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ASSESSMENT OF VEGETATION COMMUNITY COMPOSITION IN YANKARI GAME RESERVE, BAUCHI STATE, NIGERIA

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ABSTRACT

This study examined vegetation cover composition in Yankari Game Reserve from 1986 to 2015 with the aim of evolving a sustainable forest resource management and biodiversity conservation. Intensive and extensive ground trotting exercise were employed to collect data on ground vegetation characteristics such as species type, number, density and information on landuse history and practice within the study area. Normalized Vegetation Index (NDVI) derived from five near anniversary imageries (November and December) of 1986 (Landsat5-TM), 1999 (Landsat7-TM), 2005 (Landsat 7- ETM), 2010 (Landsat 7- ETM), and 2015 (Landsat-8 OLI) were corrected for atmospheric attenuation using UTM-32 map projection. Quadrant samples were used to generate data on species diversity and distributions of woody plants. The finding reveals that in terms of density, quadrant B shows the lowest value which is as a result of intense pressure on the vegetation cover, while quadrant D shows the highest value. The endangered species recorded in the study area were Eleusine indica and Echinochloa stagnina in quadrant A, Eragrostis tenella in quadrant B. Loudetia annual in quadrant C, and Fuirena ciliaris species in quadrant D. The finding also reveals a decrease in dense woodland vegetation cover over the study period. It is recommended that clear guidelines on the legal activities be developed by the state government with public participation to regulate the use of its resources as well as a balance between utilization of the forest resources and biodiversity conservation.

Key Words: Vegetation community, composition, endangered species, Yankari Game Reserve.

INTRODUCTION

A nation's system of protected areas is designed to suit its own requirements for conserving the resources as a sustainable base for human development (Ejidike, 2008). Conservation practices of natural resources are positive, embracing preservation, maintenance, sustainable utilization, restoration and enhancement of the resources (International Union for Conservation of Nature, 2004). Countries worldwide have designated some land as protected areas that have many benefits. This includes the role they play in socio-economic development of local inhabitants in surrounding rural areas; they contribute to the better lifestyle and standard of living (Ayo, 2006). In national parks, game reserves and other protected areas such as Gashaka Gumti, Kainji and Okomu national Park among others, unique flora and fauna, sceneries and landscape are protected, managed and regulated for human benefit from one generation to another (Ejidike, 2008).

Proper management of natural resources in any nation projects good image and strength of the country because vegetation cover plays indispensable roles in creating and preserving

quality environment (Nwoboshi, 2000). Conservation of the resources of a nation environment plays essential role in the development of such country, these intend at revealing different efforts being made by the Federal and State Governments in promulgating new National Parks and Game Reserves in different states in pursuance of conserving wildlife and vegetation of the nation (Nwoboshi, 2000).

Forest areas worldwide have continued to reduce owing to deforestation. According to Food and Agriculture Organization (2008), Nigeria lost an average of 409,700 hectares of forest per year between 1990 and 2000. This amounts to an average annual deforestation rate of 2.98%. Between 2000 and 2005, the rate of deforestation increased to 3.12% per annum. In 1990 and 2005, Nigeria lost 6,145,000 hectares (35.7%) of its forest cover. In other words, Nigeria lost 1,230,000 hectares of its forest cover from 1990 to 2005. This development in land cover change have also raised the concern as to whether the land, be it in natural condition or cultivated, can continue to hold its environmental functions needed to sustain man (Mortimore, 2009).

Monitoring vegetation cover change over time provides important information about the stability of the ecosystem and whether significant changes are taking place or not. The rates and pattern of the changes in vegetation cover could be achieved through trend analysis (Jensen, 2000). Remote sensing techniques have been identified to provide a viable source of data from which updated land cover information can be extracted efficiently in order to monitor these changes (Houghton, 2003; Roy *et al.,* 2009; Mas, 2006; Vasconcelos *et al.*, 2010; Potter *et al.,* 2007). In addition, the importance of indigenous knowledge in natural resource management has, since the beginning of the 21st century, been identified (Wells *et al.,* 2002; Altieri, 2002). In particular, it has been recognized that local farmers around the world are able to manage their lands in a sustainable way (Mazzucato and Niemeijer, 2004).

In northern Nigeria, Game Reserves have presently become dependent on rainfall, human activities such as shifting cultivation, bush burning, lumbering and grazing. Different studies suggest that vegetation index correlates well with leaf area index, green leaf biomass and annual net primary productivity of any given area (Ahlcrona and Solomon, 2006; Viña *et al.,* 2004). Moreover, little is known quantitatively, regarding the degree to which the spatial variation of the vegetation index depends on rainfall seasonality in the tropics at regional scale (Barbosa and Lakshmi, 2011).

Circumstantial evidence from reconnaissance survey shows that Yankari Game Reserve has witnessed severe degradation within 2010-2015, partly due to decline in rainfall from 377 mm in 2005 to 264 mm in 2010 (Muchena and Niemeijer, 2005) but largely due to increased human activities such as; arable farming, grazing and fuel fuelwood harvesting. The implication of a decline on the ecology of the reserve particularly in relation to vegetation cover change, biomass production and wildlife management has not been investigated of recent, particularly since the reported decline in species numbers and the encroachment into the traditional grazing areas by other forms of landuse (Rao and Kasper 2009); therefore the need to examine vegetation cover composition in Yakari Game Reserve.

Thus, evidence suggests Yakari Game Reserve has witnessed severe degradation within the past thirty to forty years due to anthropogenic activities associated with expansion and clearances of arable land for farming to meet the needs of a rapidly growing human population around the reserve (Apeldoorn, 2008). The ecology of the reserve particularly in relation to forage species composition, vegetation cover distribution has not been investigated, particularly since the reported increase in grazing by nomads and the encroachment into the traditional grazing areas by other forms of landuse. However, it is not clear to what extent these activities have affected the vegetation condition of the area (Munyati, 2008). Consequently, this study investigated the spatial composition of vegetation cover change that has occurred as a result of human activities in Yankari Game Reserve from 1986 to 2015.

MATERIALS AND METHODS

Study Area

Yankari Game Reserve occupies an area of about 47.48 km.sq. It is located between latitudes 9^{o} 40' 00" N and 10^{o} 0' 00" N and longitudes 10^{o} 20′ 00" and 10^{o} 40' 00" E which covers Duguri, Pali and Gwana Districts of Alkaleri Local Government Area of Bauchi State, Nigeria (Figure 1).

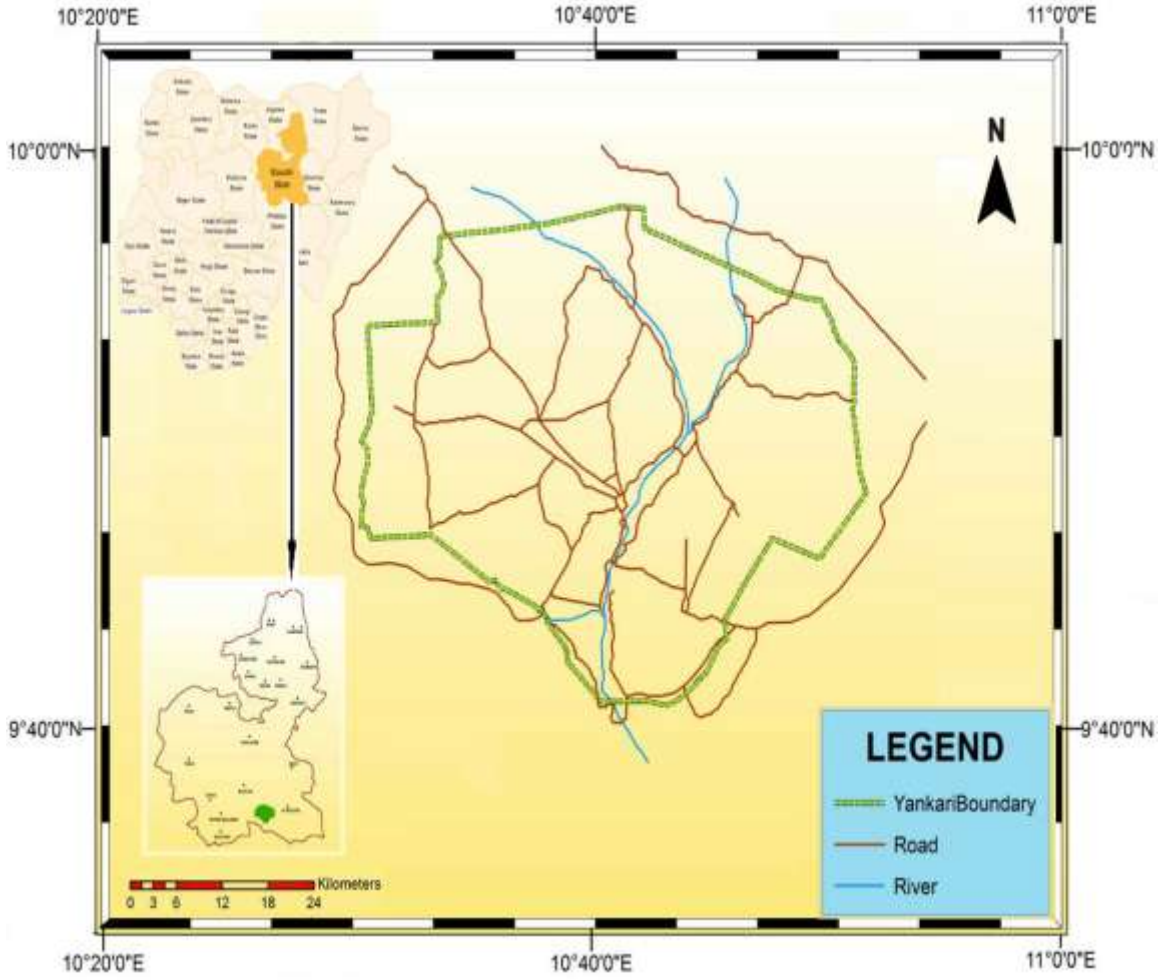

Figure 1: Yankari Game Reserve
Source: National Remote Sensing Centre, Jos (2015)

Rainfall in Yankari Game Reserve ranges between 350 mm and 1300 mm per annum. The rainy season begins around May and ends in November while the dry season begins in early October and lasts until April (Anyadike, 1993). Rainfall in the study area is clearly marked by a monomodal regime, which peaks in August (Areola, 2008). Temperatures in Yankari Game Reserve are relatively high with a mean annual of 32 ^{o}C (Ayoade, 2000). Diurnal temperature ranges from 32 to 38 ^{o}C, influenced by katabatic (Bora winds) and Anabatic (Foehn winds) of the surrounding hills of the Jos Plateau during the night and morning hours (Ayoade, 2009). Temperature ranges from 18-36 ^{o}C in dry season and 20-31 ^{o}C in the rainy season (Aondover and Mingko, 2010).

The soils are mainly clay loams, alluvial soils are found around the Fadama. Generally, the soils in Yankari are dark and rich in humus "A horizon" and laterites occur in the "B horizon" (Udo, 2000). The Reserve is almost entirely underlain by the kerri formation, silt stones, kaolinites and grits while on the valleys of the Gaji, Yashi and Yuli rivers are covered with alluvium soils that supports dense vegetation cover (Udo, 2000). Yankari Game Reserve is basically composed of crystalline rock made up of basement complex rocks of Precambrian origin (Barrett, 2001).

The Reserve spans across the Sudan-Sahelian zone of Nigeria. The vegetation is richer towards the south and along the course of the major river (Gaji) as well as communities along its tributaries (Walter, 1997). Nevertheless, the vegetation is less uniform and grasses are shorter than what is in the South (Turner *et al.,* 1999). The Sahel Savanna, also known as the Semi-desert vegetation type, becomes evident from the middle of the State to the north characterized by isolated stands of thorny shrubs. The South-Western part of the area is mountainous as a result of the continuation of the Jos Plateau while the Northern part is generally sandy (Walter, 1997). The vegetation is affected by human activities such as arable farming, fuelwood harvesting, pastoralism, bush burning and selective logging for timber. The adverse effects of these activities include reduction in distribution and species diversity.

During the dry season, the environment gets patchy and dry with trees and shrubs shedding leaves to conserve water and developed resistance against the dry weather and bush burning (Iloeje, 2009). Major trees found in area are locust bean, "*Ashiwali"*, tamarind, host of herbs and shrubs (Udo, 1997 and Iloeje, 2009). Yankari Game Reserve is a restricted area with a high density and diverse species of trees (Badamasi, 2014). The dominant species within the Game Reserve includes *Isoberlinia doka, Khaya senegalensis, Vitex doniana, Anogeissus leiocarpus, Tamarindus indica, Detarium microcarpum and Pterocarpus erinaceus* (BirdLife International, 2007; Geerling, 1993; Green and Amance, 1997). On the floodplains of rivers Gaji, Gongola and Jama'are the woody plants are dense and taller than on the hilly spots (Abdullahi, 2010). The vegetation provides essential materials such as fuelwood, fruits and vegetables to the people and serves as a habitat for wildlife's and sources of nutrition.

Data Collection Procedure and Experimental Design

The data used for this study was categorized into the following: Remotely sensed and ancillary data. The primary data for the research was obtained through quadrat samples of vegetation species.

To sample the vegetation distribution and species diversity, sample quadrants were adopted (Dombois and Ellenberg, 2001). The area was divided into four strata as shown on Figure 2. From each stratum, one sample was purposively located in an area where the required data on woody plant stands were available for observation and measurements. Likewise, area devoid of grass and woody plant stands such as bare land surfaces; water body and arable land were purposively sampled out. Equally observation was carryout on the possible usage of each of the plants. Furthermore, the study covered a period of 29 years (1986 to 2015), the sampled years were 1986, 1999, 2005, 2010 and 2015 respectively.

Landsat imageries provide data on Normalized Difference Vegetation Index (NDVI) and landuse landcover changes. Availability, affordability and data quality forms the bases for the choice of landsat imagery used in this study. The landsat data series covering a time frame of 1986 to 2015 with sampled years of 1986, 1999, 2005, 2010 and 2015 selected for the study were acquired freely via the United States Geological Survey (USGS) Global Visualization Viewer (Glo Vis). The imageries were downloaded as a compressed Geotiff files and imported to ArcGIS environment via the Landsat import module.

Data Analysis

The generated data on vegetation distribution and species diversity, Normalize Deferential Vegetation Index (NDVI) was analysed through comparison using statistics such as frequency and percentage calculated for each of the vegetation type observed within each quadrant sampled. Overall cover, density and frequency estimates were then calculated for each species from the entire data set by combining all of the quadrats together.

$$\text{Density} = \frac{\text{Population}}{\text{Area}}$$

To detect the leaf index from satellite images for NDVI comparison, the classes were categorized namely; dense vegetation cover which include areas with distress foliage cover such area are observed on rocky surface; hilly areas and areas that are frequently burnt. Also, to generate statistics for the various attributes on landuse landcover and NDVI, the data were classified and the magnitudes were determined using ArcGIS software. More

importantly woody plants dominated by tree species such as *Acacia albida* thorny shrubs that shed leafs during the dry season are identified with red colour. Riparian represent areas that are along river floodplain represented in blue. The vegetation cover is greenish than the adjacent areas because deep, fertile and moist soils are found along the Gaji River, such areas are depicted in green.

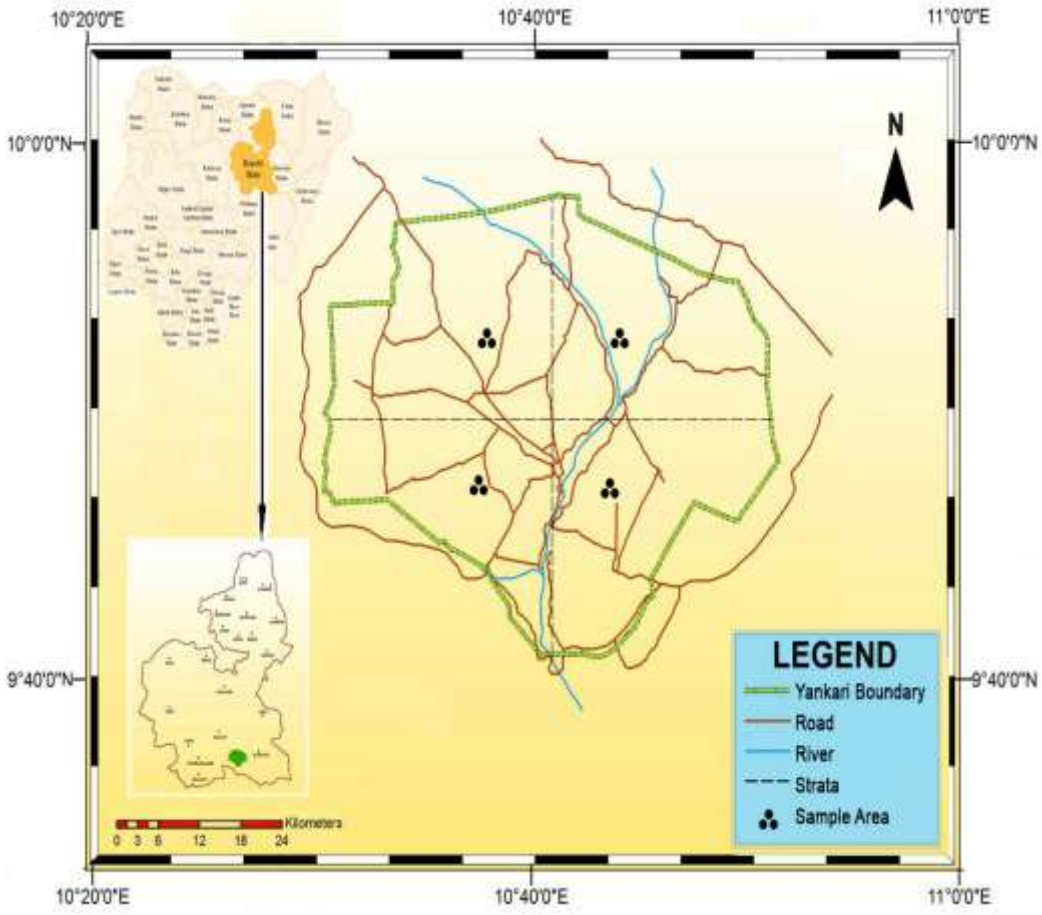

Figure 2: The Study Area Showing Quadrat Samples

Source: Field Work (2016)

RESULTS

Composition of Vegetation Community in Yankari Game Reserve.

Table 1 presents summary of woody plant species observed in quadrant A (25sq.m) using quadrant samples. Table 1 shows there are 11 different species of grass and woody plants observed in quadrant A measuring 25 m^2. *Echinochloa pyramidalis* has the highest species distribution with 17.5% while *Eleusine indica* is the least with 1.8%. The magnitude varies from 1.8 to 17.5% while the density ranges from 0.04 to 0.4. The result implies species such as *Echinochloa pyramidalis* and *Digitaria horizontalis* are the dominant species while *Eleusine indica* and *Echinochloa stagnina* are the rare or endangered species. Thus, *Eleusine indica* (1.8%) and *Echinochloa stagnina* (3.5%) are observed to be used as herbal medicine and fodder for animals respectively which could be the reason why these species did not appear in abundance in quadrant A.

Table 2 shows 11 species of grass plants that were observed from quadrant B. Using a quadrant size of 25m^2; the frequency of the various grass plants was used to calculate the density of species within quadrant B. Furthermore, the results obtained revealed *Fuirena umbellate*, *Hyparrhenia rufa* and *Eragrostis tenella* to be in abundance and rare respectively, the threat to *Eragrostis tenella* (2.13%) also increases when animals graze and feed on them.

Table 1: Grass and Woody Species Diversity of quadrant A (25sq.m.) in Yakanri Game Reserve

Species	Local Names (Hausa)	Frequency	Percentage (%)	Density
Echinochloa pyramidalis (Grass)	Gyaushe	10	17.5	0.4
Digitaria horizontalis (Grass)	Karanin dawaki	9	15.8	0.36
Ctenium newtoni (Grass)	Wútsííyàr ɓééráá	8	14.0	0.32
Cyperus difformis (Grass)	Zaitun	7	12.3	0.28
Rotboellia exaltata (Grass)	Jazama	6	10.5	0.24
Acroceras amplectans (Woody)	Géérón tsúntsààyéé	5	8.8	0.2
Digitaria exilis (Woody)	Firo	4	7.0	0.16
Digitaria gayana (Grass)	Gajele	3	5.3	0.12
Cyperus exaltaltus (Grass)	Kajiji	2	3.5	0.08
Echinochloa stagnina (Grass)	Geron Tsuntsu	2	3.5	0.08
Eleusine indica (Grass)	Ciyawa tuji	1	1.8	0.04
Total		**57**	**100**	**2.28**

Source: Field Work (2016)

Table 2: Grasses Specie Diversity of Quadrant B (25sq.m.)

Grasses Specie	Local Names (Hausa)	Frequency	Percentage (%)	Density
Eleusine indica	Ciyawa tuji	4	8.51	0.16
Eragrostis tenella	Kyasuwa	2	4.26	0.08
Fimbistylis exilis	Gemun Kwudi	5	10.64	0.2
Fimbristylis ferruginea	Ríídĩn tùùjìì	3	6.38	0.12
Fuirena ciliaris	Kirni	6	12.77	0.24
Fuirena umbellate	Lállàkí	9	19.15	0.36
Hyparrhenia cyanensis	Tsintsiya	7	14.89	0.28
Hyparrhenia rufa	Badayi	1	2.13	0.04
Imperata cylindrical	Zarenshi	6	12.77	0.12
Eragrostis tenella	Kyasuwa	1	2.13	0.04
Fimbistylis exilis	Gemun Kwudi	3	6.38	0.12
Total		**47**	**100**	**1.76**

Source: Field Work (2016)

Table 3 shows eleven different species of grass and woody plants were observed within quadrant C. Making use of 25 m^2 as the size of quadrant, the various woody plant species percentage and density were calculated from the frequency of distribution. Thus, *Oryza lonistaminata* obtained the highest number of individual stands of 13 and Percentage of 20.64% respectively, while *Loudetia annual* species recorded the lowest individual stand and percentage of 1 and 1.59% respectively. The low occurrence of *Loudetia annual* in quadrant C might be as a result of increased animal grazing and arable farming among other activities on the species as observed in processes of data collection, thereby making it rare while *Oryza lonistaminata* found along Wikki Camp has reached a naturalization stage due to the species ability to adapt to the environment due to the presence of the Gaji River.

Table 3: Grass and Woody Species Diversity of Quadrant C (25sq.m.)

Species (Woody and Grass)	Local Names (Hausa)	Frequency	Percentage (%)	Density
Oryza lonistaminata (Grass)	Ɗán ciso	13	20.64	0.52
Fuirena umbellate (Grass)	Lállàkí	9	14.29	0.36
Panicum subalbidum (Grass)	Macara	8	12.70	0.32
Imperata cylindrical (Grass)	Zarenshi	8	12.70	0.32
Pharagmites karka (Woody)	wútsíyàr gííwáá	7	11.11	0.28
Hyparrhenia cyanensis (Grass)	Tsintsiya	6	9.52	0.24
Leersia hexandra (Grass)	Madariki	4	6.35	0.16
Oryza barthii (Grass)	Lállàkíí	3	4.76	0.12
Pennisetum polystachion (Grass)	Daura	2	3.17	0.08
Hyparrhenia rufa (Grass)	Badayi	2	3.17	0.08
Loudetia annual (Grass)	Kajinjiri	1	1.59	0.04
Total		**63**	**100**	**2.52**

Source: Field Work (2016)

Table 4, showed fifteen (15) different woody and grass plant species observed within quadrant D. The data computed from Table 4 were generated from quadrant D which has a total area of 25 m^2. From the analysis it was indicated that species *Oryza lonistaminata* has highest value of individual stand with a percentage cover of 13 and 17.57 respectively while the species *Fuirena ciliaris* has the lowest individual stand and percentage.

Fuirena ciliaris species is rare and it is at a higher risk of extinction than other vegetation cover because of the medicinal quality it offers. Herbal collectors of rare plants are contributing to the recent decline in species number of *Fuirena ciliaris* within the Reserve. The main cause of decline in *Fuirena ciliaris* is as a result of loss of its natural habitat which is mainly due to population explosion which will in turn result to intense harvesting for medicinal purposes. As population increase, vegetation cover tends to decline more and more as a result of construction of roads and development of communities (Mai'ari and Mainamaji villages) along the boundaries of the Reserve.

Normalized Difference Vegetation Index (NDVI) 1986

The satellite imageries were classified into three classes; they include dense woodland, riparian and bare land. The vegetation classification map for 1986 clearly illustrates the spatial patterns of vegetation cover distribution within the reserve as shown in Figure 3.

The spatial distribution of Normalized Difference Vegetation Index (NDVI) based on the analysis of vegetation index from the landsat imagery is as depicted in Figure 4. Dense woodland is the dominant vegetation cover while bare land surfaces were observed along the fringes of the Reserve boundary. Normalized Difference Vegetation Index (NDVI) map of 1999 is classified into three (3) classes.

The classification index overlay was achieved with the aid of the reclassifying tool of spatial analysis in the ArcGIS 10.4 using the maximum likelihood supervised classification method. Three classes were derived by the classification as seen in Figure 5 which ranged from dense woodland, riparian and bare land.

Table 4: Grass and Woody Species Diversity of Quadrant D (25sq.m.)

Species	Local Names (Hausa)	Frequency	Percentage (%)	Density
Fuirena umbellate (Woody)	*Lállàkí*	8	10.81	0.32
Hyparrhenia cyanensis (Woody)	*Tsintsiya*	4	5.41	0.16
Hyparrhenia rufa (Grass)	*Badayi*	2	2.70	0.08
Imperata cylindrical (Woody)	*Zarenshi*	7	9.46	0.28
Leersia hexandra (Grass)	*Madariki*	5	6.76	0.20
Loudetia annual (Woody)	*Kajinjiri*	2	2.70	0.08
Oryza barthii (Grass)	*Lállàkíí*	1	1.35	0.04
Oryza lonistaminata (Grass)	*Ɗán ciso*	13	17.57	0.52
Panicum subalbidum (Grass)	*Macara*	6	8.11	0.24
Pennisetum polystachion (Grass)	*Daura*	9	12.16	0.36
Pharagmites karka (Woody)	*wútsíyàr gííwáá*	2	2.70	0.08
Fimbristylis ferruginea (Grass)	*Ríídĩn tùùjìì*	4	5.41	0.16
Acroceras amplectans (Woody)	*Géérón tsúntsàáyéé*	6	8.11	0.24
Fimbristylis ferruginea (Woody)	*Ríídĩn tùùjìì*	4	5.41	0.16
Fuirena ciliaris (Grass)	*Kirni*	1	1.35	0.04
Total		**74**	**100**	**2.96**

Source: Field Work (2016)

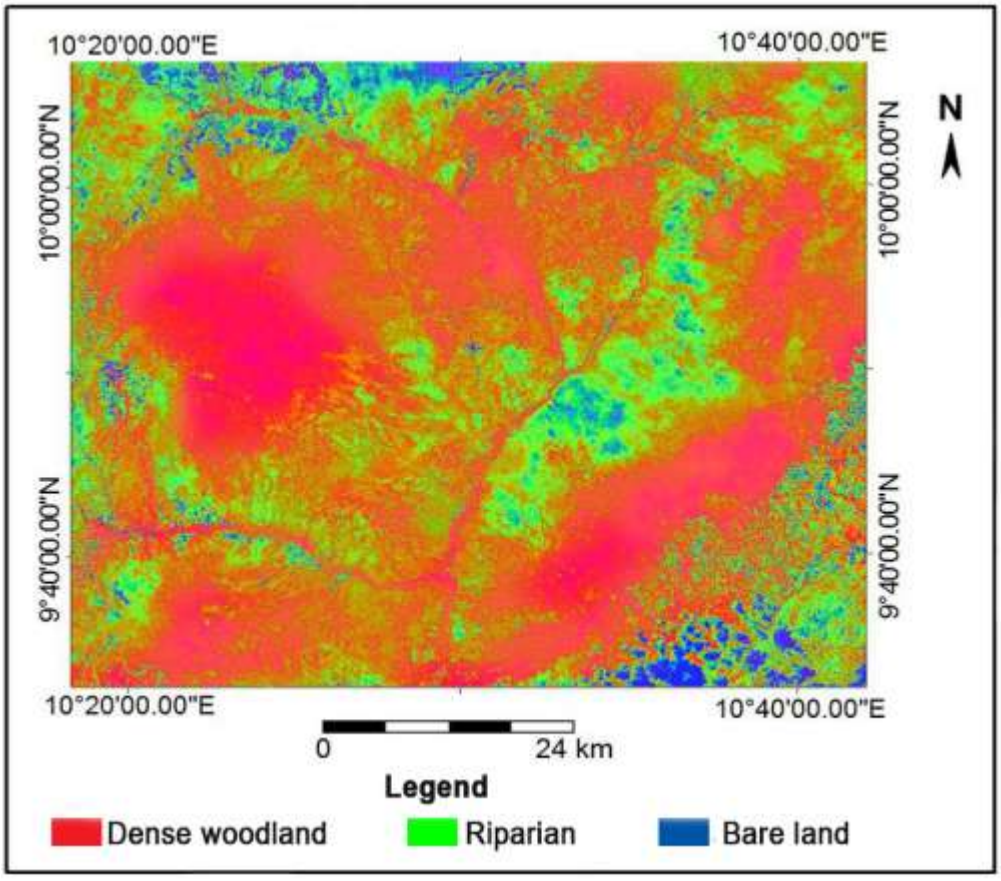

Figure 3: Normalized Difference Vegetation Index (NDVI) 1986
Source: USGS (2017)

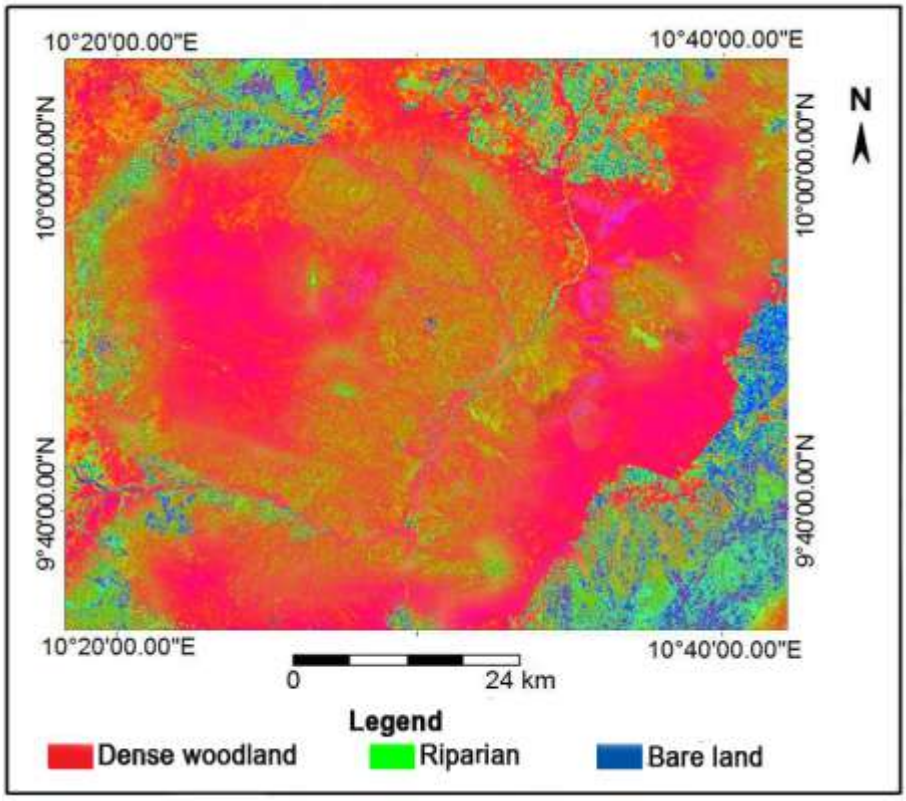

Figure 4: Normalized Difference Vegetation Index (NDVI) 1999
Source: USGS (2017)

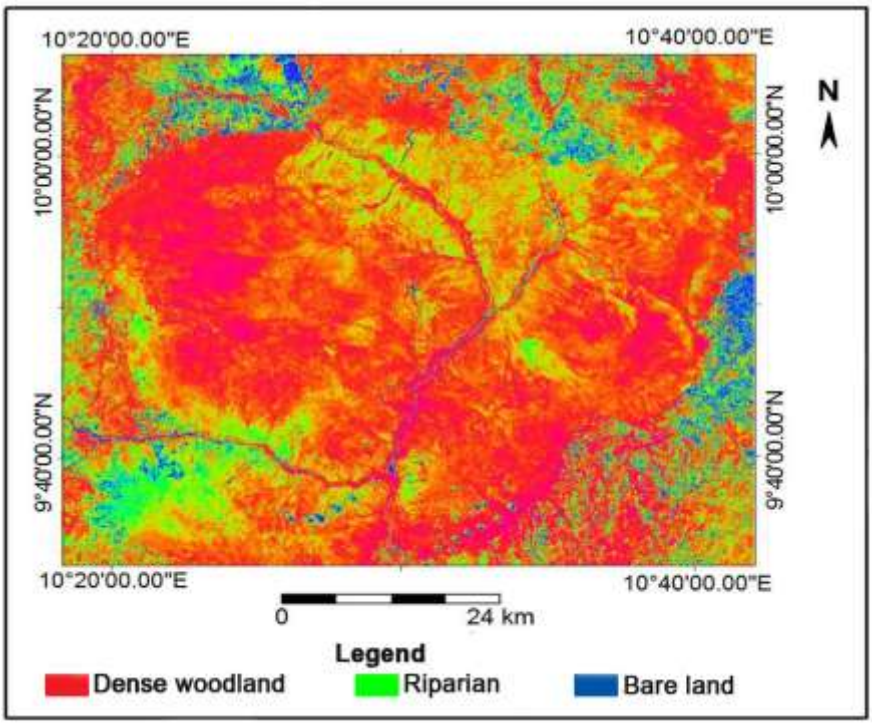

Figure 5: Normalized Difference Vegetation Index (NDVI) 2005
Source: USGS (2017)

The spatial distribution of vegetation cover class within the study area is as shown in Figure 6. Dense woodland is the dominant vegetation cover within the reserve, riparian vegetation cover is the second dominant vegetation cover class in the north eastern part of the study area. Bare land surfaces which stood at 17.84% were found in the north east, south east and north western part of the reserve respectively.

The spatial distribution of Normalized Difference Vegetation Index (NDVI) from landsat-8 Oli, is as presented in Figure 7. Dense woodland is the dominant vegetation cover while bare land surfaces were found at the fringes of the reserve and along the Gaji River, Dauda Usman track, Wiki camp, Kashim Ibrahim road and Bello road.

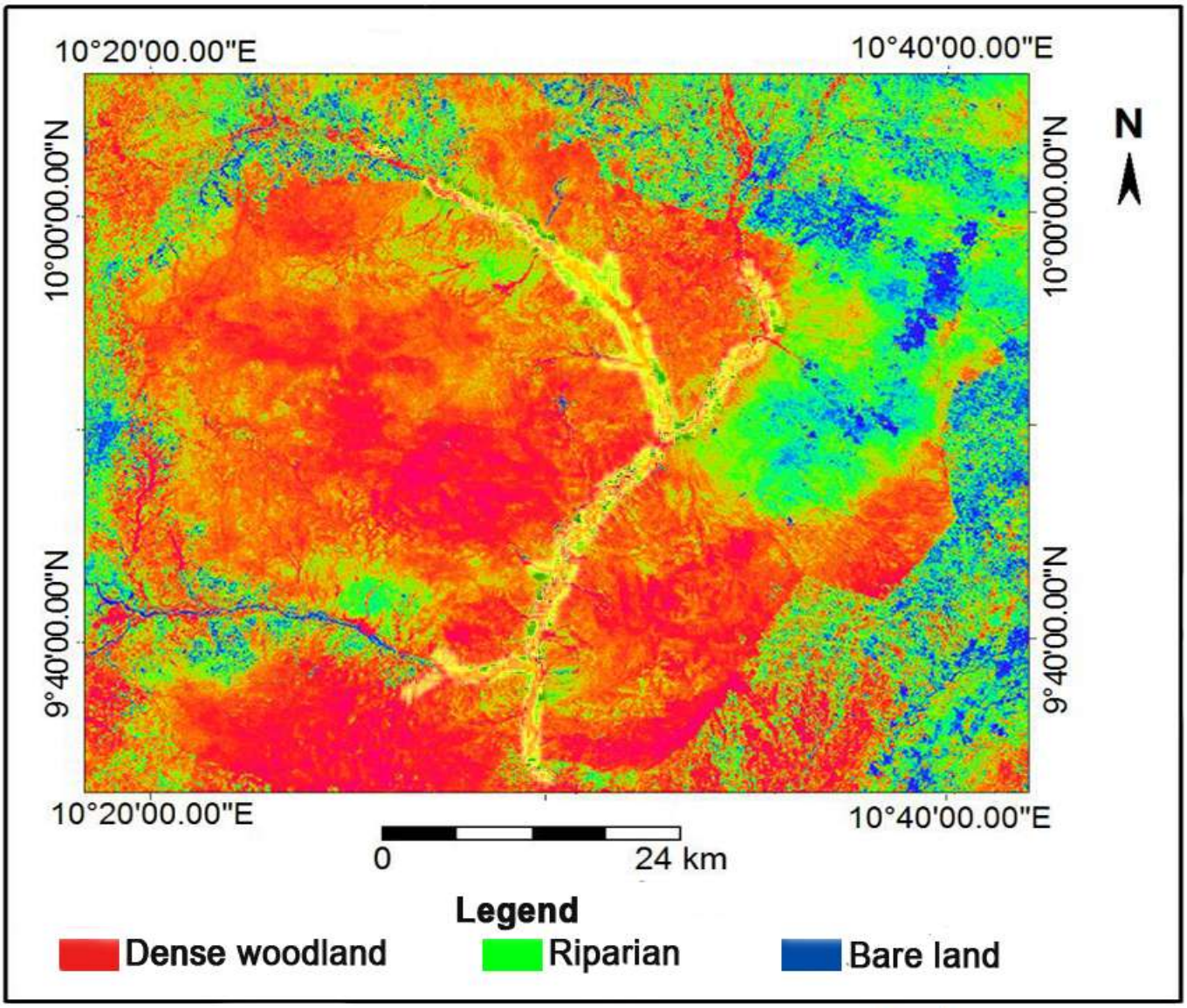

Figure 6: Normalized Difference Vegetation Index (NDVI) 2010
Source: USGS (2017)

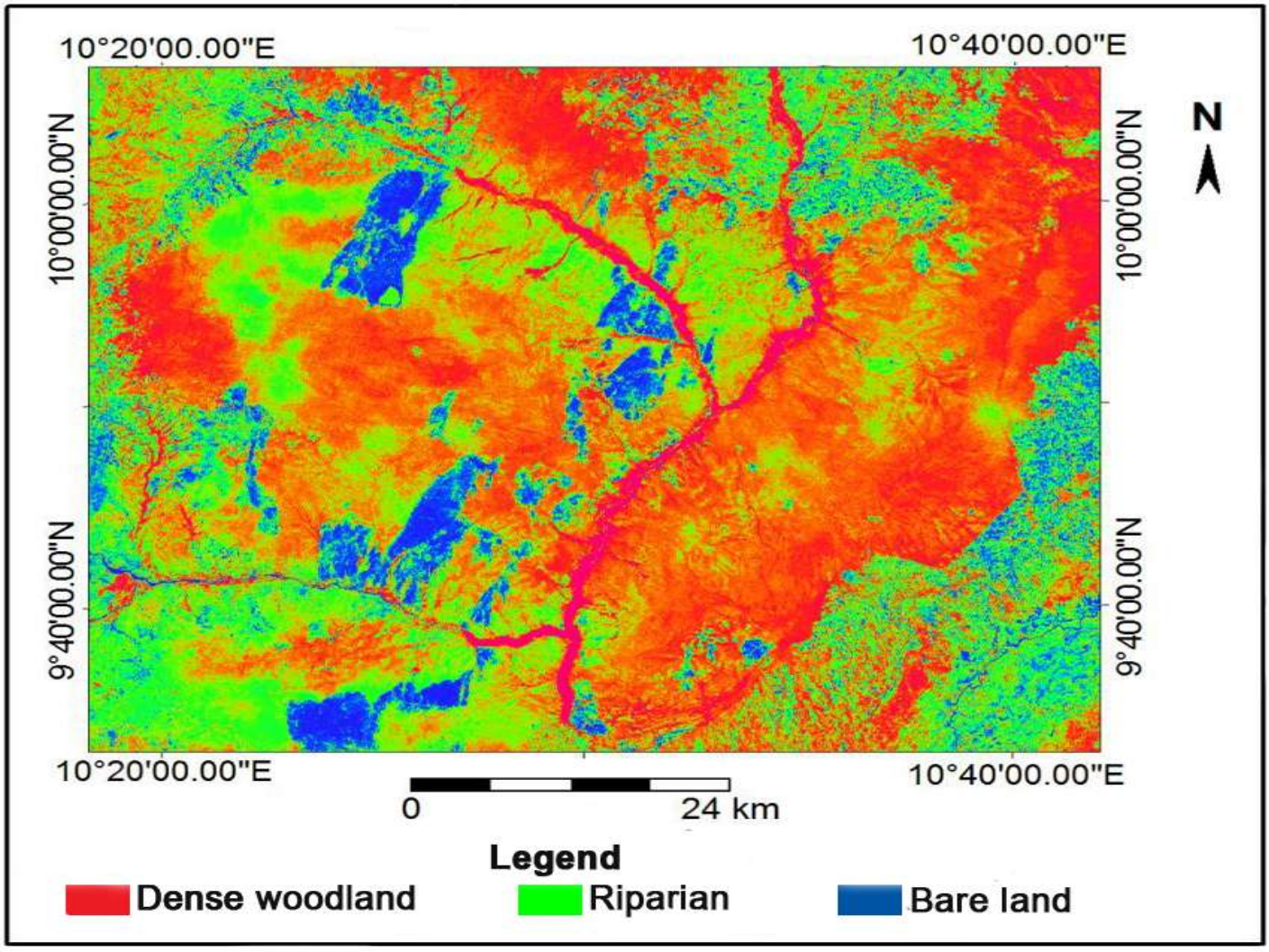

Figure 7: Normalized Difference Vegetation Index (NDVI) 2015
Source: USGS (2017)

The summary of trends detection of the Normalized Difference Vegetation Index (NDVI) from 1986 to 2015 with sample years of 1986, 1999, 2005, 2010 and 2015 landsat imageries, are as shown in Table 5. Thus, the summary revealed that dense woodland vegetation cover class indicated to be stable despite the slight decrease in area coverage of 24.03 km.sq as against the classified images of the base year (1986) 29.10km.sq.

The spatial pattern was entirely different for the 2015 landsat image; the vegetation cover shows an increase in riparian vegetation class which accounted for about 27.80% of the total landmass in 1986 as against the earlier coverage of less than 29.02% in 2015 respectively. The pattern remains relatively similar for riparian vegetation class except for a slight increase in the area coverage of bare land surface which amounted to about 9.46% over the period under study (1986 to 2015).

Table 5: Summary of Normalized Difference Vegetation Index Statistics of Yankari Game Reserve for 1986, 1999, 2005, 2010 and 2015

NDVI Classes	1986		1999		2005		2010		2015	
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Dense woodland	29.10	61.29	27.22	57.33	27.13	57.14	25.62	53.96	24.03	50.61
Riparian	13.20	27.80	14.85	31.28	14.35	30.22	13.39	28.20	13.78	29.02
Bare land	5.18	10.91	5.41	11.39	6.00	12.64	8.47	17.84	9.67	20.37
Total	**47.48**	**100.00**	**47.48**	**100.00**	**47.48**	**100.00**	**47.48**	**100.00**	**47.48**	**100.00**

DISCUSSION

Rare species within the study area poses greater risk of extinction which might be as a result of tremendous pressures arising from fuelwood harvesting, rapid population growth, arable farming among others which has led to encroachment into the boundaries of the reserve. It is however apparent from field observation that the rate and intensity of grazing and arable farming is relatively higher in quadrants A, B and C than in quadrant D. In terms of density, quadrant B shows the lowest value which is as a result of intense pressure on the vegetation cover present due to increased human activities along Wikki Camp and Dauda Usman Track which could be explained by the nature and intensity of landuse practices within the Reserve, this concord with the findings of Isaaks and Srivastav (2009) and Chima *et al.* (2011).

The trends detection of the Normalized Difference Vegetation Index (NDVI), revealed that dense woodland vegetation cover class indicated to be stable despite the slight decrease in area coverage of 24.03 km.sq as against the classified images of the base year (1986) 29.10km.sq. Decrease in dense woodland vegetation cover could be as a result of selective logging and illegal forest product harvesting for medicinal purpose by trespassers among other activities within the study area as observed in the process of data collection. Furthermore, analysis of satellite image shows that bare land surfaces are on the increase as a result of pressure on the reserve due to anthropogenic activities and results showed that extremely small populations underwent human disturbances and threats such as construction of roads and buildings as well as cultivation of land for arable farming purposes, this is in agreement with the findings of Kulawardhana, (2008) which reveals that the study area is under pressure as a result of human activities within the reserve.

CONCLUSION

This study found that the vegetation cover of Yankari Game Reserve has changed over time, the changes which could be attributed largely to anthropogenic factors present within the reserve. Quadrant samples showed that the species diversity and distribution of *Fuirena umbellate* and *Oryza lonistaminata* grasses have the highest frequency of occurrence within the quadrant sampled with a number of individual stands of 26 while *Cyperus exaltaltus* and *Echinochloa stagnina* were the least with a density of 0.02 respectively. Thus, rare species within the study area poses greater risk of extinction which might be as a result of tremendous pressures arising from fuelwood harvesting, rapid population growth, arable farming among others which has led to encroachment into the boundaries of the reserve.

According to the Normalised Difference Vegetation Index, the summary of trends detection from 1986 to 2015 indicated a slight increase in the area coverage of bare land class which amounted to 9.46% of the entire study area which might be as a result of encroachment by trespassers, consistent clearance of land for agricultural purpose, construction of roads and building of accommodation for tourists among other activities. The study concludes that there was substantial decrease in Yankari Game Reserve greenness from 1986 to 2015. Furthermore, NDVI analysis shows that Yankari Game Reserve dynamics is reducing in

terms of vegetation cover. The study also concluded that anthropogenic activities are the key driving factor of vegetation cover degradation.

Recommendations

In light of the observations in this study the following recommendation were suggested.

i. Government should enforce laws that will discourage the cutting down of trees, and view deforestation in the reserve as a serious ecological disaster to be keenly monitored and addressed by adequately funding for reforestation.
ii. Fuelwood vendors should be included in any forest policy decision making and desertification awareness campaigns.
iii. The reserve boundary should be redefined to prevent farmers from encroaching in to the reserved,

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