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Current State of Forest Resources in Guinea-Bissau

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Abstract: The article examines the ecological state of forest resources in Guinea-Bissau, a country that possesses approximately 2–3 million hectares of forests encompassing diverse ecosystems, including sub-humid and dry forests, gallery forests, savannas, palm groves, and mangrove formations. Forest resources provide significant energy wood, consisting of an estimated 650,000 tons of firewood annually for domestic use and about 137,000 tons of charcoal. However, these resources face considerable anthropogenic and natural pressures. Forest fires, intensive logging, pest infestations, heavy metal accumulation, land degradation from mining, industrial and transport emissions, and excessive recreational exploitation are among the main factors negatively affecting forest stability. Current assessments indicate that Guinea-Bissau's forested area covers 2,080,284 hectares, with bush savannah dominating (1,503,534 ha), followed by open forests (706,998 ha), mangroves (290,482 ha), and dense forests (65,775 ha). Forest pathological monitoring shows that 67.5% of forest stands remain healthy (condition category ≤1.5), while 31.9% exhibit reduced stability (condition category 1.5–4.5), with common pathologies including fusarium infections, root rot, leaf chlorosis, and necrosis. Key drivers of forest decline include logging for fuelwood and charcoal production, agricultural expansion–related deforestation, and both natural and human-induced fires. In 2019 alone, forest fires burned 44,336.7 hectares in Bafata and 38,701.5 hectares in Gabu. Overall, the findings underscore the urgent need for integrated forest management strategies to safeguard Guinea-Bissau's vulnerable forest ecosystems.

Keywords: Forest Condition Monitoring, Forest Degradation, Forest Resources, Guinea-Bissau, Rational Forest Management.

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1. Introduction

Guinea-Bissau is a tropical country where natural resources are abundant, many of them fragile and susceptible to degradation if biodiversity is poorly or poorly managed. The forests of Guinea Bissau, occupying a vast territory, are the largest and functionally significant part of the natural landscape, a necessary factor in the ecological balance and sustainable development of the country. Forest and forestry management is very specific. A forest is, first of all, a natural object with its own mechanisms of life, ecological properties, biological diversity, long-term cycles of growth and development and many other features.

Problems such as forests in relation to climate, development of bioenergy, protection of land from degradation, conservation of water resources, and conservation of biodiversity are becoming increasingly relevant. At the same time, the country's needs for various forest products and services are growing. Considering the global role of forests in all regions of the country, the development of processes of sustainable forest management, improvement of law enforcement and strengthening of government regulation in the forest sector, aimed primarily at preventing illegal logging and trade in forest products, illegal seizure of forest lands, forest arson, poaching, corruption in the forestry sector. Great importance in this process is given to the initiatives of public organizations, the private sector and the population, increasing the role of local governments, forest certification, intersectoral and international cooperation.

The purpose and objectives of the study is to assess the ecological state of forest resources in Guinea-Bissau

2. Literature Review

Guinea-Bissau is located in West Africa between Senegal to the north and Guinea-Conakry to the south and east; in the west it is limited by the Atlantic Ocean (Figure 1). Guinea-Bissau has a total area of 36,125 km² and its continental offshore platform is 53,000 km².

Forests in Guinea Bissau, in accordance with the country's constitution, are the exclusive property of the state. The objects of forest relations in accordance with the Forest Code of Guinea Bissau are the forest fund, individual areas of the forest fund, and the rights to use them. The forest fund consists of forests and lands covered by them, as well as lands not covered with forests, but intended for its restoration (clearings, burnt areas, dead plantations, etc.) and non-forest lands, represented by clearings, roads, fire-fighting facilities, reclamation networks, swamps, reservoirs and other similar lands located among forests [1] [2].

Forests fall under the category of land - forest land, a country with huge soil potential, approximately 3,830,000 hectares, the country has significant forest resources covering 2,080,284 hectares of surface with a variety of ecosystems and forests (sub-humid, dry forests, galleries, savannas, palm trees and mangrove forests) [3] [4].

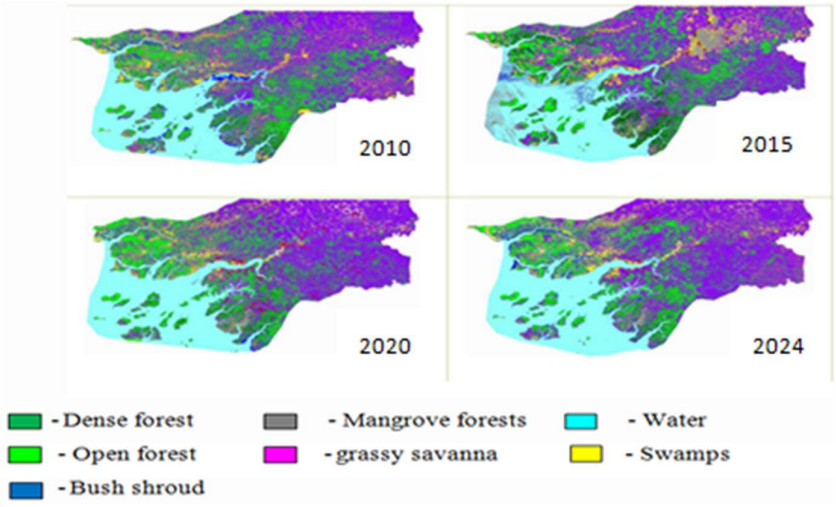

Figure 1. Map of Guinea-Bissau with Classified Land Cover by Year: 2010, 2015, 2020 and 2024

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In general, in Guinea-Bissau the following types of soils with forests are distinguished: hydromorphic soils, which are divided into marine (halohydromorphic) and continental; plateau or ferralite and tropical ferruginous soils; lytic soils (lithosols) and regosols.

There are 4 main botanical sectors in the country. The fauna of Guinea-Bissau is closely related to the botanical regions [5] [6] (habitats) existing in the country (Table 1).

Table 1. Botanical sectors of Guinea Bissau

Sub-Humid &Humid Sector of Guinea	Sudanese-Guinean Sector	Guinean Sector	Coastal Zone
3 regions: • Quinara • Bolama • Tombali	7 regions: • Oio • Tombali • Biombo • Cacheu • Gabú • Bafatá • Bissau	5 regions: • Quinara • Bolama • Bissau • Biombo • Cacheu	4 regions: • Bolama • Cacheu • Tombali • Biombo

Source: Directorate General of Forestry (DGF)

3. Methodology

3.1. Study Area

Guinea-Bissau is located in West Africa between Senegal to the north and Guinea-Conakry to the south and east; in the west it is limited by the Atlantic Ocean. Guinea-Bissau has a total area of 36,125 km² and its continental offshore platform is 53,000 km². Forests fall under the category of forest land, with huge soil potential, approximately 3,830,000 hectares.

3.2. Data Analysis and Classification

The study utilized maps of Guinea-Bissau with classified land cover to analyze the transition between 4 forest cover classes (Dense Forest, Open Forest, Bush Savanna, Mangrove Forests) for the periods 2010-2015, 2015-2020 and 2020-2024.

3.3. Fire Rotation Period (PRF)

To analyze fire impact, the 'Fire Rotation Period' (PRF) method was used. PRF is a simple method that determines the number of years required to burn an area equivalent to the area being analyzed and is estimated using the equation: *PRF = number of years in analysis / (amount of burning / area of study)*. The inverse PRF is the annual percent area burned and determines the average proportion of the study area burned in each year.

3.4. Sanitary and Forest Pathological Monitoring

Since 2016, the Institute of Biodiversity of Protected Areas (IBAP) has been organizing and conducting forest pathological monitoring. In 2024, monitoring was carried out on 100,054.5 thousand hectares of forests in the south of the country. Changes in the state of forest plantations were monitored at permanent observation points located in strata or in the corners of a virtual network in the areas of the international program (ICP Forests).

4. Finding and Discussion

Open forest is the second class of forest with the largest occupied area with an average of 25.5%. for the same period. However, between 2010 and 2024 this class lost 15%. This class is distributed throughout the territory, especially in the western region. Mangroves are located on the continental coast and the Bijagos archipelago and constitute on average about 9% of the territory of GB. This type of coverage increased by 14% between 2010 and 2024, despite a slight loss of 3% in area between 2012 and 2018. The largest loss of area recorded over the 18 years of study was Dense Forest at approximately 50% due to loss or degradation of the area and the fact that it was largely converted to Open Forest. However, it should be noted that 9.50 hectares of dense forests account for 3% of the entire territory of the GV and are located mainly in the southwest of the territory [7] [8].

The transition between 4 forest cover classes was calculated for the periods 2010-2015, 2015-2020 and 2020-204. All transitions showed high values of land cover change for Dense Forest (49.3% between 2010 and 2015; 43.6% between 2015 and 2020 and 55.9% between 2020 and 2024) and Open Forest to the wooded savanna with values from 42.2% to 37.0%. in the 2000s and 30% in the transition period 2020-2024 [9] [10]. The increase in the area of the Bush Savana occurred mainly due to a decrease in the area of open forest. During the study period, mangroves were the most stable cover class, accounting for 79.7% of all mangrove area classified in 2010 - 2024. It should be noted that the results for mangroves were presented at the International Symposium on Remote Sensing of Environment. The data in Table 2 presented is preliminary as it only covers the area for 4 years.

Table 2. Proportion Of Area Occupied by Each Type of Forest Class

	2010	2015	2020	2024
Dense Forest	4.3%	3.0%	3.0%	2.2%
Open Forest	27.2%	25.8%	25.5%	23.5%
Bush Savanna	43.5%	47.8%	49.4%	49.9%
Mangrove Forests	8.3%	8.8%	10.0%	9.6%

The class with the largest area in Guinea-Bissau is scrub savanna, followed by open forest, mangroves and dense forest (Table 2). Open and dense forests are gradually declining between 2000 and 2018, in contrast to the bush savanna and mangroves, which are gradually increasing during the same period.

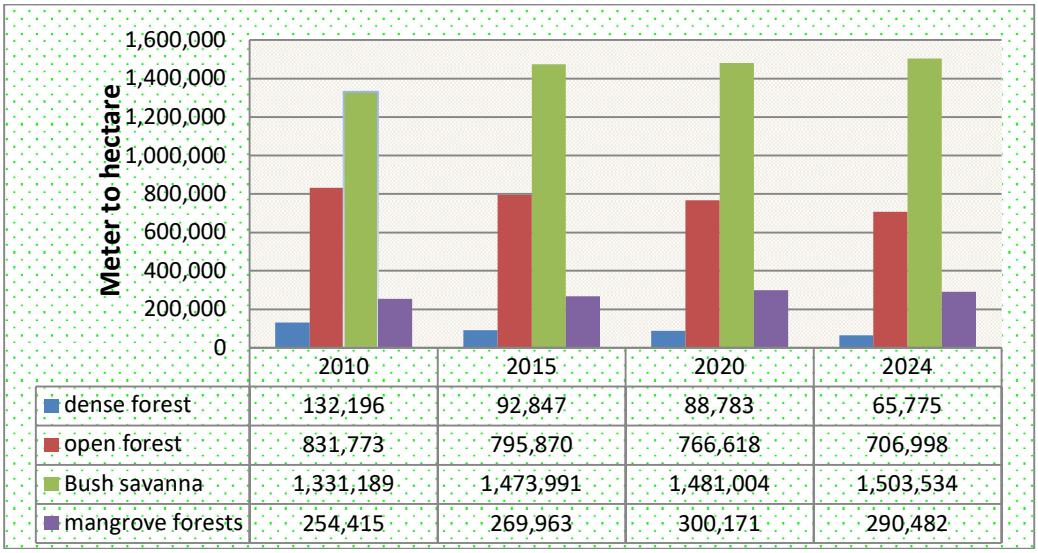


Figure 2. Area of forest classes for 2010, 2015, 2020 and 2024

1) Main Botanical Regions and Climatic Conditions of Guinea-Bissau

- **Subhumid and Humid Sectors of Guinea**

They are located in the south of the country, occupying a vast area in the south of Guinea-Bissau (region "Quinara, Bolama, Tombali", where semi-soluble or sub-humid and humid forests occur. They mainly occupy ferralite and deep clay-sandy soils; which represent favorable conditions for good fixation of tree roots. Degraded subhumid forests are often located on the edges of dense subhumid forests, the lower layer of which is formed by tree species and without grasses. Ecologically, these are mesophilic forest [5] [11].

Climate is influenced by two fundamental factors:

- their situation between Ecuador and the Tropic of Cancer. This determines that the Sun passes through the zenith of Guinea twice in its apparent annual motion, carrying with it the intertropical convergence zone.
- proximity to the ocean under the influence of sea and continental trade winds, forming here the intertropical convergence zone. This leads to a warming difference between the oceanic and continental masses with the establishment of the monsoon regime.

Average monthly temperatures rise to around 28°C in April and May (before the rains), fall to around 23°C in August and September and 16°C in January, with a corresponding maximum (and minimum) of 35°C (10°C) respectively.

- **Sudanese-Guinean Sector**

Extending from the north to the east of the country and characterized by open forest or forest savanna. These formations are associated with deep soils that are not very fertile and have a sandy texture. The forest vegetation is clear, even very distinct [12] [13].

Average monthly precipitation reaches a maximum of more than 400 mm in August, falling to around zero from December to April. Average monthly temperatures rise to around 30°C in April and May (before the rains), fall to around 25°C in August and September and 13°C in January, with a corresponding maximum (and minimum) of 36°C (10°C) respectively C) [14].

- **Guinea Sector**

In the central-northern and central-southern regions of the country, where dry and semi-dry forests alternate. Average monthly temperatures rise to around 29°C in April and May (before the rains), fall to around 25°C in August and September and 15°C in January, with a corresponding maximum (and minimum) of 34°C (10°C) respectively.

- **Coastal Zone of Guinea-Bissau**

Stretching from the north to the south and east of the country and characterized for the most part by mangroves, palm forests and forest gallery, in terms of conservation, it is recognized worldwide for both the number of waterfowl and the great diversity of species [15].

Table 3. Evolution of Plant Formations in Guinea-Bissau between 2022 and 2024

Forest type	2022	2024	Difference
Subhumid forest	178.800 (ha)	135.431 (ha)	43.369 (ha)
Dry forest	848.300 (ha)	844.959 (ha)	3.341 (ha)
Gallery forest	112 700 (ha)	109 389,49 (ha)	3.310,51 (ha)
Savannah	1.237.900 (ha)	996.985 (ha)	240.915 (ha)
Mangrove forests	287 000 (ha)	250 761,1 (ha)	36.238,9 (ha)
Total	2.663.900 (ha)	2.337.525,59 (ha)	327.174,05 (ha)

Source (International - Spacecraft Event Time SCET)

2) Sanitary and Forest Pathological Monitoring

Forest pathological monitoring is the information basis for state control of the sanitary condition of forests and the forest pathological situation in the territory of the Guinea-Bissau forest fund and forests. It includes a system for collecting, storing and using forest pathological information [16] [17].

Since 2016, the Institute of Biodiversity of Protected Areas (IBAP) has been organizing and conducting forest pathological monitoring on the lands of the forest fund of Guinea-Bissau. In 2022-2024, the area of forest pathological monitoring was systematically increased annually. In 2024, forest pathological monitoring was carried out on 100,054.5 thousand hectares of forests in the south of the country [5] [18].

During the work, all methods of forest pathological monitoring were used. Changes in the state of forest plantations were monitored at permanent observation points located in strata or in the corners of a virtual network in the areas of the international program (ICP Forests) [19]. Control was carried out using the same methods as when turning over seedlings. And the main pathologies were discovered:

- Fusarium. A disease caused by soil fungi that destroys tender and succulent tissue during germination and rooting of seedlings, leading to death. During the pre-emergence period, the seeds rot or the seedlings die. Post-emergence necrotic lesions form in the hypocotyl or in roots generally at ground level [13] [20]. Lesions can occur on the epicotyl, cotyledons and apical bud.
- Root rot caused by "Armillaria". Root rot caused by Armillaria affects a large number of woody plants. This disease was found in coniferous species of the genus Pinus and Araucaria.

Chlorosis is a change in the color of plant leaves, warning of a lack of nutrients in the soil, while Necrosis is a type of disease characterized by the death of a tissue or part of a plant [21] [22]. The causes of necrosis are: unfavorable abiotic factors (freezing, burns, friction, lack or excess of nutrients), chemical effects (spray burns), microorganisms (bacteria, fungi, viruses).

After analyzing all the data obtained, it was found that in the forest pathological monitoring area, the share of healthy plantings (average condition category - up to 1.5) accounts for 67.5% of the forested area. Plantings with impaired stability (average condition category - from 1.5 to 4.5) make up 31.9%.

Declining Forest Resources in The Country

The main factors responsible for the decline of forest resources in Guinea-Bissau are of natural origin and human actions through the exploitation of forest resources. Natural events are unlikely to damage Guinea-Bissau's forest resources as mitigation measures are very expensive [6] [23]. Anthropogenic factors are the main factors that greatly influence the degradation and reduction of forest resources in the country. Deforestation rates vary depending on the region of the country. The main causes of deforestation in Guinea-Bissau are the rotation of crops in forested areas [7] [24]:

- Cutting of some forest essences for the production of charcoal and firewood-Currently, there is a lot of pressure on forests due to the use of various forest essences for the production of charcoal and the use of firewood as energy for domestic consumption and export sales. According to the report ("Deuxiéme Atelier Regional Sur l´information en Bois Energie en Afrique" 2021);
- Strong pressure on the land, leading to serious social conflicts; the predominant economic role of commercial agriculture (cashew plantations);
- Deforestation for agricultural purposes (n 'pam-pam) – shifting agriculture;
- Fire regime (fires) – The country's rural population practices burning for agricultural and non-agricultural purposes, with control of uncontrolled fire spread varying depending on the type of vegetation and purpose in question, and, more recently, the presence or absence of gardens.

Table 4. Annual Absolute Values of Burnt Area (ha) by Region of Guinea-Bissau

Regions	2018	2019	2020	2021	2022	2023	2024
Bafatá	64,289.60	48,562.60	57,081.60	16,338.00	56,464.20	48,938.50	44,336.70
Biombo	0	44.8	0	0	21.5	0	0
Bissau	0	0	0	21.5	0	0	0
Bolama	1,330.90	629	107.3	279.1	21.5	880.1	987.4
Cacheu	8,971.50	5,972.80	19,601.60	8,069.50	9,874.90	8,897.10	5,731.80
Gabu	69,016.00	76,873.80	81,430.80	34,615.10	76,388.40	44,246.50	38,701.50
Oio	39,142.90	54,359.30	48,826.80	18,658.20	34,503.40	27,436.00	24,143.60
Quinara	9,287.10	10,944.60	9,041.80	8,236.50	15,117.30	15,821.80	4,021.00
Tombali	3,953.00	2,566.00	2,823.60	2,413.30	6,684.30	6,020.30	1,069.10
Total	118,991.10	152,240.30	199,075.50	88,631.20	218,913.50	199,952.90	195,991.00

Source: (International - Spacecraft Event Time SCET)

Fire Rotation Period (PRF) is a simple method that determines the number of years required to burn an area equivalent to the area being analyzed (in this case a region) and is estimated using the equation:

$$\text{PRF} = \frac{number\ of\ years\ in\ analysis}{amount\ of\ burning\ /\ area\ of\ study} \quad (1)$$

The inverse PRF is the annual percent area burned and determines the average proportion of the study area burned in each year or the average probability of burning at a given location in the study area in a given year. For each region of Guinea-Bissau, the percentage of area burned in each of the years analyzed was determined, as well as PRF values for the set of years analyzed (Table 4).

The Biombo and Bissau regions have the highest PRF. This high PRF suggests that fires in these areas are infrequent and that when they do occur, they are small in size [8]. Gabu, Oyo and Bafata are the regions with the lowest PRF with a minimum value of 12 years for Bafata, which means it takes only 12 years to burn an area equivalent to that of the Bafata region. Bolama, Biombo and Bissau are the regions with the smallest area burned over the period analyzed, with values so low that they are meaningless in percentage terms. The regions with the highest annual percentage of burned areas are Gabu and Bafatah with values between 7 and 8%.

The graphs below show the dynamics of log and total wood production and their forecast up to 2030 according to the graph below, where the blue dots show the change in wood production in logs, including charcoal and firewood, and the red line indicates the maximum limit that production can reach in 1974, and the green dots are the forecast and production is likely to increase by 2030 (see Figure 3).

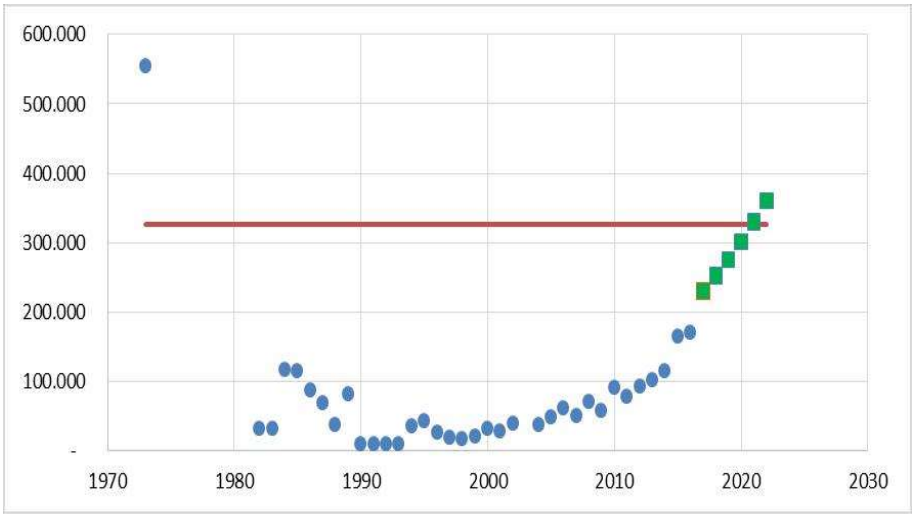


Figure 3. Dynamics of Wood Production in m³

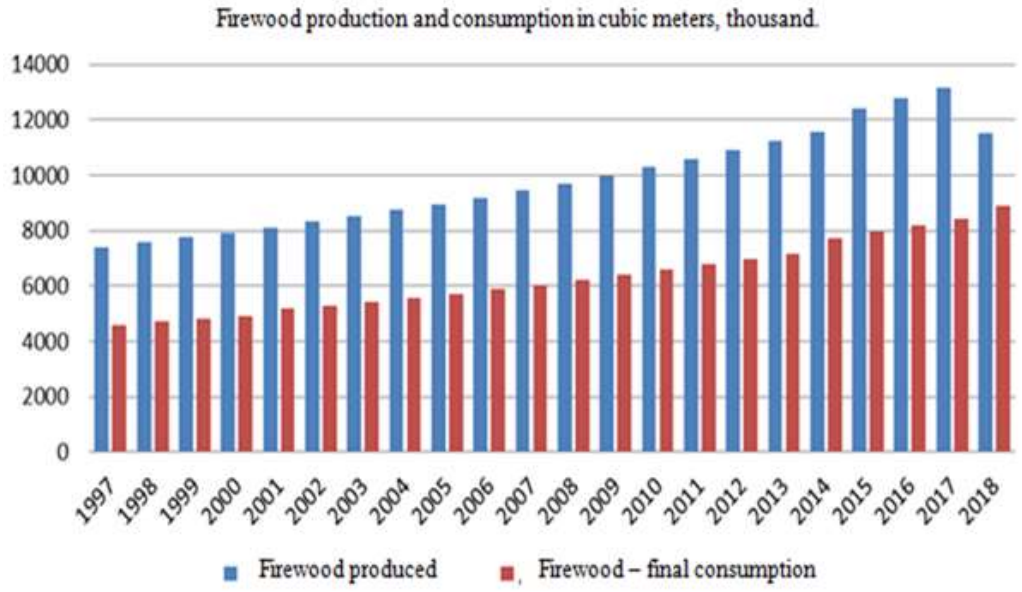
The vast areas of the country's forests are susceptible to deforestation and desertification, either due to natural phenomena such as droughts or due to their exploitation (coal mining, mining, etc.), uncontrolled burning due to traditional agricultural and hunting practices [9] [25]. The Global Forest Resources Assessment estimates that Guinea-Bissau is losing an average of about 106,000 hectares of natural forests and 370 hectares of plantations at rates of 0.2% and 0.5% respectively (see Figure 4).

Statistics on the use and production of firewood or charcoal are not well known in Guinea-Bissau, making it difficult to assess the impact of this practice. Some statistics available from the database (UN Statistics Division Energy Statistics Database – 2014) show some indicative trends for firewood and charcoal in Guinea-Bissau. As can be seen from (Fig. 4), the production of firewood and, consequently, its consumption has been increasing in recent years, with the final consumption of firewood for energy purposes.

Which is about 39% of the total [10] [26]. The vast majority of firewood production (61%) comes from processing into charcoal. The vast majority of firewood production (61%) comes from processing into charcoal [27].

Ecological Assessment of The Simulation Model of The State of Forest Resources

The system's boundaries are a complex transition (ecotone) between two fundamentally different classes of ecosystems—forest and non-forest [11] [28]. This transition is characterized by a particular increase in natural complexity due to the penetration of fragments of forest and non-forested areas.



Source: UN Statistics Division Energy Statistics Database – 2014 г.

Figure 4. Quantities of Charcoal Production and Consumption

This system is open, information and energy are exchanged [12] [29]. Information enters the forest in the form of rain, sunlight, toxic substances (herbicides, pesticides, etc.), mineral and organic fertilizers, waste and manure from livestock farms, animals, insects, biologically active substances, CO2, tree felling, unextinguished fires, hunting, and the destruction of rare plants [30].

5. Conclusion

There are few conclusions:

1) Guinea-Bissau's forest resources cover 2,080,284 hectares of surface with diverse ecosystems (subhumid, dry forests, galleries, savannas, palm and mangrove forests). The largest area in Guinea-Bissau is bush savannah at 1,503,534 ha, followed by open forest at 706,998 ha, mangrove at 290,482 ha and dense forest at 65,775 ha.
2) In areas where forest pathological monitoring is carried out, healthy plantings (average category of condition - up to 1.5) account for 67.5% of the forested area. Plantings with impaired stability (average condition category - from 1.5 to 4.5) make up 31.9%. Forest pathological monitoring of forest resources in Guinea-Bissau revealed their main pathologies - mycoses: fusarium and root rot; plant leaf chlorosis and necrosis.
3) Reasons for the decline in forest resources in Guinea-Bissau:
   - Logging for the production of firewood and coal;
   - Deforestation for agriculture;
   - Fires of natural and anthropogenic origin. As a result of monitoring forest fires in 2019, 44,336.7 hectares burned in bafata, and 38,701.5 hectares in gabu.

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