofera arrecta* Hoch.		X	X	X	X	X	√	X	√	X	Occasional
225	*Jatropha gossypifolia* Linn.		√	X	√	√	√	√	√	√	X	Abundant
226	*Sesbania sesban* (Linn.) Merr.		√	X	X	X	X	√	X	√	√	Frequent
227	*Albizia lebbeck* (Linn.) Benth.	Shade tree	√	X	X	X	X	√	X	√	X	Occasional

Table 1, Contd.

228	*Desmodium gangeticum* Linn.		√	X	X	√	X	√	X	√	√	Occasional
229	*Balanites aegyptiaca* (Linn.) Del.	Soap berry tree	√	X	√	√	X	√	X	√	√	Frequent
230	*Setaria barbata* (Lam.) Kunth.		√	X	X	√	√	√	X	√	√	Occasional
236	*Phyllanthus amarus* Schum. and Thonn.		X	X	X	X	√	X	X	X	X	Rare
231	*Ceiba pentandra* (Linn.) Gaertn.	Silk cotton	√	X	X	√	√	√	X	√	X	Occasional
232	*Digitaria horizontalis* Willd.		√	X	X	√	√	X	X	√	X	Occasional
233	*Euphorbia heterophylla* Linn.		√	X	X	√	√	X	X	√	X	Occasional
234	*Portulaca oleracea* Linn.	Portulaca	X	X	X	√	√	√	X	√	X	Occasional
235	*Desmodium uncinatum* (Jacq.) DC.		√	X	√	√	√	√	X	√	X	Frequent
236	*Ipomoea aquatica* Forssk.		√	X	√	√	√	√	X	√	√	Frequent
237	*Ziziphus mucronata* Willd.		X	X	X	X	√	X	X	√	X	Occasional
238	*Terminalia superba* Engl. and Diels.		X	√	√	√	√	√	X	√	√	Abundant
239	*Stylosanthes mucronata* Willd.		X	√	√	√	√	√	X	√	√	Abundant
240	*Anthocleista djalonensis* A. Chev.		X	X	X	√	√	√	X	√	X	Occasional
241	*Borreria verticillata* (Linn.) Mey.		√	X	X	√	√	√	X	√	X	Occasional
242	*Cassia siamea* Lam.		√	X	√	√	√	√	√	√	√	Frequent
243	*Moringa oleifera* Lam.	Moringa	√	√	√	√	√	√	√	√	√	Abundant
244	*Carica papaya* Linn.	Pawpaw	√	√	√	√	√	√	√	√	√	Abundant

√ Means present, X means absent.

Species abundance

The relative abundance of the identified botanicals within 2 km radius from each of the sampling centers were determined according to Bongers et al. (1988) and Kayode (1999) as: Less than 5 individuals as rare, 5 to 10 as occasional, 11 to 30 as frequent, 31 to 100 as abundant and over 100 individuals as very abundant.

RESULTS

A total number of 244 plant species of different families were identified. There was great diversity in the distribution of plants across all the local governments sampled. However, the highest plant diversity in terms of different species was recorded in Wamba local government area (Table 1).

Three plants have been identified as rare species namely *Emilia praetermissa, Tecoma stans* and *Phyllanthus amarus.* The total percentage occurrence of herbs, shrubs and trees in the 9 local governments are 31.19, 16.29 and 47.91%, respectively (Table 2). A total of 57 plant families

Table 2. Percentage distribution of the life forms of plants in Nasarawa State.

Habit	Local Government Areas								
	Akwanga	Awe	Keffi	Kokona	Nasarawa	Nasarawa eggon	Obi	Toto	Wamba
Percentage of herbs, climbers and grasses	25.71%	36.36%	16.67%	39.39%	31.25%	47.62%	44.44%	29.27%	45.98%
Percentage of shrubs	18.57%	18.18%	33.33%	9.09%	6.25%	4.76%	22.22%	14.63%	19.54%
Percentage of trees	55.71%	45.45%	50%	51.52%	62.5%	47.62%	27.78%	56.09%	34.48%

Table 3. Percentage occurrence of plant families.

S/N	Name of family	Percentage in local governement areas									Overall percentage
		Akwanga	Awe	Keffi	Kokona	Nasarawa	Nasarawa eggon	Obi	Toto	Wamba	
1	Acanthaceae	0	0	0	0	0	3.33%	0	0	0.94%	0.47%
2	Agavaceae	0	5%	0	0	0	0	0	0	0	0.56%
3	Anonnaceae	2.5%	0	0	2.32%	2.85%	0	4%	3.03%	2.83%	1.95%
4	Ampelidaceae	0	0	0	0	0	0	0	0	1.89%	0.21%
5	Asteraceae	7.5%	10%	9.5%	2.32%	2.85%	3.33%	4%	3.03%	6.6%	5.46%
6	Apocynaceae	2.5%	0	0	4.65%	2.85%	0	0	3.03%	1.89%	1.66%
7	Araceae	2.5%	0	0	2.32%	2.85%	3.33%	4%	3.03%	0.94%	2.11%
8	Araliaceae	0	0	0	0	0	3.33%	0	0	0	0.37%
9	Arecaceae	7.5%	0	0	0	0	0	0	0	0.94%	0.94%
10	Asclepiadaceae	0	0	0	0	0	0	4%	0	0.94%	0.55%
11	Amaranthaceae	0	5%	0	2.32%	0	3.33%	0	0	1.89%	1.39%
12	Anacardiaceae	2.5%	0	0	4.65%	5.71%	3.33%	4%	6.06%	0.94%	3.02%
13	Balanitaceae	0	0	0	0	2.85%	0	0	0	0	0.32%
14	Bignoniaceae	0	0	4.8%	4.65%	0	0	0	0	0.94%	1.15%
15	Bombacaceae	0	0	0	0	2.85%	0	0	3.03%	0.94%	0.76%
16	Burseraceae	0	0	0	0	0	3.33%	0	0	0	0.37%
17	Caesalpiniaceae	7.5%	10%	4.8%	2.32%	2.85%	0	4%	9.09%	6.6%	5.24%
18	Capparidaceae	0	0	0	0	0	3.33%	0	0	0	0.37%
19	Cochlospermaceae	2.5%	0	0	0	0	0	0	0	0	0.28%
20	Combretaceae	0	0	4.8%	2.32%	2.85%	3.33%	4%	6.06%	1.89%	2.81%
21	Commelinaceae	0	0	0	2.32%	0	0	4%	0	0	0.7%
22	Connaraceae	2.5%	0	0	0	0	0	0	0	0.94%	0.38%
23	Convolvulaceae	2.5%	0	14.3%	4.65%	2.85%	3.33%	4%	3.03%	2.83%	4.17%
24	Cucurbitaceae	0	15%	4.8%	4.65%	2.85%	3.33%	0	3.03%	0	3.74%

Table 3,contd.

25	Cyperaceae	0	0	9.5%	6.98%	2.85%	6.67%	4%	3.03%	0.94%	3.77%
26	Dioscoreaceae	0	0	0	2.32%	2.85%	3.33%	4%	0	3.77%	1.81%
27	Euphorbiaceae	2.5%	0	4.8%	2.32%	8.57%	3.33%	4%	3.03%	5%	3.73%
28	Fabaceae	5%	5%	4.8%	2.32%	2.85%	3.33%	4%	3.03%	3.77%	3.79%
	Hymenocardiaceae	0	0	0	0	0	0	0	0	2.83%	0.31%
29	Lamiaceae	0	5%	0	0	0	0	0	0	1.89%	0.77%
30	Liliaceae	0	0	0	2.32%	0	0	0	0	0	0.26%
31	Loganiaceae	0	0	4.8%	0	0	0	0	0	0	0.53%
32	Loranthaceae	0	0	0	0	0	0	0	0	0.94%	0.1%
33	Malvaceae	7.5%	0	4.8%	4.65%	2.85%	10%	4%	6.06%	1.89%	4.64%
34	Meliaceae	2.5%	10%	0	2.32%	0	0	0	3.03%	0	1.98%
35	Menispermaceae	0	0	0	0	0	0	0	0	0.94%	0.1%
36	Mimosaceae	2.5%	0	4.8%	2.32%	2.85%	3.33%	4%	3.03%	2.83%	2.85%
37	Moraceae	2.5%	0	4.8%	2.32%	5.71%	3.33%	0	12.1%	1.89%	3.63%
38	Myrtaceae	0	0	0	2.32%	0	3.33%	4%	6.06%	1.89%	1.96%
39	Musaceae	0	0	0	4.65%	2.85%	3.33%	0	0	0.94%	1.31%
40	Nyctaginaceae	2.5%	0	0	0	0	0	8%	0	0.94%	1.27%
41	Ochnaceae	0	0	0	0	0	0	0	0	0.94%	0.1%
42	Papilionaceae	7.5%	0	4.8%	6.98%	2.85%	3.33%	4%	3.03%	8.49%	4.55%
43	Pedaliaceae	0	0	0	0	0	0	4%	0	0.94%	0.55%
44	Poaceae	7.5%	20%	9.5%	9.3%	5.71%	10%	4%	6.06%	14.2%	9.59%
45	Portulacaceae	0	0	0	0	2.85%	0	0	0	0	0.32%
46	Rhamnaceae	0	0	0	0	2.85%	0	0	0	0	0.32%
47	Rubiaceae	2.5%	0	0	0	0	0	0	0	3.77%	0.69%
48	Rutaceae	2.5%	0	0	2.32%	2.85%	3.33%	4%	0	0.94%	1.77%
49	Sapotaceae	2.5%	0	0	0	0	0	0	0	0.94%	0.38%
50	Sapindaceae	0	0	0	0	0	0	0	0	0.94%	0.1%
51	Smilaceae	2.5%	0	0	0	0	0	0	0	0	0.28%
52	Solanaceae	2.5%	10%	4.8%	2.32%	5.71%	3.33%	4%	3.03%	0.94%	4.07%
53	Sterculiaceae	2.5%	0	0	2.32%	2.85%	0	0	0	0.94%	0.96%
54	Tiliaceae	2.5%	5%	0	0	0	0	4%	0	0.94%	1.38%
55	Verbanaceae	5%	0	0	0	5.71%	3.33%	4%	6.06%	1.89%	2.89%
56	Vitaceae	0	0	0	2.32%	0	0	0	0	0	0.26%
57	Zingiberaceae	0	0	0	0	0	0	0	0	1.89%	0.21%

Table 4. The predominant food crops in all the local governments.

S/N	Local Government Area	Predominant Food Crop
1	Akwanga	*Sorghum bicolor*
2	Awe	*Sorghum bicolor*
3	Keffi	*Sorghum bicolor*
4	Kokona	*Sorghum bicolor*
5	Nasarawa	*Sorghum bicolor*
6	Nasarawa Eggon	*Curcubita* spp. and *Sorghum*
7	Obi	*Sorghum bicolor*
8	Toto	*Sorghum bicolor* and *Sesame indica.*
9	Wamba	*Musa sapientum* and *Zea mays*

were identified out of which the families Asteraceae, Poaceae, Combretaceae, Euphorbiaceae, Moraceae and Papilionaceae were the most highly distributed across the entire 9 local government areas (Table 3). Poaceae family has the highest overall percentage distribution across the entire nine local government areas. The predominant food crops in all the local governments are *Musa sapientum Zea mays, Sorghum bicolor*, *Curcubita* spp. and *Sesame indica* (Table 4). Trees have the highest percentage occurrence and spread across the entire areas sampled in the state. Awe local government area has the lesser diversity of plant species.

DISCUSSION

The lower percentage distribution recorded in some of the identified plant families could be attributed to some of the factors affecting indigenous biodiversity in Nigeria. The destruction of natural habitats as observed by Imeht and Adebobola (2001) continues in Nigeria at a rapid rate in which about 65 of 560 species of trees are now faced with extinction, while many others are at different stages of risk; thereby, leading to the depletion of the country's biodiversity. Awe local government area which recorded the lowest diversity of plant species is suspected to be due to the effects of intensive salt mining activities in the area. However, the outcome of this research agrees with the report of Kutama et al. (2015) that Nigeria is so much blessed with almost uncountable number of plant species.

The massive rate of deforestation is a direct cause of biodiversity loss (Borokini et al., 2010) and Nigeria has been declared to have the highest rate of deforestation of primary forests in the world (FAO, 2005). Also, Eneobong (1997), reported that the rapid reducing rate of Africa's forests and bioresources is linked with civil war, conversion of land for agriculture, wild fires, poor management of available land, uncontrolled search for food, fuel wood, medicine, construction timber, over-grazing by cattle, displacement and loss of landraces, lower yielding varieties, pests and diseases, pollution (e.g. acid rain) and incomplete knowledge of the biology of many plants, especially the propagation genetics aspect and adaptability of many forest plants.

Furthermore, Nasarawa state has been described as an agrarian state with large percentage of the masses engaged in farming of crops such as sorghum, sesame, cassava and agro-allied activities (Abu et al., 2012). Farming and cultivation of food crops have dominated some of the local governments in the state such as Obi, Kokona, Akwanga, Nasarawa and Keffi leading to loss of some plants species.

This is similar to the report of Aliyu et al. (2013) on the impact of deforestation on the socio-economic activities of Akwanga, Nasarawa State that the area has been seriously affected negatively by erosion, bush-burning and fire-wood fetching activities. According to Uyoh et al. (2003), there has to be a balance between the uses of bioresources and their conservation thereby preserving an ecosystem, which although altered would still be rich in bioresources and at the same time would provide food and other needs as well as perform vital environmental functions on a long term basis.

The highest plant diversity distribution observed in Wamba Local Government Area could be attributed to lesser disturbances of the natural ecosystem. In addition, there is a large area of protected land by government in this local government. In line with the mandate of some governmental agencies and NGOs like Nigerian conservation foundation (NCF), the National Resources Council (NARECO) in collaboration with the United Nations Environmental Programme (UNEP) and the World Wide Fund (WWF) engaged in protecting and preserving the country's biodiversity, this research has provided a baseline account of the preponderance diversity status of some of the plants in Nasarawa State. Three plants *Emilia praetermissa, Tecoma stans* and *Phyllanthus amarus* were identified as rare species and deliberate conservation strategies need to be adopted appropriately to avoid total genetic erosion or extinction.

Of these valuable species. In addition, the loss of biodiversity due to deforestation should be minimized when it is necessary to utilize natural vegetation in order

to create industrial development (Akinnibosun and Omatsola, 2011). This preliminary work has provided a baseline data and reference point for future taxonomical and biosystematics stratagem in Nasarawa State. It is thereby recommended that priority must be placed on creating protected areas across all the local government areas that will prevent indiscriminate exploitation of plant resources in Nasarawa State. Also, the use and implementation of the Environmental Impact Assessment (EIA) before embarking on any construction projects in the state must be encouraged.

Conflict of interest

The authors have not declared any conflict of interest

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Determination of informant consensus factor and fidelity level of ethnomedicinal plants used in Misha Woreda, Hadiya Zone, Southern Ethiopia

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In developing countries, traditional medicines occupy a central place among rural communities since they contribute to provide health care to them. However, studies on the identification and documentation of medicinal plant (MP) species used for treatment of various ailments, plants parts used, remedies, preparation and administration of herbal drugs have been scarce, especially to determine the consensus factor among local communities and evaluate the potential for new drugs of herbal origin. This paper aims to determine informant consensus factor and fidelity level of ethnomedicinal plants used in Misha Woreda, Southern Ethiopia. A total of 200 informants were selected randomly for the study. Data were collected through semi-structured interview, focus group discussions, observation and guided field walks with informants. The secondary source data were collected from previous annual reports, documented information and relevant literatures. Data were analyzed by using suitable statistical tools such as correlation coefficient, Mann-Whitney U test, informant consensus factor (ICF*),* Fidelity Level (FL), and various ranking methods. A total of 126MP species belonging to 110 genera and 50 families were recorded. Of the total identified species, 66 were used to treat 34 human ailment, 13 MPs to treat 28 livestock ailments, and 47 MP species were common for both human and livestock treatment. Leaves forming 41% and herbs making 52% of the total identified MPs were dominantly harvested plant parts and plant growth forms, respectively. The dominant mode of remedial preparation was crushing (44%), and most MPs (61%) were administered orally. The highest ICF values were recorded for oral & pharyngeal, and respiratory (0.95 each), depicting the agreement among informants knowledge on MPs used to treat these aliments categories. Medicinal plans species such as *Datura stramonium, Prunus africana,* and *Ruta chalepensis* had the highest fidelity level (100% each) indicating the concordance of knowledge on species of best healing potential. Preference ranking indicated that *Allium sativum* was ranked first and found most effective MP to cure Pneumonia. Therefore, the documented MPs can be used for future pharmacological research, and awareness creation among the traditional healers and community at large becomes vital so as to preserve the indigenous knowledge associated with MP species.

Key words: *Ethnobotany,* Indigenous knowledge, Medicinal plant, Misha*, Informant consensus.*

INTRODUCTION

The usage of natural products with therapeutic properties is as ancient as human civilisation and, for a long time,

products of plant and animal continued as the main sources of traditional medicines (De Pasquale, 1984). People have used plants as sources of traditional medicines in such a way that they interact with their surrounding environment (Abbott, 2014). Such inter-actions have contributed to enrich the ethno-medicinal knowledge of people that often involves traditional diagnosis, collection of raw materials, preparation of remedies and prescription to the patients (Gidey et al., 2011). Ethno medicines playing an important role in human health care practices are sources of tradition and culture of many ethnic groups. The importance of such medicinal practices has driven the increase of demands at international and local levels because these herbal medicines are cheap, more effective, and easily available and supposed to have no side effects (Mequanente, 2009), which is also true in many parts of the African continent. In tropical Africa, more than 4,000 plant species are used for medicinal purposes and 50,000 tons of medicinal plants (here after MPs) are used and consumed annually (Yirga, 2010). In Ethiopia MPs are widely used and they contribute to play an important role in treating and preventing a variety of diseases (Mequanente, 2009). WHO (2011) has highlighted that about 90% of human populations rely on traditional medicines. In addition, more than 800 plant species have been employed as MPs in Ethiopia (Tesema et al., 2002). According to Edwards (2010), more than 480 species of wild trees, shrubs and herbs are known as useful forest-food sources and MPs vital for local food and health security. The greater concentrations of MP species are found in the south and south western parts of Ethiopia. This has to do with the important concentration of biological and cultural diversity encountered in the areas (Edwards, 2001).

Traditional medicines have been practiced by all cultures for ages, and they are often part of a local community's culture and traditions (Megersa et al., 2013). Some of the key reasons for the wide spread of the traditional health care system are among the following: i) traditional healers are found within a short distance in a community, ii) uses fall within the patient's culture and environment, and iii) the costs associated with disease treatment are minimal compared to modern medicine (Abebe, 2001), including among minority nationalities in Ethiopia such as the Hadiya. Despite the previously mentioned advantages, MPs species are subjected to increasing anthropogenic pressures that contribute to threaten the resources base (Maryo et al., 2015). Among the well-known drivers of MPs include land clearance for agricultural filed, fuel wood collection, construction, recurrent drought, and overgrazing (Kelbessa et al., 1992). Although the importance of MPs has been overlooked in the past by the Ethiopian government, however there is a new and increasing emphasis of the government to promote and document indigenous knowledge based on MPs as approach to preserve traditional knowledge before it diminishes (Abebe and Ahadu, 1993). Such promotion and documentation of traditional knowledge would contribute to prepare a database of MPs, conserve and manage MP species in a sustainable way (Abebe and Ahadu, 1993; Maryo et al., 2015). This is particularly true in the case of Misha *woreda* (stands for a district) where MPs play a crucial role in the lives of many ethnic groups and traditional healers. The purpose of this study was to document MP uses and associated indigenous knowledge in Misha *Woreda*, Hadiya Zone, Southern Ethiopia; which is a part of initiative to document baseline data for future phytochemical and pharmacological studies.

MATERIALS AND METHODS

The study was carried out from February 2014 to March 2015 in Misha *woreda*, Hadiya zone, Southern Ethiopia. Misha *woreda* is 204 km distant from the capital city of the Southern Nations, Nationalities and Peoples Regional State, Hawassa. The study area covers a total area of 43976 ha (Figure. 1). Fifty four percent of the study *woreda* lies in the *Dega* agro-climate (highland 2400-3200m a.s.l) whereas 39% the *Woyna Dega* falls within the (mid highland, 1800-2400m a.s.l), and 7% lies in the *Kola* agro-climate (lowland, Semi desert, 500-1800m a.s.l). The *Woreda* comprises undulating topography with the major characteristic vegetation of mild tropical rainforest type (Friis et al., 2011). The highest rainfall named locally as "Hagayye" is encountered during summer (from May to September). The rainfall distribution of the area is unimodal with mean annual temperature and rainfall representing 16.7°C and 172.9 mm respectively (MWAO, 2014). As a result of its agroclimatic situation, the region is highly suitable for both human habitation and agricultural production. Agriculture is one of the dominant economic activities in the woreda. Annual crops are the major components of land use patterns followed by perennial crops such as enset and coffee. Seasonal crop accounts for 71.12% (31276 ha) of the area, followed by perennial land crop 13.16% (5786 ha) and other crop types 15.72 % (6913 ha). Among the dominant soil types in the *Woreda* include: clay loam, red clay loam and black grey loam (MWAO, 2014).

Selection of Study Sites and Informants

Misha *Woreda* has long been occupied by people who have a long tradition of using MPs to treat human and livestock ailments. Permanently increasing population growth combined with overexploitation of MPs, and agricultural land expansion threatened MPs in the area. Thus, in order to document the ethnomedicinal knowledge of the people reconnaissance survey was carried out before the sampling exercise in the *kebeles* (*Kebele* is the lowest administrative part in Ethiopia), of the *Woreda*. An ethnobotanical study was carried out in Misha *Woreda* on 10 rural *kebeles* that

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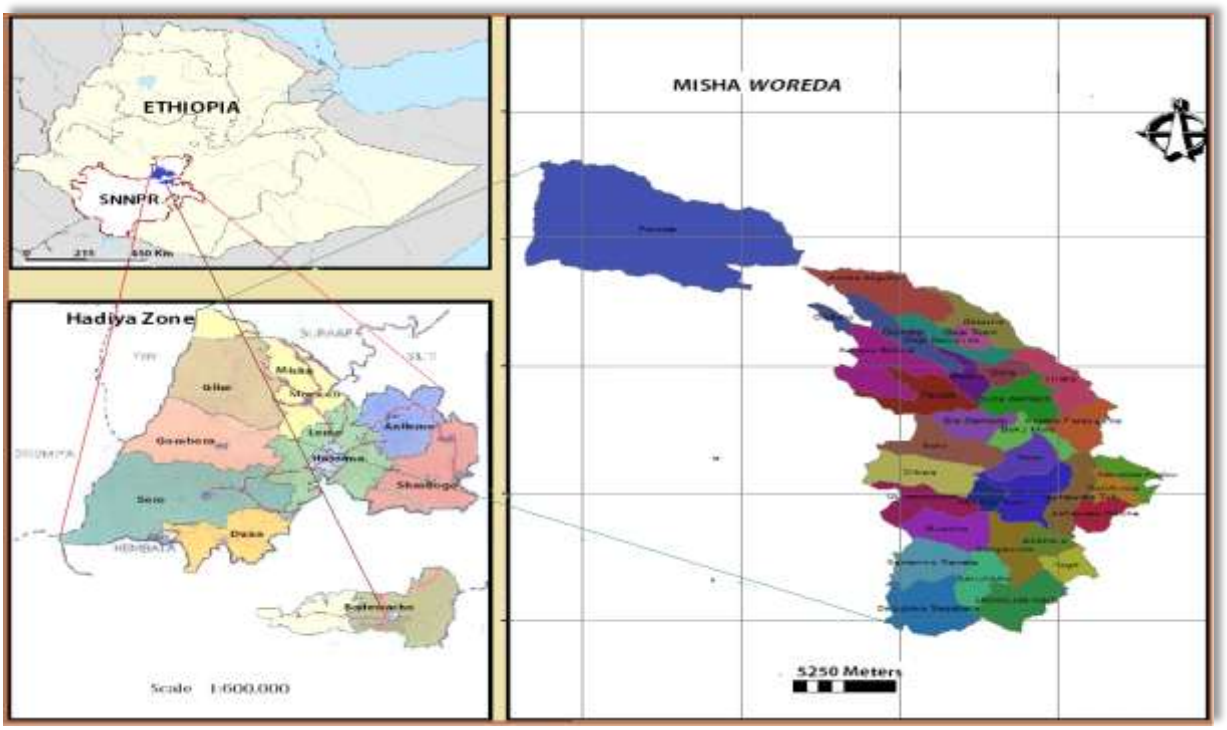

Figure 1. Administrative map of the study area

were randomly selected. Similarly, sampled villages in each kebele were randomly selected following Martin (1995) and Cotton (1996) approaches. As a result, a total of 200 individual informants (118 males and 82 females) whose age ranging from 22 to 70 were selected from 10 rural *kebeles* (20 from each). Out of the total number of individual informants 95 were males and 70 female, making a total of 165 people. The selection of the general informants was also random (23 males and 12 females) constituting 35 people. On the contrary, ten key informants were selected purposively from the entire list of informants based on their MP knowledge and long experience in the area, and the selection was facilitated by the local elders and local authorities (*kebele* administrators and development agents, DAs).

Ethnobotanical data collection

To answer and validate the research questions, ethno botanical data were collected from both primary and secondary sources. Primary data source were collected from the field study conducted in the sample kebeles and the secondary data source were collected through annual reports and relevant literatures. Participatory Rapid Appraisal (PRA) methods were used to collect the primary data sources. A designed questionnaires and key informants interview were elaborated and directed to the traditional healers and the knowledgeable elders, followed by field observation, semi-structured interviews, group discussions, preference ranking and market survey using the local language “Hadiyisa”. Information about medicinally useful plants used and grown in their natural habitats including parts used, methods of preparation, dosage, marketability, the role of multipurpose MP species and the associated threats to plant genetic resources and their conservation status were collected following the methods described by Martin (1995) and Cotton (1996). Group discussions with key informants were made in 5 kebeles to complement the data already gathered and cross-check them along with and the informant consensus methods. In addition, focus group discussions were held to gather data on the status of MPs and traditional medicinal knowledge of the community and its transferability from generation to generation (Martin, 1995). This method assumes that there are variations in informants’ opinions, experiences and knowledge related to MPs. Field observations were used to assess the healers and households’ knowledge. All the plants collected were tagged and the details of the plants were recorded while information provided by the local healers on MPs was kept secret.

A visit to the local markets provides an idea of the market availability of the MPs **(**Worede, 2002). Market surveys were made to record the diversity, quantity of MPs and the parts sold in the local markets as well as market value records. In total, three local markets, namely Wasgebeta, Morsuto and Geja were visited twice in the study area. Semi-structured interviews were conducted with herbal drug sellers to assess the varieties and amounts of plant materials sold in the market, and to see the income generation from local market. Finally, the voucher specimens of MPs were reported twice or more during key informant visits were collected, pressed and taken to the National Herbarium of Addis Ababa University for further identification, and preserved as Dilla University data base.

Data Analysis

Data were entered into the MS Excel spreadsheet for statistical analysis. Both descriptive and inferential statistics were applied. Proportions, preference ranking, direct matrix ranking, informant consensus factor (ICF), and species consensus (Fidelity level) were employed, and the results were presented using tables, graphs and percentages following Martin (1995). The ICF was calculated to see the agreement of informants for a plant species in treating a

Table 1. The diversity of MP species and their families in the study area

S.No	Family name	No.of species	Percent (%)	S.No	Family name	No.of species	Percent (%)
1	Acanthaceae	1	0.79	26	Loganiaceae	1	0.79
2	Aloaceae	1	0.79	27	Malvaceae	2	1.58
3	Alliaceae	2	1.58	28	Moraceae	1	0.79
4	Amaranthaceae	1	0.79	29	Musaceae	1	0.79
5	Anacardiaceae	2	1.58	30	Myricaceae	1	0.79
6	Apiaceae	1	0.79	31	Myrsinaceae	2	1.58
7	Arecaceae	1	0.79	32	Myrtaceae	3	2.38
8	Asclepiadaceae	2	1.58	33	Oleaceae	1	0.79
9	Asphodalaceae	1	0.79	34	Phytolaccaceae	1	0.79
10	Asteraceae	9	7.14	35	Pittosporaceae	1	0.79
11	Boraginaceae	2	1.58	36	Poaceae	6	4.76
12	Brassicaceae	3	2.38	37	Podocarpaceae	1	0.79
13	Caricaceae	1	0.79	38	Polygonaceae	2	1.58
14	Caryophyllaceae	1	0.79	39	Ranunculaceae	2	1.58
15	Celastraceae	3	2.38	40	Rhamnaceae	1	0.79
16	Convolvulaceae	1	0.79	41	Rosaceae	4	3.17
17	Crassulaceae	1	0.79	42	Rubiaceae	3	2.38
18	Cucurbitaceae	4	3.17	43	Rutaceae	4	3.17
19	Cuppressaceae	1	0.79	44	Santalaceae	1	0.79
20	Ebenaceae	1	0.79	45	Sapindaceae	2	1.58
21	Euphorbiaceae	4	3.17	46	Salicaceae	1	0.79
22	Fabaceae	10	7.94	47	Simaroubaceae	1	0.79
23	Flacourtiaceae	1	0.79	48	Solanaceae	10	7.94
24	Lamiaceae	13	10.32	49	Verbenaceae	2	1.58
25	Linaceae	1	0.79	50	Zingiberaceae	2	1.58
						126	100

particular disease using a formula, **ICF = (nuc –ns)/(nuc – 1)**, where **nuc** = number of use citations, **ns** = number of species used for each use citation following Heinrich et al (1998). Fidelity Level (FL) values were also used to estimate the relative healing potential of each MPs based on the proportion of informants who agreed on its use against a given ailment category (Friedman et al ., 1986). This method has contributed to recommend that a particular MP species could be suggested effective and that it can be further analyzed for its bioactivity and therapeutic properties. FL was calculated using FL (%) = **SF/TF** (100), where SF = frequency of citation of a given specie for a specific ailment and TF = total number of citations of that species. Finally, traditional knowledge dynamics on the use of MPs against the socio-economic profile of the respondents including gender, informants types, and educational status were statistically tested by Mann-Whitney U test using IBM SPSS version 20. Direct matrix ranking exercises were also used to relate the multiple uses of a given plant species following the methods recommended by Cotton (1996) and Martin (1995). The multipurpose uses of the seven MPs species were selected out of the total MPs. The uses of these plants were enumerated by ten key informants. These key informants were asked to assign use values to each of the seven MPs species as followed: (5 = best, 4 = very good, 3 = good, 2 = less used, 1 = least used and 0 = not used). The average values (scores) of each species were summed up and ranked. Finally, preference ranking from informants responses on issues related to disease treatment was analyzed following Martin (1995). According to their preferences ranking they ranked individually those selected MPs in treating the mentioned aliments on the basis of the method described by Cotton (1996). A direct matrix ranking exercise on perceived threats to seven MPs species was conducted for multipurpose species were conducted with ten key informants following previous scholars (Martin, 1995; Cotton, 1996). The selection of multipurpose species was carried out and their uses were also listed while the key informants were asked to assign use values to each species. The average scores of each species were summed up and ranked. Finally, the ten key informants were also involved in priority ranking exercise that was focusing on perceived threatening factors of the MPs species (Martin, 1995; Cotton, 1996).

RESULTS

The diversity of medicinal plants

The diversity of the MPs species encountered in the area is shown in Table 1. In total, 126 MPs species belonging to 110 genera and 50 families were identified in the study area. Among the identified families of MPs, Lamiaceae contributed to the maximum number of species (13 species= 10%) followed by Asteraceae, Fabaceae and Solanaceae (10 species each).

Indigenous knowledge of the community

Of 126 medicinally important plants identified in the study

Table 2. Statistical test of significance, Mann-Whitney U, on average number of reported MPs among different informant groups in Misha *Woreda*, 2015.

Parameter	Informant group	N	%	Average ± SD	Z- value	p-value
Gender	Male	118	59	10 ± 5.72	-1.2	0.23
	Female	82	41	8.7 ± 4.35		
Age	Young (≤ 40years	120	60	7.98 ± 4.23	-4.8	0.000**
	Senior (≥ 40 years)	80	40	11.69 ± 5.81		
Educational status	Illiterate	60	30	13.13 ± 6.02	-5.8	0.000**
	Literate	140	70	7.89 ± 3.93		
Informant	Key informant	35	18	1.58 ± 6.99	-0.22	0.82
	General informant	165	83	9.22 ± 4.75		
Total			100			

Note: **Significant difference ($p < 0.05$)

Table 3. Proportion of plants for human and livestock remedial preparation

Target organism	No of Species	% total	Growth forms (%)				Part used (%)				
			Tree	Herb	Shrub	Others	Leaf	Root	stem	Seed	Others
Human only	66	52	8	27	12	5	23	9	3	8	9
Livestock only	13	10	3.9	0.7	3.9	1.5	3.9	2.2	1.5	1.5	0.9
Human & livestock	47	38	9.5	15	10.5	3	13	5	5	3	12
Total	**126**	**100**	**21.4**	**42.7**	**26.4**	**9.5**	**39.9**	**16.2**	**9.5**	**12.5**	**21.9**

area, 39 species (31%) were mentioned by male informants, 36 species (29%) by female informant and 51(40%) by both sexes. In the current study, more number of MPs were reported by male informants than female informants but the difference was not significant ($P > 0.05$) (Table 2). However, there was a significant difference ($P < 0.05$) in the number of MPs reported by senior members of the community (41–70 years old) and young to middle aged members (22–40 years old). The result also showed significant difference when the educational status (illiterate and literate) of informants compared with the MP Knowledge. The difference was not significant in the case of key and general informants. However, more information on MPs was given by senior informants (above 40 years age) and key informants than young and general informants. There was a significant difference ($P < 0.05$) in the number of MPs reported by elderly members of the informants (41–80 years old) and young aged ones (20–40 years old) where more information on MPs was given by senior informants (> 40 years age) than young ones. The age and MP knowledge were directly correlated as the age of informants increases, traditional ethno medicinal knowledge also increase (Table 2).

There was statistically significance difference between the number of MPs reported and the educational level of informants where illiterate informants reported large number of MPs than literate informants (Table 2). The Spearman correlation analysis also showed that education correlates negatively and significantly with the knowledge of MP species ($r= -0.27$, $P<0.05$).

Growth forms and medicinal plant parts used

Medicinal plants used to treat human ailments were more in number than those used to treat livestock ailments, which could be associated with the prevalence and abundance of human disease. The most common growth forms used to treat human and livestock ailments were herbs (43% = 54 MP species), followed by shrubs (26%). However, leaves were the most common plant parts (40% = 50 MP species) used by Hadiya community to treat ailments (Table 3).

Modes of remedy's preparation

The analysis from the informants response showed that remedies were mainly prepared from freshly harvested plant parts (71%) to treat human ailments, followed by dried plants parts (25%), and the combination of fresh

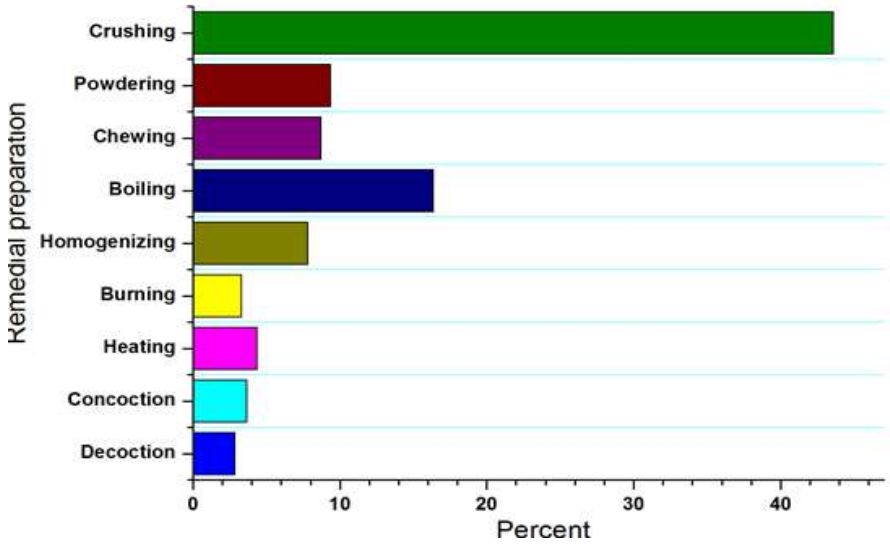

Figure 2. The various modes of remedy preparation to treat human ailment in the study area

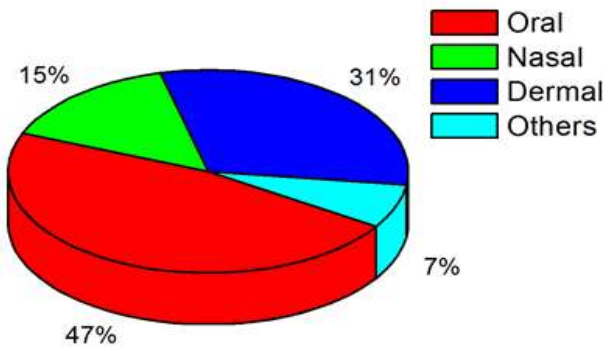

Figure 3. The common routes of administration of traditional medicinal remedies

and dried plant parts (4%). Figure 2 depicts the various modes of remedy preparations in the study area. The most common mode of remedy preparation was crushing 44%, followed by boiling (17%), powdering (10%), chewing (9%) and others (20%).

Routes of Administration

The current study indicated that the oral administration (47%) to treat human ailment was the major route (includes drinking, chewing, and eating) followed by dermal (pasting, creaming, and washing) (31%), and nasal (smoke inhaling, and sniffing) (15%) routes (Figure 3). This emphasizes on the diversity of approaches used by traditional healers to prepare traditional remedies from MPs. Table 4 shows the proportion of various local units of measurements used by traditional healers to quantify/ measure liquid herbal preparations, which include cup (see Figure. 4), mug, and bottle. About 44% of the healers quantify herbal medicines in liquid form. Most informants indicated that the doses for liquid preparations are prescribed through estimation such as full, half or ¼ of a coffee cup, mug, bottle or other measures depending on the situation being treated. Similarly, traditional healers use various cultural units of measurement like finger length, pinch, and numbers (for leaves, flowers, seeds and fruits).

Marketability of medicinal plants in the study area

The market survey revealed that twenty one percent (n= 27 species) of the identified MPs were marketable (Figure 4 and Table 5). The availability and quality of traditional medicines in the markets was uncommon. Only 7% of the total identified MPs were sold for medicinal purpose. However, ninety three percent of the MP species was sold for food e.g., *Allium sativa, Nigella sativum, Lepidium sativum, Aframomum corrorima, Allium cepa, Brassica carinata, Carica papaya, Coffea arabica, Cucurbita pepo, Ensete ventricosum, Guizotia abyssinica, Hordeum vulgare, Linum usitatissimum, Pisum sativum* and *Zingiber officinale.* These are occasionally applied as medicine when the need arises.

The seeds were measured using a cup or mug in local markets and the average price was 7.5 Ethiopian Birr per cup or mug, whereas for leaves and pieces of stems such as *Echinops kebericho* were sold by estimation or counting pieces and the powder form such as *Nicotiana tabacum* was sold by pinching, the root materials were

Table 4. The proportion of various local units of measurements used by traditional healers in the study area.

Local unit of measurement	Frequency	Percent
Number/Handful (Leaf, Seed)	5	4
Finger length (Root)	8	6
Pinch/Teaspoon (powder)	13	10
Cup/Mug/Bottle/Can/Jog (Liquid form from varied plant parts)	56	44
Drop	3	2
Undetermined	41	33
Total	**126**	**100%**

Figure 4. Some marketable MPs and their measurements (Photo: at Geja local market)

sold using bunch or using hypothetical measurements.

Efficacy of medicinal plants

The reported MP species were found to treat different human and livestock ailments. As shown in Table 3 the highest proportion (40%) of MP parts were leaves, harvested to treat 55% of the total ailments. Table 6 highlights informant consensus factors (ICF) values for 15 ailment categories that were recorded in Misha *Woreda.* In the current study more than eleven different disease categories were reported by the respondents in the study *Woreda*. Respiratory, oral and pharyngeal had the highest ICF values (0.95 each), followed by gastro-intestinal and parasitic and external injuries each accounting for 0.94. In this study most values for ICF were greater than 0.7 which may indicate that ailments were common in the community.

Fidelity level

The percentage of informants claiming the use of a certain plant for the same major ailment was calculated for the most frequently reported ailments to evaluate species consensus. Table 7 showed the Fidelity level (FL) values for some MPs that were claimed to be used by informants against the corresponding ailment. The highest FL of 100% was recorded for MP species such as *Cucumis ficifolius, Datura stramonium, Guizotia abyssinica, Hagenia abyssinica, Prunus africana, Rumex nepalensis,* and *Ruta chalepensis,* followed by *Calpurnia aurea* (88.9%), and *Millettia ferruginea* (85.7%). The highest FLvalue (100%) was obtained under the internal therapeutic category (dry coughing, mental illness,

Table 5. Medicinal plants those were observed in the markets of the study area

S.No	Scientific name	Local name	Functional group	Parts of MP sold
1	*Aframomum kororima* (Braua.)Jansen	Wokkaashsha	Spice	Seed
2	*Allium cepa* L.	Kashar sunkurutta	Spice	Bulb
3	*Allium sativum L.*	Tuma	Spice	Bulb
4	*Brassica carinata L.*	Shaana	Spice	Leaf
5	*Brassica niger (*L.) Koch	Sanaaficca	Spice	Seed
6	*Carica papaya L.*	Papaayya	Fruit	Fruit
7	*Citrus lemon (L.)* Burm. F.	Loome'e	Fruit	Fruit
8	*Coffea Arabica L.*	Buna/Qaawwa	Stimulant	Seed
9	*Cucurbita pepo L.*	Dabaaqula	Fruit	Fruit
10	*Ensete ventricosum* (Welw.) Cheesman	Weesa	Root & Tuber	Corm
11	*Guizotia abyssinica L.*	Shuqoota	Spice	Seed
12	*Hordium vulgare L.*	Heemach So'o	Cereal	Seed
13	*Lepidium sativum L.*	Shuumfa/Feexo'o	Medicinal	Seed
14	*Linum usitatissimum L.*	Talba	Oil	Seed
15	*Lippia adoensis Hochst.*	Kosarata	Spice	Seed
16	*Nicotiana tabacum L.*	Tambaa'a	Stimulant	Leaf
17	*Nigella sativum L.*	Heemachchenja	Spice	Seed
18	*Ocimum basilicum L.*	Gimmenja	Spice	Leaf
19	*Ocimum tenuiflorum L.*	Qadaalenja	Spice	Leaf
20	*Piper longum L.*	Qaare'e	Spice	Pod
21	*Piper nigrum L.*	Mixmixo'o	Spice	Pod
22	*Pisum sativum L.*	Gite'e	Pulse	Seed
23	*Rhamnus prinoides* L'Herit	Geesho'o	beverage	branch
24	*Ruta chalepensis L.*	Qantalaama	Spice	Leaf
25	*Zingiber officinale Rosk.*	Jaanjubeela	Spice	Rhizome
26	*Cymbopogon citrates* (DC.) Stapf	Xejsaara	Spice	Whole plant
27	*Echinops kebericho* Mesfin	Qebericho	Medicinal	stem

threatened MP species are among the forest resources diarrhea, taeniasis) while the lowest FL value (6%) were found for external disease categories (skin cuts and wounds, and black leg).

Ailment treatments

From the focus group discussion a total of 62 disease types (34 for human and 28 for livestock) were recorded during our survey period. Bronchitis, typhoid, intestinal disorders (diarrhea and taeniasis), fibril illness, and tonsillitis were among the most commonly reported health problems, especially under the human disease's category. On the contrary, hypocalcaemia, bloat and hypotrotonemia and bacterial diseases (such as anthrax) were the most commonly reported health problems, under livestock disease category. Informants responses indicated that the treatment process of the patient, visual inspection (skin color, eye color, tonsillitis or throat, tongue, status of sores, bleeding, infections and sensing body temperature) and questioning for symptoms identification were the common method that were used by traditional healers to diagnosis the patient prior to the application of any herbal medicine prescription in the community. Patients with skin infections were reported to be treated by rubbing and pasting herbal preparations whereas those with sore problems were treated by chewing the part of the MP and spitting the juice on the sore area. On the contrary, for internal ailments in most cases, herbal preparations were prescribed to be administered orally and for a general malaise steam bath and vapor inhalation were commonly prescribed.

Direct Matrix Ranking

In this study, the output of the direct matrix ranking (DMR) exercise on seven multipurpose MPs was aimed not only to identify the type of multipurpose plants species under pressure in the area but also to identify the corresponding factor threatening the resources base. The most threatened MP species ranked first was *Cordia africana*, followed by *Eucalyptus globulus, Podocarpus*

Table 6. Informant consensus factors (ICF) values for 15 ailment categories in Misha *Woreda*

S. No	Sickness category	Number of Species (ns)	Number of use reports (Nuc)	ICF
1	Gastro-intestinal and parasitic	24	376	0.94
2	Oral and pharyngeal	11	240	0.95
3	Respiratory	14	291	0.95
4	Dermatological	11	102	0.90
5	Urogenital and venereal	8	81	0.91
6	Fibril illness (*Mitch*)	13	162	0.92
7	External injuries	12	216	0.94
8	Liver infection	3	27	0.92
9	Evil spirit	9	114	0.92
10	Bites and bleeding	4	18	0.82
11	Constipation and appetite loss	7	53	0.88
12	Others	10	213	0.95

Table 7. Fidelity level (FL) values for some MPs claimed to use by informants against corresponding ailment

Name of MP used	Ailment	TF	SF	FL
Acanthospermum hispidum DC.	Skin cuts and wounds	15	6	40
Ajuga remota L.	Abdominal pain	46	27	58.7
Allium sativum L.	Evil eye illness	28	19	67.9
Brucea antidysenterica J. F. Mill	Stomachach	59	38	64.4
Calpurnia aurea (Ait.) Benth	Skin bits	18	16	88.9
Cucumis ficifolius A.	Dry coughing	14	14	100
Datura stramonium L.	Mental illness	7	7	100
Euclea divinorum Hiern.	Tonsilitis	23	16	69.7
Guizotia abyssinica (L,f.) Cass	Diarrhea	10	10	100
Hagenia abyssinica (Bruce). F. Gmel.	Taeniasis	28	28	100
Lagenaria abyssinica (Hook.f.) C.Jeffrey.	Body swelling	14	10	71.4
Millettia ferruginea (Hochst.) Bak.	Nose bleeding	21	18	85.7
Myrica salicifolia A. Rich	Ascariasis	31	26	83.8
Ocimum lamiifolium Hochst. ex Benth.	Fibril illness *(Mitch)*	45	37	82.2
Prunus africanus (Hook. f.)Kalms	Anthrax *(Abasanga)*	7	7	100
Rumex nepalensis Spreng.	Black leg *(Abagorba)*	6	6	100
Ruta chalepensis L.	Abdominal pain & evil eye illness	87	87	100
Solanum incanum L.	Skin bites (Snake, Ticks)	15	12	80
Teclea nobilis Del.	Anthrax	11	8	72.7
Thymus schimperi Ronniger	Hypertension	79	56	70.9
Vernonia amygdalina Del	Intestinal worms & exoparasites	66	49	74.2

N.B: **FL**= Fidelity Level, SF= is the number of informants who independently cited the importance of a species for treating a particular disease, and TF= total number of citations.

falcatus and *Millettia ferruginea* (Table 8). The most that were also used as construction material and firewood. From the socioeconomic study respondents indicated that MP species of the study area were used by the community for different purposes including medicinal use only 34(27%), fire wood 23(19%), food and spices 21(17%), and others such as adding soil fertility and farm tool making 12(9%) (Figure 5).

Preference Ranking

The informants' simple preference ranking for ten MPs that was used to treat pneumonia is shown in Table 9.

Table 8. Average DMR score results of ten informants for seven multipurpose MPs species. (5 = best, 4 = very good, 3 = good, 2 = less used, 1 = least used and 0 = no value)

Species name	Use categories								Total	Rank
	Md	Fw	Co	AT	Fu	Fo	LF	Ch		
Prunus africanus	5	4	3	3	2	0	1	3	21	5
Cordia africana	4	4	5	5	5	2	2	2	29	1
Juniperus procera	4	3	5	4	4	0	0	0	20	6
Millettia ferruginea	5	4	3	3	3	1	3	3	25	4
Eucalyptus globulus	5	5	5	4	3	0	5	0	27	2
Podocarpus falcatus	5	5	5	3	4	0	3	1	26	3
Hagenia abyssinica	5	3	4	0	3	0	2	1	18	7
Total	33	28	30	22	24	3	16	10	166	

Description: Md= Medicine, Fw=Firewood, Co=Construction, AT=Agricultural tools, Fu=Furniture, Fo=Forage, LF=Live fence, Ch=Charcoal

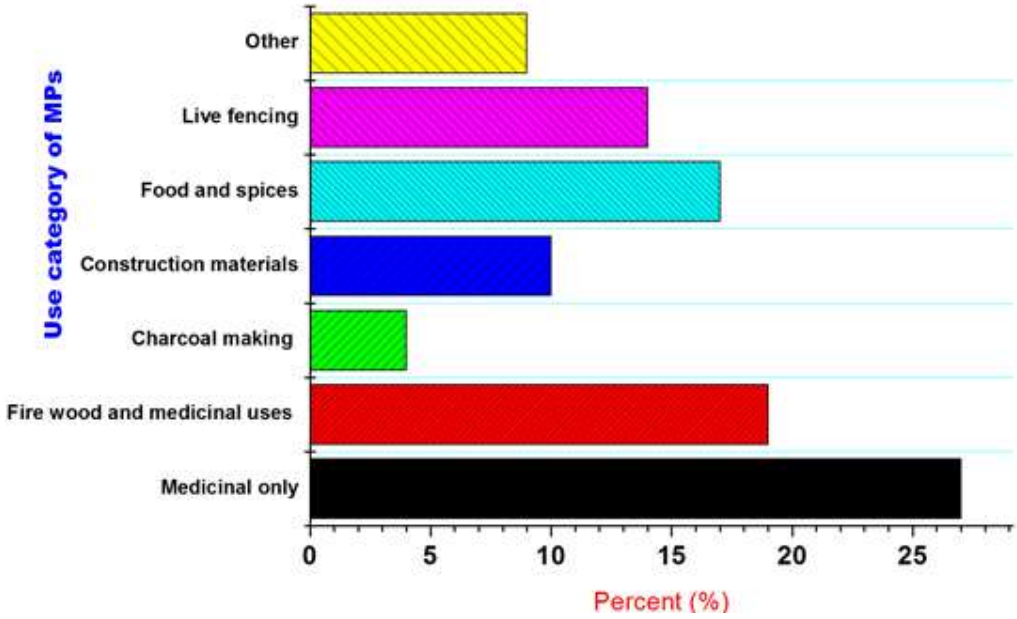

Figure 5. Use categories of MPs of the study area

Table 9. Results of a simple preference ranking for ten MPs against Pneumonia. (5 = the most preferred but 1 is the least preferred)

MPs Species reported	Key Informants (A to L)												Total score	Rank
	A	B	C	D	E	F	G	H	I	J	K	L		
Cucumis ficifolia	5	5	4	4	5	5	5	4	5	4	4	5	55	2
Allium sativum	5	5	4	5	5	5	5	4	5	5	4	5	57	1
Nigella sativum	4	3	5	5	5	3	2	5	3	5	3	5	48	6
Leucas acquistylosa	4	3	5	5	5	3	2	5	2	5	3	5	47	7
Lepidium sativum	5	3	4	4	3	5	4	4	4	4	5	5	50	5
Clausena anistata	5	3	4	4	3	5	4	5	4	4	5	5	51	4
Ocimum lamiifolium	5	5	4	3	5	5	5	4	5	4	3	5	53	3
Arthemisia afra	4	4	3	2	2	3	3	5	4	5	2	3	40	9
Eucalyptus globulus	4	4	3	4	2	3	3	5	4	5	4	3	44	8
Cymbopogon citirates	3	2	2	3	5	2	3	2	4	2	2	3	33	10

The preference exercise indicated that *Allium sativum*, *Cucumis ficifolius* and *Ocimum lamiifolium* were the most preferred MP species to treat pneumonia in the study area.

DISCUSSION

A total of 126 MP species were identified to manage diverse human and livestock ailments in the study area. Such MP species diversity may depict the contribution of MPs as well as the traditional health knowledge held by the Hadiya ethnic group in assisting the primary health care needs of the *Woreda*. Similar indigenous ethno-medicinal knowledge were reported by various workers from different regions of Ethiopia, including the 120 MP species from Konta special *Woreda* (Tesfaye et al., 2009), 126 MP species from Wayu Tuka district (Megersa et al*.,* 2013), and 145 MPs species from Kambata Tambaro Zone (Maryo et al., 2013). The local people in the study area traditionally use various MPs to treat the variety of ailments. Among the documented MPs, sixty six species were used to treat 34 diverse human ailments, 13 MP species to treat 28 livestock ailments, and 47 MP species were used to treat both 41 human and livestock ailments. Of the total MP species identified, herbs (43% = 54 MPs) were the most dominant growth forms, followed by Shrubs 32 MPs (27%). trees 21%, and others mainly climbers (9%). This finding agree with the works of Gidey (2001), Endalew (2007), Tesfaye et al. (2009), Megarsa et al. (2013), and Maryo et al. (2015) who have reported herbs to be the most harvested growth forms. However, the findings of Yineger et al .2008) indicated that woody plants species (shrubs) were the most harvested growth form of the MPs used by local people.

The study revealed that leaves were the most widely used plant part for the human remedial preparations that accounted 41%, followed by root 26%. This result is in agreement with the previous works (Gidey, 2001; Gidey, 2010; Gidey et al., 2011; Maryo et al*.*, 2015). On the other hand, there are other works which had indicated that roots are the most commonly used MP parts to treat ailments (Alemayehu, 2010; Ermias Luleka et al., 2013). The observations of most informants and researchers showed that the main cause for the incidence of common ailments is associated with poor sanitation practice. The actual observations of the researchers to the life style of the local people of the study area do support this fact. The reason could be due to low income and weak economic status. Most of these plants were collected from wild habitats (72%) indicating the existence of pressure on wild plants. The findings of many Ethiopian researchers (Gidey, 2010; Maryo et al*.,* 2015) indicated that the majority of MPs were obtained from wild vegetation source. Various Methods of remedy preparations from traditional MPs were used in the study area. The most popular mode of preparation was crushing which accounted 44% (Figure. 2). Similar results were also reported by different earlier researchers (Gidey, 2001; Tesfaye et al., 2009; Habtamu et al., 2014; Maryo et al., 2015).

The current study result confirmed that family Lamiaceae has contributed the highest number of plant species for medicinal purposes, which is in agreement with studies conducted elsewhere in Ethiopia (Abraha et al., 2013; Alemayehu, 2010). Most of the MP species investigated in this study were also medicinally useful in other parts of Ethiopia and elsewhere in Africa (Kebu, 2004; Bayafers, 2000). The study confirmed that the main route of administration was oral, which accounted 47%, of which drinking (remedial preparations in liquid form) was the dominant as claimed by the informants. This is in agreement with many previous studies (Gidey, 1999; Kalayu et al., 2013, and Megersa et al., 2013). These routes of remedial administrations were represented by drinking and/or swallowing, washing and/or creaming, smoke inhaling and drop application into eyes. The finding of the current study revealed that 71% the MP preparations were in fresh form, 25% dried and 4% was the combination of fresh and dried forms. Most informants explained that remedies prepared from fresh plant materials are effective in treatment as the contents are not lost before use as compared to the dried forms. Similarly, other studies reported that freshly harvested plant parts to be dominant in the remedial preparations (Ermias et al., 2013; Gidey, 2010; Megersa et al*.,* 2013; Maryo et al*.,* 2015). The similarity may indicate the dependency of local people on freshly available plant materials. This can strongly affect the diversity and existence of medicinally valuable plants if fresh plant materials are harvested and used directly without the replacement as described by Maryo et al. (2015). Traditional people are collecting and using MPs with less attention when seen from the conservation viewpoint of plant resources. This may call for the domestication of wild MP species around the homegarden as reported by Maryo et al. (2015). According to the informant response, leaves were being the most harvested plant part of remedial preparation in the area but the destruction of mother MP found to be minimal as compared to rampant destruction to the mother plant, which could happen when the root is harvested. Medicinal plant harvest that involves roots, stems, barks, bulbs and rhizomes have destructive effect on the survival of mother plant (Cotton, 1996). On the other hand, many other researchers (Etana, 2007; Ermias et al*.,* 2008; Ermias et al., 2013) reported that roots to be the most popular plant part used for remedial preparation followed by leaf. There were cases where one species may be used to treat a single disease or a number of diseases. Likewise, one ailment can be used in combination with using several plant species or with a single plant part. For example, abdominal pains are treated with 5 different MP species.

Similar results were reported by Maryo et al. (2015). Remedial preparations of MPs in the current study area did not have standardized doses. In the most cases practitioners determined dosages depending on the age, sex and the strength of the patients treated. Some of the MP remedial preparations were measured in a small cup, a mug, spoonful, a pinch and others. Herbal preparations could have side effects, which may result in diarrhea and vomiting unless special care is taken. To avoid this, practitioners use antidotes like milk, honey, milk whey, yogurt, butter, coffee, *atakana* (soft food made from *Ensete ventricosum* product called *kocho*) and homogenized powder of bean, pea or barley. Comparable results were described by Maryo et al. (2015). However, the dosage of some herbal preparations that is considered harmless depends on the interest and/or the capacity of the patient to chew a particular plant for a given health problem (*e.g*. chewing the leaves of *Ruta chalepensis* to get relief from abdominal pain).

With regards to dosage unless special care is not given, some herbal preparations have side effects and resulted in diarrhea and vomiting (Ermias et al*.,* 2008). When such conditions happen, antidotes like milk, honey, milk whey, yogurt, butter, coffee, *atakana* (soft food made from *Ensete ventricosum* product) and homogenized powder of bean, pea or barley were used by most practitioners in Misha *Woreda* to reverse the condition. The current study showed that the knowledge of MP is directly related to the age of the informants where elderly people conveyed large number of MP than young people. Many former investigations confirmed that the age of respondents being positively correlated with the number of MPs reported (Mohammed and Berhanu, 2011; Kalayu et al*.,* 2013; Ermias Lulekal et al., 2013; Habtamu et al., 2014; Maryo et al., 2015). On the contrary, some investigations revealed that age and MP knowledge have inverse correlation (Mohammed and Seyoum, 2013). The indigenous knowledge on the use of traditional MPs found that there is a top secrecy in passing within the family or close relatives otherwise kept hidden from others (Gidey, 2010; Ermias et al*.,* 2013). Most of the knowledge on herbal remedies (42%) was handled by the elderly members of the community in Misha *Woreda*. Informants in the study area claimed that traditional healers transfer the indigenous knowledge on MPs to their selected family member or close relative by the words of mouth. Such knowledge transfer is poor, which may cause the attrition of local ethno-medicinal knowledge. Similar works were reported from Kambata Tembaro Zone (Maryo et al., 2015). However, the ethno-medicinal works like the current studies are advisable to document the local knowledge. Fourty percent of the MPs recorded in this study are also medicinally useful in other parts of Ethiopia (Kefyalew, 2010; Tamene, 2011; Maryo et al., 2015). Some of those MPs reported by the informants in the study area include *Ajuga remota, Artemisisa absinthium, Brucea* antidysenterica*, Solanum incanum, Croton macrostachyus, Buddleja polystachya, Citrus lemon, Erythrina brucei, Pittosporum abyssinimum, Cucumis ficifolius, Rumex nepalensis, Datura stramonium, Hagenia abyssinica, Ocimum lamiifolium, Phytolacca dodecandra, Ruta chalepensis, Leucas acqistylosa, Clausena anisata,* and *Carica papaya* are few among others. Such similarity in the use of MP species in different localities of the country have been tested by different cultures can be taken as an indication of their pharmacological effectiveness.

The introduction of modern medicine has lead to decrease in use of herbal medicines in the study area. Nowadays, young people in the study area preferred modern medicines to traditional remedies. This being a cause currently people don't give special attention to the traditional MPs. The current finding agrees with the previous reports by Maryo et al. (2015). The people in Misha *Woreda* owns indigenous ethno botanical knowledge with the diverse use of MPs. Most of the MPs of the study area play vital roles in fire wood, construction and furniture making. Some of these use categories are destructive whereas others are not. The multiple role of some plants other than medicinal significance was report as one of the threats for plant biodiversity conservation (Maryo et al., 2015).The current study indicated that there is a statistical significance in the MP knowledge between two age groups (young and elder). Similarly, there was a statistical significant difference was observed in the MP species knowledge between educated and illiterate people. This study is consistent with Ermias et al*.,* (2013) where the education correlates negatively and significantly with the knowledge of MP species ($r = -0.27$, $P<0.05$), showing that education has influenced MP knowledge, which in turn can affect MP knowledge and distribution. However, a study done by Yinger et al. (2008) in Bale, Ethiopia showed that education correlates with the knowledge of MP. The result of our finding calls for the awareness rise among the young and educated generation the fact that still most in rural areas of Ethiopia, including the poor largely depends on traditional MP, which should be conserved properly, including its knowledge.

CONCLUSION

The current study on traditional MPs in Misha *Woreda*, Hadiya Zone, Southern Ethiopia has disclosed that a diversity and various uses of MPs to treat a wide range of diseases in the community. The wide use of MPs based on the high values of ICF and FL could validate the effectiveness and efficacy of the ethno botanical practices of Hadiya communities. MPs are largely distributed in the wild habitat, and the dominant growth forms of MPs are herbs where leaves are preeminent MP parts used for remedial preparation, which could have less impact on the conservation of MPs. Medicinal plant remedies are

mostly administered orally showing the prevalence of internal ailments in the study area. There is a gap in MP knowledge transfer where ethno-medicinal knowledge is hardly being transferred to young people. The knowledge tends to decline as community members get educated for they largely depend on modern medicine. Thus, there is a need to raise awareness on the significance of ethno-medicinal plants for the primary health care. Similarly, farmers need to be assisted in domesticating some of the commonly useful MPs of wild origin, which assists to the conservation of MPs. Lastly, Plants with high ICF and FL values can be subjected to bioassay investigation whereas those with low use value scores require analysis of their bioactivity to vindicate their use for treating a given ailment.

Conflict of Interests

The authors have not declared any conflict of interests.

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Plant diversity in *terai* grassland vegetation: a landscape level assessment with special reference to north-eastern uttar pradesh, India

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The landscape level plant diversity was measured in *Terai* grassland of north-eastern Uttar Pradesh. The field assessment, based on random quadrats, was undertaken at 11 sites, sampling an area of 333.75 ha. The grassland vegetation was comprised of a greater species richness compared to old-field vegetation. The grassy landscape as a mosaic of grassland patches contained 287 species in the sampled quadrats, which represented 177 genera from 53 families. The species composition of sites varied significantly with an increase in species richness corresponding with landscape heterogeneity. The species richness of a few sites was significantly high due to mesic condition and topographic heterogeneity. The fully exposed sites had average moisture with moderate disturbance and showed greater diversity and lower dominance. However, the partially shaded locations had high moisture and low disturbance resulting in minimum diversity and maximum dominance. The presence of high levels of disturbance in the form of severe grazing, trampling and/or cutting favoured prostrate, perennial, herbaceous-grasses such as *Cynodon dactylon* and *Imperata cylindrica* as well as the forbs such as *Desmodium triflorum, Evolvulus nummularis,* and *Rungia repens.* The marked differences among grassland habitats and the intensity of various biotic processes within the grassy landscape of the adjoining forest result in an array of grassland patches with marked differences in their diversity. Due to changes in agricultural practices and grazing intensification, the *Terai* grassland has been significantly reduced and highly fragmented resulting into the rarefaction of species that were once common and widespread. The shrinkage of specialized habitat owing to intense cultural activities, severe grazing and recurrent trampling has pushed several medicinally important and other rare plant species towards local extinction. Therefore, we suggest that appropriate management guidelines be implemented in order to conserve at risk species from extinction on the *Terai* grassland.

Key words: Grassy landscape, Disturbance, Habitat fragmentation, Patch size, Species diversity.

INTRODUCTION

Grassland is one of the most widespread ecosystem types worldwide. It is closely related to agro-ecosystem

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and forms over 24% of the world's vegetation (Shantz, 1954). Species richness is currently the most widely used measure and easily interpretable indicator of biological diversity (Whittaker, 1977; Stirling and Wilsey, 2001). The number of species reflects the quantum of gene pool and adaptation potential of the plant community (Odum, 1963) and has long been used to characterize its taxonomic structure (Simpson, 1949; Margalef, 1958). Diversity is regarded as the result of species interaction or community adaptation to its environment over its evolutionary time (Whittaker, 1972; Rice and Westboy, 1982). Disturbance is a common and widespread phenomenon in nature. It is a distinct event that modifies population structure, community, ecosystem and landscape beside the passage of time and therefore, the role of disturbance in the dynamics of ecological system can be seen as one of the basic ideas in modern ecology (Pickett and Whyte, 1985). Disturbance contributes to long-term maintenance of ecological diversity (Huston, 1994). An understanding of the response of communities to both repeated and new disturbance regimes is, therefore, necessary.

In India, grasslands constitute one of the major biomes and form an important component of terrestrial vegetation. Indian grasslands are seral in nature but they tend to be stable under the constant influence of biotic disturbances (Pandeya, 1953). Grassland vegetation of different parts of India has been managed by a number of organisations [grassland vegetation of Bombay (Bharucha and Dave, 1944), Varanasi (Misra, 1972; Ambasht et al., 1972), Jodhpur (Gupta and Sharma, 1973) and Kurukshetra (Singh and Yadava, 1974)]. The grass-cover types recognized by Dabadghao and Shankarnarayan (1973) are not homogeneous.

There are two distinct eco-climatic zones parallel to sub-Himalayan in north India *viz*. *Bhabhar* and *Terai. Bhabhar* is a narrow, dry ecosystem in comparison to the *Terai* which is significantly larger and wetter ecosystem. The grassy landscape lies between the Sarju River and the foothills of the Himalayas, covering 11 districts of eastern Uttar Pradesh. A major part of this landscape is adjacent to the managed Sal forests of the eastern *Terai* and the region is known for its unique biodiversity and high productivity (Ansari et al., 2006; Krishnan et al., 2012). These grasslands consist of patches of natural herbaceous vegetation interspersed among agricultural fields. The region has undergone severe alterations due to the expansion of agriculture coinciding with urbanization, resulting in fragmentation and degradation of natural habitats (Johnsingh et al., 2002) which have adversely affected the *Terai* flora and fauna (Javed and Rahmani, 1998). Tripathi and Shukla (2007) undertook a comparison of species richness between the vegetation found in a natural grassland with those found in managed grassland. Shukla (2009) discussed the abundance and diversity patterns of plant species across different physiognomic units over a considerably large *Terai* landscape and found that natural sal and mixed forests had higher species diversity than plantations and other forest types. Most of the rare and threatened species were confined to forest edges and scrub vegetation. . Srivastava et al., (2014) observed changes in indigenous community composition due to invasive plant species.

The present study aimed, to create baseline data on *Terai* grassland vegetation with special reference to north-eastern Uttar Pradesh (U. P.), ecologically the least explored region of India. We measured plant diversity and analyzed the grassland floristic community of the region on a landscape scale. Our study is in contrast to other phytosociological studies which work out the distribution of species abundance in ecological assemblages of various sites as determined by natural as well as anthropogenic disturbances. The results found in this study will provide critical baseline data for management decisions.

MATERIALS AND METHODS

Study sites

The plains of north-eastern U.P. cover 16 districts of eastern U.P. The study was conducted in 11 of these districts (Figure. 1). The climax vegetation is forest. The natural forest has largely been converted into plantation forests and grassy landscapes; the major part is agricultural fields. The abandoned arable land has developed into grassland through secondary succession and may remain stable under the influence of biotic disturbances such as fire, grazing and cutting practices. The study area is bordered by Nepal in the north and Bihar state of India in the east. The regional plain slopes gently from north-west to south-east and is transversed by many rivers, rivulets, nullahs, lakes and ponds.

Climate

The climate of the region is typically tropical monsoonal with three distinct seasons, *viz.,* summer (March to mid-June), monsoon (mid-June to mid-October) and winter (mid-October to February). Average annual rainfall is 1814mm with 87% occurring during the wet summer and monsoon seasons. The number of rainy days per annum is 51±3.2 with average relative humidity ranging between 74 to 87%. The north -eastern plains of Uttar Pradesh receive more rainfall over a longer period and therefore, possess much richer plant biodiversity than western and southern districts of the state. Mean maximum and minimum temperature range during wet summer 26.2 to 35.2°C, winter 12.1 to 27°C and dry summer season 24.2 to 9.3°C respectively (Indian Metrological Department, 2000 to 2005).

Soil

The soil of this region is part of the trans-Sarju Plain and comprises Gangetic alluvium brought down by the rivers Ghaghara, Rapti, Rohin and Gandak from the Himalayas in the north. The texture is sandy loam and pH is near neutral. In the northern area there are a few elevated mounds, locally called *Dhus*, which range in size from a few hundred meters 4 to 5 km consisting of brown sandy soil.

Vegetation

The grassland vegetation presents a mosaic of plant communities.

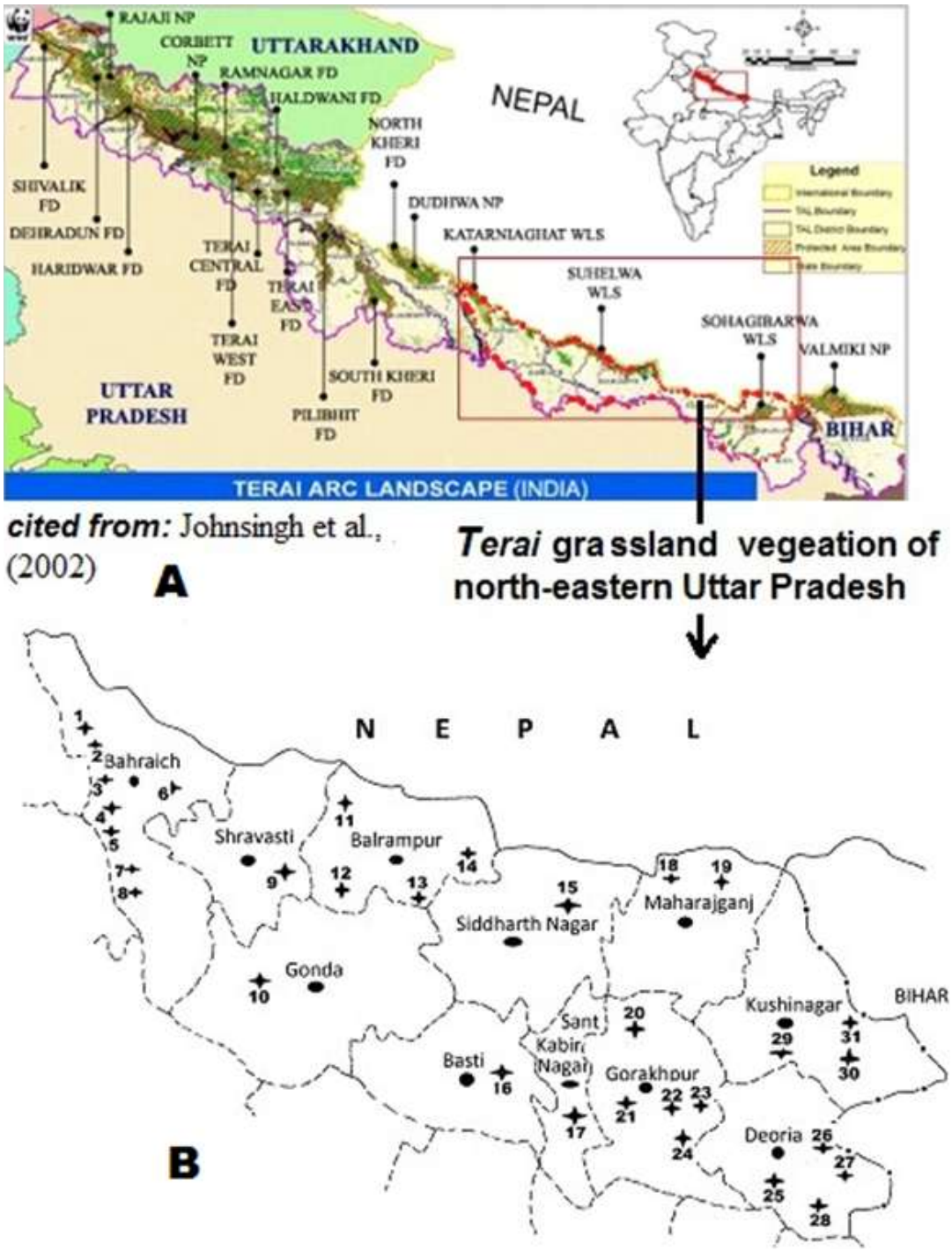

Figure 1. The red rectangle within the inset map shows the position of grassy landscape (A) and the sampled location (B) within different districts (study sites) are numbered from 1to 31.

These grasslands, developed and maintained by various cultural practices represent compositions which vary primarily according to the type of soil and available moisture within the upper layer. The growing season extends from mid-June to mid–September when most species flower and set seed. Many annuals are ephemerals and complete their life cycle before the end of October, while perennial species dry off in winter.

Sampling

This study commenced in June 2011. A general survey was conducted over a vast stretch of grassland vegetation of north-eastern Uttar Pradesh covering an approximate area of about 35, 48,000 ha encompassing 11 districts with marked differences in habitat conditions. Thirty – one sites were selected and sampled

Table 1. The combination of major factors determining habitat condition at different study sites, *Light:* o = open, ps = Partial shade; *Soil moisture*: Mh = High moisture, Ml = Low moisture, Ma = Average moisture;*Textural type*: S = Sandy, G = Gravel, C = Clay, L = loam and Disturbance: Dh = High disturbance, Dm = Moderate disturbance, Dl = Low disturbance.

Study sites	Habitat factors				Habitat condition
	Light	Moisture	Soil texture	Disturbance	
1.Bahraich	Lo	Ml	SL	Dh	Lo, Ml, SL, Dh
2. Balrampur	Lo	Mh	C	Dh	Lo, Mh, C, Dh
3. Basti	Lps	Ma	CL	Dm	Lps, Ma, CL, Dm
4. Deoria	Lps	Mh	CL	Dm	Lps, Mh, CL, Dm
5. Gonda	Lo	Ml	L	Dh	Lo, M_l, L, Dh
6. Gorakhpur	Lps	Ma	CL	Dh	Lps, Ma, CL, Dh
7. Kushinagar	Lo	Ml	SL	Dm	Lo, M_l, SL, Dm
8. Maharajganj	Lps	Ml	CL	Dm	Lps, M_l, CL, Dm
9. Sant Kabir Nagar	Lo	Mh	C	Dh	Lo, Mh, C, Dh
10. Shrawasti	Lo	Ml	G	Dh	Lo, M_l, G, Dh
11. Siddharth Nagar	Lo	Ma	C	Dm	Lo, Ma, C, Dm

Table 2a. Rare species categories based on geographic distribution, habitat specificity, and local population size (Rabinowitz 1981; Rabinowitz et al., 1986).

Geographic range	Wide		Narrow	
Habitat specificity	Broad	Restricted	Broad	Restricted
Abundance (large population)	Common	Predictable	Unlikely	Endemics
Abundance (small population)	Sparse		Non-existent	

from August, 2011 to March, 2014. Differences in habitat conditions appeared mainly in the degree of exposure, soil moisture and soil texture as related to topography and disturbance in the form of grazing and trampling (Table 1). Twenty 50 cm x 50 cm quadrats, were randomly laid at each sites i.e., with a total of 620 quadrats across the region. The occurrence and population density of species occupying each quadrat was recorded. The total basal area of individuals of each species was measured through chart-quadrat method (Mishra, 1972). Based on these values, various phytosociological and diversity indices were derived through conventional methods (Mueller-Dombois & Ellenberg 1974; Magurran, 2004). Predictor variables selected for analysis were; frequency, density, vegetal cover, their relative values and *Importance Value Index* (IVI). Several other indices like *Simpson's dominance index* ($Cd = \sum p_i^2$), *Shannon's diversity index* ($\bar{H} = -\sum p_i \ln p_i$), *Pielou's Evenness index* ($E = \bar{H}/ln\ S$), *Abundance/ Frequency Ratio* (Whitford, 1948) and *Family Importance Value* (FIV) were derived. FIV was taken as the sum of relative density, relative diversity, and relative vegetal cover. The relative diversity of a family was evaluated as the number of species within the family expressed as percentage of total number of species within all the families represented in the community (Mori *et al*., 1983). The degree of similarity among communities at different study sites was computed through Jaccard's methods for Coefficient of Similarity (Jaccard, 1908). The Rabinowitz classification scheme was used to categorize each of threatened and endangered taxa into one of the seven types. They were defined on the basis of geographic range size (*wide vs. narrow*), habitat specificity (*broad vs. restricted*), and population size (*large, dominant vs. small, scattered*) (Table 2a). From the combination of these traits, eight categories were formed to decide commonness *vs*. rarity of a given species (Rabinowitz, 1981 and Rabinowitz et al., 1986) (Table 2b). The causes of threats to plant species may be natural or anthropogenic. All species were assigned to one or more threats as per the observations (Srivastava *et al.,* 2015). All the data was analysed by using PAST (Paleontological Statistics software) Version 2.17.

RESULTS

Species richness and diversity

The landscape-level plant diversity assessment was made within 333.75ha of the grassy landscape. The details of each study site, sampled area and quadrats laid are shown in Table 3. A total of 287 plant species were encountered within the sampled quadrats, which represented 177 genera under 53 families. Dicotyledons made up 94.5% of the total families, 74.1% of genera and 69.7% of total species. The remaining species were monocots. The species: genus ratio was 1.62 and species: family ratio was 5.42. The site of Gorakhpur district which represented mostly intermediate upland topography and mesic habitat showed maximum species richness (147) of plant species and shared 51.2% of total species richness of the grassy landscape. The minimum species richness occurred at Sant Kabir Nagar (45 species). All other sites showed some intermediate value of species richness (Table 4). While *Cynodon dactylon* commonly occurred at all sites, species like *Aneilema nudiflorum, Desmodium triflorum, Launaea asplenifolia, Lindernia deccusata, Oldenlandia corymbosa, Rungia*

Table 2b. Seven form of rarity (2-8) of regional rare taxa. Each plant species was assigned to a rarity category based on their trait combinations. Category 1 is for common species. Our categorization has been compared with that of Rabinowitz's (1981).

	Trait combinations	According Rabinowitz's (1981)	Our observation (Srivastava et al., 2015)
1.	Large geographic range, wide habitat specificity, large population size	Common	Common
2.	Large geographic range, wide habitat specificity, small population size	Rare	Common
3.	Large geographic range, narrow habitat specificity, large population size	Rare	Rare
4.	Large geographic range, narrow habitat specificity, small population size	Rare	Rare
5.	Small geographic range, wide habitat specificity, large population size	Rare	Rare
6.	Small geographic range, wide habitat specificity, small population size	Rare	Rare
7.	Small geographic range, narrow habitat specificity, large population size	Rare	Rare
8.	Small geographic range, narrow habitat specificity, small population size	Rare	Rare

repens, Setaria glauca, Sida cordata and *Sida rhombifolia* were absent from quadrats sampled especially at sites in Sant Kabir Nagar.

The analysis of various phytosociological attributes shows that the erect annual herbs shared maximum values of various analytic indices (Table 5). The number of individuals/m^2 was also maximum for erect annuals (490.97) followed by prostrate perennials (39.87). The annual twiner climbers showed much less values (0.17). The erect annual herbs were much more abundant (1081.87) as compared to prostrate annuals (236.93). Shrubs were least abundant (6.12 to 6.52). Furthermore, erect annual herbs also showed much more basal area cover (30.27) as compared to twiner annuals. Overall, the landscape vegetation of *Terai* showed fairly high species diversity dominated by annual herbs (H=3.74) and quite low dominance (Cd = 0.058). The total vegetation density, however, was 811.5 individuals m^{-2}).

The life-span data of different grassland species showed that about 90% of species were annuals and the remainder perennials. There were a variety of different growth habits and dominant families within each study sites across the grassy landscape vegetation of *Terai* (Table 6). The maximum number of herbaceous plant species was encountered in Gorakhpur district (129) followed by Deoria (102) and Balrampur (103), with Sant Kabir Nagar having the minimum number of herbaceous plant species (40). Further, the number of shrubs and climbers was also much greater in Gorakhpur district as compared to Siddharth Nagar, Maharajganj, Basti and Gonda. No climbers were observed in Gonda district. At the landscape level, 250 species of herbs, 28 climbers and nine shrubs were found. Poaceae and Cyperaceae were the most *speciose* and ubiquitous families of the region.

Species richness and Importance value of different families

Six dominant families accounted for 56% of total species richness. Poaceae was the most common (17.2%), followed by Cyperaceae (11.2%), Papilionaceae (10.5%), Asteraceae (9.8%), Scrophulariceae (4.9%) and Euphorbiaceae (3.5%). The remaining 44% of species represented 47 families. Six families were represented by more than 10 species. Poaceae, Asteraceae and Papilionaceae showed maximum genera richness in that order with 38, 19 and 16 genera, respectively. In terms of individuals, two families, Scrophulariaceae and Poaceae were dominant with a total > 25,000 individuals within the sampled quadrats of the grassy landscape (Table 7).

The actual importance of a family within its community comes from FIV, an index which heavily depends upon the vegetal cover of component species in addition to the density values. Family Poaceae accounted for 17.4% of total species and 19.9% of total individuals of the landscape. They shared 18.49% of the total vegetal cover and contributed 18.6% to its FIV. Further, the other dominant families like Cyperaceae, Papilionaceae, Asteraceae, Scrophulariaceae and Euphorbiaceae shared 39.72% of total species richness and 52.37% of total individuals. These families together shared 47.49% of total vegetal cover and 52.37% of density (individual/m^2) sum and also contributed 46.52% to sum of FIV. The families, Scrophulariaceae, Poaceae, Papilionaceae and Acanthaceae accounted for >10,000 individuals within the sampled area. The 31 families were poorly represented in terms of the number of individuals. Of these families, Martyniaceae, Sphenocleaceae and Zygophyllaceae were monotypic and shared only 0.40; 0.38 and 0.36% FIV respectively across the *Terai* grassy landscape (Table 8).

Abundance distribution

The value of sum of frequency, density and abundance at 11 different sites across the grassy landscape were compared (Figure 2). The fluctuations in the sum of density were more conspicuous as compared to that of abundance and frequency. The sum of density was

Table 3. Details of study sites and sampling of grassy landscape.

S/N	Study sites (District)	Code	Latitude	Longitude	Altitude (Meter)	Geographical Area (ha)	Sampled Area (ha)	Number of quadrats
1.	Bahraich	BAH	27.34 N	81.38 E	126	469,680	97.94	160
2.	Balrampur	BLP	26.75 N	82.07 E	106	334,900	13.34	80
3.	Basti	BST	26.48 N	82.46 E	103	730,900	3.24	20
4.	Deoria	DEO	26.23 N	83.42 E	68	252,700	18.96	80
5.	Gorakhpur	GKP	26.46 N	83.22 E	69	348,380	40.88	100
6.	Gonda	GND	27.28 N	82.01 E	120	444,800	80.94	20
7.	Kushinagar	KHN	26.45 N	83.24 E	75	287,350	9.31	60
8.	Maharajganj	MRG	25.85 N	83.70 E	66	293,410	4.48	40
9.	Siddharth Nagar	SDN	27.30 N	83.09 E	88	275,200	38.45	20
10	Shravasti	SHW	27.70 N	81.93 E	122	194,820	12.14	20
11.	Sant Kabir Nagar	SKN	26.48 N	82.46 E	86	164,100	11.33	20
Total						3,796,240	333.01	620

Table 4. Richness of various plant taxa *viz.*, family, genera and species across grassy landscape.

Study sites	Family	Genera	Species	Species/Genera Ratio	Species/Family Ratio
BAH	29	66	98	1.48	3.38
DEO	28	85	109	1.28	3.89
GKP	38	101	147	1.45	3.87
GND	16	40	52	1.3	3.25
SKN	21	35	45	1.29	2.14
BLP	35	90	120	1.33	3.43
MRG	27	70	98	1.4	3.63
SDN	20	49	66	1.35	3.30
BST	20	48	55	1.15	2.75
KHN	27	72	98	1.36	3.63
SHW	25	60	69	1.15	2.76
North-Eastern U. P.	53	177	287	1.62	5.42

maximum in Gonda and Bahraich. Conversely it was low for both Sant Kabir Nagar and Kushinagar. The sum of abundance was higher only for Bahraich, Gorakhpur and Maharajganj as compared to other sites. Increase in abundance of species is a quantitative indication of its patchiness or hyper-dispersion. Several common herbaceous species showed hyper-dispersion across the landscape as evident from the

Table 5. Phytosociological indices for different habit group of species (summation values) across the grassy landscape. (No. of occur. = number of occurrence, ni = number of individuals, BA = Basal area, F = Frequency, D = Density, A= Abundance, A/F = Abundance /Frequency ratio, RF = Relative Frequency, RD = Relative density, RVC = Relative Vegetal Cover, IVI = Importance Value Index, Σ pi ln pi=Shannon's diversity index; Σ $(pi)^2$ = Dominance and E= Evenness).

Species Groups	No. of occur.	Σ ni	Σ BA (cm^2)	Σ F	Σ D	Σ indivi./m^2	Σ A	Σ A/F	Σ%VC	Σ RF	Σ RD	ΣRVC	Σ IVI	ΣpiInpi	Σ$(pi)^2$	E
Herbs																
Erect Annual	6757	76101	469206	1089.88	122.74	490.97	1081.87	522.69	30.27	60.09	60.50	49.63	170.22	2.31	0.040	0.41
Perennial	351	2119	16067	56.61	3.45	13.67	25.89	5.99	1.04	3.12	1.68	1.69	6.50	0.09	0.0001	0.02
*Prostrat*e Annual	2133	22255	182611	344.03	35.89	143.58	236.93	101.45	11.78	18.97	17.69	19.31	55.98	0.69	0.007	0.12
Perennial	1618	24687	263047	260.97	39.87	159.27	85.22	3.04	16.97	14.39	19.63	27.82	61.84	0.61	0.01	0.11
Climbers																
Twiner Annual	65	107	2335	10.48	0.17	0.69	13.46	25.694	0.15	0.58	0.08	0.25	0.911	0.007	2.13E-07	0.001
Perennial	89	153	3787	14.35	0.25	0.99	13.28	20.334	0.24	0.79	0.12	0.40	1.32	0.010	4.26E-07	0.002
Tendril Annual	68	135	2819	10.97	0.22	0.87	14.56	12.024	0.18	0.60	0.11	0.30	1.01	0.009	2.48E-07	0.002
Shrubs																
Erect Annual	75	111	2425	12.10	0.18	0.72	6.12	5.254	0.16	0.66	0.09	0.26	1.01	0.007	4.22E-07	0.001
Perennial	89	112	3125	14.35	0.18	0.72	6.52	5.694	0.20	0.79	0.09	0.33	1.21	0.007	2.84E-07	0.001
Grassy landscape (Sum)	11245	125780	945422	1813.71	202.87	811.48	1483.88	702.16	66.99	100	100	100	300	3.74	0.058	0.661

Table 6. Species of different habit forms and dominant plant families (represented by >5 species) at different study sites.

Study sites	No. of Species under different Habit categories			Speciose Family (represented by >5 Species)	
	Herb	Shrubs	Climber		
BAH	90	3	5	Poaceae, Cyperaceae, Asteraceae, Euphorbiaceae,	Malavaceae Papilionaceae Scrophulariaceae
GKP	129	05	13	Cyperaceae, Poaceae, Papilionaceae, Asteraceae	Malavaceae, Scrophulariaceae, Euphorbiaceae, Caesalpiniaceae
GND	51	01	-	Poaceae	Papilionaceae,
SKN	40	02	03	Cyperaceae	Scrophulariaceae
DEO	102	02	05	Poaceae, Asteraceae, Cyperaceae,	Papilionaceae, Euphorbiaceae Malvaceae
BLP	103	04	13	Papilionaceae, Poaceae, Cyperaceae, Asteraceae,	Amaranthaceae, Euphorbiaceae Scrophulariaceae
MRG	93	01	04	Poaceae, Asteraceae, Papilionaceae,	Cyperaceae, Euphorbiaceae Malvaceae
SDN	63	01	02	Poaceae, Cyperaceae, Asteraceae,	Papilionaceae Scrophulariaceae
BST	52	02	01	Asteraceae, Poaceae	Scrophulariaceae
KHN	93	02	03	Poaceae, Asteraceae,	Papilionaceae Cyperaceae
SHW	61	03	05	Poaceae, Papilionaceae,	Asteraceae Malvaceae
Grassy landscape	250	09	28	Poaceae, Papilionaceae Scrophulariaceae	Cyperaceae, Asteraceae, Euphorbiaceae

Table 7. The number of plant genera, species and their individuals under different families as recorded within the sampled area.

S/N	Family	Genera	Species	Individual	S/No	Family	Genera	Species	Individual
1	Scrophulariaceae	6	14	32279	28	Primulaceae	1	1	71
2	Poaceae	38	50	25045	29	Unknown	5	5	65
3	Papilionaceae	16	30	15366	30	Portulacaceae	1	1	64
4	Acanthaceae	6	6	10004	31	Apocynaceae	1	1	62
5	Cyperaceae	4	32	8844	32	Molluginaceae	1	2	53
6	Convolvulaceae	4	7	8604	33	Solanaceae	2	4	34
7	Rubiaceae	4	5	6532	34	Cucurbitaceae	4	4	25
8	Asteraceae	19	28	5213	35	Chenopodiaceae	1	1	24
9	Euphorbiaceae	5	10	4165	36	Urticaceae	1	1	19
10	Boraginaceae	2	4	3065	37	Menispermaceae	3	3	18
11	Commelinace	3	4	1725	38	Apiaceae	1	1	17
12	Malvaceae	3	9	852	39	Vitaceae	1	1	16
13	Caesalpiniaceae	1	5	721	40	Martyniaceae	1	1	10
14	Amaranthaceae	6	9	542	41	Sphenocleaceae	1	1	10
15	Polygonaceae	2	4	503	42	Aizoaceae	1	1	8
16	Lamiaceae	5	7	341	43	Amaryllidaceae	1	1	8
17	Onagaraceae	1	4	196	44	Capparidaceae	1	1	7
18	Tiliaceae	2	4	189	45	Papaveraceae	1	1	7
19	Verbenaceae	4	4	154	46	Moraceae	1	1	5
20	Lobaliaceae	1	1	141	47	Zygophyllaceae	1	1	5
21	Violaceae	1	1	122	48	Cuscutaceae	1	2	4
22	Lytharaceae	1	2	120	49	Ranunculaceae	1	1	4
23	Nyctanginaceae	1	1	120	50	Basellaceae	1	1	3
24	Sterculiaceae	1	1	118	51	Bignoniaceae	1	1	3
25	Polygalaceae	1	1	94	52	Cannabinaceae	1	1	1
26	Oxalidaceae	1	1	92	53	Fumariaceae	1	1	1
27	Asclepidaceae	3	3	89	Total		177	287	125780

difference between their density and abundance values. *Lindernia decussata,* however, showed closely similar value of frequency and abundance resulting into A/F ratio near unity. Other distinctly dominant species like *Desmodium triflorum, Evolvulus nummularis, Imperata cylindrica, Lindernia ciliata* and *Rungia repens* showed abundance values of >20 and frequency value of > 40 (Table 9). The A/F ratio for these species was very low (< 1) with exception of *Imperata cylindrica.* Analysis of Jaccard coefficient of similarity showed that the Deoria and Kushinagar districts shared maximum similarity of 0.50 followed by Deoria and Maharajganj (0.44). The least similarity (0.09) was observed between sites at Siddharth Nagar and Sant Kabir Nagar. Over 70% of species were found to be common to all sites within the grassy landscape of north-eastern region (Figure 3).

Dominance- diversity relationship

The resource utilization and niche occupancy of the species within a community is frequently expressed by dominance-diversity curve. Only a few species pre-empted most of the niches at 11 different study sites (Figure 4). The pattern of niche pre-emption by *Lindernia decussata* was quite comparable for Bahraich and Kushinagar. The topography and soil type of the two sites were quite similar but the disturbance regime was different at Bahraich, the grazing intensity was higher as compared to Kushinagar. Further, the Gorakhpur and Shrawasti sites were similar in habitat conditions and disturbance regime. They showed quite similar niche occupancy pattern. The species such *as Desmodium triflorum, Evolvulus nummularis, Rungia repens* and *Cynodon dactylon* occupied maximum niche space of all other species in total. *Evolvulus nummularis* showed maximum number of individuals and occupied maximum niche space at sites of Balrampur, Gonda and Basti. Balrampur and Gonda sites were similar in light and disturbance regimes, grazing pressure and moisture regimes except for some marginal soil differences. Sant Kabir Nagar sites showed unique habitat conditions with fully open, high moisture and complex disturbance conditions and showed maximum niche occupancy by

Table 8. Species richness and Family Importance Value (FIV) of constituent families across grassy landscape of *Terai*.

Family	Species richness	FIV*	Family	Species richness	FIV
Poaceae	50	55.83	Cuscutaceae	2	0.72
Scrophulariaceae	14	42.17	Nyctanginaceae	1	0.66
Papilionaceae	30	41.18	Lobaliaceae	1	0.61
Cyperaceae	32	24.31	Apocynaceae	1	0.57
Asteraceae	28	20.51	Polygalaceae	1	0.57
Convolvulaceae	7	19.26	Violaceae	1	0.56
Acanthaceae	6	17.78	Oxalidaceae	1	0.55
Rubiaceae	5	11.39	Portulacaceae	1	0.49
Euphorbiaceae	10	11.39	Primulaceae	1	0.48
Boraginaceae	4	6.05	Vitaceae	1	0.41
Malvaceae	9	5.65	Chenopodiaceae	1	0.40
Amaranthaceae	9	4.36	Martyniaceae	1	0.40
Commelinaceae	4	3.99	Apiaceae	1	0.39
Lamiaceae	7	3.61	Urticaceae	1	0.38
Caesalpiniaceae	5	3.15	Sphenocleaceae	1	0.38
Polygonaceae	4	2.36	Capparidaceae	1	0.37
Tiliaceae	4	1.92	Aizoaceae	1	0.37
Unknown	5	1.89	Moraceae	1	0.37
Onagaraceae	4	1.86	Papaveraceae	1	0.37
Verbenaceae	4	1.78	Zygophyllaceae	1	0.36
Cucurbitaceae	4	1.59	Amaryllidaceae	1	0.36
Solanaceae	4	1.49	Basellaceae	1	0.36
Asclepiadaceae	3	1.33	Bignoniaceae	1	0.36
Menispermaceae	3	1.13	Ranunculaceae	1	0.36
Lythraceae	2	0.92	Cannabinaceae	1	0.35
Molluginaceae	2	0.84	Fumariaceae	1	0.35
Sterculiaceae	1	0.72	Total	287	300

*FIV = relative density + relative diversity + relative vegetal cover.

Medicago polymorpha.

The Siddharth Nagar site was quite similar to the former site except some degree of fire as disturbance factor. *Imperata cylindrica* occupied its maximum niche space. The fire, grazing and trampling together increased its occurrence and density. The expansion of the species is facilitated by its rhizomatous growth. Deoria and Maharajganj sites were quite similar in habitat condition with some difference in moisture regimes. The two moisture-loving species *Rungia repens* and *Phyllanthus urinaria* occupied their maximum niche spaces.

Rare species and its population

The total number of individuals or density, habit, posture categories, distribution, population status and the specific habitat conditions of rare species revealed that at the landscape level, only 31 species showed rare occurrence and occupied specific habitats (Table 10). They represented 27 genera under 18 families. The common species with large distribution range showed wide habitat specificity. The intense agricultural practices, mining, livestock grazing and trampling were found to be the major threats causing rarity of a great number of grassland herbs. A few species such as *Chyranthellum indicum* and *Spermacoce pusilla*, however, were encountered only at one of the eleven sites (Bahraich) but in the localized spots the individuals were much greater in number. These species occupied a habitat possessing sandy to sandy loam soils with average moisture and exposed condition. A few highly medicinal plant species such as *Astercantha longifolia, Bacopa monnieri, Centella asiatica, Chyranthellum indicum, Ionidium suffructicosum, Evolvulus alsinoides, Leucas aspera, L. cephalotus, Vernonia adscendens* and *Tribulus terrestris* have suffered seriously due to voracious harvesting for medicinal purpose from the wild. The very rare and poor occurrences of some lowland species such as *Cyperus niveus, Lobelia alsinoides and Sphenoclea zeylanica* may be attributed to severe grazing just before their full bloom or seed-setting stage.

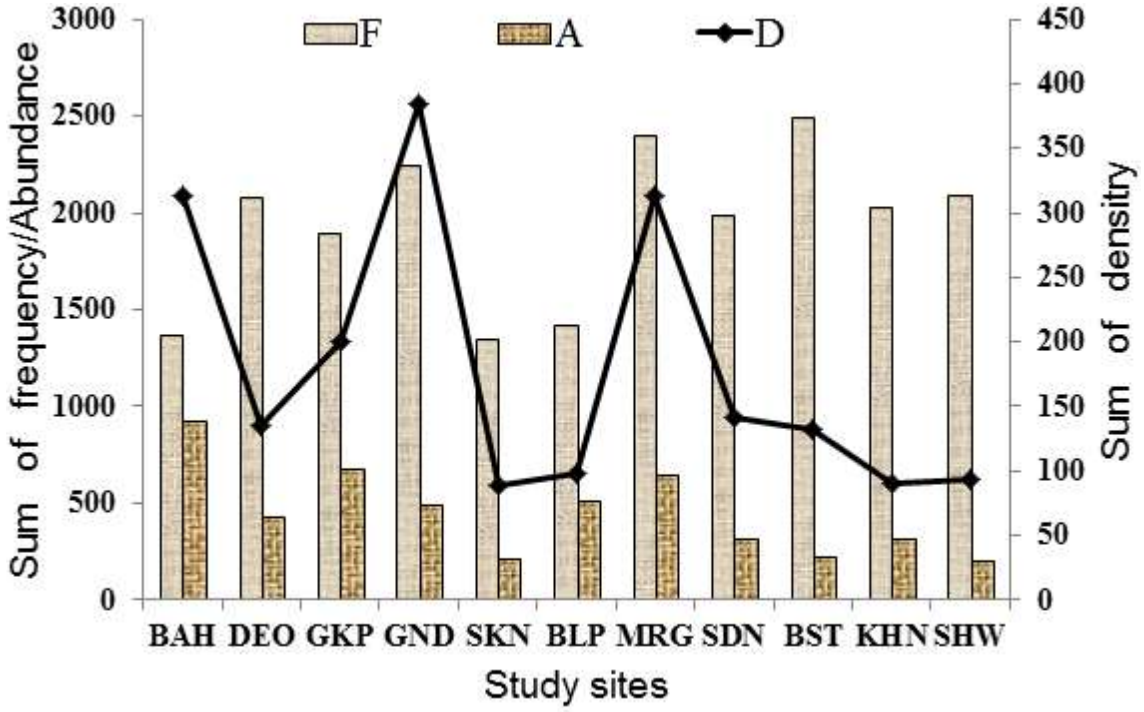

Figure 2. Sum values of frequency, density and of abundance of plant species at different study sites. (BAH = Bahraich, DEO = Deoria, GKP = Gorakhpur, GND = Gonda, SKN = Sant Kabir Nagar, BLP = Balrampur, MRG = Maharajganj, SDN =Sidharthnagar, BST = Basti, KHN = Kushinagar and SHW = Sharawasti

Table 9. Species showing most frequent and most prolific distribution across grassy landscape.

Species	Average Density	Abundance	Frequency	A/F ratio
Lindernia deccusata	143.79	60.73	59.19	1.03
Rungia repens	62.59	28.77	54.35	0.53
Desmodium triflorum	58.16	20.49	70.97	0.29
Lindernia ciliata	56.52	31.74	44.52	0.71
Evolvulus nummularis	50.36	22.27	56.61	0.39
Cynodon dactylon	23.51	11.87	49.52	0.24
Zornia gibbosa	21	19.97	26.29	0.76
Imperata cylindrica	19.58	28.90	16.93	1.71
Phyllanthus urinaria	17.36	22.80	19.03	1.20

The dominant families also shared maximum number of rare species. For example, *Papilionaceae* and *Poaceae* had five rare species each, *Lamiaceae* three species and *Asteraceae, Boraginaceae* and *Caesalpinaceae* contained two rare species each. Another 12 families showed single rare species. The families *Apiaceae, Lobaliaceae, Martyniaceae, Sphenocleaceae* and *Zygophyllaceae* had single rare species under monotypic genera *viz*., *Lobalia alsinoides, Martynia annua, Sphenoclea zeylanica* and *Tribulus terrestris.*

DISCUSSION

The *Terai* grassland vegetation has considerable diversity represented by plant species of different habits. A landscape level approach addresses the changes in biodiversity due to anthropogenic activities and the effect of such changes in biodiversity on the functioning of biological system (Franklin 2001). Since humans play a key role in altering ecosystem level processes, its integration as part of the ecosystem is quite obvious.

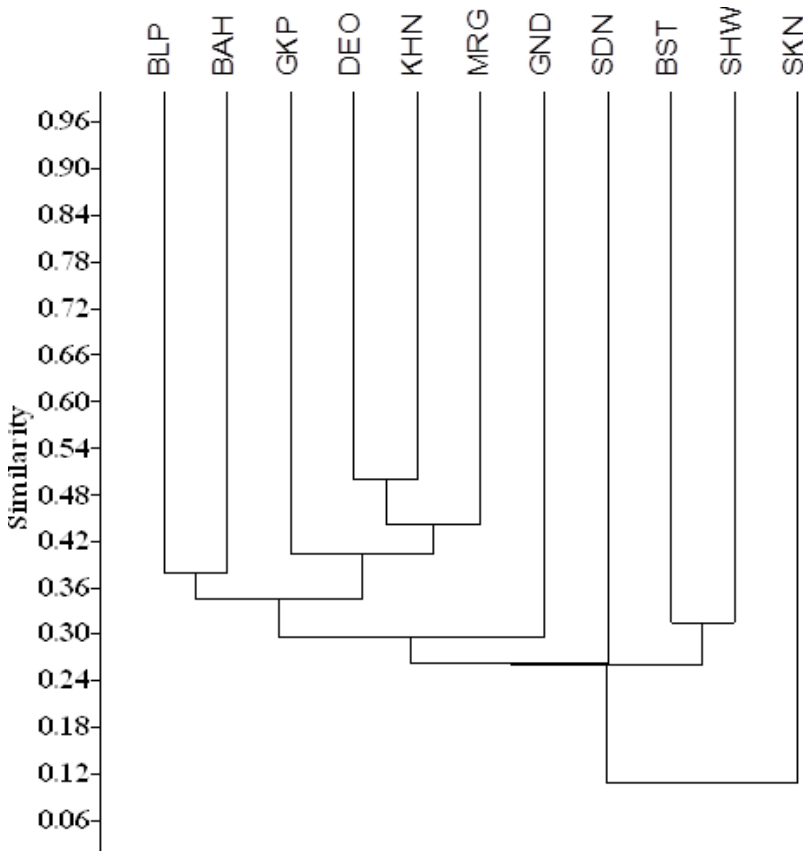

Figure 3. Dendrogram showing similarity among study sites (based on Jaccards coefficient).

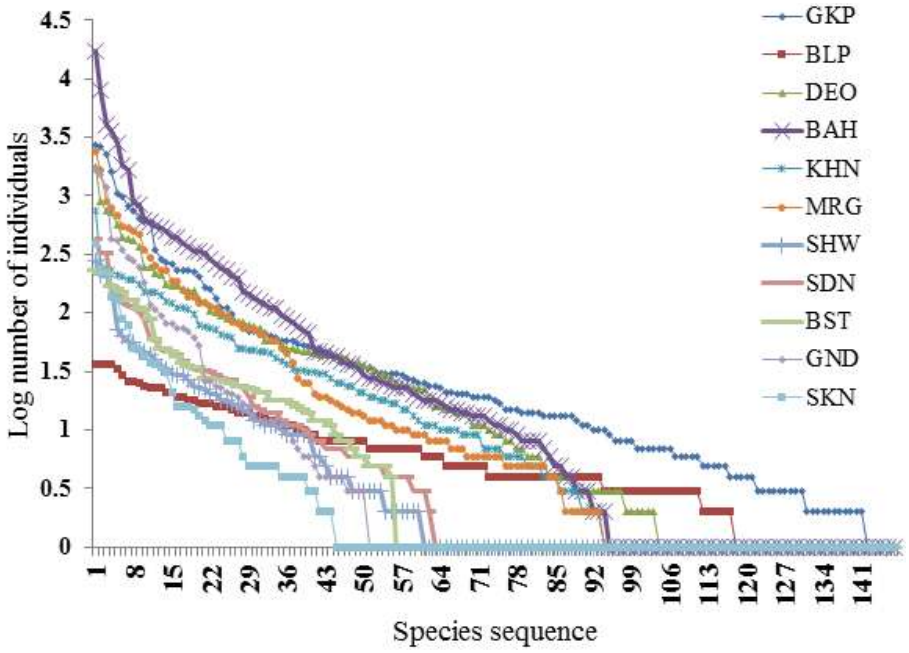

Figure 4. Rank-abundance model (dominance-diversity curve) for different study sites (based on Jaccards coefficient).

Table 10. The distribution and population status of rare species with their habit and posture categories. Abbreviation: *Light:* O= open, PS= Partial shade; *Soil moisture*: HM= High Moisture, LM= Low moisture, AS= Average moisture and Textural types: SS=Sandy soil, GS= Gravel soil, CL= Clayey soil, L= loam.

Plant species	Family	Habit	Posture	Total number Individuals	Density (m^2)	Habitat factors			Population Size	Habitat Specialization	Geographical Range
						Light	*Moisture*	*Soil*			
Alternanthera pungens	Amaranthaceae	H	PA	9	0.06	O	LM	GS	Large	Narrow	Narrow
Alysicarpus bupleurifolius. Dc.	Papilionaceae	H	EA	33	0.21	O	AM	CS/CLS	Large	Narrow	Narrow
Astercantha longifolia	Lamiaceae	H	EA	13	0.08	O	HM	CS	Large	Broad	Narrow
Bacopa monnieri Linn.	Scrophulariaceae	H	EA	8	0.05	O	HM	CS	Small	Narrow	Narrow
Cassia absus Linn.	Caesalpiniaceae	H	EA	7	0.05	PS	AM	CLS	Small	Narrow	Narrow
Cassia pumila Lamk. WG	Caesalpiniaceae	H	PA	13	0.08	PS	AM	CLS	Large	Narrow	Narrow
Centella asiatica Linn.	Apiaceae	H	PA	17	0.11	O	HM	CS	large	Narrow	Wide
Chrysanthellum indicum Dc. Prod.	Asteraceae	H	PA	595	3.84	O	AM	SS/SLS	Large	Narrow	Narrow
Crotalaria calycina Linn.	Papilionaceae	H	EA	15	0.10	O	LM	SLS	Large	Narrow	Narrow
Crotalaria palida	Papilionaceae	H	PA	1	0.01	O	LM,	SLS	Small	Broad	Wide
Cynoglossum lanceolatum Forsk.	Boraginaceae	H	EA	123	0.79	O	LM	SLS	Large	Narrow	Narrow
Cyperus niveus	Cyperaceae	H	EA	2	0.01	O	AM	SLS	Small	Narrow	Narrow
Eragrostis capensis	Poaceae	H	EA	45	0.29	O	AM	SLS	Small	Narrow	Narrow
Eragrostis cilianensis	Poaceae	H	EA	29	0.19	O	AM	CS/CLS	Small	Narrow	Narrow
Evolvulus alsinoides Linn.	Convolvulaceae	H	PPer	763	4.92	O	AM	SLS /SL	large	Narrow	Wide
Heliotropium ovalifolium	Boraginaceae	H	EA	12	0.08	O	HM	CS	Small	Narrow	Narrow
Hemarthria compressa	Poaceae	H	EA	47	0.30	O	HM	CS	Large	Narrow	Narrow
Hetropogon contortus Linn	Poaceae	H	EA	25	0.16	O	LM	SLS	Large	Narrow	Narrow
Ionidum suffructicosum Roe&She	Violaceae	H	EA	122	0.79	O/PS	AM	SLS/CLS	Small	Narrow	Wide
Leucas aspera Willd. Spreng.	Lamiaceae	H	EA	19	0.12	O	LM	SLS	Small	Broad	Narrow
Leucas cephalotus	Lamiaceae	H	EA	51	0.33	O	AM	SLS	Small	Broad	Narrow
Lobelia alsinoides	Lobaliaceae	H	EA	141	0.91	PS	HM	CLS	Small	Narrow	Narrow
Martynia annua Linn.	Martyniaceae	H	EA	10	0.06	O	LM	CLS	Small	Narrow	Narrow
Perotis indica Linn.	Poaceae	H	PA	174	1.12	O	LM/AM	SLS	Large	Narrow	Narrow
Psoralea corylifolia	Papilionaceae	H	EA	191	1.23	PS	AM	SLS	Small	Narrow	Narrow
Spermacoce pusilla	Rubiaceae	H	EA	4076	26.30	O	AM,	SLS	Large	Narrow	Narrow
Sphenoclea zeylanica	Sphenocleaceae	H	EA	10	0.06	O	HM	CS	Small	Narrow	Narrow
Teramnus labialis	Papilionaceae	C	PerTw	8	0.05	PS	AM	GS	Small	Narrow	Narrow
Tribulus terrestris Linn.	Zygophyllaceae	H	PA	5	0.03	O	LM	SS	Small	Narrow	Narrow
Vernonia adscendens	Asteraceae	H	EA	9	0.06	O	LM	SLS	Small	Narrow	Narrow
Zephyranthes citrina Baker	Amaryllidaceae	H	EA	8	0.05	O/PS	AM	GS & CS	Small	Narrow	Narrow

Table 11. The number of rare species (decreasing order) and their % share against total species within different families.

Family	Total species	Rare species	Percentage (%) share of rare species
Papilionaceae	30	5	(16.7%)
Poaceae	50	5	(10 %)
Lamiaceae	7	3	(43%)
Asteraceae	28	2	(7.1%)
Boraginaceae	4	2	(50%)
Caesalpiniaceae	5	2	(40%)
Zygophyllaceae	1	1	(100%)
Scrophulariaceae	14	1	(7.1%)
Rubiaceae	5	1	(20 %)
Amaranthaceae	9	1	(11 %)
Sphenocleaceae	1	1	(100%)
Martyniaceae	1	1	(100%)
Apiaceae	1	1	(100%)
Amaryllidaceae	1	1	(100%)
Violaceae	1	1	(100 %)
Cyperaceae	32	1	(3%)
Convolvulaceae	7	1	(14.3 %)
Lobaliaceae	1	1	(100%)

Habitat modifications and management practices that change functional diversity and functional composition are likely to have large impacts on ecosystem processes (Tilman et al., 1997). Societies, by their activities also affect landscape function (Ramakrishnan, 1992). The developmental stage of community is complicated by disturbance types and their intensity. Disturbance may increase species richness by lowering the dominance of a few species, freeing resources for early successional plants, and providing opportunities for herbaceous species to spread rapidly (Tripathi, 1999; Sood et al., 2011).

The landscape of north-eastern Uttar Pradesh forms an interrupted regional community of grassland which is quite heterogeneous due to small-scale changes in topography, soil and light conditions and, therefore, may be easily recognized on the basis of species composition, habitat characters and patch size. The different patch type characterise different habitats and species composition, and the total number of species in a landscape increases with increase in heterogeneity of landscape (Sluis et al., 2014). Our result showed clear difference in species richness of patch sizes at different study sites. The total number of species of two sites such as Gorakhpur and Balrampur were fairly high. At Gorakhpur, 147 species were encountered within 40.88 ha area; with 120 species recorded within 13.34 ha at Balrampur. Further, Sant Kabir Nagar recorded only 45 species within 11.33ha area. These results indicated that the sizes of patches are significantly related neither to species richness nor species composition as also evident from the Bisteau and Mahy (2005). Other studies have however, reported that size is the main factor affecting species richness in fragmented grasslands (Krauss et al., 2004) and isolation may also be a significant factor (Piessens et al., 2005). Low species richness may result from the dominance of a few competitors and ruderals. Both, a reduction in species richness and increased dominance of a few species are common phenomenon in highly fertilized grasslands (Berendse and Elberse, 1990).

The density and abundance distribution of individual species are measurable indicators of plant diversity (Wattenberg and Breckle, 1995). The importance of natural and anthropogenic disturbance in maintaining species richness and diversity have been pointed out by many authors including Grime (1979), Pickett et al., (1989) and van der Maarel (1993). Variation in disturbance intensity exerts profound influence on the pattern of diversity and species richness; the ever-increasing biotic pressure often leads to a mosaic of patches with various degrees of ecological maturity (Rescia et al., 1994). Increased diversity and reduced dominance has been found in case of fully exposed locations having average moisture and facing moderate disturbance. It was minimum in case of partially shaded locations having high moisture and facing low disturbance. It has been shown to be associated with increased stability (McNaughton, 1967). Bahraich and Gonda showed low diversity and high dominance in

comparison to other sites. This may be due to the presence of severe disturbances in the form of grazing, trampling and cutting. The disturbance in the form of periodic clipping caused greater dominance and low diversity, and the species of prostrate habit dominated the localities. It has already been established that diversity is lower in absence of disturbance as well as in presence of too much of disturbance (Srivastava et al., 2015). The moderate level of anthropogenic disturbance, therefore, are compatible with maintenance of high biodiversity of landscape (Gentry, 1991).

The annual herbaceous species have been reported to respond more positively to disturbance (Belsky, 1986). The prostrate perennial herbaceous grasses like *Cynodon dactylon* and *Imperata cylindrica* and few forbs such as *Desmodium triflorum, Evolvulus nummularis,* and *Rungia repens* had maximum dominance due to multiple reproductive strategies (Patrica et al., 2002) and rapidly occupied the horizontal space created by disturbance especially by severe trampling and grazing. Annual and perennial species showed maximum seed and ramet proliferation even in regularly trampled habitat. The abundance of a species in an area depends on the ability of its propagule and tolerates features of the environment (Harper, 1967). *Lindernia decussata* exhibited the greatest density, abundance and A/F ratio of all other species. The species is ephemeral, moisture loving and produces numerous seeds where discrimination is favoured by grazing. The species such as *Cynodon dactylon, Desmodium triflorum, Evolvulus nummularis* and *Rungia repens,* showed overall maximum occurrence in the region. *R. repens* also exhibited maximum density and abundance but its A/F ratio was low in comparison to annual species. The high importance value of these species may be attributed to efficient mode of seed production and ramet growth. Relatively, privileged number of species can be attributed to moderate grazing and grazing may develop mutualism between the grazers and grazed species. The saliva and dung of grazers may also promote the growth of some species (Grace and Jutila, 1999).

The sum of frequency value changed notably from one to other study sites which may be attributed to the sudden increase in the number and abundance of a few more opportunistic weeds in response to increased exposure. Low value of both abundance and frequency showed rare occurrence of species while very high value indicated their dominance quite often in the form of extensive patches. Hubbell and Foster (1986) found that most rare species were specialist either in habitat utilization (topography or edaphic condition) or in regeneration niche (regenerative condition in gap openings) which implies that a high heterogeneity of environmental condition is necessary to accommodate so many specialist species. The sum of frequency may be much lower in highly disturbed sites because of much greater abundance of a few adaptive species (Stachurska, 1994, Pandey and Shukla, 2003, 2005).

The ability of large, fast-growing perennial herbs suppressed the growth of smaller species. A nearly non-random species distribution within the community in the form of widely distributed dominant species and locally distributed subordinate species is quite common (Kolasa et al., 1989). The pattern of species abundance may be related to habitat factors and growth pattern of the species which specialize the niche (Brown et al., 1995). Our results are consistent with the prediction that, as generalists use various habitat types in the landscape, they should be less affected by habitat fragmentation than specialists, which are more dependent on one or few habitat types (Brouat et al., 2004). Specialist's plant species are also expected to be adversely affected by landscape disturbance (Kithahara et al., 2000, Kassen, 2002). Our observations are also consistent with the empirical findings that the human induced landscape degradation cause decline of specialist species (Krauss et al., 2003, Devictor et al., 2007a,). We found little support for the hypothesis that common species are competitive dominants and rare species are weak competitors (Whittaker 1965; McNaughton and Wolf 1970). Our results indicate that response to competition may be important for coexistence. We found that rare species were relatively tolerant of competition which allowed them to persist at low abundances and coexist with common species (Rabinowitz et al., 1984). The rare forbs suffered weak competition from common species because they started growing and flowering earlier in the spring allowing them to get a head-start before competition from other species was established.

Severe change in habitat conditions resulted in fall of specialist species and rise of opportunist species. The population of some grassland species such as *Chrysanthellum indicum* and *Spermacoce pusilla* showed least tolerance to these disturbances and were found limited to one site having sandy to loamy soils. On the other hand, species such as *Baccopa monnieri, Cassia absus, Cyperus niveus, Eragrostis capensis, Eragrostis cilianensis, Heliotropium ovalifolium, Leucas cephalotus, Leucas aspera, Lobalia alsinoides, Martynia annua, Psoralea corylifolia, Sphenoclea zeylanica, Atylosia scarabaeoides, Teramnus labialis, Tribulus terrestris, Vernonia adscendens* and *Zephyranthes citrina* generally occupied quite specialized habitats and had a small population size within a narrow distributional range. Due to their medicinal importance they have been over-exploited, their natural habitat is almost destroyed and they are at the verge of local extinction. Voracious and unmanaged harvesting is another major threat to the existence of several minor but valuable plant species of the region (Shukla, 2009).

The recent urbanisation and associated disturbances have caused a much greater loss to specialized niches of

the region. For example, *Crotolaria calycina,* and *Ionidium suffruticosum* happen to be rare and their population size has reduced significantly during the last decade. Considerably shaded and damp habitats within village forests or orchards are preferred. The species have suffered seriously, due to the fast reduction of such habitats mainly by increased urbanization and agricultural expansion. It has been established that the shade tolerant species are more sensitive to habitat fragmentation than shade intolerant species (Metzger, 2000). Species like *Astercantha longifolia, Bacopa monnieri, Centella asiatica* and *Heliotropium ovalifolium* mostly grew in areas facing some degree of water-logging on clayey soil and most often show aggregation.

Currently, they have become infrequent across water-logged or lowland regions despite their two-pronged regeneration strategy that is, through seeds as well as through sprout and ramets. Thus, not only upland but also the marginally lowland habitats of the region are severely disturbed. The highly specialized species in nature have significant positive associations and they cannot survive outside of their natural habitat (Hubbell and Foster, 1986). Bruun (2000), identified numerous functional groups including specialist grassland species which were positively correlated with habitat area. With the small population size and restricted habitats more species will be prone to localized extinction (Menges, 1998; Butaye et al., 2005).

The resource sharing and occupancy of niche space are frequently expressed by dominance-diversity curve (Whittaker, 1975). As evident from these curves, generally fewer species in the landscape preempted most of the niches. The conditions like moderate grazing and lesser clipping and trampling allowed relatively greater number of species to share community resources, thus reducing the degree of dominance at community level, as evident from the less steeper and more flattened curve (Raizada et al., 1998). Disturbance has positive effects on the grassland vegetation as reported earlier by some workers (Sundriyal et al., 1987). Further, disturbance caused by herbivores may reduce the negative effect of competition (Nautiyal et al., 2004). In comparison to other species of exposed community, erect herbaceous component was dominant especially in condition of low moisture and moderate disturbance. *Lindernia decussata* was more frequent, highly dominant and occupied maximum niche space (Bahraich and Kushinagar). *Desmodium triflorum, Evolvulus nummularis, Rungia repens* and *Cynodon dactylon* showed high dominance and occupied maximum niche space at two other study sites (Gorakhpur and Shrawasti). The latter two sites showed slight differences in habitat conditions but their disturbance regime was quite similar. On the contrary, almost uniform and periodic clipping inhibited the establishment of most of the upper strata species and promoted dominance of only a few prostrate species like *Rungia repens* and *Desmodium triflorum* which occurred most frequently within low disturbance zone (Dwivedi, 1978).

Habitat modification or fragmentation due to persisting disturbance (grazing and other anthropogenic pressure), creates a platform for the onset of biological invasion by species such as *Hyptis suaveolens*, *Parthenium hysterophorus* and *Solanum sisymbriifolium* (Srivastava et al., 2015). The replacement of many endemic species by a few widespread species could, by itself, promote large-scale homogenization especially in open habitats with reduced competition, often created by grazing and man-made disturbance (Wu et al., 2004; Huang et al., 2009). The survival and growth of small population into large population of several plant species indicated that the habitat quality was not always worse for all species especially invaders. They can easily colonize and fruitfully outcompete the native species. So, the invasive alien species form one of the major threats after fragmentation, against the survival and growth of several native species (CBD, 2005). They have potential to damage or eliminate already small populations of rare taxa (Menges, 1991a).

The anthropogenic disturbance is an important factor in determining the vegetation pattern across different habitat and often more dominating as compared to other (Angassa & Oba 2010; Dargie & Demerdash 1991; Gunaga et al. 2013, Körner, 1995). The human induced changes have caused, major changes in vegetation composition of *Terai* and a vast area of grasslands is converted into agro-ecosystem. Currently anthropogenic disturbance has affected the structural variability of these grasslands at local scale.

Conclusion

The present study explores the species composition and diversity pattern of *Terai* grassland vegetation with special reference to north-eastern Uttar Pradesh. This analysis emphasizes that for conservation of species, their habitat priority should be given to the maintenance of large grassland patches. The common species often show intraspecific competition and rare species show interspecific competition. The strong competitive effects for common species and weak effects for rare species suggest that competition promotes, rather than inhibits diversity. The land use change and agricultural intensi-fication have led to the loss of habitat heterogeneity. Our analysis showed that generally, the moderate level of disturbance specially, grazing, trampling and cutting play a major role in maintaining optimum species diversity of the landscape but habitat condition such as marginal differences in soil, light condition and moisture regime also affect the level of species richness and overall biodiversity.

During the first phase of restoration it is important to focus on improvement of immigration. Connectivity between different sites is better as the main management tool because animals transport propagules and thus increase the speed of formation of field layer.

Conflict of Interests

The authors have not declared any conflict of interests.

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