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Research Article

Forest Systems Services Provisioning in Africa: Case of Gambari Forest Reserve, Ibadan, Nigeria

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This study, therefore, which is focused on forest systems services provisioning in Africa, case of Gambari Forest Reserve, Ibadan, Nigeria, provides policy makers, decision makers, ecologists, environmentalists, the academia, and other stakeholders with a document geared towards promoting national development through sustainable forest products utilization practices. In this study, a total of 200 key respondents participated in it, out of which 194 copies were returned and distributed among the seven main communities in the study area, namely, Ibusogbora, Oloowa, Daley north and south, Onipe, Mamu, Olubi, and Onipanu, respectively. The respondents stated that moringa 164 (84.5%), mint leaf (166 (85.6%), bitter kola 143 (73.7%), and shea tree accounts for 176 (90.7%), and the wood species utilized by producers in the study area include *Leucaena leucocephala*, *Leucaena glauca*, *Gliricidia sepium*, *Tectona grandis*, and *Gmelina arborea*, among others. The study recommends that there is need for African governments to restore public awareness campaign in the area of timber planting initiatives and sustainable forest resource management and increase allocation to fund forestry research in the African continent.

1. Introduction

Vegetation accounts for two-thirds of all different types of terrestrial ecosystems in tropical, subtropical, temperate, Mediterranean, and boreal regions [1]. From the foregoing, forest ecosystems offer an enormous variety of environmental roles and services, which include sequestration of carbon, conservation of biodiversity, water supply, flood control, protection against soil erosion, and desertification. According to Olatoye et al. [2], the ecological benefits of forests are highlighted.

(i) Photosynthesis: this is a procedure that involves the interaction of the biotic (plants) and abiotic (such as water and carbon dioxide) constituents of the environment for the improvement, distribution, and continued existence of all living organisms. Plants are also the only living components of the biosphere that have the functional capability of transforming and utilizing carbon dioxide into usable forms such as chemical energy or starch. In addition, photosynthesis plays important roles.

(ii) Forest ecosystems restock the supply of atmospheric oxygen, which could otherwise be rapidly exhausted by respiration processes of organisms and by burning substances. Put differently, the process of photosynthesis produces oxygen required for respiration by animals; hence, photosynthesis is the only process involved in the elimination of carbon dioxide when released through respiration, combustion, and decomposition into the biosphere.

(iii) Forests ecosystems serve as the only process that can utilize the enormous energy supply from the sun and is therefore very essential in food cycles.

(iv) They ultimately ensure the continued survival through the supply of energy requirements for all

biotic components in the biosphere. Unfortunately, the tremendous volumes of carbon dioxide in the atmosphere far outweighs the available vegetal resources required to carry out photosynthesis on account of inadequate self-regulatory mechanisms required by plants for the regulation of carbon dioxide concentration levels.

(v) Air conditioning: the release of oxygen in the atmosphere during photosynthesis helps in environmental purification, and as a result of this, vegetal resources in coastal and tropical climes have adopted survival strategies by serving as sinks for carbon dioxide concentration.

(vi) Shelterbelts or windbreaks: the establishment of shelterbelts and other tree shelters has been established in coastal environments so as to mitigate the effects of flooding and ameliorate the environmental conditions to conducive levels for biota conservation and growth. Vegetation protects the top soil and sustains soil fertility, in addition to inhibiting watershed disturbance by acting as barriers against soil or gully erosion. They also shelter buildings and other biotic components from natural phenomena such as intense heat from sunlight and windstorms.

(vii) Forests also serve as a safe haven for hydrological and wildlife conservation

(viii) Forests perform a very important function of atmospheric humidification, as well as ensuring the regulation of the earth's weather and climate

(ix) Forest vegetation is an essential ecosystem component which establishes a vital link in nutrients in addition to the absorption of inorganic components and integrating them into organic compounds in living tissues

(x) Recent studies have shown (such as [3]) that coastal vegetation is among the most efficient carbon sinks in the world. From the foregoing, the ecological and economic benefits of costal ecosystem services are further illustrated with the cascade model as shown in Figure 1.

Figure 1 shows the cascade framework proposed by Potschin and Haines-Young [5]. The model provides a linkage between natural systems to elements of human wellbeing, following a pattern similar to a production chain, from ecological structures and processes generated by ecosystems to the services and benefits eventually derived by humans [6]. According to La Notte et al. [4], the advantage of this framework is to effectively communicate societal dependence on ecosystem services in key areas such as observations from a biocentred or holistic approach, i.e., biophysical structures and processes/functions belonging to the ecological sphere and which are considered as a whole. Furthermore, the word function is generally used interchangeably with the ecological process and/or ecosystem service. Additionally, the cascade model explains the function and benefits of ecosystem services are generally defined as the ecosystem processes considered useful to humans. The benefits accruable from ecosystems (as elucidated by the cascade model) include tangible natural resources derived from provisioning services (e.g., vegetation, crops, wood, and water) or some regulating services (e.g., clean water for multiple uses provided by water purification).

2. Aim of the Study

The aim of this research is to investigate forest systems services provisioning in Africa: Case of Gambari Forest Reserve, Ibadan, Nigeria.

2.1. The Study Area. Gambari Forest Reserve (GFR) is located in the Mamu locality (Gambari Forest), Coordinate 3.7 and 3.9E'' and latitude 7.05 and 7.14, i.e., 17 km southeast of Ibadan on the Ijebu-Ode road, 2 km from the nearest road. GFR consists of one compact block of 311.6 acres. The effective productive area of the reserve is therefore 306.9 acres, no allowance being made for subsidiary roads and compartment boundaries. The forest reserve is owned by Oyo/Ogun state governments. Formerly, Ibadan District Council Forest Reserve and Gambari Forest Reserve. Gambari Forest Reserve is divided into five series, namely, Onigambari, Busogboro, Onipe, Olonde, and Mamu. It was originally 12,535.6 ha of which 1,036 ha was dereserved by the Oyo State Government for the Cocoa Research Institute of Nigeria. Later in 1986, another 1,000 hectares were given to Safa Splints Nigeria Limited for industrial use. Present, the working area in the reserve is 10,429.6 ha. The study area is shown in Figure 2, presenting Gambari Forest Reserve within Oyo State and Nigeria.

A low ridge runs from the northern to southern direction on the western side of the central part of the reserve. The drainage runs westwards from the north and west into the River Ona. In the southeast, streams drain into River Awun which flows southwards. The topography of the study area is more or less undulating. The average altitude in the whole reserve is 122–152 m above the sea level.

2.2. Vegetation and Land Use. The vegetation of the area lies between the lowland rainforest. The vegetation of the area is dominated by tree forms ranging from shrubs to dense vegetation. A number of strata of trees can be recognized though they are not always clearly differentiated. The tallest stratum has a discontinuous foliage canopy made up of emergent trees with rounded crowns. Below the stratum of emergents, another set of trees with spreading crowns forms a continuous canopy at a height varying from 15 to 30 meters. The third tree stratum is less regular, being made up of varying sizes of trees with much foliage. Under the tree strata, shrub forms which are quite distinct from small trees form a significant layer with foliage at a height of about two meters. Apart from trees, the rainforest is composed of herbs, climbers, epiphytes, saprophytes, and parasites. The rainforest is evergreen, and there is no time in the year that

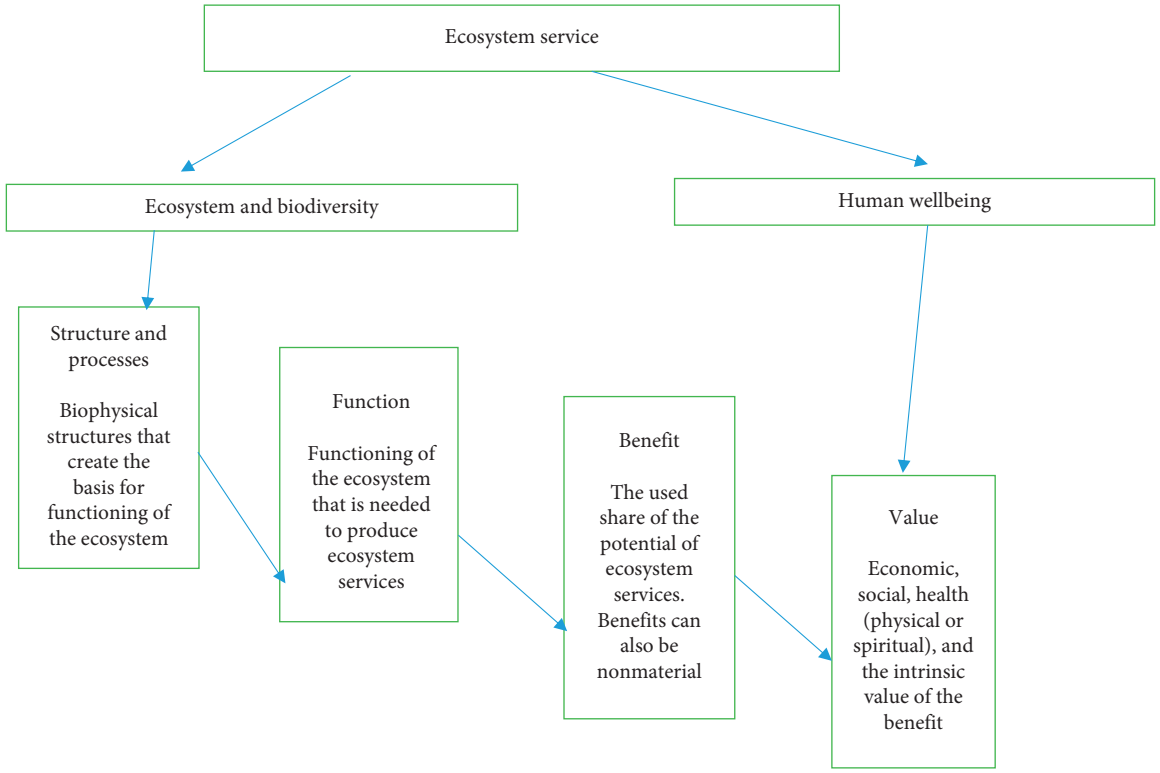


Figure 1: The cascade model with integrated indicators of ecosystem service (La Notte et al. [4]).

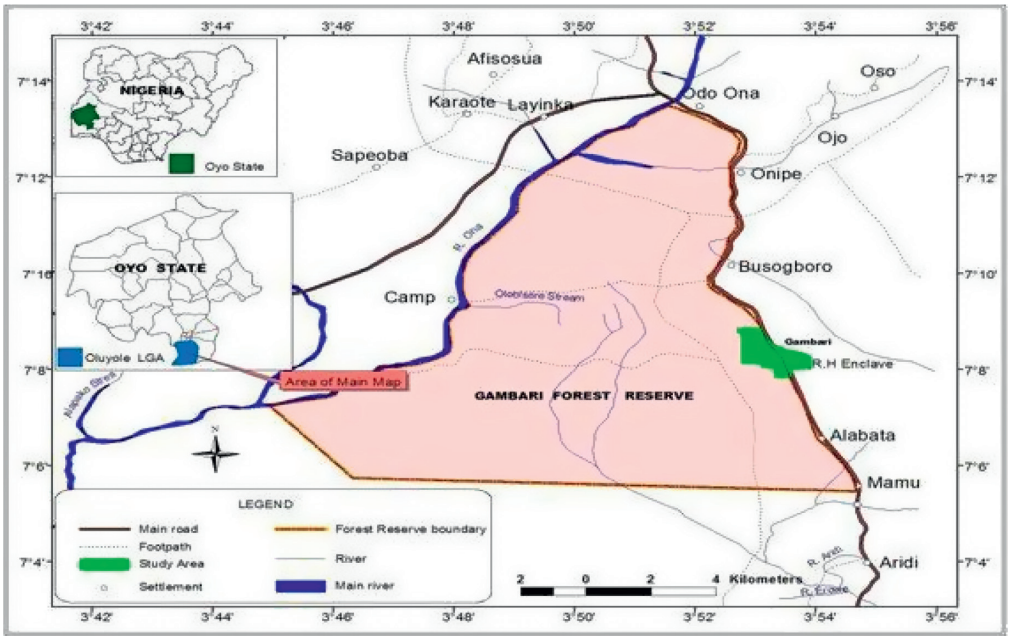


Figure 2: Map of the study area within Oyo State and Nigeria.

the trees shed their leaves. Most forest trees have whitish-grey barks, tall and slender boles, and spreading foliage canopies. Some of the larger varieties also develop impressive buttresses at their bases. Researchers have noted that the lowland tropical rainforest is noted for being the most diverse, luxuriant, and productive in terms of organic matter on earth; hence, a reservoir of genetic materials unequalled elsewhere. There are many tree species in the forest reserve such as *Celtis zenkeri*, *Sterculia rhinopetala*, *Strombosia* spp., *Trilepsium madagascariensis*, and *Triplochiton scleroxylon*. Other exploitable species include *Terminalia superba*, *Antiaris africana*, *Milicia excelsa*, *Terminalia ivorensis*, *Tectona grandis*, *Gmelina arborea*, and *Pinus caribaea*. The dominant rural land use in the forest

reserve is for agriculture. Shifting cultivation is the system of agriculture that is mostly practiced. The food crops include *Manihot esculenta* (cassava), *Xanthosoma sagittifolium* (cocoyam), and *Zea mays* (maize), among others. Tree crops such as *Theobroma cacao* (cocoa), coffee, and *Cola* spp. are also found in the study area. The dominant species are *Cola millenii*, *Angylocalyx oligophyllus*, *Cissus* spp., *Dioscorea* spp., *Combretum* spp., and *Chromolaena odorata*. All land use activities are geared towards the establishment and maintenance of forest units.

3. Materials and Methods

The methodology adopted in the course of this research includes qualitative and quantitative methods. In this study, a total of 200 key respondents participated in it, drawn from the seven main communities, namely, Ibusogbora, Oloowa, Daley north and south, Onipe, Mamu, Olubi, and Onipanu, respectively. These included government officials, civil servants (related to vegetation conservation), headsmen, local leaders, traditional healers, farmers, traders, artisans, grass root dwellers, fishermen, hunters, lumbers, community members, and the general public residing in the study area. Out of the 200 copies of the questionnaire distributed, 194 were returned, giving a response rate of 97%. This offered rich information about the impacts of forest loss at the study area. Both primary (i.e., field survey) and secondary (i.e., review of e-books, journals, e-databases, and reports) data sources were employed for this study. The questionnaire was designed to capture information by respondents regarding obtainable ecosystem goods and services and the utilization of forest resources. Copies of the questionnaire were distributed covering the areas given in Table 1.

3.1. Research Findings

3.1.1. Benefits Derived from the Study Area. Results from analysis of the questionnaire revealed that 171 (86.6%) respondents stated that there were raw material benefits, while 186 (95.8%) and 166 (85.5%) respondents stated that they derived medicinal and economic benefits from the study area, respectively, as shown in Figure 3.

3.1.2. Obtainable Medicinal Plants Collected by the Respondents. The authors sought to investigate the medicinal plants collected from the study area, for the purpose of utilizing their barks, roots, and leaves for treatment of different types of ailments and diseases. The results revealed that moringa 164 (84.5%), mint leaf (166 (85.6%), bitter kola 143 (73.7%), and shea tree (176/90.7%), among others were obtainable in the study area. The results are tabulated in Table 2.

3.1.3. Wood Species Utilized by Fuelwood Producers. Most of the fuelwood production in Gambari Forest Reserve area originates from a handful of species: *Leucaena leucocephala*, *Leucaena glauca*, *Gliricidia sepium*, *Tectona grandis*, *Gmelina arborea*, *Swietenia macrophylla, Acacia* spp., *Albizia* spp., *Cassia siamea*, and *Pithecellobium saman*.

Table 1: Gender respondent' characterization.

Variable	Frequency	Percentage
Sex		
Males	101	52.1
Females	93	47.9
Age		
21–30	39	20.1
31–40	51	26.3
41–50	47	24.2
51 and above	57	29.4
Marital status		
Single	76	39.2
Married	83	42.8
Divorced	12	6.2
Widow/widower	23	11.9
Educational level		
No formal education	38	19.6
Primary education	29	14.9
Secondary education	73	37.6
Tertiary education	14	7.2
Household size		
≤3	11	5.7
4–6	65	33.5
7–9	54	27.8
10–12	46	23.7
Above 12	18	9.3
Income level		
≤N20,000	54	27.8
N21,000–N40,000	61	31.4
N41,000–N70,000	33	17
N71,000–N90,000	28	14.4
Above N90,000	18	9.3

Source: Fieldwork 2020.

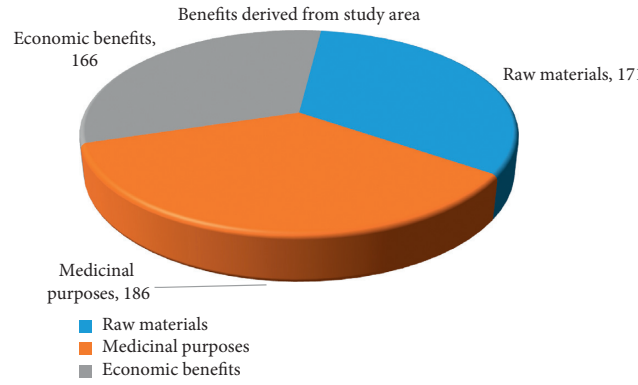


Figure 3: Pie chart depicting the benefits derived from study area (source: Fieldwork 2020).

Findings from the study show that supplies from preferred species are inadequate, and selectivity in terms of species has declined significantly. Producers noted that species which in the past were not utilized, owing to less than optimal characteristics, are now being burnt for fuel.

3.1.4. Pattern of Energy Consumption. Emphasis in this section is laid on the analysis of the pattern of fuel wood consumption in the study area relative to commercial fuels

Table 2: Obtainable medicinal plants collected by the respondents ($N = 194$).

Variable	Scientific name	Availability of medicinal plants	Nonavailability of medicinal plants
Awopa (Yaani)	*Enantia chlorantha*	136 (70.1%)	58 (29.9%)
Beau (Jenjoko)	*Cissampelos owariensis*	128 (65.9%)	66 (34.0%)
Benth (Oruwo)	*Morinda lucida*	129 (66.4%)	65(33.5%)
Bitter kola (Orogbo)	*Garcinia kola*	143 (73.7%)	51 (26.3%)
Coral plant (Ogege)	*Jatropha multifida*	172 (88.7%)	22 (11.3%)
Cotton leaf (Botuje pupa)	*Jatropha gossypiifolia*	168 (86.6%)	26 (13.4%)
Cut leaf cherry (Koropo)	*Physalis angulata*	142 (73.2%)	52 (26.8%)
Ginger (Ata ile)	*Zingiber officinale*	150 (77.3%)	44 (22.7%)
Girdle pod (Irawo ile)	*Mitracarpus scaber*	157 (80.9%)	37 (19.1%)
Iyeye	*Spondia mombin*	149 (76.8%)	45 (23.2%)
Mint leaf (Ewe minti)	*Mentha* x *piperita*	166 (85.6%)	28 (14.4%)
Moringa (Ewe ile)	*Moringa oleifera*	164 (84.5%)	30 (15.5%)
Locust bean (Igi iru)	*Parkia biglobosa*	101 (52.1%)	93 (47.9%)
Satinwo	*Terminalia ivorensis*	157 (80.9%)	37 (19.1%)
Schumach (Ajinrin)	*Momordica foetida*	99 (51.1%)	95 (48.9%)
Shea tree (Ori)	*Butyrospermum paradoxum*	176 (90.7%)	18 (9.3%)
White weed (Imiesu)	*Ageratum conyzoides*	144 (74.2%)	50 (25.8%)

Source: Fieldwork 2020.

such as fuelwood, kerosene, and electricity. Analysis shows that those using fuel woods constituted the highest number of respondents (157/80.9%), as given in Table 3.

This is followed by electricity (138/71.1%). This result implies that fuel wood accounted for major sources of energy, and consequently, its impact on deforestation will also be significant. This indicates that fuel wood contributes positively to the livelihood of the community, and there is strong evidence that the poor in the community engage in fuel wood extraction because it is less capital intensive. The respondents utilize fuelwood to supplement their income and engage in it as business due to unemployment, while others are involved in it as hobby. In addition, with farming being the major occupation of residents in the study area, it is easier for residents to fetch firewood from the reserve. There are a number of reasons why respondents prefer the use of fuel wood to other sources. The result of this analysis is presented in Table 4.

Table 3: Domestic energy utilization ($N = 194$).

Energy	Frequency	%
Fuel wood	157	80.9
Electricity	138	71.1
Kerosene	56	28.9

Source: Fieldwork 2020.

Table 4: Reason for fuel wood preference.

Reasons	Frequency	%
Cheap	124	63.9
Easy to get	20	10.3
Convenient	14	7.2
Availability	36	18.6
Total	194	100

Source: Fieldwork 2020.

4. Discussion

4.1. The Conflicts between Sustainable and Nonsustainable Forces in the Study Area. The relevance of ecological system services to human wellbeing in the study area cannot be overemphasized [7]. Consequently, there is need for sustainability regarding the conservation and protection of timber species in the study area on the one hand and the utilization of the timber species for fuelwood, furniture making, and pole and paper making on the other. While timber species utilization is viewed from the perspectives of promoting human wellbeing, environmentalists and ecologists, on the other hand, underscore the need to conserve the timber species in the study area, by providing a common platform, which is the landscape for conservationists, geographers, planners, scientists, and engineers to function together so as to ensure an optimum society where man and nature can both flourish optimally over time. It is on this premise that the author advocates the need to ensure sustainable utilization of the timber species and other ecological resources found at the study area.

5. Conclusion

It is germane to state that fuel wood production in Gambari Forest Reserve is a profitable business. Aside from its potential role for domestic cooking and agricultural processing, it also has significant potential of providing reliable income for rural households and other forest-dependent people in the area. The market price of fuel wood do not reflect their full economic costs, profit on fuel wood has a negative relationship with what fuel wood collectors pay to the government, and the market is dominated by supplies originating from open access to forest. The bulk of the fuel wood supplied to the market has zero stumpage value; this does not reflect the social cost or true value of the wood and creates a disincentive for farmers and private entrepreneur who want to grow trees for fuel wood because production cost will reduce profit margin. Furthermore, the renewable

nature of the forest also offers potential for sustained output of wood for fuel, provided appropriate harvesting and management can be instituted; hence, there is a clear need for the development of integrated management approaches to this forest resource such as establishment of fuel wood or village woodlots so as to ensure the sustainability of the resource.

5.1. Recommendation. In conclusion, forest systems services provisioning in Africa can be developed in the following ways:

(i) First, there is need for African governments to restore public awareness campaign in the area of timber planting initiatives as well as sustainable forest resource management in the study area

(ii) Increasing allocation to fund forestry research in the continent

(iii) Recycling and reduction of wood wastes and establishment of gene banks to prevent timber species extinction, introduction of domestication programmes, and workable legislation in the forestry sector

(iv) Creation of implementable poverty alleviation and youth empowerment programmes so as to control the use of fuelwood in local African communities

(v) There is need for African governments to develop alternative, accessible, and affordable sources of energy

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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