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Threatened medicinal and economic plants of the Sudan Savanna in Katsina State, northwestern Nigeria

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Background: The loss of biodiversity in Nigeria is escalating alarmingly. However, there is generally a paucity of information as to what taxa are endangered because of a dearth of functioning conservation agencies in Nigeria.

Objectives: The aim of this research is to record the endangered medicinal and other economic plant species in the Sudan Savanna vegetation in Katsina and to provide an assessment of the various threats faced by these plants.

Method: Medicinal plants were identified through oral interviews with traditional medical practitioners within the study area. Conservation statuses were assessed using a bespoke data collection and assessment form; the data were then evaluated using the International Union for the Conservation of Nature Red List categories and criteria.

Results: A total of 169 species belonging to 62 families were recorded. Of these, 43 taxa were reported to be used for ethnomedicinal practices. It was found that more than half (108) of the 169 species were threatened with extinction and one taxon (*Xeroderris stuhlmannii* [Taub.] Mendonca & Sousa) qualifies as being Extinct locally. Threats recorded include overexploitation (24%), agriculture (15%), deforestation and desertification (12% each), invasive plants (11%), urban residential development (7%) and erosion (6%).

Conclusion: Most of the plants are already under threat and require urgent conservation measures. The data point to the critical need for further research into conservation strategies and a more sustainable use of threatened plants. We recommend that the Nigerian government should establish a national Red List agency and ensure effective protected area management and community-based natural resources management.

Keywords: conservation; endangered species; Hausa community; IUCN; threat categories; Nigeria; Sudan Savanna.

Introduction

The loss of biodiversity in Nigeria is escalating alarmingly ('Assessment of the threats to biodiversity' Convention on Biological Diversity [CBD] n.d.; Ihunweze n.d.). This is more pronounced in seven states across the northwestern and northeastern geopolitical zones of Nigeria, which are threatened by the adverse effect of desertification, posing a significant threat to agriculture, food security and water resources (Dike & Obembe 2012; Gbile 1992; Wakili 2016). These seven states, mostly bordering the Republic of Niger and characterised by Sudano–Sahelian Savanna, are grappling with the challenge of desertification, which advances at 0.6 km every year, leading to soil erosion and disruption of the ecosystem (Smith 2000: 2). This adverse effect is attributed primarily to persistent deforestation and a loss of ground cover, extensive overgrazing and other faulty farming practices (Borokini 2014; Dike & Obembe 2012; Emma-Okafor & Ibeawuchi 2010). The vegetation cover of the Savanna is economically and medicinally important as a large number of Africans use medicinal and aromatic plants that are known to be reservoirs of curative elements in the treatment of various diseases ranging from malaria, diabetes, mental disorders, cancer and hypertension to HIV and AIDS (Bello et al. 2011a, 2011b; Dike & Obembe 2012; Okigbo 2009). However, increasing demand, coupled with harmful unsustainable collecting habits, threatens the survival of these plants as well as the livelihood of the general population who rely on the overall natural system (Borokini 2014; Emma-Okafor & Ibeawuchi 2010).

Katsina State lies in the Sudan Savanna vegetation zone (Keay 1949; White 1983) between 12° 15'N latitude and 7° 30'E longitude and is one of the 11 states that comprise the northwestern and northeastern geopolitical zones of Nigeria, which are impacted by the adverse effects of desertification and

excessive indiscriminate felling of trees for firewood and timber (Bello pers. obs.; Gbile 1992). The plants that are the most threatened are the numerous medicinal and economically important trees, which were once found abundantly in farmlands across the region, but which are no longer easy to come by. Some of these species include *Neocarea macrophylla* (Sabine) Prance ex F.White (Gawasa), *Sclerocarya birrea* (A.Rich) Hochst. (Daniya), *Detarium microcarpum* Harms. (Taura) and *Prosopis africana* (Guill. & Perr.) Taub. (Kirya) (Borokini 2014; Emma-Okafor & Ibeawuchi 2010; Mudansiru et al. 2016). There is therefore a need for a more sustainable forest resource management to ensure that the current generation utilises the available natural resources wisely without compromising the availability of the resources for future generations (Chukwuma, Soladoye & Feyisola 2015; Taylor 2015).

A major impediment to a more sustainable management is the lack of information on which taxa are endangered due to the paucity of functioning conservation agencies in Nigeria (CBD 2015; 'Red List 2013: Threatened species across the regions of the world'). The major significance of this study is, therefore, to provide up-to-date information about endangered plant species in the Sudan Savanna vegetation zone in Katsina, in accordance with the guidelines set by the International Union for the Conservation of Nature (IUCN). The study also aimed at providing criteria to determine the relative rate of the risk of extinction of medicinal plants, with the main purpose being to catalogue and highlight those plants that are facing a risk of extinction. In addition, we want to assess previous recommendations about conserving the remaining patches of the available plant resources. Specifically, the objectives of this study are to (1) identify the indigenous medicinal and economic plants used by the people of Katsina State; (2) assess the conservation status of the indigenous medicinal and economic plants of the Katsina Sudan Savanna based on the Red Listing criteria developed by the IUCN; and (3) outline the various threat categories affecting the plants.

Internationally, 199 countries have signed an accord to create biodiversity action plans that will aim to protect endangered and other threatened species (Hariramamurthi 2000). One of the recent efforts by the Nigerian government to reduce the loss of biodiversity was the signing of the bill by the president of Nigeria on 30 December 2016 to stop the trafficking of endangered species (Wakili 2016). In Katsina State, the Ministry of Environment implemented the Great Green Wall Project (greatgreenwall.org; UN Convention to Combat Desertification), which seeks to establish shelter belts in dry regions of the world as a step to tackle the menace of desertification. To the best of our knowledge, there has never been an up-to-date assessment of the status and distribution of threatened species in Katsina as has been reported from some other places, for example the southern part of Nigeria (Chukwuma et al. 2015; Dike & Obembe 2012; Emma-Okafor & Ibeawuchi 2010), Senegal (Zizka et al. 2015) and southern Africa (Victor & Dold 2003). The list compiled here is primarily to identify those taxa most in need of conservation attention, thereby assisting conservationists, farmers, landowners and land managers by providing clear information for conservation of threatened species.

Methodology

Study area

This research was carried out in the Sudan Savanna vegetation zone in Katsina State, northwestern Nigeria (Keay 1949; White 1983). The area consists of nine local government areas including Jibia, Katsina, Kaita, Mashi, Maiadua, Daura, Sandamu, Zango and Baure (Figure 1). The area has a mean annual rainfall of about 800 mm – 1000 mm (Olofin 1985). The vegetation is characterised by a variety of scattered trees in an expanse of grassland (Olofin 1985). The area is known to enjoy four distinct seasons: a dry and cool season, which starts from around November and ends in late March and is characterised by Harmattan winds; a dry and hot season, which is a short transitional period from March to about mid-May characterised by the warmest temperature of the year; a wet and warm season, which starts around May and ends in October during which 90% of the annual rainfall is received; and lastly, a dry and warm season, which starts from the end of October to mid-November (Olofin 1985).

Users consulted in the study and sampling techniques

To determine which medicinal and economic important plants were being used in the region, we targeted users such as herbalists, traditional medical practitioners, traditional midwives, housewives, farmers and other elders who have practised with or used medicinal plants. These groups effectively sub-sampled the larger population thereby enabling us to generalise the findings more easily. These targeted consultees were identified after conferring with village heads in the study area. The number of consultees varied according to the size of the population of the study area. This ensured a proportionate representation of the share of the population. Random sampling was adopted to select villages in the north, east, south and west of each of the nine local government units in the study area thereby minimising bias and oversimplification of the results.

Sources of information on medicinal plants and Red List data

The primary source of data was derived from (1) the questionnaire designed to obtain information about plants used for medicinal purposes (Appendix 1) and (2) the species collection or assessment form for conservation assessment (Appendix 2).

The secondary source of data includes the IUCN Red List website (http://www.iucnredlist.org), which was used to ascertain the global conservation status of each species; GeoCAT (http://geocat.kew.org/) and Global Biodiversity Information Facility (GBIF) (http://www.gbif.org/). The IUCN Red List is the world's most comprehensive information source on the extinction risk of plant and animal species (Rodrigues et al. 2006). The information in the IUCN Red List is widely used to inform biodiversity conservation policy and practice, making the IUCN Red List a preferable method

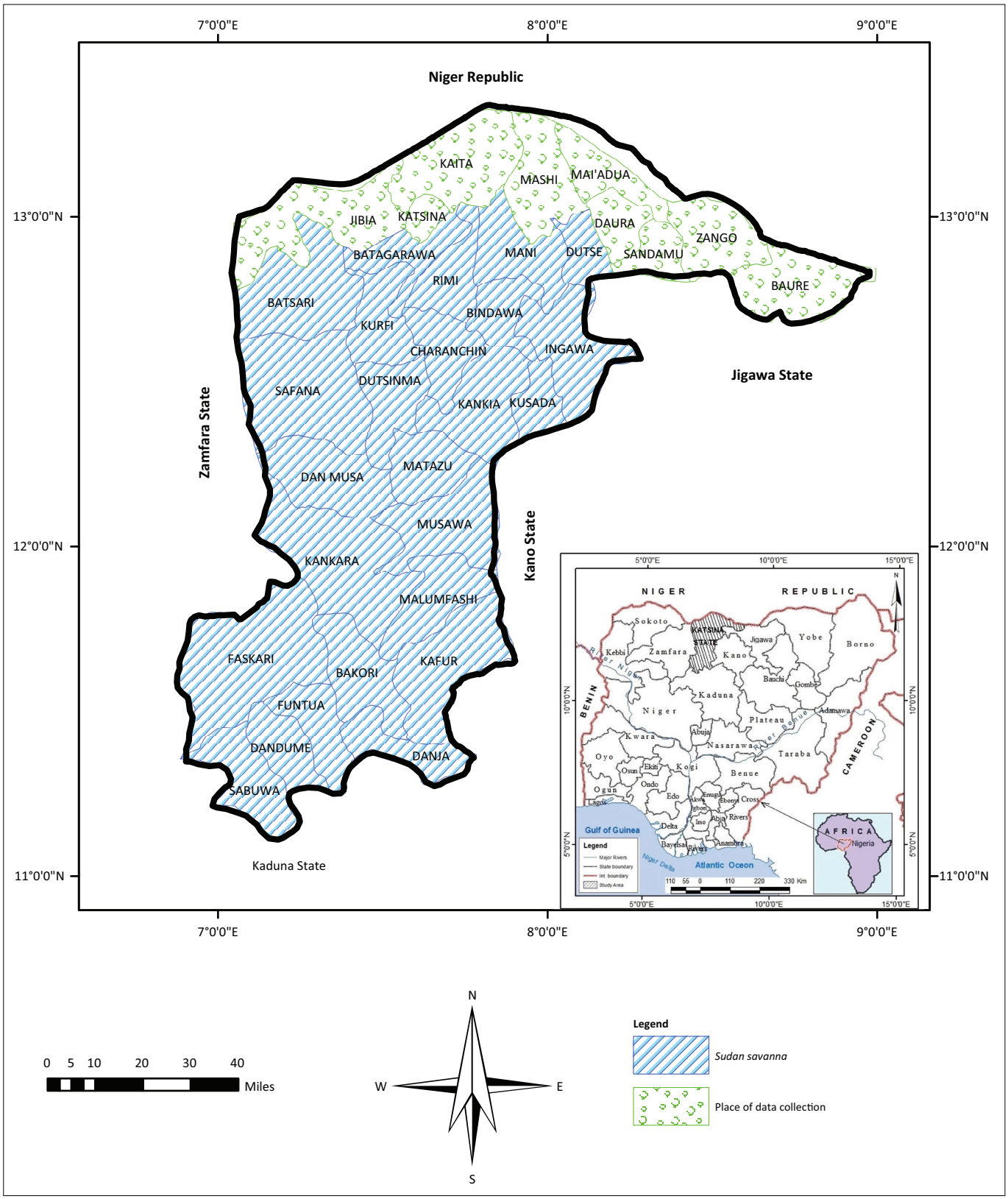


FIGURE 1: Map of Katsina State, northwestern Nigeria, showing the study area.

for conservation decision-making (see MedPlant 2015). GeoCAT performs rapid geospatial analysis for Red Listing taxa. It utilises spatially referenced primary occurrence data and focuses on two aspects of the geographic range of a taxon: the extent of occurrence (EOO) and the area of occupancy (AOO), which form part of the IUCN Red List categories and criteria and have often proved challenging to obtain in an accurate, consistent and repeatable way (Bachman et al. 2011). GBIF is an open-data research infrastructure funded by all the governments in the world and aimed at providing anyone, anywhere access to data about all types of life on the Earth.

Data collection

Field study trips in the study area were made between June 2015 and June 2017. Plants of medicinal and economic importance were identified through oral interviews with the targeted groups representing the categories mentioned above. On the advice of these informants, plants were shortlisted for inclusion in the study. Then, the researchers, with the help of the local individuals, proceeded to the field to make conservation assessments of the listed plants using the pro forma noted in the previous section (Appendix 2). Each of the listed species was assessed individually in the field. Additionally, the informants were asked various questions regarding the conservation status of the medicinal plants. These helped in outlining the major threats causing the reduction in population size of the various medicinal and economic plants listed. To ensure that only valid samples and information are used in the study, we used both semi-structured and unstructured interviews as the best approach because in a rural or indigenous context, people often do not respond well to highly structured interview approaches. We went to the interview with a few questions relating to the topic of discussion. One of the advantages of this is that if the conversation deviates significantly, the interviewers can gently steer it back to their topics of focus. We ensured that our interviewees were at ease by starting the interview with informal chats. We also explained how the data would be used. We allowed the interviewees to do most of the talking without interruption and used simple, clear language and short questions. The technique for eliciting information during informal conversations is to get people on to a topic (see MedPlant 2015).

Information on the decline in the population size of the species, decline in the AOO, EOO, loss of habitat, actual or potential level of exploitation and effects of introduced taxa noted in the field were used in the evaluation of the taxa following the IUCN Red List criteria version 3.1 (IUCN 2012a, 2012b: Appendix 3). Voucher collections of the taxa facing any of the three categories of threat were made and deposited in the herbarium of Umaru Musa Yarádua University, Katsina (UMYUK).

Data analysis

The IUCN Red List criteria were used to classify species according to one of the three categories of threat, or a category of lower risk (IUCN 2001; SANBI 2010, see also Appendix 3). Briefly, the three categories of threat in order of decreasing risk of extinction were Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). If a taxon no longer exists in the wild, it is classified as Extinct (EX) or Extinct in the Wild (EXW). Categories of lower risk are Near Threatened (NT) or Least Concern (LC). The NT category has been used where there is a concern that the taxon may become threatened in the future, but where the taxon does not qualify as 'threatened with extinction'. Taxa that were not threatened with extinction are listed as LC. The minimum amount of information required for performing an assessment is the total distribution area of the taxon (EOO), the number of locations in which it grows (AOO) and whether or not it is declining (the reason is also recorded). The AOO and the EOO were calculated using the GeoCAT tool (Bachman et al. 2011). Where a continuing decline was observed to be affecting the population as a whole, the B criterion was applied; and in some cases, if a percentage decline could be estimated, the A criterion was used. Quite often, for a very narrowly restricted taxon under threat from a stochastic event because of its rarity, the D criterion was used.

Result

The result of the socio-demographic information of the respondents interviewed during the ethnobotanical survey of the medicinal plants in the study area is shown in Table 1. The table presented the sex, age and educational status, occupation of the respondents as well as their frequency and percentage. It shows that there are more male respondents, 83 (78.9%) than female, 22 (21.2%) respondents and that the majority, 33 (31.4%) falls within the age range of 51–60 years. It also showed that the majority of the respondents, 59 (56%) have no formal education and very few, 5 (4.8%) have tertiary education. In terms of occupation, the majority of the respondents, 42 (30.9%) are traditional medical practitioners (Table 1).

Table 2 shows the list of 43 plant species distributed across 20 families used for the treatment of various common illnesses and ethnomedicinal practices by the people of Katsina. All taxa are listed in alphabetical order by families. Each plant is reported with the type of disease it cures, part of the plant used and the method of usage. The local (Hausa) and scientific names were also provided for the benefit of the native Hausa speakers and the general scientific community, respectively. Fabaceae has the highest record of 15 species, followed by Anacardiaceae (4), Moraceae and Combretaceae with three species each and Connaraceae and Malvaceae with two species each. The remaining families were represented by a single species (Table 2).

Table 3 shows the list of 61 assessed medicinal and economic plants that either may become threatened with

TABLE 1: Socio-demographic information about the respondents (N = 105).

Bio-data	Frequency (*n*)	Percentage (%)
Sex		
Male	83	78.85
Female	22	21.15
Age		
20–30	7	6.66
31–40	13	12.38
41–50	22	20.95
51–60	33	31.42
61–70	19	18.09
70 and above	11	10.14
Educational status		
Tertiary	5	4.76
Secondary	14	13.33
Primary	27	25.72
No formal education	59	56.19
Occupation		
Farmers	6	5.71
Herbalist	22	20.95
Traditional medical practitioners	42	30.48
Traditional midwives	22	20.95
Housewives	16	15.24
Others	7	6.67

Note: The table presented the sex, age, educational status and occupation of the respondents as well as their frequency and percentage.

TABLE 2: Medicinal plants used by the people of Katsina.

Scientific name	Family	Local name	Part use	Disease cured	Method of preparation and administration
Adansonia digitata L.	Malvaceae	Kuka	L	Piles	Powder of leaves is taken with soup.
Allium sativum L.	Amaryllidaceae	Tafarnuwa	B	Colds	Powder of bulb taken orally.
Albizia chevalieri Harms.	Fabaceae	Katsari	B	Stomach ache	Soaked in water, the extract is taken orally.
Anogeissus leiocarpus (DC.) (Guill. And Perr.)	Combretaceae	Marke	B	Piles and fever	Soaked in water, a cup full of the extract is taken daily.
Balanites aegyptiaca (L.) Delile	Zygophyllaceae	Aduwa	F	Piles	Fruit is taken orally.
Bauhinia rufescens Lam.	Fabaceae	Tsattsagi	B	Dysentery	Soaked in water and taken orally.
Byrsocarpus coccineus Schum. and Thonn.	Connaraceae	Tsamiyar kasa	WP	Supplementing breast milk	Powder taken with milk or pap.
Zaleya pentandra (L.) C.Jeffrey	Nyctaginaceae	Gadon Maciji	T	Stomach ache	An infusion of root and leaves is taken orally.
Boswellia dalzielii Hutch.	Burseraceae	Hano	T	Piles	Soaked in water for 3 days and the extract then taken orally. Root is mixed with honey.
Calotropis procera (Aiton) Dryand.	Asclepiadaceae	Tunfafiya	T	Cancer, eye problems	Powder smeared on the cancerous area. Fruit liquid is used as an eye drop.
Chamaecrista mimosoides (L.) Greene	Fabaceae	Bagaruwar kasa	L	Skin rashes	Ointment is rubbed onto the skin.
Ceiba pentandra (L.) Gaertn.	Malvaceae	Rimi	L	Diarrhoea	Powder of leaves is taken with pap.
Combretum micranthum G.Don	Combretaceae	Geza	L	General well being	Decoction is taken orally.
Rourea coccinea (Schum. & Thonn.) Benth.	Connaraceae	Tsamiyar kasa	F	Piles	Fruit soaked in water and then taken orally.
Citrus aurantiifolia (Christm.) Swingle	Rutaceae	Lemun Tsami	F	Fever and mouth rashes	Steaming using the decoction. Fruit juice is applied to mouth.
Detarium microcarpum Harms.	Fabaceae	Taura	B, F	Piles	Fruit or decoction is taken orally.
Diospyros mespiliformis Hochst. ex A.DC.	Ebenaceae	Kanya	B	Piles	Soaked in water and taken orally.
Entada africana Guill. & Perr.	Fabaceae	Tawatsa	B	Stomach ache	Cup full of decoction is taken orally.
Erythrina senegalensis DC.	Fabaceae	Minjirya	B	Dysentery	Powder is taken orally with pap.
Faidherbia albida (Delile) A.Chev.	Fabaceae	Gawo	B	Body pain	Soaked then taken orally.
Ficus trichopoda Baker	Moraceae	Baure	B	Diarrhoea	The decoction is taken orally.
Ficus thonningii Blume	Moraceae	Cediya	B	Fever	Powder is added on a pap or soaked in water then taken orally.
Ficus platyphylla Delile	Moraceae	Gamji	B	Piles	Soaked and taken orally.
Guiera senegalensis J.F.Gmel.	Combretaceae	Sabara	L	Diarrhoea and vomiting	Powder of leaves is taken orally.
Indigofera astragalina DC.	Fabaceae	Kai kai koma kan mashekiya	WP	Arthritis	Powder applied to affected area.
Khaya senegalensis (Desv.) A.Juss.	Meliaceae	Madachi	B	Stomach ache	Soaked for 3 days then taken orally.
Lannea acida A.Rich.	Anacardiaceae	Faru	B	General well being	Decoction taken orally.
Jatropha curcas L.	Euphorbiaceae	Cindazugu	WP	Body pains	The decoction is taken orally.
Leptadenia lancifolia (Schumach. & Thonn) Decne.	Apocynaceae	Yadiya	L	Ulcers	Cooked leaves are taken as food.
Mangifera indica L.	Anacardiaceae	Mangoro	B	Malaria	The boiled decoction is taken orally.
Moringa oleifera Lam.	Moringaceae	Zogala	L	Blood tonic and general well being	Cooked and taken as food.
Parkia biglobosa (Jacq.) G.Don	Fabaceae	Dorawa	B	Dysentery	The decoction is taken orally.
Psidium guajava L.	Myrtaceae	Gwaba	L	Fever	The decoction is orally taken for 3 days.
Bauhinia reticulata DC.	Fabaceae	Kalgo	R	Piles	Root extract plus red potash is taken orally.
Ozoroa mucronata (Bernh.) R.Fern. & A.Fern.	Anacardiaceae	Kasheshe	L	Vomiting	Leaf powder added to milk and taken orally.
Prosopis africana (Guill. & Perr.) Taub.	Fabaceae	Kirya	B	Piles	Powdered bark applied to the affected area.
Sclerocarya birrea (A.Rich.) Hochst.	Anacardiaceae	Danya	B	Body pain	Stem bark soaked in water and taken orally.
Senna occidentalis (L.) Link	Fabaceae	Tafasar masar	L	Fever	The decoction is taken orally.
Strychnos spinosa Lam.	Loganiaceae	Kokiya	B	Ulcers	Soaked and taken orally.
Tamarindus indica L.	Fabaceae	Tsamiya	F	Stomach upset	Soaked in water and taken orally.
Vachellia nilotica (L.) P.J.H.Hurter & Mabb.	Fabaceae	Bagaruwa	F	Healing piles and wounds	A decoction is taken with pap every morning for at least a week. It is also soaked and tied to wounds for healing.
Vachellia sieberiana (DC.) Kyal. & Boatwr.	Fabaceae	Farar kaya	WP	Easing joint pain	Soaked in water and taken orally.
Ziziphus jujuba Mill.	Rhamnaceae	Magarya	L	Blood clotting	Leaf powder is applied to wound.

Note: The table lists 43 plant species from 20 plant families used in the treatment of various common illness and ethnomedicinal practices.
B, bark; F, fruit; L, leaves; R, root; T, tuber; WP, whole plant.

extinction in the future, or for which there is some conservation concern, that is, the NT category (36), or those that are not threatened with any extinction risk and did not qualify to be listed in the NT category, that is, the LC category (25). Table 4 showed the list of 108 taxa that are either EX or are threatened with extinction. Of these, one taxon qualifies as EX, 36 as CR, 25 as EN and 46 as VU (see also Figure 2).

Figure 2 shows the percentage of each of the threat categories affecting the various medicinal and economic plants in the study area. Fifteen per cent are LC, 21% NT, 27% VU, 15% EN, 21% CR and 1% EX. The various categories of threats faced by the plants and the number of taxa affected in each of the threat categories are shown in Figure 3. These are (in descending order): overexploitation 26 (24.1%); agricultural practices 16 (14.8%); deforestation and desertification 13

TABLE 3: Medicinal and economic plant taxa that either may become threatened with extinction in the future, or for which there is some conservation concern, that is, the Near Threatened category (36), or those that are not threatened with any extinction risk and did not qualify to be listed in the Near Threatened category, that is, the Least Concern category (25). These taxa (61) do not meet the criteria for being listed as 'threatened with extinction' according to the International Union for the Conservation of Nature version 3.1.

Family	Species	Local name	Local assessment	Global assessment
Aizoaceae	*Zaleya pentandra* (L.) C.Jeffrey	Gadon maciji	NT	NE
Amaranthaceae	*Amaranthus spinosus* L.	Zarangade	NT	NE
Amaryllidaceae	*Allium sativum* L.	Tafarnuwa	NT	NE
Amaryllidaceae	*Scadoxus multiflorus* (Martyn) Raf.	Albasar kwadi	NT	NE
Anacardiaceae	*Mangifera indica* L.	Mangwaro	NT	DD
Anacardiaceae	*Ozoroa mucronata* (Bernh.) R.Fern & A.Fern.	Kasheshe	LC	NE
Anarcadiaceae	*Anacardium occidentale* L.	Yazawa	LC	NE
Apocynaceae	*Anisopus mannii* N.E.Br.	Sakayau	NT	NE
Apocynaceae	*Calotropis procera* (Aiton) Dryand.	Tumfafiya	NT	NE
Apocynaceae	*Leptadenia lancifolia* (Schumach. & Thonn) Decne.	Yadiya	NT	NE
Arecaceae	*Borassus aethiopum* Mart.	Giginya	NT	NE
Asteraceae	*Vernoniastrum ambiguum* (Kotschy & Peyr.) H.Rob.	Tattaba	LC	NE
Brassicaceae	*Lepidium sativum* L.	Zamantarori	LC	NE
Caricaceae	*Carica papaya* L.	Gwanda	LC	DD
Cleomaceae	*Cleome gynandra* L.	Gasaya	NT	NE
Cochlospermaceae	*Cochlospermum tinctorium* Perr. ex A. Rich.	Rawaya	NT	NE
Commelinaceae	*Commelina caroliniana* Walter.	Balasana	NT	NE
Convolvulaceae	*Evolvulus alsinoides* (L.) L.	Kafi malam	NT	NE
Convolvulaceae	*Ipomoea asarifolia* (Desr.) Roem. & Schult.	Duman kada	NT	NE
Cucurbitaceae	*Citrullus lanatus* (Thunb.) Matsum. & Naka.	Guna	NT	NE
Cyperaceae	*Cyperus articulatus* L.	Kajiji	NT	NE
Cyperaceae	*Cyperus rotundus* L.	Aya Aya	NT	LC
Euphorbiaceae	*Chrozophora senegalensis* (Lam.) A.Juss ex Spreng.	Damaigi	NT	NE
Euphorbiaceae	*Euphorbia balsamifera* Aiton	Aliyara	NT	NE
Euphorbiaceae	*Jatropha curcas* L.	Cin da zugu	NT	NE
Euphorbiaceae	*Euphorbia convolvuloides* Hoschst. ex Benth.	Nonon kurciya	NT	NE
Fabaceae	*Senegalia polyacantha* (Willd.) Seigler & Ebinger	Karaki	NT	NE
Fabaceae	*Vachellia sieberiana* (DC.) Kyal. & Boatwr.	Farar kaya	LC	NE
Fabaceae	*Bauhinia reticulata* DC.	Kalgo	NT	NE
Fabaceae	*Crotalaria juncea* L.	Bakar biyar rana	LC	NE
Fabaceae	*Crotalaria pallida* Aiton	Farar biyar rana	LC	NE
Fabaceae	*Dichrostachys cinerea* (L.) Wight & Arn.	Dundu	NT	LC
Fabaceae	*Indigofera astragalina* DC.	Kaikai koma kan mashekiya	NT	NE
Fabaceae	*Senna obtusifolia* (L.) H.S.Irwin & Barneby	Tafasa	LC	NE
Fabaceae	*Senna occidentalis* (L.) Link	Tafasar Masar	LC	NE
Fabaceae	*Senna singueana* (Delile) Lock	Runhu	NT	NE
Lamiaceae	*Leucas martinicensis* (Jacq.) R.Br.	Bunsurun fadama	LC	NE
Lamiaceae	*Ocimum basilicum* L	Daddoya	LC	NE
Malvaceae	*Gossypium hirsutum* L.	Gurya	LC	NE
Malvaceae	*Hibiscus sabdariffa* L.	Sobo	LC	NE
Malvaceae	*Sida ovata* Forssk.	Miyar tsanya	LC	NE
Moringaceae	*Moringa oleifera* Lam.	Zogala	NT	NE
Myrtaceae	*Psidium guajava* L.	Gwaba	NT	NE
Nyctaginaceae	*Boerhavia diffusa* L.	Babba jibji	NT	NE
Pedaliaceae	*Ceratotheca sesamoides* Endl.	Yaudo	LC	NE
Pedaliaceae	*Sesamum alatum* Thonn.	Ridin barewa	LC	NE
Poaceae	*Andropogon gayanus* Knuth	Gamba	NT	NE
Poaceae	*Cynodon dactylon* (L.) Pers.	Tsarkiyar zomo	LC	NE
Poaceae	*Pennisetum glaucum* (L.) R.Br.	Gero	LC	NE
Poaceae	*Pennisetum hordeoides* (Lam.) Steud.	Kyasuwa	LC	NE
Poaceae	*Phragmites australis* (Cav.) Trin. ex Steud.	Katala	LC	LC
Poaceae	*Cenchrus biflorus* Roxb.	Karangiya	NT	NE
Poaceae	*Digitaria debilis* (Desf.) Wild.	Harkiya	NT	NE
Poaceae	*Eragrostis tremula* Hochst. ex Steud.	Burburuwa	NT	NE
Rubiaceae	*Mitragyna inermis* (Willd.) Kuntze	Giyayya	LC	NE
Rubiaceae	*Mitracarpus hirtus* (L.) DC.	Gogamasu	NT	NE
Rubiceae	*Spermacoce stachydea* DC.	Alkamar Turwa	NT	NE
Rutaceae	*Citrus aurantiifolia* (Christm.) Swingle	Lemun tsami	LC	NE
Solanaceae	*Schwenkia americana* Kunth	Dandana	NT	NE
Solanaceae	*Solanum americanum* Mill.	Gautan kaji	LC	NE
Vitaceae	*Cissus populnea* Guill. & Perr.	Loda	LC	NE

NE, No entry, DD, Data deficient; NT, Near Threatened; LC; Least Concern.

TABLE 4: Taxa threatened with local extinction in Katsina, assessed according to the International Union for the Conservation of Nature categories and criteria version 3.1.

Family	Species	Local name	Local assessment	Global assessment
Acanthaceae	*Hygrophila auriculata* Schumach.	Zazargiwa	VU B1ab (i,ii);D2	LC
Acanthaceae	*Peristrophe bicalyculata* (Retz) Nees	Tubanin dawaki	VU A1 c,d	NE
Aizoaceae	*Tricanthema portulacastrum* L.	Dankalin yara	VU B1ab(v);D2	NE
Amaryllidaceae	*Urelytrum giganteum* Pilg.	Jema	CR B1ab(iv,v);D1	NE
Anacardiaceae	*Lannea acida* A.Rich	Faru	VU B1abc (i,ii,iii,iv,v);D2	NE
Anacardiaceae	*Sclerocarya birrea* (A.Rich.) Hochst.	Danya	EN C2 b, D&E	NE
Annonaceae	*Annona senegalensis* Pers.	Gwandar daji	EN Aide; C2a(i)	NE
Apocynaceae	*Caralluma dalzielii* N.E.Br.	Karan masallaci	EN B1ab (i,ii,v)	NE
Apocynaceae	*Pergularia tomentosa* L.	Fatakka	VU B2ab(iv,v);D2	NE
Apocynceae	*Adenium obesum* (Forssk.) Roem. & Schult.	Karya	EN D	NE
Araceae	*Anchomanes difformis* (Blume) Engl.	Hantsar gada	VU D2	NE
Araceae	*Stylochiton lancifolius* Kolchy & Peyr.	Kunnen Jakki	VU B2ab(iv,v);D2	NE
Arecaceae	*Phoenix dactylifera* L.	Dabino	VU B1ab(i,ii,iv,v);D2	NE
Arecaceae	*Hyphaene thebaica* (L.) Mart.	Goruba	VU D2	LC
Aristolochiaceae	*Aristolochia albida* Duch.	Duman dutsi	VU B1a	NE
Asteraceae	*Acanthospermum hispidum* DC.	Yawo	VUA1 a,b	NE
Asteraceae	*Artemisia annua* L.	Tazargade	VU	NE
Asteraceae	*Baccharoides adoensis* (Sch. Bip. ex Walp.) H.Rob.	Dumashi	VUA2 c,d	NE
Asteraceae	*Centaurea acarnanica* (Matthäs) Greuter	Dayi	VUA2 c,d	NE
Asteraceae	*Centaurea perrottetii* DC.	Surandi	VU B1ab (i,ii,iv,v)	NE
Asteraceae	*Vernonia amygdalina* Delile	Shuwaka	EN B1 b(iii)	NE
Asteraceae	*Vernonia kotschyana* (Sch.Bip. ex Walp.)	Kumbura fage	VU B1ab(iv,v);D2	NE
Bignoniaceae	*Stereospermum kunthianum* Cham.	Sansami	VUA2 c,d	NE
Bombacaceae	*Bombax brevicuspe* Sprague	Kurya	CR A1 b, B2 a &C2 b	VU A1cd
Boraginaceae	*Cordia africana* Lam.	Alilliba	CR B12b (i,ii,iii,iv,v)	NE
Brassicaceae	*Lepidium sativum* L.	Zamantarori	VU B1ab(iv,v);D2	NE
Burseraceae	*Boswellia dalzielii* Hutch.	Hano	CR B1ab (i,ii,iii) + 2ab (i,ii,iii,iv)	NE
Burseraceae	*Commiphora kerstingii* Engl.	Baazana	ENA2 d,e &E	NE
Burseraceae	*Commiphora hildebrandtii* (Engl.) Engl.	Dashi	EN B1ab (i,ii,iii); 2ac(ii)	NE
Cannabaceae	*Celtis toka* (Forssk.) Hepper & J.R.I.Wood	Zuwu	CR B1ab (iii,iv,v)	NE
Capparaceae	*Boscia salicifolia* Oliv.	Zure	CR B2ab (i,iv,v)	NE
Capparaceae	*Cadaba farinosa* Forssk.	Bagai	CR B1a + 2ab (ii,iv,v)	NE
Capparaceae	*Crateva adansonii* DC.	Ungududu	CR B12b (i,ii,iii,iv,v)	NE
Chrysobalanaceae	*Neocarya macrophylla* (Sabine) Prance ex F.White	Gawasa	EN B1ab(i,ii,iv,v)	NE
Cochlospermaceae	*Cochlospermum tinctorium* Perr. ex A.Rich.	Rawaya	EN B1ab (i,iii,iv,v); 2ab(i,ii,iii,iv,v)	NE
Combretaceae	*Anogeissus leiocarpa* (DC.) Guill. & Perr.	Marke	EN C2b; D.	NE
Combretaceae	*Combretum glutinosum* Perr. ex DC.	Tarauniya	CR B2ab (i,ii,v)	NE
Combretaceae	*Combretum micranthum* G.Don	Geza	VU D2	NE
Combretaceae	*Combretum molle* R.Br. ex G.Don	Gogen Damo	VU B1ab (i,iii,v); D2	NE
Combretaceae	*Guiera senegalensis* J.F.Gmel.	Sabara	VUA1 d,e	NE
Combretaceae	*Terminalia avicennioides Guill. & Perr.*	Baushe	CR B1ab (iv, v); D1	NE
Connaraceae	*Rourea coccinea* (Schumach. & Thonn.) Benth.	Tsamiyar kasa	VUB2 b(i,ii,iii)	NE
Cucurbitaceae	*Momordica balsamina* L.	Garahuni	VU A1abcde;D2	NE
Dioscoreaceae	*Dioscorea bulbifera* L.	Tuwon biri	EN B1ab (iii,iv,v)	NE
Ebenaceae	*Diospyros mespiliformis* Hochst. ex A.DC.	Kanya	CR B1 b(i) &C2 b	NE
Euphorbiaceae	*Chrozophora senegalensis* (Lam.) A.Juss. ex Spreng.	Damaigi	VU B1ab (i,ii,iii,iv,v)	NE
Euphorbiaceae	*Euphorbia poissonii* Pax.	Tunya	CR D1	NE
Fabaceae	*Ptercarpus erinaceus* Poir.	Madobiya	VUA1 b,e	NE
Fabaceae	*Senegalia ataxacantha* (DC.) Kyalangaliwa & Boatwr.	Sarkakiya	VU D2	NE
Fabaceae	*Vachellia nilotica* (L.) P.J.Hurter & Mabb.	Bagaruwa	EN A1cde	NE
Fabaceae	*Senegalia senegal* (L.) Britton	Dakwara	VUA2 c,d	NE
Fabaceae	*Albizia chevalieri* Harms.	Katsari	VU D2	NE
Fabaceae	*Bauhinia rufescens* Lam.	Tsatstsagi	EN A2cde	NE
Fabaceae	*Cassia arereh* Delile	Malga	VU C2a(i)	NE
Fabaceae	*Chamaecrista mimosoides* (L.) Greene	Bagaruwar kasa	EN B2ab (i,ii,iv,v)	NE
Fabaceae	*Detarium microcarpum* Harms.	Taura	CR B1ab (i,ii,iii,iv,v)+2ab (i,ii,iii)	LC
Fabaceae	*Entada africana* Guill. & Perr.	Tawatsa	CR B1ab(iv,v);D1	NE
Fabaceae	*Erythrina senegalensis* DC.	Minjirya	CR A2 c &B1 b(v)	LC
Fabaceae	*Faidherbia albida* (Delile) A.Chev.	Gawo	VUA2 c,d	NE
Fabaceae	*Xeroderris stuhlmannii* (Taub.) Mendonca & Sousa	Jina jina	EX	NE
Fabaceae	*Parkia biglobosa* (Jacq.) G.Don	Dorawa	VUA1 b,e	NE

Table 4 continues on the next page →

TABLE 4 (Continues...): Taxa threatened with local extinction in Katsina, assessed according to the International Union for the Conservation of Nature categories and criteria version 3.1.

Family	Species	Local name	Local assessment	Global assessment
Fabaceae	*Prosopis africana* (Guill & Perr.) Taub.	Kirya	CR B1ab(iv,v);D1	NE
Fabaceae	*Sesbania dalzielii* E.Phillips & Hutch.	Kalumbo	CR A2acd;B1ab(iii)	NE
Fabaceae	*Stylosanthes erecta* P.Beauv.	Fasafako	VU D2	NE
Fabaceae	*Tamarindus indica* L.	Tsamiya	ENA2 b,c & B2 c(i)	NE
Fabaceae	*Isoberlinia doka* Craib & Stapf	Doka	VU B1ab(i,iv,v);D2	LC
Fabaceae	*Burkea africana* Hook.	Bakin makarfo	CR B1ab (iv,v);D1	NE
Guttiferae	*Harungana madagascariensis* Lam. ex Poir.	Alillibar rafi	CR B1ab(iv,v);D1	NE
Lamiaceae	*Vitex doniana* Sweet	Dinya	VU D2	NE
Loganiaceae	*Strychnos spinosa* Lam.	Kokiya	EN B2ab(i,ii,iv,v);D1	NE
Lythraceae	*Lawsonia inermis* L.	Lalle	EN B1ab(iv,v); D2	NE
Malvaceae	*Adansonia digitata* L.	Kuka	VU D2	NE
Malvaceae	*Ceiba pentandra* (L.) Gaertn.	Rimi	CRA1 d & B1 a,b(i,v) D,E	NE
Malvaceae	*Gossypium barbadense* L.	Kada 'yarkarfi	VU B1ab (i,ii,iv,v);D2	NE
Malvaceae	*Pavonia hirsuta* Cav.	Zamarke	EN A2acde;B1ab(iv,v)	NE
Malvaceae	*Pavonia senegalensis* (Cav.) Leistner	Tsu	CR A2abcd;C1+2a(i,ii)	NE
Malvaceae	*Sterculia setigera* Delile	Kukkuki	CR B1ab (iv,v);D1	NE
Malvaceae	*Grewia mollis* Juss.	Dargaza	VU B1ab(v);D2	NE
Meliaceae	*Khaya senegalensis* (Desv.) A.Juss.	Madacci	VU D2	VU A1cd
Moraceae	*Ficus trichopoda* Baker	Baure	CR A3 b &B1(v)	NE
Moraceae	*Ficus ingens* (Miq.) Miq.	Kawuri	CR A3 b &B1(v)	NE
Moraceae	*Ficus platyphylla* Delile	Gamji	ENA2 a	NE
Moraceae	*Ficus sur* Forssk.	Uwar yara	CR A3b	NE
Moraceae	*Ficus umbellata* Vahl.	Yandi	CR A3b	NE
Moraceae	*Ficus vallis-choudae* Delile	Lubiya	CR B2ab (i, v);D1	NE
Moraceae	*Ficus thonningii* Blume	Cediya	VUA3 d	NE
Nymphaeaceae	*Nymphaea lotus* L.	Bado	VU B2ab(i,ii,iv,v);D2	NE
Olacaceae	*Ximenia americana* L.	Tsada	CR B1ab(i,ii,iv,v);D1	NE
Onagraceae	*Ludwigia octovalvis* (Jacq.) P.H.Raven	Shashatau	CR B1ab (i,ii,iii)+2ab (i,ii,iii)	NE
Opiliaceae	*Opilia amentacea* Roxb.	Rugaggada	EN A3c;B1ab(i,ii,iii,iv)	NE
Orobanchaceae	*Striga hermonthica* (Delile) Benth.	Gogai	VU B2ab(i,ii,v);D2	NE
Papaveraceae	*Argemone mexicana* L.	Kankamarka ta bika	VU D2	NE
Phyllanthaceae	*Bridelia ferruginea* Benth.	Kirni	CR A2 b,c,d,e&B1 a	NE
Plantagineaceae	*Scoparia dulcis* L.	Ruma fada	VU B2ab(i,v);D2	NE
Poaceae	*Dactyloctenium aegyptium* (L.) Willd.	Guda gude	VU A2acd;D2	NE
Poaceae	*Eleusine indica* (L.) Gaertn.	Tuji	VU B1ab (iv,v);D2	LC
Polygalaceae	*Securidaca longipedunculata* Fresen.	Sanya	CR B1ab(i,ii,iv,v);D1	NE
Rhamnaceae	*Ziziphus jujuba* Mill.	Magarya	CRA2 c,d &B2 b(v)	LC
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	Kurna	ENA2 d, B1 b(i)	NE
Rubiaceae	*Gardenia aqualla* Stapf & Hutch.	Gaude	CR B1ab (iv, v); D1	NE
Rutaceae	*Citrus aurantiifolia* (Christm.) Swingle	Lemun tsami	EN A2 d,e &E	NE
Sapotaceae	*Vitellaria paradoxa* C.F.Gaertn.	Kadanya	CRA3 c &B1 b(i)	VU A1cd
Solanaceae	*Datura metel* L.	Zakami	VU D2	NE
Vitaceae	*Ampelocissus africana* (Lour.) Merr.	Farun makiyaya	CR B12b (i,ii,iii,iv,v)	NE
Vitaceae	*Cissus populnea* Guill & Perr.	Loda	EN B2ab (iii,v)	NE
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	Aduwa	EN A1 b,c,d &B1 c(i)	NE

Note: The table lists 108 taxa that are either EX or are threatened with extinction. One taxon qualifies as EX, 36 as CR, 25 as EN and 46 as VU (see also Figure 2).
EX, Extinct; NE, No entry; CR, Critically Endangered; EN, Endangered; VU, Vulnerable.

(12.03%) each; impact of invasives 11 (10.2%); urban residential development 8 (7.40%); soil erosion 6 (5.55%); grazing, habitat loss and timber with 5 (4.6%) taxa each, respectively (Figure 4).

Discussion

One of the objectives of this study was to undertake an ethnobotanical survey of medicinal and economic plant diversity used in the treatment of various common ailments by the people of Katsina. The socio-demographic information showed that most of the respondents of the questionnaire dealing with ethnobotanical knowledge of the medicinal plants are males. This may not be unconnected to the fact that men are more engaged in outdoor activities such as farming, hunting and marketing and is also reflective of the religious and cultural setup of the people of northern Nigeria. Results also showed that most of the respondents lack formal education as already recorded by other studies around Katsina (e.g. Kankara et al. 2015; Mudansiru et al. 2016). This may affect negatively the traditional medicinal practices of knowledge sharing and dissemination, which prevents it from being lost. It was discovered during this study that most of the respondents were unwilling to share their ethnobotanical knowledge for fear of losing their inherited biological and genetic resources (see Etkin 2002). This has

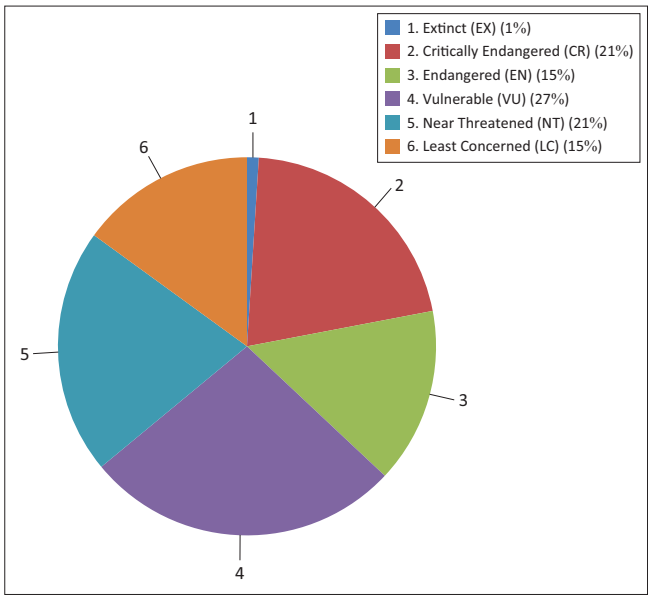


FIGURE 2: Percentage of threat category affecting the various medicinal and economic plants that occur in Katsina State, northwestern Nigeria.

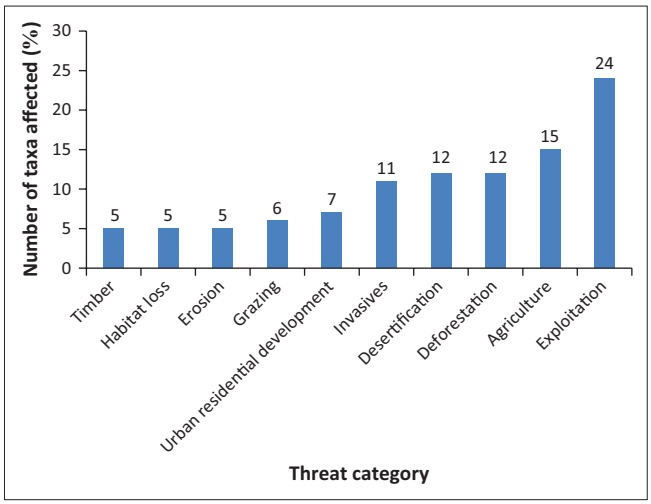


FIGURE 3: Various categories of threats faced by the plants and the number of taxa affected in each of the threat categories.

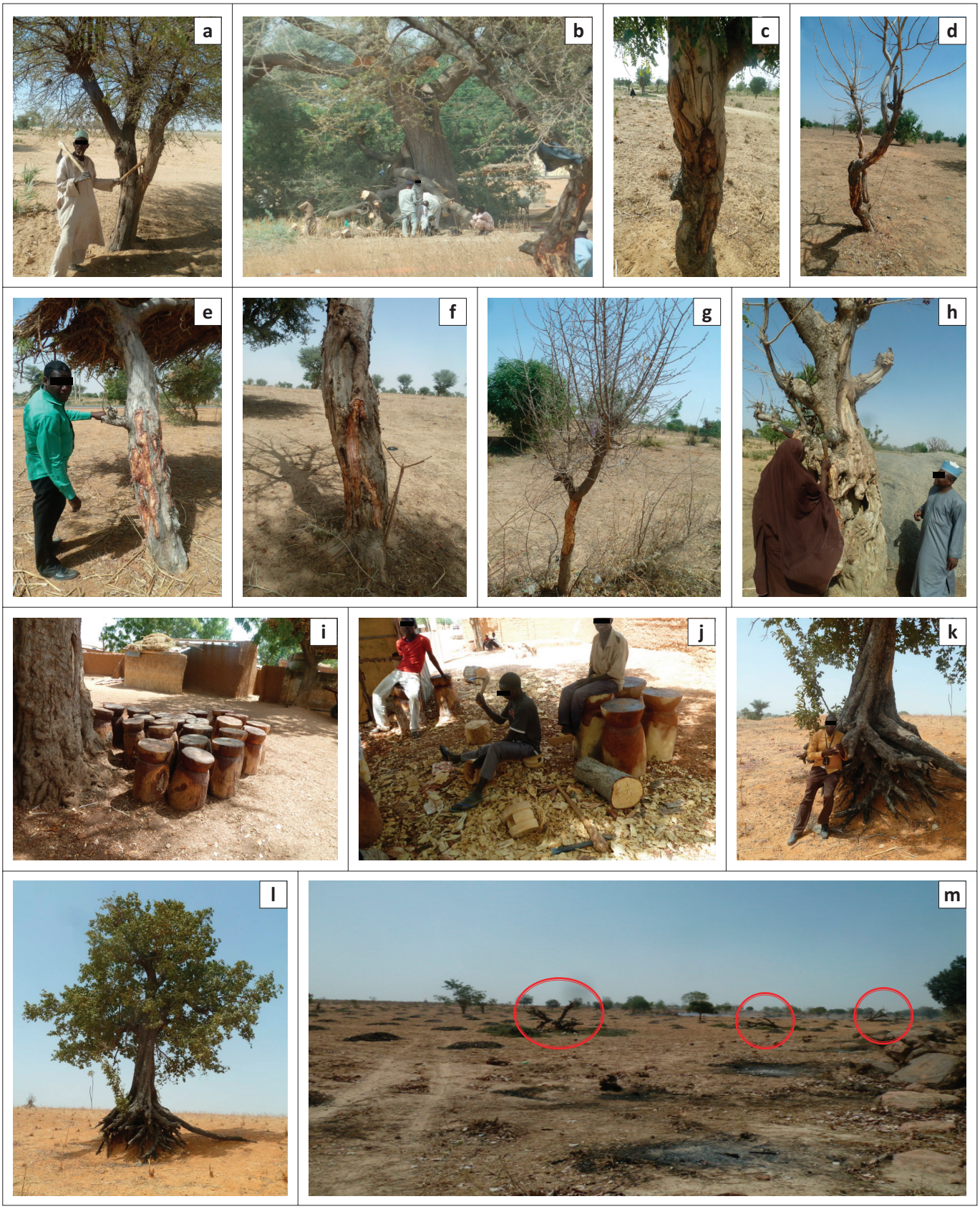
elevated the need to embrace more proactive strides in the preservation and utilisation of this knowledge. However, the idea is not adequately understood by the local inhabitants as the majority of the older population who possess knowledge and information on the use and conservation of most of these medicinal plants are gradually declining in number without adequate documentation of their knowledge (Garba et al. 2014; Ekor 2013; Etkin 2002; Muul 1993).

Our ethnobotanical survey showed that Fabaceae has the highest record of 15 species of medicinal plants. This agrees with the findings of Kankara et al. (2015) in which the Fabaceae was recorded as the dominant family used in the treatment of various illnesses associated with maternal healthcare in Katsina State, Nigeria. This high occurrence of Fabaceae could be attributed to the fact that most of the species used for medicinal purposes belong to the Caesalpiniodeae and Mimosoideae clades, which are dominant in the tropical regions and therefore could survive the adverse effects of environmental changes in Savanna vegetation. Several other studies have also reported Fabaceae as the dominant family providing medicinal plants in Nigeria (Dambatta & Aliyu 2011; El-Ghani 2016; Ene & Atawodi 2012; Mudansiru et al. 2016).

A second objective of this study was to provide a conservation assessment of medicinal and economic plants found in the study area using the criteria and categories set up by the IUCN. Our results showed that more than half of the taxa studied (108) are threatened with extinction. This is alarming considering that most of the plants belonging to these groups are slow-growing native species that take several years before they reach maturity (Cunningham 1993). For example, while the cultivation of alternative sources of supply of popular, high conservation priority species has been proposed as one of the key solutions to the sustainable conservation management of the slow-growing or slow-reproducing species, commercial cultivation of such species is not an easy solution and at present is unlikely to be profitable because of the slow growth rates for most tree species and low prices paid for traditional medicines (Cunningham 1993). A good example of this limitation is the 60-year-old trial plot for *Pterocarpus angolensis* (Fabaceae) on the Mozambique coastal plain where growth on nutrient poor sands has been very slow (Cunningham 1993).

The Sudan Savanna vegetation is known to be characterised by the presence of sparsely scattered trees growing in patches. These trees (used as firewood) are by far the people's most important source of energy, accounting for more than 90% of the energy used in the region. It is known that the disappearance of trees dispossesses the land of its ability to retain water (FAO 2011). This may eventually lead to other detrimental effects such as drought, desertification leading to excessive erosion and the depletion of surface and groundwater (Smith 2000). With a loss of the natural vegetation, people are not only losing a valuable medicinal resource, but also the possibility of discovering new medicines (Aronson et al. 2010; Chukwuma et al. 2015). It has been reported that more than 80% of people in developing countries still rely on traditional medicines, which are largely sourced from plants (Etkin 2002; WHO 2001). By destroying these plants, rural people will lose access to their main supply of medicines. It is unfortunate that the level of understanding about these issues is at such a basic level in Nigeria, even at the very highest levels of government (Etkin 2002; Garba, Ajibade & Appah 2014). Cunningham (1993) suggests that the conservation strategy for African medicinal plants must address the problem at two levels: recommendations which have socio-economic effects must be incorporated at the policy level and recommendations for conservation methodology must be addressed at the national and local levels. The recommendations cover the following areas: (1) international and national policy; (2) *in-situ* and *ex-situ* conservation methods; and (3) education and research.

Our results showed that out of the 169 taxa evaluated, only 12 had been evaluated globally. The majority of the plants were not recorded in the IUCN Red List database.



Source: Photos courtesy of A. Bello

FIGURE 4: Various categories of threat affecting the medicinal and economic plants in the Sudan Savanna vegetation zone: (a) Exploitation in *Vachellia nilotica*. (b) Exploitation in *Faidherbia albida*. (c) Exploitation in *Sclerocarya birrea*. (d) Exploitation in *Lannea acida*. (e) Exploitation in *Anogeissus leiocarpa*. (f) Exploitation in *Annona senegalensis*. (g) Exploitation in *Entada africana*. (h) Exploitation in *Lannea acida*. (i) Exploitation of *Prosopis africana* wood used for making mortar and pestle (j) and local stool making. (k-l) Roots of *Diospyros mespiliformis* exposed by erosion. (m) Exploitation and deforestation on *Parkia biglobosa*. (n) Neem (*Azadirachta indica*) invasion (o) competing with legume *Bauhinia thonningii* (twisting), (p)-(x) neem growing with legume *Faidherbia albida* and (y) neem growing with *Annona senegalensis*. (z), (aa), (bb) and (cc) Trunk of *Diospyros mespiliformis* used for timber making (dd) cattle grazing.

Figure 4 continues on the next page →

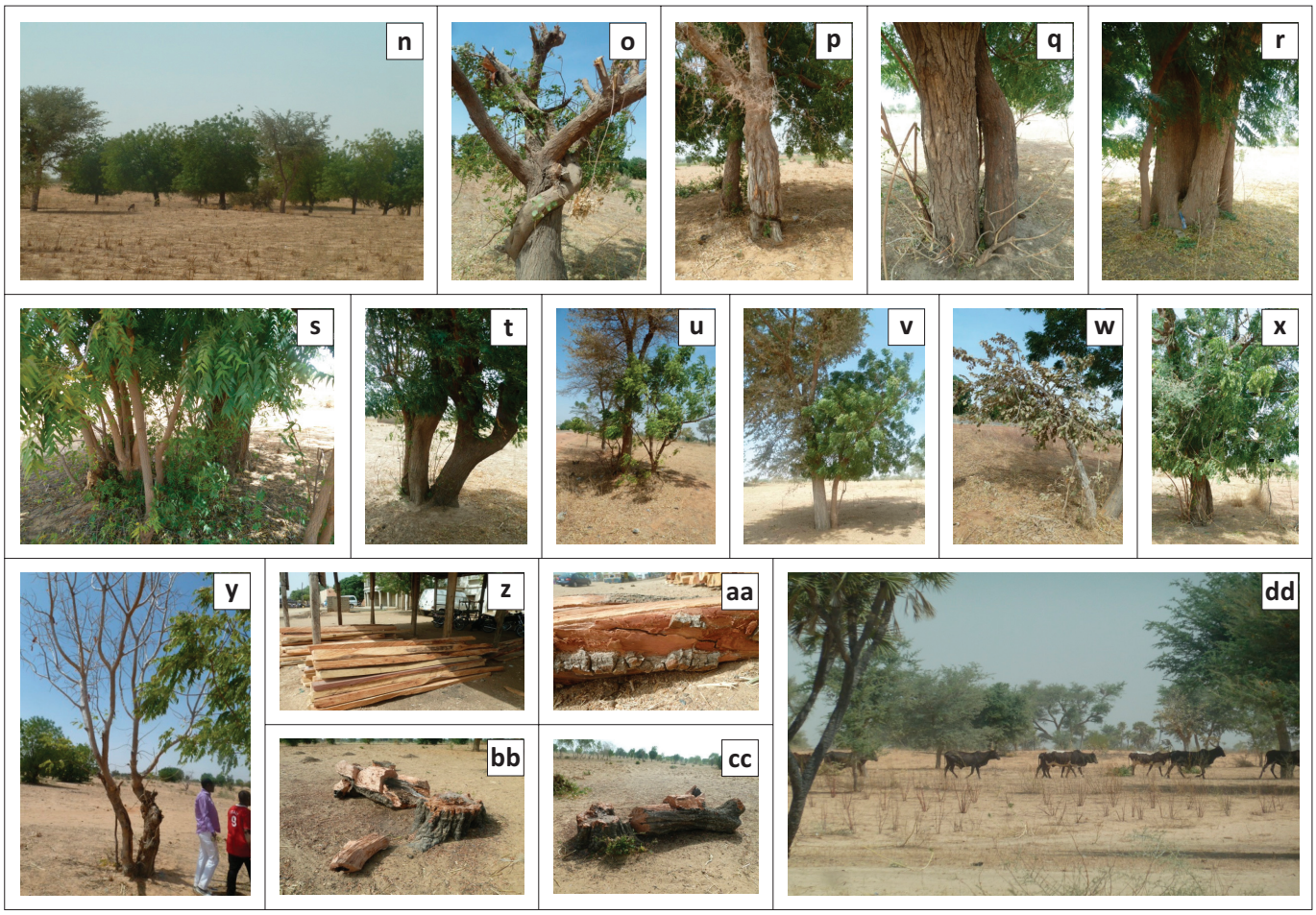
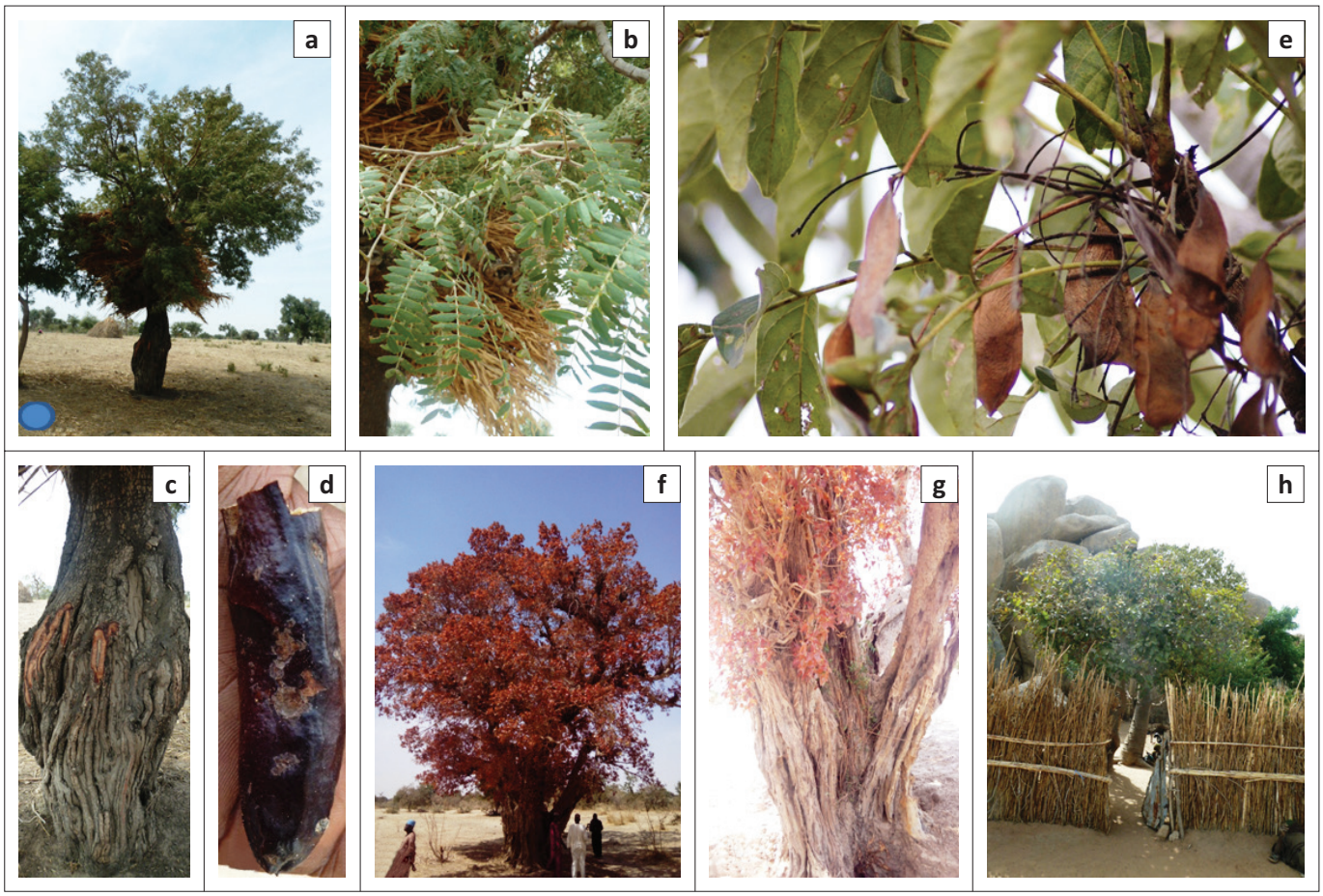


FIGURE 4 (Continues...): Various categories of threat affecting the medicinal and economic plants in the Sudan Savanna vegetation zone: (a) Exploitation in *Vachellia nilotica*. (b) Exploitation in *Faidherbia albida*. (c) Exploitation in *Sclerocarya birrea*. (d) Exploitation in *Lannea acida*. (e) Exploitation in *Anogeissus leiocarpa*. (f) Exploitation in *Annona senegalensis*. (g) Exploitation in *Entada africana*. (h) Exploitation in *Lannea acida*. (i) Exploitation of *Prosopis africana* wood used for making mortar and pestle (j) and local stool making. (k-l) Roots of *Diospyros mespiliformis* exposed by erosion. (m) Exploitation and deforestation on *Parkia biglobosa*. (n) Neem (*Azadirachta indica*) invasion (o) competing with legume *Bauhinia thonningii* (twisting), (p)-(x) neem growing with legume *Faidherbia albida* and (y) neem growing with *Annona senegalensis*. (z), (aa), (bb) and (cc) Trunk of *Diospyros mespiliformis* used for timber making (dd) cattle grazing.

This implies that the majority of species are either endemic to the Sudan Savanna vegetation zone or have never been evaluated. This vegetation type is usually neglected by the scientific community because of either a lack of abundant biodiversity or the harsh environmental conditions (Etkin 2002). The species are therefore prone to localised or global extinction stochastic effects. Some of the most important plant species observed were represented by only one individual throughout the region and include *Prosopis africana* listed as EN (Figures 5a–d) and *Ficus ingens* listed as CR (Figures 5f and g). *Prosopis africana* is prized for its very strong red wood that is used for making mortar and pestle, as a charcoal used by the local blacksmiths, and for cooking. It is also used in making Islamic writing boards, chairs and other household accessories. It is being observed that the wood of *P. africana* is resistant to destruction by termites, which are known as major pests of woods. The only surviving individual of *P. africana* is found in the Baure Local Government Area although there is an unconfirmed report of its existence in the Kankia Local Government Area. The stem and the roots of *F. ingens* are known to be used for many ethnobotanical purposes. This might be the reason for the demise of most of the individuals. The only *F. ingens* individual found in Baure Local Government Area, estimated to have survived for about a century, has had its stem severely damaged and the roots have been dug out extensively (see Figures 5f and g). Through this research, we are currently making some efforts to protect these remaining individuals through the adoption of the key sites of conservation concern and working with landowners to conserve the remaining threatened species.

We found one plant accessed as Extinct in this region. The plant *Xeroderris stuhlmannii* is a papilionoid legume in the family Fabaceae (Figure 5e). It is a deciduous tree of the Savanna woodland growing up to 12 m – 15 m high. Its bark separates into thick scales and the trunk is known to exude blood-red sap when cut. Its white hysteranthous flowers are aggregated in grey- or rusty-tomentose panicles (Hutchinson & Dalziel 1927). This plant is endemic to Savanna vegetation. The bark is purgative. It is used in traditional medicine to treat coughs, colds, rheumatic arthritis, stomach ache, dysentery, eye infections and wounds. Its roots are anti-helminthic. When applied externally, a root decoction is very active against ringworm. A decoction of the bark is used as a treatment for internal parasites, elephantiasis, gonorrhoea,



Source: Photos courtesy of A. Bello

FIGURE 5: Trees in which either none or only one last individual is found in the study area: (a) *Prosopis africana* tree. (b) Leaves of *Prosopis africana*. (c) Damaged stem of *Prosopis africana*. (d) Fruit of *Prosopis africana*. (e) *Xeroderris stuhlmannii*. (f) *Ficus ingens*. (g) Damaged stem bark of *Ficus ingens*. (h) *Detarium microcarpum*.

syphilis, dysmenorrhoea, chest pains and urinary complaints. Similarly, the pounded roots are applied to sores. This root usage might probably be a contributing factor to its disappearance because it is one of the slow-growing species. The leaves of *X. stuhlmannii* are used in the treatment of colds, coughs, wounds, stomach problems, amenorrhoea and malaria fever (Fern 2014).

This study found that the main reasons for the decline of these important medicinal and economic plants include overexploitation, agriculture, deforestation, desertification, alien invasives and the indiscriminate felling of trees for firewood, charcoal making and timber for construction and the making of utensils. These reasons have been reported several times as major threats to plants diversity and distribution (Allen et al. 2014; Dold & Cocks 2002; Victor & Dold 2003; Williams, Victor & Crouch 2013). In Katsina, the most serious threat faced by plant taxa at risk of extinction now appears to be an overexploitation for medicinal purposes. Overexploitation has been a serious threat to medicinal plants for a long time. Plants mostly affected include mahogany (*Khaya senegalensis* (Desv.) A.Juss), African grape (*Lannea acida* A.Rich.), frankincense tree (*Boswellia dalzielii* Hutch.) and katsari (*Albizia chevalieri* Harms). There has been a significant decline in these species in particular. These plants are now being exploited commercially. This is a new potential threat, which has not yet received the attention it deserves. Possible solutions for overcoming the problem of overexploitation, apart from public education, are the establishment of *ex-situ* cultivation programmes to satisfy the commercial demand for these species and the enforcement of laws against indiscriminate felling of trees (Victor & Dold 2003; Zizka et al. 2015). The new bill to regulate the trafficking of endangered species in Nigeria, which has been assented by the Nigerian President, is to bring the penalty provisions in line with economic realities and to act as a deterrent or deter people from trafficking and trading in endangered species. The act aims to discourage trafficking in endangered species and will encourage a culture of the preservation of endangered species.

Agriculture has recently created the most severe threat to species survival (Victor & Dold 2003). This is not surprising because farmers in these communities often resort to burning large tracts of vegetation to clear land for crops. There is also a recent trend of felling trees for timber production. Trees mostly affected are the jackal berry (*Diospyros mespiliformis* Hochst. ex A.DC.; assessed as CR, see Figures 4z, 4aa, 4cc and 4dd) and *Faidherbia albida* (Delile) A.Chev. (assessed as VU). These plants are slow growing and take a long time to achieve maturity. Unless appropriate measures are taken to conserve them, these plants will likely disappear before 2020

because of the rate at which they are being exploited, the year set aside by the Convention on Biological Diversity (CBD) to prevent the extinction of the known threatened plants (CBD 2011).

Of more immediate concern is the threat posed by alien species in this region, particularly from the neem tree (*Azadirachta indica* A.Juss.) and eucalypts (*Eucalyptus camaldulensis* Dehnh.) (see Figure 4n-x). A research study to check the menace of these alien species is currently underway by our research group. It has been observed in the field that neem tree grows attached to the roots of local plants, competing for nutrients and water. It could be that neem is stressing these native trees, leading to an earlier death. It has been reported that neem is allelopathic (Bello et al. 2010; Judd 2004), has a detrimental effect on many types of plants and is known to be a strong competitor. However, there is considerable empirical evidence that the neem tree has numerous positive medicinal benefits for local people elsewhere in West Africa and India and that if more information was made locally available as to their use and preparation, they could take off pressure of local medicinal species (Bello et al. 2010; Judd 2004). This will be considered a part of our further studies.

The information presented here underpins the importance and urgency for the Nigerian government and other conservation agencies to develop regionally appropriate conservation methods and strategies to minimise the main threats identified here and therefore reduce the risk of extinction of the threatened taxa identified. This aim is in accordance with the CBD's Target 12: 'By 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained' (CBD 2010). This will ensure that the plants in the NT category are prevented from becoming threatened and will also enhance the securing of knowledge on data deficient taxa.

Conclusion

The results of this study have identified the most important economic and medicinal plants of the Sudan Savanna in Katsina State, northwestern Nigeria. The medicinal use of 43 plants species belonging to 20 different families was recorded. This showed that Savanna is naturally endowed with a diversity of important medicinal plants. It is critical therefore to promote their conservation and sustainable utilisation if they are not to disappear. We have also provided a conservation assessment of the plants based on the criteria developed by the IUCN. Most of the plants are already under threat and require conservation measures. Unfortunately, most of the people of the region seem to be unaware of the great threat facing medicinal plants in the wild as well as their own livelihoods. The data point to the critical need for better public education on these issues plus further research into conservation strategies and sustainable use of threatened plants and into better management of the useable exotic species identified in the region. The main current threats observed were because of human activities including overexploitation (for medicine), agriculture (other than livestock), deforestation, indiscriminate felling of trees for firewood and timber, and alien invasion.

Based on the findings of this study, our research supports and reiterates the following recommendations (see Gundu & Adia 2014):

- The Nigerian government at all levels (federal, state and local) should consider implementing the two main methods of conserving biodiversity including *ex-situ* and *in-situ* conservation methods. Other methods of species conservation, such as natural regeneration and planting of indigenous plants, should be given priority through incentives and provision of nursery materials to rural people and resource users as they are adaptive and cost-effective.
- All sectors (governments and None Governmental Organisations [NGOs], as well as community-based initiatives) must ensure an integrated approach to tree multiplication and propagation of the local trees through policies and programmes and enlightenment campaigns. This is because universal education is key to biodiversity conservation.
- Researchers should undertake further research on Threatened and Near Threatened medicinal plants species and ensure the adequate identification and management of their critical habitats to inform conservation programmes and identify gaps in conservation actions.
- Threatened plants should be reassessed at least every five years and whenever new information becomes available.
- The government should enforce laws and regulations to protect endangered species. The plant part substitution method of plant conservation should be adopted, that is, the leaves and fruit of plant should be used instead of the root or bark, the use of which may lead to complete loss of the species.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

A.B. was the project leader. A.B., S.J., M.T.E., S.S.Y., S.S.K. and N.H.W. did the fieldwork. A.B., C.H.S. and M.M. analysed the data and wrote the manuscript.

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Appendices starts on the next page →

Appendix 1

Questionnaire for obtaining information on medicinal plants and their mode of administration.

Informants' consent for the participation in the study:

I _____ (name of informant) hereby give my full consent and conscious to participate in this study and declare that to the best of my knowledge, the information that I have provided are true, accurate and complete.

Date_____ (Signature/Thumb impression of Informant)

Informants' details:

Name_____

Gender _____

Age _____

Occupation _____

Education_____

Location/Residence _____

Data about medicinal plant and its use:

Plant (Local name) _____

Habit (Tree/ Herb/ Shrub/Climber/_____)

Plant part used _____

Cultivated/ Wild_____

If cultivated, cultivated for _____

If wild, availability in natural resources (easy/ difficulty/ very difficult)

Conservation needs _____

Conservation efforts made by Government and local residents_____

Method of collection and storage _____

Name of disease(s) treated _____

Method of crude drug preparation _____

Mode of administration _____

Dosage _____

Other uses (if any _____

Remarks:

Plant identified as _____ (Botanical name and family)

Information provided by informants will be used for research purposes only

Signature of Researcher

Appendix 2

Conservation data collection and assessment form

DEPARTMENT OF BIOLOGY, FACULTY OF NATURAL AND APPLIED SCIENCES,
UMARU MUSA YARADUA UNIVERSITY, KATSINA, NIGERIA
APPENDIX 2
SPECIES COLLECTION/ASSESSMENT FORM

Observer & Locality (* Compulsory fields)

Collectior _____ **Date** _____

POPULATION INFORMATION (Compulsory fields)

No. Individuals in population _____

Estimated No. of Individuals
- ☐ 1–10
- ☐ 10–50
- ☐ 50–100
- ☐ 100–250
- ☐ 250–500
- ☐ 500–1000
- ☐ >1000

Description of locality

Distr. of plant
- ☐ Even
- ☐ Variable
- ☐ Clumped

Area of extent _____ x _____ m **Dist.To next pop.** _____ km

Species _____

Population composition:
☐ Adults ☐ Juvenile ☐ Seedlings ☐ Dead Individuals

Dimensions of the population

Corner 1*	N		E		Aittude
Corner 2*	N		E		Aittude
Corner 3*	N		E		Aittude
Corner 4*	N		E		Aittude

HABITAT

Landform:
- ☐ Mountain Peak
- ☐ Mountain Slope
- ☐ Hiltop
- ☐ Shiblope
- ☐ Ciff face
- ☐ Flat/plain
- ☐ Reverine
- ☐ Wetland/marsh ☐
- Other _____

Soil type:
- ☐ Sand
- ☐ Loam
- ☐ Clay
- ☐ Peat
- ☐ Gravel
- ☐ Rocky

Geology
- ☐ Conglomerate
- ☐ Sandstone
- ☐ Shale
- ☐ Limstone
- ☐ Dolomite
- ☐ Granit
- ☐ Quarzite
- ☐ Silcrete
- ☐ Other ☐

_____

Slope:
- ☐ Gentel
- ☐ Steep
- ☐ Flat
- ☐ Variable

Aspect: N

THREATS & DISTURBANCES*

Code	Part	Future	RATING

Present

Aliens:
- ☐ Neem
- ☐ Eucalypes
- ☐ Pints
- ☐ Grasses
- ☐ Other _____

Aliens density:
- ☐ Scattered
- ☐ Abondant
- ☐ Dense
- ☐ Imoenetrable

_____

Notes

Land use:
- ☐ Crops ☐ Urban ☐ Conservation
- ☐ Game ☐ Industry ☐ Plantations
- ☐ Mining ☐ Orchards ☐ Recreational
- ☐ Stock ☐ Poultry ☐ Other

Ownership
- ☐ Private
- ☐ Communal
- ☐ State
- ☐ Other

Note and Sketches

Rating - Degree of Impact

1. Very low 2. Low 3. medium
4. High 5. Very High

THREATA & DISTURBANCES

1. Habitat loss degradation
- A Agriculture
- B Plantations
- C Uvestock
- D Abordonment
- E Mining
- F Timber harvesting
- G Groundwater estractions
- H Urbanization
- I Roady/Railways
- J Power Lines
- K Dams
- L Telecommunications
- M Tourism/Recreation
- N Aliens
- O Too Frequent fines
- P Too Irregular fines
- Q Wrong season fines

2. **Alens (Effect to Species)**
- A Competors
- B Hybridusers

3. Harvesting
- A Food
- B Medicine
- C Fuel
- D Materials
- E Morticultural
- F Cultural/Leisure

4. Pollution
- A Agricultural
- B Commercial
- C Water Pollution

5. Change in Native Species Dynamics
- A Pollinatons
- B Dixpersing Agents

6. Climate Change
- A Evidence of drought related death

Appendix 3

International Union for the Conservation of Nature assessment categories and criteria.

SUMMARY OF THE FIVE CRITERIA (A-E) USED TO EVALUATE IF A TAXON BELONGS IN AN IUCN RED LIST THREATENED CATEGORY (CRITICALLY ENDANGERED, ENDANGERED OR VULNERABLE).[1]

A. Population size reduction. Population reduction (measured over the longer of 10 years or 3 generations) based on any of A1 to A4

	Critically Endangered	Endangered	Vulnerable
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3 & A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred, or suspected in the past where the causes of the reduction are clearly reversible AND understood AND have ceased.

A2 Population reduction observed, estimated, inferred, or suspected in the past where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction projected, inferred or suspected to be met in the future (up to a maximum of 100 years) *[(a) cannot be used for A3]*.

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of the following:

- **(a)** direct observation *[except A3]*
- **(b)** an index of abundance appropriate to the taxon
- **(c)** a decline in area of occupancy (AOO), extent of occurrence (EOO) and/or habitat quality
- **(d)** actual or potential levels of exploitation
- **(e)** effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)

	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals			

C. Small population size and decline

	Critically Endangered	Endangered	Vulnerable
Number of mature individuals	< 250	< 2,500	< 10,000
AND at least one of C1 or C2			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future):	25% in 3 years or 1 generation (whichever is longer)	20% in 5 years or 2 generations (whichever is longer)	10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(ii) % of mature individuals in one subpopulation =	90–100%	95–100%	100%
(b) Extreme fluctuations in the number of mature individuals			

D. Very small or restricted population

	Critically Endangered	Endangered	Vulnerable
D. Number of mature individuals	< 50	< 250	**D1.** < 1,000
D2. *Only applies to the VU category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	-	-	**D2.** typically: AOO < 20 km² or number of locations ≤ 5

E. Quantitative Analysis

	Critically Endangered	Endangered	Vulnerable
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

1 Use of this summary sheet requires full understanding of the *IUCN Red List Categories and Criteria* and *Guidelines for Using the IUCN Red List Categories and Criteria*. Please refer to both documents for explanations of terms and concepts used here.