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SAVANNA BIOMES IN NIGERIA: INDICATOR SPECIES AND PLANT ADAPTATION STRATEGIES

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ABSTRACT

Savannas are considered an exclusively tropical biome, largely found in Africa. It comprises of grasslands with scattered trees that are sufficiently widely spaced so that the canopy does not close. The savanna biome covers more than 86% of Nigeria's vegetation cover. There are three major savanna belts in Nigeria, namely: the Guinea savanna, the Sudan savanna, and the Sahel savanna. The Guinea savanna is the most extensive ecological zone, covering more than half of the country's land area. It has typically short trees and tall grasses and is the most luxuriant of the Savannah vegetation belts in Nigeria. The Sudan savanna belt is found in the northern parts of Nigeria. The Sudan savanna is characterised by high rainfall variability, frequent droughts, and poor soil fertility. The Sahel savanna is found in the extreme northwest and northeast of the country. It has sparse vegetation that is dependent on uncertain rainfall, dominantly grasses with discontinuous shrubs and scattered trees, which are often thorny, and extensive sparse grasses. Savannah plants are faced with some delimiting factors, such as seasonal drought, low water and nutrient availability, the impacts of regular fire, and herbivory, among others, which threaten their survival. This article discusses the Savanna biome in Nigeria, its indicator species, and the adaptative features exhibited by plants in the savanna to ensure their survival.

INTRODUCTION

Savannas are broadly defined as grasslands with scattered trees. Grasslands are lands on which the existing plant cover is dominated by grasses. (Anderson *et al.,* 1999; Janior *et al.,* 2006; Gandiwa, 2011). Savanna ecosystem is one consisting of a continuous or near continuous grass dominated understorey, with a discontinuous woody overstorey. The woody components can be a mixture of evergreen or deciduous, needle-like or broad-leafed trees and shrubs. The grass-dominated understory can consist of a mix of species with either annual or perennial habit (often >1 m in height). Ecosystems that fit this definition have ambiguously been termed woodlands, rangelands, grasslands, wooded grasslands (Werner *et al.,* 1991; Hutley and Setterfield, 2018).

Figure 1: A typical savanna vegetation (source: google.com)

In other words, savanna is a mixed woodland-grassland ecosystem characterized by the trees being sufficiently widely spaced so that the canopy does not close (Isichei and Muoghalu, 1992; Anderson *et al.,* 1999). The open canopy allows enough light to reach the ground to support an unbroken herbaceous layer composed primarily of grasses.

HISTORY AND DISTRIBUTION

Grasslands evolved during the Cenozoic era, in the course of a period of cooling and drying of the global climate. It's possible that the Eocene and Oligocene epochs saw the beginning of the evolution of savanna ecosystems and the organisms that make them up. Grasslands and savannas can be either anthropogenic or natural, by definition. Grasslands and savannas together make up an estimated 20% of Earth's terrestrial biomes (Sankaran *et al.,* 2005). Savannas have wide socio-economic importance regarding land use and biodiversity. Savannas are the central biome in the transition between grasslands and forests, they are characterized chiefly by the coexistence of two types of vegetation: Trees (i.e., woody vegetation), and Grasses (i.e., grasses and herbs) (Janior *et al.,* 2006).

Figure 2: An extensive grassland (source: google.com)

Savanna Biome exists all- across the globe, broadly divided as Temperate savanna and Tropical Savanna. Tropical savanna occupies an area of approximately 27.6 Mkm2. Savanna in the temperate regions is found in North America (Florida, TX), Mediterranean Europe, and Russia, although these temperate savannas are far smaller in extent at approximately 5 Mkm2. In total, the savanna biome occupies 1/5th

of the global land area and supports a large and growing human population (Hutley and Setterfield, 2018).

Climatic and edaphic factors are majorly the factors affecting its distributions. The savanna occupies about 60% of the surface of tropical Africa, with its appearance and degradation status largely determined by human activities (Laube, 2007). Savannas are conventionally considered an exclusively tropical biome, largely found in Africa. Also the term 'tropical grasslands' and 'savannas' are always used interchangeably (encyclopedia of life support system). Savanna occurs naturally or could be as a result of anthropogenic activities.

Natural and anthropogenic savanna

By definition, grasslands and savannas can be either manmade or natural. **Anthropogenic grasslands** such as farmlands, pastures, sports fields, require some sort of perpetual disturbance to survive. Such as cultivation, intensive grazing, burning, or mowing. Grasslands that have been created by humans are widespread and essential to human welfare because, whether managed as farmland or rangeland, they offer a significant supply of food. In addition to providing a source of wood products, anthropogenically created savannas offer humans food, grazing pasture for animals, and recreational space. Savannas and grasslands have been manipulated by people for thousands of years for human benefit (Hutley and Setterfield, 2018), it can be difficult in some areas at times to separate the influence if humans from that of nature in the formation or maintenance of these ecosystems.

Natural grasslands Natural grasslands may be found in a variety of climatic and geological settings, with soil and climate serving as the primary determinants of where they can be found. Natural savannas, which are typically thought of as tropical savannas, are found in the seasonal wet-dry zones sandwiched between the humid equatorial zones and the arid zones in the mid latitudes: between lat 10 $^\circ$ and 30 $^\circ$ north and south of the equator (Buba, 2015; Hutley and Setterfield, 2018) In general, natural grasslands and savannas can be considered intermediates in an environmental gradient, with forests at one end and deserts at the other. Savannas are found where moisture, soil texture, nutrients, herbivory, and fire allow co-dominance of grasses and trees.

CHARACTERISTICS OF SAVANNA BIOME

The mean annual precipitation varies from 550 mm in the north of the Sudan Savanna Zone to 2,500 mm in the southwestern part of the Guinea Savanna Zone. The rainfall pattern is predominantly monomodal, but locally it is pseudo-bimodal or bimodal. The latter pattern occurs only in the southernmost parts of the Guinea Savanna Zone. As in the forest ecology, the differences in floristic composition of the savanna are determined by the range of total amounts of rainfall and its distribution, the soils, the hydrology, and the physiography, also by forest fire occurrences (Moncrieff *et al.,* 2016). The structure of the savanna is much more open than that of the forest and varies from a more or less closed savanna woodland in the more humid zone, to grasses with sparse trees in the drier parts. The sheer bulk of the savanna vegetation is only as high as 67,000 kg/ha (oven-dry weight), excluding roots (Keay, 1949; Staver *et al.,* 2011).

Unlike the forests, the savanna vegetation is hardly arranged in different vertical layers, especially the more open vegetation in the northern part of the inventory area. The graminaceous layer is the most prominent element of the savanna ecological system (Jibrin, 2013; Buba, 2015). Almost all human and faunal activity is concentrated in this layer. Because of its open structure, the savanna vegetation does not create its own micro- climate and is not buffered against changes in temperature, relative humidity, and other climatological variables (Buba, 2015). As a result, sunshine and rains have a direct impact on the soil surface.

Figure 3: Savanna vegetation (source: google.com)

The water and nutrient cycles of the savanna ecological system are determined by the seasonality of water availability. Because of the prevailing short humid period in the Savanna Zones and the open structure of their vegetation, the soils of the Savanna Zones dry up for a certain period during the dry season. This process is strengthened by the relatively shallow root system of the savanna vegetation, which is not as effective as the forest in pumping water from great depths. Water deficiency in the dry season has an inhibiting effect on the nutrient uptake by the vegetation (Ariko *et al.,* 2019).

As outlined above, the Savanna Biome in Nigeria is characterized by;

- Predominance of grasses
- Presence of short but scattered trees
- Absence of stratified canopies
- Presence of fire-resistant tress with small-sized leaves
- Presence of drought resistant trees

- Presence of underground stems

- Presence of deep-rooted plants

- Presence of modified leaves, e.t.c.

Two factors common to all savannah environments are annual variations in rainfall and dry season wildfires (Muoghalu, and Isichei, 1991; Staver, 2011; Jibrin, 2013; Moncrieff *et al.,* 2016).

SAVANNA BIOMES IN NIGERIA

In Nigeria, depending on annual rainfall and growing season length, we have three (3) major savanna belts namely:

1: Guinea savanna

2: Sudan savanna

3: Sahel savanna

Figure 4: Nigerian ecological zones showing the Savanna belts

GUINEA SAVANNA IN NIGERIA

The Guinea savanna (or savanna woodland/wooded savanna) is the most extensive vegetation in the middle belt of Nigeria, and consist of a mixture of trees and grass. As described by Sarumi *et al.,* (1996); It receives annual rainfalls between 1000 – 1500 mm with about 6-8 months of rainfall. The typical vegetation is an open woodland with tall grasses (1 to 3m high) in open areas and trees (up to 15m high) usually with short boles and broad leaves. This vegetation is burnt almost annually by fierce fires in the dry season, therefore fire-resistant species predominate (NFREL Report, 2019).

Characteristic of this zone is the woodland savanna, which consists of an open stand of trees, the crowns of which form a canopy from 8 - 20 m or more in height and cover at least 40% of the surface. The crowns of adjacent trees are often in contact but are not densely interlocking as in the Equatorial Forest climax vegetation (Muoghalu and Isichei, 1991; Buba, 2015).

The plants to adapt themselves to the climatic environment, by developing long tap roots and thick barks, which enable them to survive the long dry season and resist bush fires. Trees in savanna also have tiny leaves to reduce transpiration. (Muoghalu and Isichei, 1991).

Soils in the zone are generally classified as Alfisols, highly weathered and fragile with low activity clays, thus making their fertility fall under continuous arable cropping (Buba, 2015).

Trees Species include; Shea butter, Oil palm, *Isoberlina spp., Daniellia oliveri, Lophira alata, and Terminalia spp.* e.t.c. (Buba, 2015).

The guinea savanna covers the most extensive region of the West African savanna. This woodland savanna can be divided into two:

- **Southern Guinea Savanna**
  This vegetation is better described as mid-way between forest in the south and woodland savanna in the north. Mean rainfall is above 1000 m, with distinct dry season. Dry season in the Southern guinea savanna is shorter and less intense. It is characterized by tall grasses which could reach up to 3 m in height.
  The main tree species are *Daniellia oliveri, Afzelia, Alida, Hypmemocardia, Lophira alata*, and *Terminalia glaucescens.* Significant grass genera are *Andropogon, Cymbopogon, Hyparrhenia,*

Pennisetum, and *Setaria* (Buba, 2015). Animal species present include; Deer, Rats, Grasshoppers and Snakes.

In Nigeria they are found in the following states: Kwara, Benue, Enugu, Ebonyi, Oyo, Ekiti, Osun, e.t.c.

- **Northern Guinea Savanna**

   It is a more open woodland savanna, which is characterized by the *Isoberlinia spp*., in association with the perennial grass *Hyparrhenia spp*. Its physiognomy is rather similar to that of the southern guinea savanna, although poorer and more distinct in its species composition. Trees are shorter, thorny and fewer in number. Dry season is longer. It is also characterized by tall, Perennial grasses quite similar to those found in the Southern Guinea Savanna which include; *Hyparrhenia, Brachiaria, Cymbopogon* e.t.c. however, *Setaria spp.* is absent. Common trees are: *Isoberlinia dalzielii* and *Monoteskerstingii, Isoberlina, Uapola, Monotes*, e.t.c. (Buba, 2015).

   Northern Guinea Savanna is found in the following states: Niger, Taraba, Kaduna, Bauchi, Kano, Adamawa, Benue, Kwara, Kogi, e.t.c.

THE SUDAN SAVANNA IN NIGERIA

The Sudan savanna belt is found to the Northern parts of Nigeria, and stretches from the Sokoto Plains through the Northern section of the High Plains of Nigeria to the Chad Basin. It includes areas around Sokoto, Kaduna, Kano and Borno States of Nigeria, comprising an area over a quarter of the country. Rainfall ranges from about 600-1000 mm and the relative humidity is generally below 40%, except for the few rainy months when this can rise to 60% and above (Challinor *et al.,* 2007; Ariko *et al.,* 2019). Daytime temperatures can fluctuate greatly, from 15°C at night to over 40°C during the day (Sandwidi, 2007). Frequently, subsoils have a clayey texture with sandy to loamy top soils, coupled with high rainfall intensities in the savanna zones, the region is very susceptible to erosion (Challinor *et al.,* 2007; Callo-Concha *et al.,* 2019). The sudan savanna is characterized with high rainfall variability and frequent droughts (Challinor *et al.,* 2007), together with poor soil fertility being major constraint to agriculture in the region (Sanchez, 2002).

Figure 5: The Sudan Savanna (Source: google.com)

The zone experiences a dry season of about 4-6 months. The zone has the largest population density in Northern Nigeria, produces important economic crops such as groundnuts, cotton, millet, and maize and has the highest concentration of cattle in the country. Sudan savanna has consequently suffered great impact from man and livestock. The landscape has less vegetation than the Guinea savanna. Existing vegetation consist mainly of short grasses, about 1-2 m high, and some stunted tree species, such as *Acacia spp*, *Ceiba pentandra* (silk cotton/ kapok) and the *Adansonia digitata* (baobab), *Hyphaene thebaica* (doum palm). *Parkia spp., Butyrospermum spp., Acacia albida* e.t.c., are also found (Challinor *et al.,* 2007; Callo-Concha *et al.,* 2019). Up north, thorny plants like Acacia spp. become more prevalent, while the grasses get shorter, less tussocky, and featherier.

Due to the drought-stress in the long dry period, most grasses are annuals. Commonly occurring annuals include *Andropogon pseudapricus, Hyparrhenia, and Loudetia spp.* A number of perennials grow vigorously: *Andropogon gayanus, Anthrophora nigritane, Aristida stipoides, Pennisetum setosum, and Hyparrhenia spp.*

SAHEL SAVANNA IN NIGERIA

The Sahel savanna, is found to the extreme Northwest and Northeast of the country, where the annual rainfall is less than 600 mm and with dry seasons exceeding 8 months (WWF, 2007). It is a transitional ecoregion of semi-arid grasslands, savannahs, steppes and thorn shrubs lying between the wooded savanna to the south, and the sahara to the north. The topography is mainly flat; usually between 200 – 400 meters in elevation (Dai *et al.,* 2004).

Figure 6: sahel savanna (source: google.com)

The region has a sparse vegetation that is dependent on uncertain rainfall, dominantly grasses with discontinuous shrubs and scattered trees 4 to 9 m in height most of them are thorny, and extensive sparse grasses.

Main tree species include *Acacia raddianna, A. Senegal, A. laeta* and *Commiphora africana;* the shrubs are *Salvadora persica, Leptadenia pyrotechnica,* and four species of Grewia; while the grasses include *Aristida stipoides, Schoenefeldia gracilis* and *Chloris priean.*

ENVIRONMENTAL FACTORS AFFECTING THE SAVANNA BIOME

The Savanna biome is grossly affected by four key environmental factors (Hutley and Setterfield, 2018), they are;

1. Availability of Water / moisture
2. Availability of Soil nutrients

3. Fire occurrence
4. Herbivory: Herbivores include vertebrate and invertebrates and consist of both browsers consuming woody biomass and grazers consuming grasses and herbs.

ADAPTIVE TRAITS OF SAVANNA VEGETATION

Savannah plants exhibit a number of characteristics to cope with seasonal drought, low water and nutrient availability, and the impacts of regular fire and herbivory.

- **Adaptations for the survival of seasonal fire**

Figure 7: Seasonal fire ravaging a savanna vegetation (source: google.com)

Savanna plants develop thick insulating bark, high wood moisture content, elevated and well-separated crowns, and significant resprouting capacity.
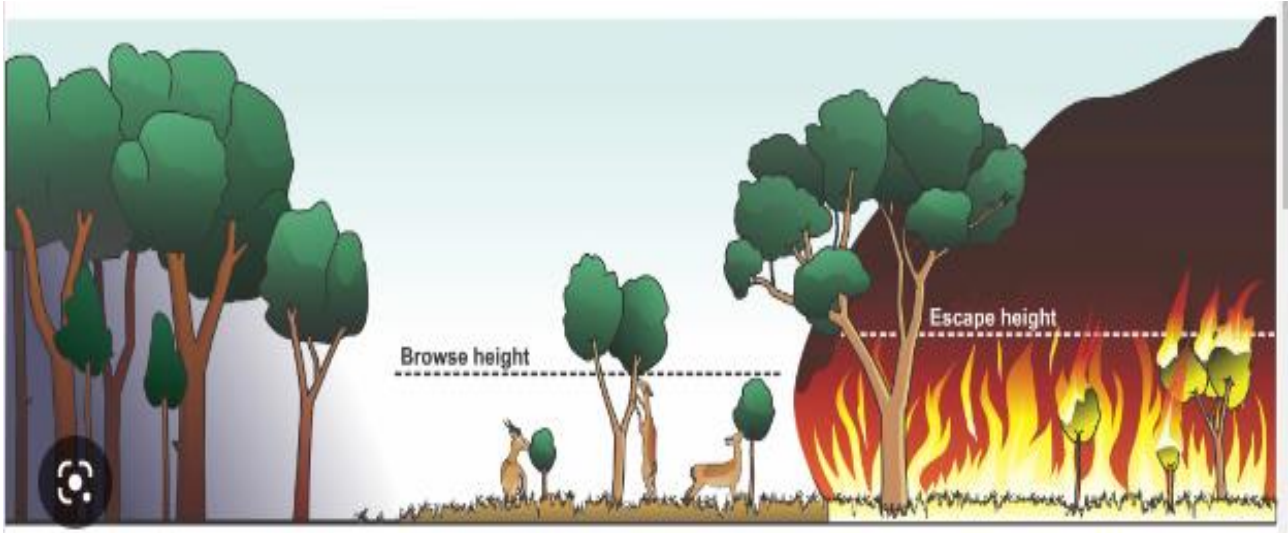
Figure 8: Savanna trees adaptation to seasonal fire occurrence (source: google.com)

Resprouting can occur via lignotubers and from other underground and stem basal tissues following the death of aerial stems. This enables recovery with minimal developmental costs. Vegetative reproduction from roots, rhizomes, or stolons is dominant in much of the savanna biome.

Figure 9: Savanna grasses sprouting after a fire occurrence (source: google.com)

Annual herbaceous species persist via a soil seed bank whereas above-ground parts of perennial herbaceous species die during dry periods, with dormant, regenerative buds protected within below-

ground rhizomes or by cataphylls. Some annual herbaceous species use hygroscopically active stems and sharp calluses on the seed that enables penetration into the surface soil protecting them from fire (Baudena *et al.,* 2015).

- **Adaptations to low nutrient availability** include root mycorrhizal associations, particularly of ectomychorrhizae. Savannah trees can rapidly transfer nutrients sequestered by leaves to other tissues (e.g. bark) before leaves fall.

- **Adaptations against herbivores**; woody savanna plants often have thorns that restrict grazing, as well as chemical features, such as tannins making leaves less palatable.

Fig. 10 *Solanum viarium* possess thorny leaves to resist herbivores

Savanna grasses also display morphological features, such as serrated edges and chemical features, including tannins and silica bodies to restrict grazing (Hutley and Setterfield, 2018).

- **Photosynthetic pathway;** The herbaceous grass layer is dominated by grasses with the C4 photosynthetic pathway. This pathway enables high photosynthetic rates at high temperatures and irradiance and low water availability. Most savannah trees and shrubs have the C3 photosynthetic pathway which has greater efficiency in low light conditions when compared to the C4 pathway; a

characteristic which facilitates establishment under shaded tree canopies (Moncrieff *et al.,* 2016; Hutley and Setterfield, 2018).

- **Adaptations to water stress:** The growth of savanna plants tends to occur mostly during the wet season with senescence or dormancy in the dry season prone to fires, a characteristic that facilitates persistence under adverse conditions. Most herbaceous species flower in the wet season, although in contrast, many woody species flower in the dry season (Jibrin, 2013; Hutley and Setterfield, 2018).

Figure 11: Reduced leaves in cactus to reduce water loss (source: google.com)

Figure 12: Deciduous plants shed their leaves in dry periods (source: google.com)

Woody species have evolved physiological and morphological mechanisms to either tolerate (**evergreen** habit) or avoid (**deciduous** habit) prolonged periods of water stress. Deep-rooting woody plants (usually evergreen) can access water resources throughout the year and attain their full photosynthetic capacity when favorable conditions occur. Deciduous species rehydrate stems before the onset of wet season rains, which is then followed by leaf expansion to maximize photosynthetic activity during the wet season.

➢ Deciduousness and evergreeness represent extremes of physiological adaptations to survive the seasonal savanna climate. Evergreen species invest more resources in longer-lived leaves, whereas deciduous species tend to support shorter-lived leaves with high leaf photosynthetic capacity.

➢ Deciduous species need to acquire enough nutrient and photosynthate to ensure persistence and reproduction during the wet season, whereas evergreen species tend to have slower growth rates but persist throughout the seasonal cycle.

➢ Evergreeness also allows opportunistic acquisition of resources when soil nutrients are severely limiting and the cost of producing new leaves to respond to change in soil moisture is prohibitive (Hutley and Setterfield, 2018).

Economic Importance of Savanna Biome in Nigeria

Like many woodland biomes in other areas across Africa, Savanna Biome in Nigeria generates a wide range of timber and non-timber products and services (Mutenje *et al.,* 2011). Products and services include;

➢ Consumptive resources such as bark for rope, building materials, fodder, fruits, fuel wood, fungi, bushmeat, gum, honey, insects, termites, leaf litter, medicines, mushrooms, roots, thatching grass, tubers, and wood for small artisanal crafts e.t.c.

➢ Social services such as cultural and spiritual benefits

➢ Aesthetic value;

➢ Recreation and wildlife experience;

➢ Employment;

➢ Ecological services such as carbon sequestration, grazing, shade, soil stabilization, water catchment,

➢ Wildlife habitat, as it serves as a source of browse for both domestic and wild animals. and act as windbreaks.

➢ Also, The savanna is home to some of the most economic fruits, which include those collected from *Adansonia digitata* and *Vitellaria paradoxa.* (Logan and Moseley, 2002; Mutandwa and Gadzirayi, 2007)

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