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Ecological Footprints of Prioritised Medicinal Plants in Some Selected Land Use Types (Lut) of Sokoto Metropolis, Sokoto State, Nigeria

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Abstract

This study examined the ecological footprints of prioritised medicinal plants (MPs) in some selected land use types (woodlot, farm-fallow and fadama) of Sokoto state, Nigeria. Data for this research were collected using focus group discussion. Focus Group Discussion (FGD) was carried out with the key members of traditional medicine practitioners (TMP) to prioritise medicinal plants in the study site. The matrix box was used for ranking of MPs. Stratified random sampling was used for the medicinal plants assessment in Fadama land, farmfallow and woodlot area in Sokoto Metropolis. The three (3) land use types were purposively selected. Sampling intensity of 2% of the total land area covered by Fadama land, farm-fallow and woodlot was used. Ecological footprints of MPs were calculated using the data obtained from the land use types. Data obtained were analysed descriptively using tables, frequencies, percentages and chart. On the ranking, the results revealed that, Senna Senegal (Senna italica), Aizen (Boscia senegalensis), Coffee senna (Senna occidentalis), Cassia Senna (Cassia acutifolia) and Moringa oleifera were the most prioritised medicinal plants in the area while Piliostigma reticulatum ranked as the last medicinal plant. Results on ecological footprints (EF) of the medicinal plants on the Fadama had revealed that Moringa oleifera had the highest EF of 0.1910 whereas the Khaya senegalensis and Mormodica balsamifera had the least EF of 0.0000. On the farmfallow Boscia senegalensis had the highest EF of 0.589 while Senna italica had the least EF of 0.2356. On the woodlot, Senna occidentalis had the highest EF of 0.042 and Moringa oleifera had the least EF of 0.0000. The highest EF was 0.3357 encountered in the farmfallow and the minimum of 0.04 on the woodlot area. The highest medicinal products EF of 0.3122 could be found on the farmfallow and the least of 0.0668 on woodlot area. This shows that, some medicinal plants are being tended in the farm-fallow after realizing their health benefits. For continued and sustained use, conservation of these therapeutic species should therefore be given top priority.

Keywords: Ecological Footprints, Land Use Types, Prioritised, Medicinal Plants, Metropolis

1. Introduction

Nigeria's ecological footprint has alarmingly increased over the past few decades due to significant strain on natural ecosystems brought on by the country's fast economic growth, urbanization, and industrial expansion which has led to some environmental consequences such as environmental degradation, climate change, and unsustainable resource consumption [1]. The main direct environmental consequence of unsustainable harvesting practices is the reduced reproduction, growth, and survival rates of the targeted species [2]. Such changes can consecutively destruct the

ecosystem balances and influence the dynamics and structure of populations or even drive species to the brink of extinction [3]. Ecological footprint (EF) is an indicator that accounts for human demand in the environment compared with the sizes of the bio-productive land and sea areas [4]. It is very important; this will aid check and balance on the town's resource consumption habit against the earth share available per capita. The ecological footprint (EF) is a measure of the distribution of production and consumption in relation to sustainability, and it indicates the productivity of land and water required to support a specific economy or population at a specific standard of life [5]. According to Wackernagel *et al*., the EF is mainly used to determine how much bio-productive land a region needs to maintain resource consumption and absorb waste produced by human activity [6]. The Ecological Footprint is used as a resource accounting tool by governments, businesses, educational institutions, and non-governmental organizations to calculate the amount of the planet's biological capacity required by a specific human activity or population. The Ecological Footprint measures the amount of biologically productive land and sea area whether it is for a person, a region, all of humanity, or a human activity that competes for ecologically productive space [6,7].

However, medicinal plants of Nigeria more especially Northern Nigeria are subjected to continuous depletion and are threatened with extinction due to habitat loss and over exploitation leading to desert encroachment. The danger poses a threat to the well-being of the rural population which has, for generations, relied on the plants to ward off some of the common ailments in both human beings and domestic animals [8]. Both the plant materials and associated traditional knowledge are being lost due to lack of ecological footprint, systematic conservation, research, proper utilisation and documentation.

A regenerative capacity of the environment is needed to meet the yearly requirement of the natural resources, based on the calculations from a five-category global land use and the carbon EF [9]. This indicates that humanity has already exceeded the global bio-capacity (BC) by depleting the stocks of the natural resources. Song *et al*., reported that food, water, waste, carbon and footprint of every household in China have increased over the years due to an increase in income per capita base [10]. The authors computed the EF of food consumption using local average productivities based on the land-use types. They, however, did not consider the total land area required to absorb the wastes and greenhouse gases generated from the production and consumption activities. The national footprint account in 2016 computed the EF of each country using data spanning from 1961 to 2013 from the global footprint network, which ranked Nigeria at 165th given the EF to be 1.16gha/capita, biocapacity (BC) of 0.7gha/capita and also the ecological deficit to be − 0.47 [11]. Despite the level of success achieved in the previous studies, there are no reported cases of the ecological footprint of the medicinal plants that has been in used for decades in Sokoto Metropolis, Sokoto State, Nigeria.

Developing countries like Nigeria among others, make use of medicinal plants for treatment of all kinds of diseases but the manner and mode of plants collection for this purpose is more disturbing as it affects the environment more especially in the Northern Nigeria which desert encroachment has almost taken over, there is urgent need for more sustainable way of the plants collection for medicinal uses and energy for sustainability. Where there has been a dearth of published information is immediately called for and this accounts for the rationale to undertake the present study. Therefore, this study if undertaken will provide a repository of knowledge on important medicinal plants in Sokoto Metropolis, Sokoto State, their abundance, distribution, uses, plant parts utilized and harvesting techniques employed. Also, with this study, the hitherto limited knowledge on the ecological footprints of medicinal plants in Sokoto metropolis will be ameliorated.

Forest resources have the natural ability to be renewed, which offers people great opportunity to tap these resources for their benefit. The availability of a reliable database on the potential, extent and state of the resources, is a basic requirement for a sound forest management strategy [12]. Diversity and abundance of tree species are fundamental to total forest biodiversity because trees provide resources and habitat for almost all wildlife species. Life and survival of man would be impossible without the use of plants and plant products [13]. Non-timber forest products (NTFPs) such as plant roots, leaves and bark and other items from the forest provide food, shelter, medicine, and materials for ceremonies and worship [14]. When people began to domesticate plants and animals, they became less dependent on wild foods and other forest materials. Non-timber forest products are components of the forest ecosystem that exist in nature and are generally not cultivated. They are non-timber, but can be made of wood [15].

Medicinal plants have been playing very important role in human health care since time immemorial. This practice of health care is based on tradition and culture of the people. Plants are reliable sources for the treatment of diseases in different parts of the world [16]. There is an increasing demand for herbal drugs in international trade because herbal medicines are cheap, more effective and easily available and supposed to have no side effects. This is why patients in developing countries such as Bangladesh (90%), Myanmar (85%), India (80%), Nepal (75%), SriLanka (65%) and Indonesia (60%) have strong conviction in this system [17]. In Nigeria, traditional medicine is filling the gap of inequalities in access to health care system [18]. Medicinal plants have maintained its popularity in all regions of the developing world and its use is rapidly expanding in the industrialized countries like China [19,20]. Nonetheless, the botanical studies which examine the medicinal use of plant resources indicate that there is great diversity in the number of plant resources that are available in many regions of the world, and that these plants are widely exploited for their medicinal qualities [21].

Globally, over-exploitation and destructive harvesting techniques have been identified as two critical threats directly or indirectly affecting medicinal plant species [22]. The main direct environmental consequence of unsustainable harvesting practices is the reduced reproduction, growth, and survival rates of the

targeted species [2]. Such changes can consecutively destroy the ecosystem balances and influence the dynamics and structure of populations or even drive species to the brink of extinction [3].

However, medicinal plants of Nigeria more especially Northern Nigeria are subjected to continuous depletion and are threatened with extinction due to habitat loss and over exploitation. The danger poses a threat to the well-being of the rural population which has, for generations, relied on the plants to ward off some of the common ailments in both human beings and domestic animals [8]. On one hand, the use of these plants has contributed enormously to the health sector, on the other hand, the demand for herbs, particularly in parts of Africa, has brought some plants near extinction (even the simplest plant may have a future importance that we cannot predict [23]. In most developing countries like Nigeria, it is well known that traditional medicines are widely used especially in the low-income rural parts of the country. According to the World Health Organization (WHO), approximately 80% of the world's population relies on traditional medicine to fulfill their daily health care needs [24].

The reasons for this dependence on plant medicine among rural/ peri urban communities in developing countries are: That plant medicine is more easily available and they are comparatively cheaper in some areas. In some instances, plant medicine is entirely free of charge. The wide utilisation of plant-based traditional healthcare is mainly attributed to the fact that it makes use of locally available plant resources. For sustainable development to be achieved in the conservation of medicinal plants there is need to document and assess the existing ecological footprints of medicinal plants species so as to serve as guide for researchers, foresters, environmentalists, botanists and wildlife specialist among others to preserve the environment from unnecessary exploitation. For this reason, the research examined the ecological footprints of medicinal plants in Sokoto Metropolis, Sokoto State, Nigeria.

2. Materials and Methods

2.1. The Study Area

The study was carried out in Sokoto Metropolis, Sokoto State. Sokoto is located in the extreme North-west part of Nigeria at the confluence of rivers Sokoto and Rima. It lies between latitude 12◦57′ 30″N to 13◦8′ 0″N and longitude 05◦9′ 0″Eto 05◦19′ 30″E. The state covers an area of 25,973kmsq or 10,028sqm. Sokoto state is made up of 23 local government areas and an estimated projected population of over 5.4 million as at 2017. The GDP of the state is $4,818m with per Capita income of about $1,274. The weather is marked by a single rainy season and long dry season, which is a typical characteristic of the tropic region. It records annual rainfall between 300mm-800mm and mean temperature of 34.5oC. The dry season temperatures exceed 45oC during the day time which is the highest recorded in Nigeria. It is dominated by the North-East Trade wind harmattan from the month of November to February [25]. The relative humidity is recorded to be constantly below 40% (20 – 35%) in the dry season and 43 – 70% in the rainy season [26]. The vegetation is Sudan savanna with predominance of trees such as *Adansonia digitata*, *Balanites aegyptiaca, Ziziphus spina-christi, Z. mauritiana*, and *Vitex doniana* and shrubs like *Senna obtusifolia, S. occidentalis,* and grasses like (*Sida acuta, Sida cordifolia, Striga hermonthica, Eragrostis tremula, Combretum glutinosum, etc*). The soil type is sand and sandy loam with low organic matter content [27].

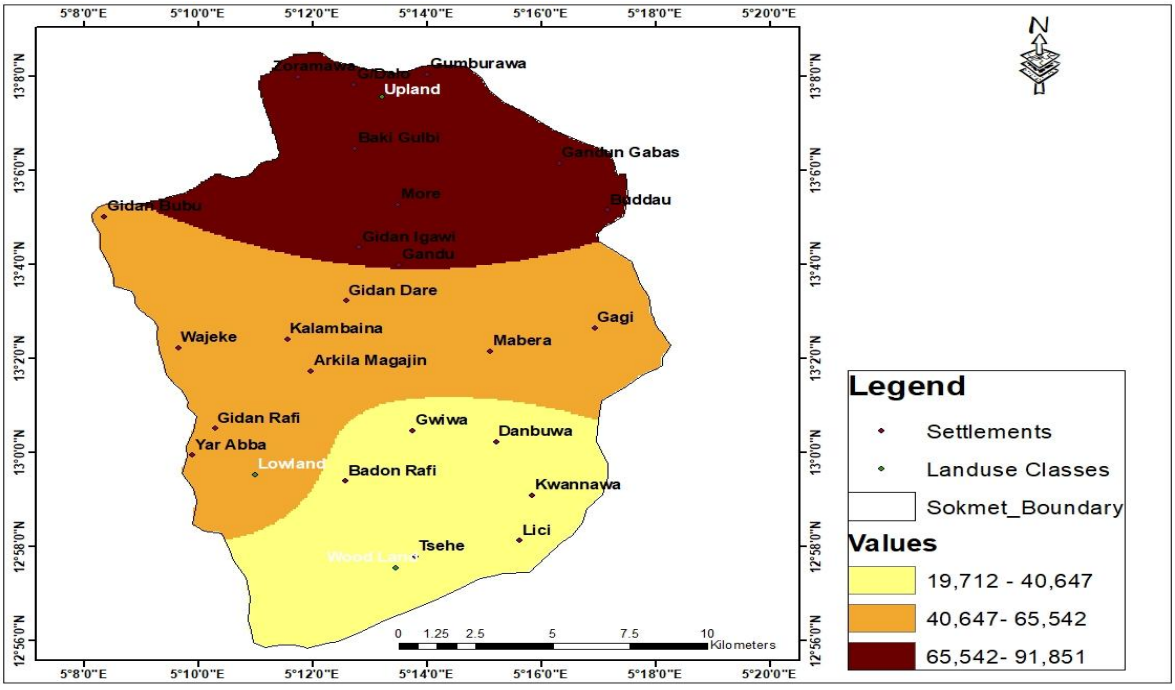

Figure 1: Map of Sokoto Metropolis showing the Land use types

Sampling Procedure

A Focus Group Discussion (FGD) with a panel of expert was conveyed to conduct a pair wise ranking exercise whereby the generated prioritized MPs were itemized in a Matrix box.

Medicinal Plants		Medicinal Plants																				Score	Rank
s/n	Names	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
1																							
2																							
3																							
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Table 1: Showing a Pair Wise Ranking Matrix for the Twenty Most Prioritised MPs

Then, this was compared with each other in a systematic way. For each pair compared, the number of the one that is most preferred is entered into the matrix box. The process is repeated until each MP has been compared with the other MPs and the matrix is filled. The number of times an MP number appears in the matrix determines its relative importance. For example, the MP with the highest frequency is ranked as number 1, and thereafter in descending order [28]. For this study, the twenty most prioritised medicinal plants were ranked as per the matrix in Table 1.

Stratified random sampling was used for the medicinal plants assessment in Fadama land, farmfallow and woodlot area in Sokoto Metropolis. Sampling intensity of 2% of the total land area covered by Fadama land, farmfallow and woodlot was used.

Landuse Types	**Land area covered (sqkm)**	**Land area covered (m2)**	**Land area covered (ha)**	**2% of Land area covered (ha)**	**Sampled Plots (ha)**	**Sampled Plots (50x50m)**
Fadama land	52.28	5228000	522.8	10.46	5.0	10
Farmfallow	115.23	11523000	1152.3	23.05	11.0	22
Woodlot	3.69	369000	36.9	0.72	1.0	4
Total	**171.20**				**17.0**	**36**
Source: Field Survey, 2022						

Table 2: Spatial land Area Covered by Land use Types in Sokoto Metropolis

Plot samples were established to estimate tree species abundance and distribution in the different land use types. Plots of hectares were demarcated from Fadama lands, Farmfallow and Woodlot proportionate to size in Sokoto Metropolis (Table 1). For Fadama land, five out of ten (10) hectares were randomly selected for the study. For farmfallow, eleven out of twenty three hectares (23ha) were randomly selected and one hectare of woodlot was used for the study. From each land use types, sampled plots of 50x50 were demarcated which gave a total sample size of thirty six (36) plots for the study (Table 2).

2.2. Data Collection and Data Analysis

Focus Group Discussion (FGD) was used to collect the data, while descriptive statistics was used to analyse the data for this research.

Tiezzi *et al*. [29], formula was used to calculate the ecological footprints of the selected landuse types. The formula is as follows:

$$EF = \frac{\Sigma Ti}{Yw} x\ EQFi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where:
T_i = annual amounts of tons of MPs product *i* that are consumed in the study area.
Y_w = is the annual yield of MPs product *i* that are collected in tons and
EQF_i = is the equivalence factor of the landuse types *i* (The potential productivity of a particular landuse relative to the potential productivity of all the land-use types in the area).

Percentage MPs = $\frac{Ti}{Yi}$ x 100
T_i = annual amounts of tons of MPs product *i* that are consumed in the study area.
Y_w = is the annual yield of MPs product *i* that are collected in tons

3. Result and Discussions

Plants have long been used as reliable sources of medicine in Nigeria and other countries [16]. The use of herbs is a significant part of traditional medicine [30]. According to the World Health Organization's policy paper from 1977, "a medicinal plant" is any plant that contains chemicals in one or more of its organs that can be used therapeutically or that serve as building blocks for the creation of potent medications [24]. According to Krishnan *et al*. medicinal plants are those that contain naturally occurring active compounds that are used to treat disease or reduce discomfort [31].

S/N	Scientific Name	Local Name (Hausa)	Family name	Ranking	Origin
1	*Boswellia dalziellia*	Hanno	**Burseraceae**	11	Wild
2	*Nauclea latifolia*	Tafashiya	**Rubiaceae**	7	Wild
3	*Prosopis africana*	Kirya	**Mimoceae**	13	Wild
4	*Cassia acutifolia*	Malga	*Fabaceae*	4	Wild
5	*Lanneaacida*	Faru	**Anaccardeceae**	13	Wild
6	*Pseudocedrela kotschyi*	Tuna	**Meliaceae**	9	Wild
7	*Khaya senegalensis*	Madaci	**Meliaceae**	11	Wild
8	*Piliostigma reticulatum*	Kalgo,	**Legumenoceae**	20	Wild
9	*Moringa oleifera*	Zogala	**Moringaceae**	5	Cultivated
10	*Ocimum basilicum*	Doddoya	**Lamiaceae**	18	Cultivated/Wild
11	*Ficus sycomorus*	Baure	**Moraceae**	19	Wild
12	*Schweinkia americana*	Dan-dana	**Solanaceae**	10	Wild
13	*Boscia senegalensis*	Anza	**Capparaceae**	2	Wild
14	*Guiera senegalensis*	Tsabara	**Combretaceae**	7	Wild
15	*Senna italica*	Filisko	**Caesalpiniaceae**	1	Wild
16	*Mormodica balsamifera*	Garahuni	**Cucurbitaceae**	6	Cultivated
17	*Ximenia Americana*	Tsada	**Olacaceae**	13	Wild
18	*Centuarea praecox*	Danyi	**Compositae**	17	Wild
19	*Balanites aegyptiaca*	Aduwa	**Balanitaceae**	13	Wild
20	*Cacia occidentalis*	Sanga-sanga	**Caesalpiniaceae**	3	Wild
Source: Field Survey, 2023					

Table 3: Most Commonly Used/Marketed Medicinal Plants in Sokoto Metropolis

On the ranking with the use of the matrix box, the results revealed that, Senna Senegal (*Senna italica*), *Aizen* (*Boscia senegalensis*), *Coffee senna* (*Senna occidentalis*), Cassia Senna (*Cassia acutifolia*) and *Moringa oleifera* were the most *prioritised medicinal* plants in the area while Piliostigma reticulatum ranked as the last medicinal plant. This could be attributed to the availability of these species because they are readily available in most of the shops visited especially *Senna italica* that is mostly used for body pain in the area. Although, *Cacia occidentalis* ranked number three (3) have enormous health benefits such as curing typhoid, malaria and other ailments. Among the twenty medicinal plants species, eighty five percent (85%) are sourced from the wild. The implication here is due to lack of cultivation and conservation of these MPs in the area. This was in line with Chekole *et al*., who use the matrix ranking of six popular multipurpose medicinal plants showed that *Cordia africana* was the most useful multipurpose medicinal plant that was ranked 1st while *Croton macrostachyus* was the least ranking [32].

Ecological footprints are the quantity of the earth's biocapacity, or regeneration capacity, that a certain activity requires. It is thus measured using this resource accounting instrument. Human activities such as food production and processing, housing construction and upkeep, transportation, and product and service consumption restrict the planet's capacity to replenish itself [6,7].

S/No	Local Names	Scientific Names	Fadama land	Farmfallow	Woodlot
1	Filisko	*Senna italic*	1.0	0.25	1.75
2	Anza	*Boscia senegalensis*	0.7	0.1	1.5
3	Sanga-sanga	*Senna occidentalis*	1.0	0.25	1.75
4	Malga	*Cassia acutifolia*	0.5	0.25	1.5
5	Zogala	*Moringa oleifera*	0.75	0.75	0.0
6	Madaci	*Khaya senegalensis*	0.0	1.0	1.5
7	Garahuni	*Mormodicabalsamina*	0.0	0.125	0.125
	Total		**3.95**	**2.725**	**8.125**

Tons (*Ti*) of Medicinal Plants Consumed per Hectare Annually

1	Filisko	*Senna italic*	0.5	0.1	0.5
2	Anza	*Boscia senegalensis*	0.25	0.1	0.5
3	Sanga-sanga	*Senna occidentalis*	0.5	0.15	0.6
4	Malga	*Cassia acutifolia*	0.25	0.1	0.5
5	Zogaa	*Moringa oleifera*	0.5	0.5	0.0
6	Madaci	*Khaya senegalensis*	0.0	0.5	0.5
7	Garahuni	*Mormodica balsamifera*	0.0	0.1	0.075
	Total		**2.00**	**1.55**	**2.675**

Annualyield (*Yw*) of Medicinal Plants That are Collected per Hectares of Land

S/No	Local Names	Scientific Names	Fadama land (x 5 ha)	Farm fallow (x 11 ha)	Woodlot (1 ha)
1	Filisko	*Senna italic*	5	2.75	1.75
2	Anza	*Boscia senegalensis*	3.5	1.1	1.5
3	Sanga-sanga	*Senna occidentalis*	5	2.75	1.75
4	Malga	*Cassia acutifolia*	2.5	2.75	1.5
5	Zogala	*Moringa oleifera*	3.75	8.25	0
6	Madaci	*Khaya senegalensis*	0	11	1.5
7	Garahuni	*Mormodica balsamifera*	0	1.375	0.125
	Total		**19.75**	**29.975**	**8.125**

Tons (*Ti*) of Medicinal Plants Consumed per Hectares Annually

S/No	Local Names	Scientific Names	Fadama land (x 5 ha)	Farm fallow (x 11 ha)	Woodlot (1 ha)
1	Filisko	Senna italic	2.5	1.1	0.5
2	Anza	Boscia senegalensis	1.25	1.1	0.5
3	Sanga-sanga	Senna occidentalis	2.5	1.65	0.6
4	Malga	Cassia acutifolia	1.25	1.1	0.5
5	Zogala	Moringa oleifera	2.5	5.5	0
6	Madaci	Khaya senegalensis	0	5.5	0.5
7	Garahuni	Mormodica balsamifera	0	1.1	0.075
	Total		**10.00**	**17.05**	**2.675**

	Percentage MPs	$= \frac{Ti}{Yi}$ **x 100**	**57.85 col**	**29.725 cons**	**51.38%**
Source: Field Survey, 2023					

Table 4: Annual yield (*Yw*) of Medicinal Plants that are Collected per Hectare

The total estimated MPs for each land use were multiplied by the total hectares of the land use types by summing up the consumed and collected MPs which revealed consumed MPs to be 29.725/ ha and collected MPs to be 57.85/ha with a percentage medicinal plants of 51.38% in all the land use types. The medicinal plants percentage was found to be 51.38% of the total MPs in the metropolis of Sokoto State. The remaining 48.62 could be attributed to either household consumption or wastage which will in turn exert more pressure to the stock of MPs and of course, this will affect the sustainability of the Medicinal plants in the study area (Table 4).

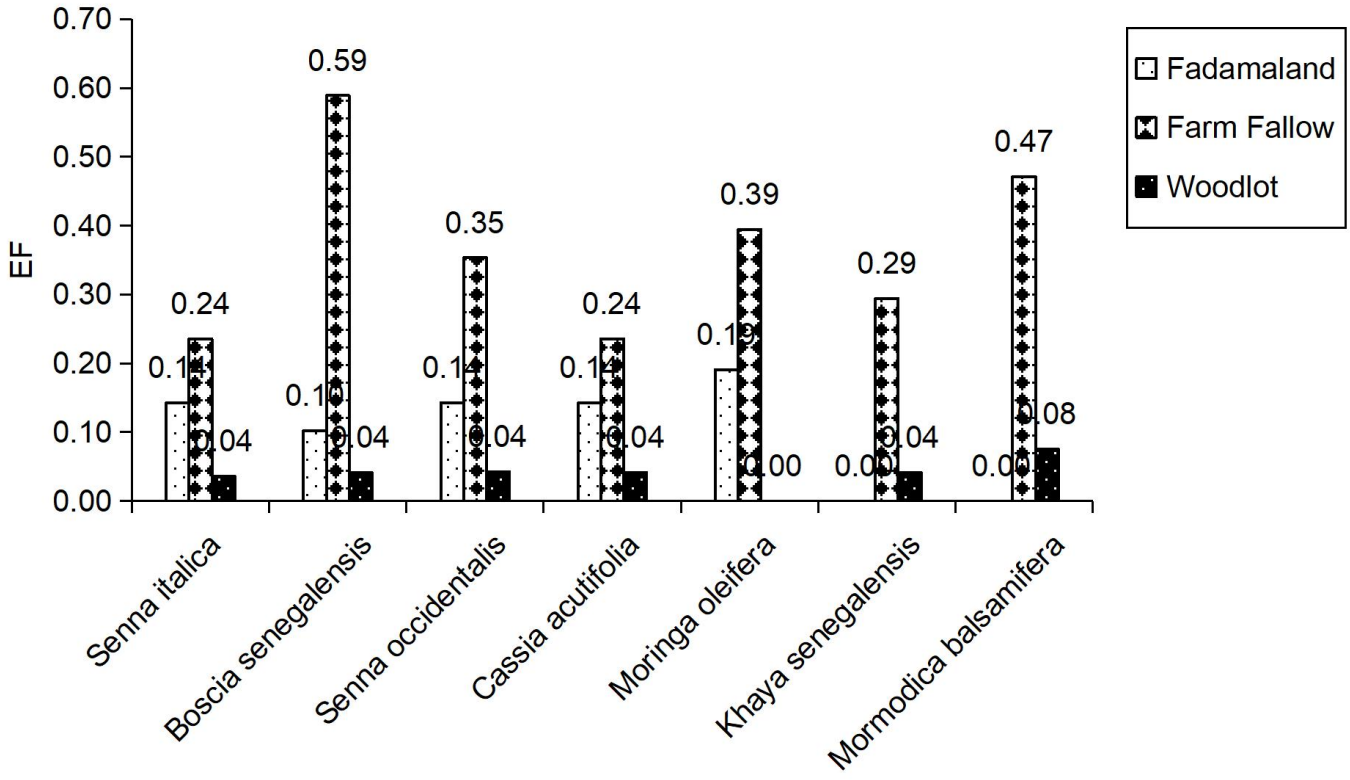

Figure 2: Ecological Footprints of each Medicinal Plant per Land use/Hectare/Capita

The ecological footprint as a tool is imperative in the elucidation of relationships amongst human beings, its habitats and natural resource consumption and sustainability. It takes into account related dynamics and the stresses brought on by the utilization of natural resources [33,34]. The ecological footprints of the medicinal plants on the Fadama had revealed that *Moringa oleifera* had the highest ecological footprints of 0.1910, this is because most of the moringa are being tended at Fadama land. On the farm fallow *Boscia senegalensis* had the highest ecological footprint at 0.589 while in woodlot, *Cacia occidentalis* had the highest ecological footprints of 0.042. This finding is consistent with research by Shakil and Muhammed [35], on consumption and ecological stress in an urban area in Khulna city of Bangladesh.

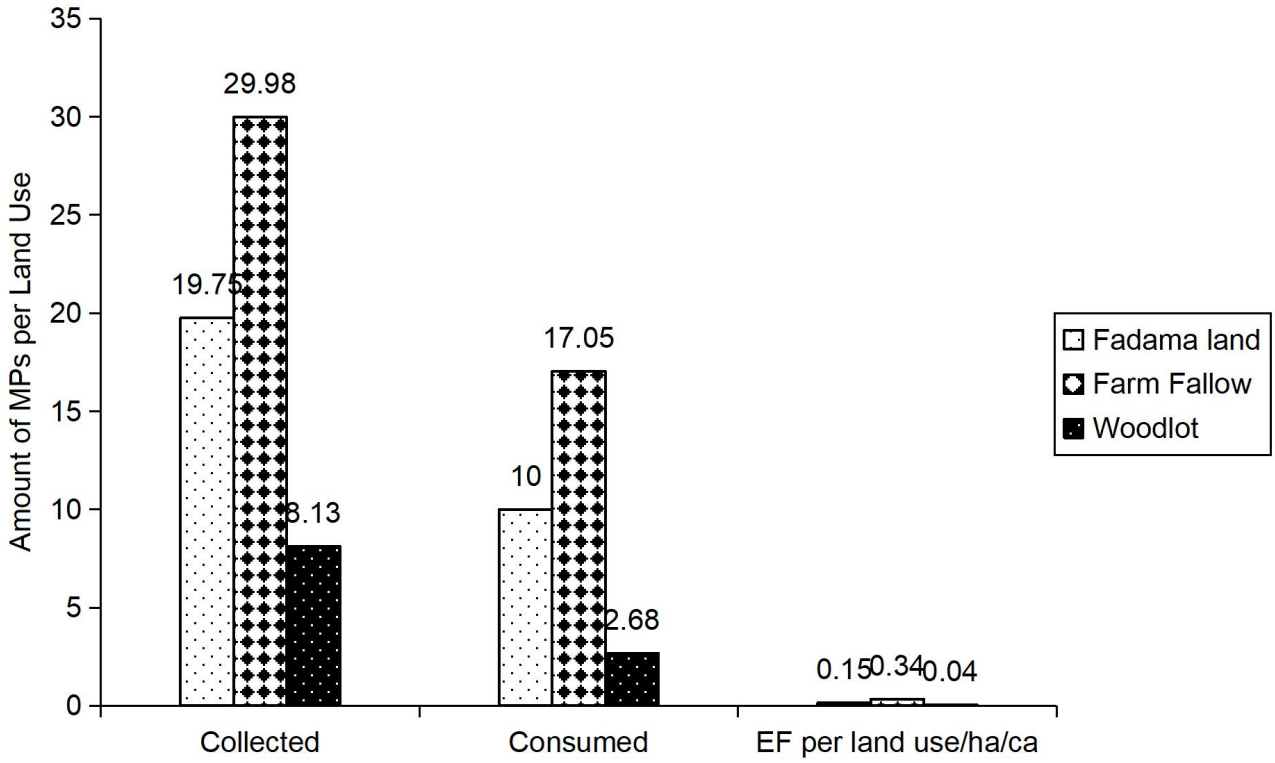

Figure 3: Ecological Footprints Based on Land used Type in Sokoto Metropolis

Considering the different types of land usage, the highest ecological footprint was 0.3357 encountered in the farm fallow and the minimum of 0.04 on the woodlot area. The implication here is that, some medicinal plants are being tended in the farm land before allowing the farm land to fallow after realizing their health benefits. According to the ecological footprint results, the production of medicinal plants could not guarantee the sustainable collection for marketing, and the study area's land use types' population densities showed that the population could not be sustainably supported by the collection and consumption of the products in those land use types. In the past, Li et al. have observed the unsustainability state of land use types in Yunnan and Kunming provinces in China [36]. In addition, the unsustainability of the usage of environmental resources has been observed from ecological footprint study in Ilorin metropolis [4]. Hence, there is more consumption of medicinal plants in Sokoto metropolis than being generated. The total medicinal plants are observed not to be sustainable in Sokoto Metropolis looking at their population size (Figure 3).

4. Conclusion and Recommendation

Conclusively, the pairwise ranking shows that Senegal senna (Senna italica), Aizen (Boscia senegalensis), Coffee senna (Senna occidentalis), Cassia Senna (Cassia acutifolia) and Moringa oleifera were the most prioritised medicinal plants in the area. From the five (5) prioritised MPs, 80% were found from the wild and only Moringa oleifera is cultivated in the area. The ecological footprints of the medicinal plants on the Fadama, farm fallow and woodlot had their highest in Moringa oleifera (0.1910), Boscia senegalensis (0.589) and Cacia occidentalis (0.042). This shows that some medicinal plants are being tended in the farm-fallow after realizing their health benefits and Exploitation increased with medicinal plant diversity, particularly in farm-fallow and fadama areas.

This study recommended that, Public Private Partnership (PPP) should be involved in research financing in order to investigate, document and utilised medicinal plants in Sokoto metropolis sustainably. The species are already in risk due to the growing usage of medicinal plants for various purposes. For continued and sustained use, conservation of these therapeutic species should therefore be given top priority.

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