1 **Land Transformation of Tropical Forest Conservation of Gashaka-Gumti**
2 **National Park, Nigeria from 1987–2014**

3

4 ABSTRACT:

5 The study utilized Landsat imageries of 1987 (Landsat Thematic Mapper (TM)), 2000 (Landsat
6 Enhanced Thematic Mapper plus (ETM+)) and 2014 (Landsat Operational Land Imager (OLI))
7 to examine land transformation in the Gashaka-Gumti National Park. The analysis indicated that
8 dense forest which occupied 367,500 hectares at 62.2% of the total area of the park in 1987 has
9 been converted into farmland and built-up area. Thus, the dense forest has reduced to 343, 300
10 hectares by the year 2000 and 107, 600 hectares in 2014 respectively. The result shows that the
11 riparian forest decreased from 21,300 hectares in 1987 at 3.6% to16, 000 hectares in 2000 at
12 2.7% and further to11, 000 hectares (1.8%) by 2014. Savannah vegetation found to be
13 concentrated in the northern part of the study area and occupied a total area of 81,260 hectares at
14 13% in 1987, reduced to 62,100 hectares at 10.5% in 2000 and increased to 183,800 hectares at
15 31.1% of the total area in 2014. The built-up area occupied a total area of 4,476 hectares at 7.5%
16 in 1987. The built-up increased to 11,070 hectares at 1.81% in 2000 but decreased to10.930
17 hectares at1.85% in 2014 as a result of the news that the insurgents were shifting their base
18 towards the park to hide from security forces and some of the people living within the area
19 became afraid and deserted their houses and resettled in the nearby towns and villages that are
20 outside the park

21 Keywords: Land Transformation, Gashaka-Gumti National Park, Landsat images.

22

23 INTRODUCTION

24 The land is defined as the earth's surface, including both land and water, and the natural
25 resources in their original states. Land use involves both the manner in which the biophysical
26 attributes of the land are manipulated and the intent underlying that manipulation – the purpose
27 for which the land is used [1]. The consequences of forest fragmentation include habitat loss for
28 some plant and animal species, habitat creation for others, decreased connectivity of the
29 remaining vegetation, decreased patch size, increased distance between patches, and an increase
30 in edge at the expense of interior habitat [2]

31 Uncontrolled human activities have led to significant modification of the natural biodiversity in
32 the world over the years. Consequentially, land use and land covers are changed abruptly without
33 adequate consideration for future developments. There is continuous deterioration from the rich
34 biodiversity. The effects of land use on the environment ranges from minor land cover changes
35 and soil modification to severe desertification, deforestation, erosion, and river encroachment
36 problems.

37 According to FAO [3], fragmentation of forest may also be as a result of natural occurrences or
38 human-induced activities, which vary in terms of the extent, severity, quality, origin, and

frequency. The natural induced process can be through fire, storm, drought, pest, and disease among others, and the human-induced activities could be unsustainable logging, excessive fuelwood collection, shifting cultivation, unsustainable hunting, overgrazing just to mention but few. The International Tropical Timber Organization (ITTO) [4] estimated that eight hundred and fifty (850) million hectares of tropical forest and forest lands could be forest edge through human-induced activities such as logging and agricultural practices.

In Gashaka-Gumti National park (GGNP), forest fragmentation is a serious problem to the environment as it affects the social activity and the economy of the nation as a whole. Gashaka-Gumti forest is one of the revenue generating sources to the nation through its timber production, wildlife conservation, and tourism. The forest service's River Benue, Donga, and River Taraba tributaries as they flow through it. These rivers serve as the transportation routes in the states as well as fishing. If the occurring of forest fragmentation is not controlled, it may lead to the loss of all these benefits and the products of the climatic variations resulting into various north-south degradations of habitats and ecosystems [5]. The habitat supports more than 1,340 species of animals among which is 274 mammalian species, making it the 8th highest in Africa [5]. Dauda et al., [6] revealed that forest fragmentation of the park led to the withdrawal of the above mention services. Besides, the park serves as carbon sequestration and contributing good health of the people. The distribution of National parks in Nigeria was done to preserve and to protect the natural resources especially the forest from fragmentation.

The ecosystem of the park lost its economic value as forest fragmentation keeps on occurring [6]. The Government of Nigeria introduced laws and policies that bound the illegal activities in GGNP to protect and to preserve the forests. Trespassers if arrested are prosecuted. In spite of these laws, the forest continues to be fragmented. The failure of this management policy could be attributed to; the negligent in supervision, inadequate training of the insufficient personnel and lack of motivation on the part of forestry officials. Other ill effects of the management policy are; Government pressure on revenue generation without regard for biodiversity conservation, active collusion of forestry officers, politicians interest, village chiefs and merchant loggers in illegal logging and ultimately forest destruction. From personal interaction with Kamaya and Dike of GGNP on the 22nd of April, 2019 on poaching and encroachment into the GGNP, they stated that poaching and encroachment into the park have become alarming since 2017 as the Park's Rangers are kept on high alert to monitor their activities every 24 hours. The poacher's and encroacher's now visit the park at the dead of the night to hunt for animals and check their traps set along the animal tracks. They also use the night to carry out logging especially for Madrid tree (*Pterocarpus erinaceus)* popularly known as the African rosewood since the ones outside the park have been exhausted. Though arrests are being made daily by the Park's rangers and other officers, these illegal activities seem to be strengthened by the lack of stringent policy and punishment of offenders on the part of the policy makers coupled with poverty, youth employment and the high value-chain of the African rosewood. The activities that result in forest destruction or fragmentation has been linked with the economic decline of the national park and global climate change, hence it must be halted [7]. Therefore, there is a need to use the fragmentation index with the available geospatial techniques to assess forest fragmentation in GGNP in Taraba /Adamawa states with a view to developing a database for monitoring.

The aim of the study is to analyze the land transformation taking place in the Gashaka-Gumti National Park from 1987– 2014, with a view of identifying the different land use/land cover types within the Gashaka-Gumti National Park; Evaluate the spatial pattern of land transformation in Gashaka-Gumti National Park and analyze the trend and rate of land transformation in Gashaka-Gumti National Park.

Functions and Objectives of the National Park Service in Nigeria

Nigerian Conservation Foundation [NCF], [8] reported that the Nigeria National Park Service has the statutory responsibilities for the following, amongst other functions, which are to:

(i) preserve, enhance, protect and manage vegetation and wild animals in the National Parks;

(ii) advise the Federal Government on the development and preservation policy of the National Parks including the financial requirements for the implementation of such policy, and to wildlife species, biotic communities, sites of special interest or of aesthetic value, the Service considers may be declared as National Parks under this Act [9]

(iii) conserve some selective and representative samples of wildlife communities in Nigeria with the aimed at the establishment of an ecologically and geographically balanced network of protected areas under the jurisdiction and control of the Federal Government [10]. The protection and the conservation of wildlife throughout Nigeria so that the abundance and diversity of their species are maintained at the optimum level commensurate with other forms of land use, in order to ensure the continued existence of wildlife for the purpose of their sustainable utilization for the benefit of the people are the priority [11].

(iv) reserve outstanding scenic, natural, scientific, recreational and other values in the National Parks, and to protect and maintain crucial wetlands and water catchment's areas [12].
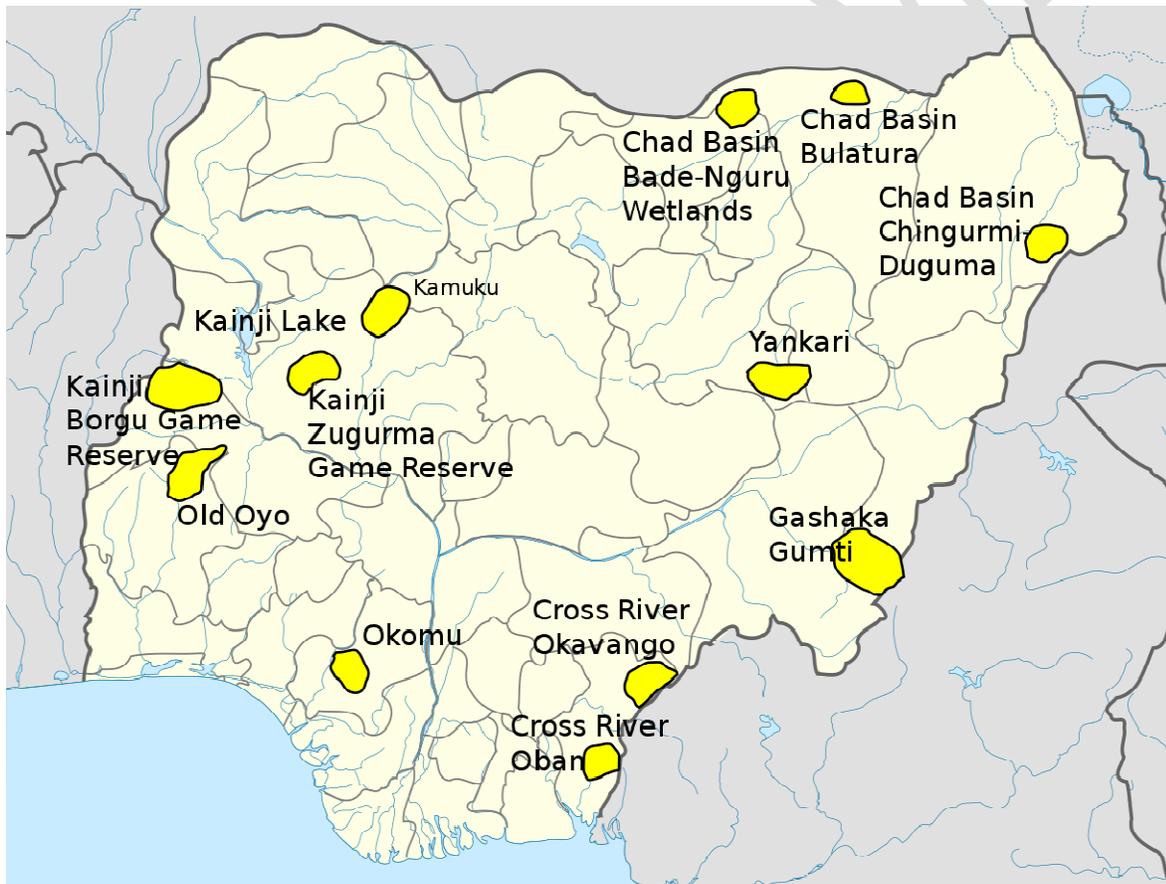
NCF (2016) reported that the government of Nigeria has the vision to manage and regulate the use of these unique ecosystems designated as National Parks by such means and measures to preserve and conserve Nigeria's heritage, particularly the fauna and flora, the habitats they live in, and the unique sceneries they afford. Its mission is to also provide human benefits and enjoyment in such manner and by such means so that these are left unspoiled for generations to come. www.panthora.org recorded that the vision was also to develop a network of National Parks (Table 1 & Figure 1) that can compete favourably with other National Parks in the world and, to achieve this; the Park Service is making efforts to put in place Operational Management Plans for each Park, and Systems Plan for the entire country.

Table 1: The distribution of National parks in Nigeria with location and sizes

S/N	NAME	STATE(S)	HEAD OFFICE	SIZE

3

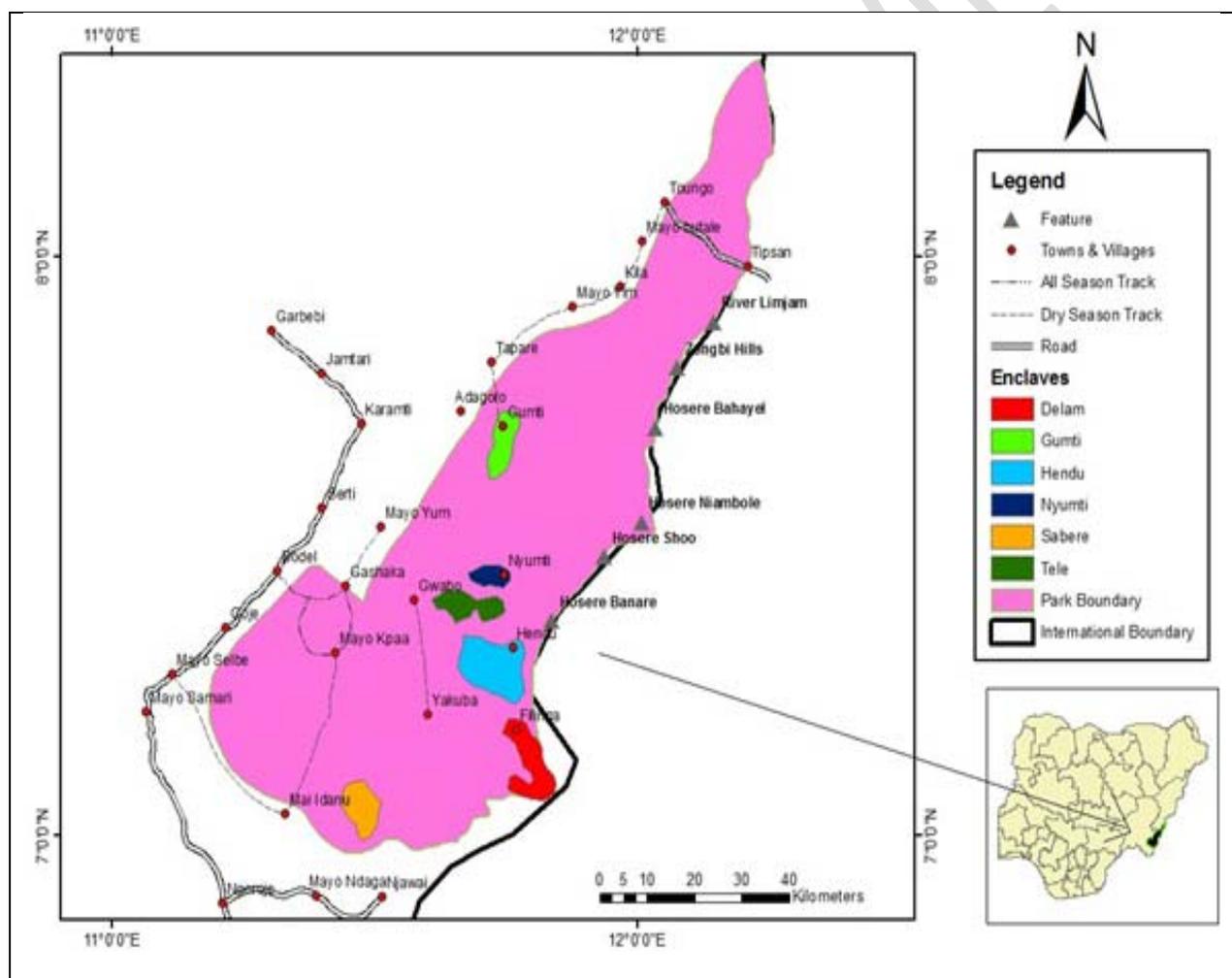| 1	Chad Basin	Borno/Yobe	Maidugari	2,258 sq.km
2	Cross River	Cross River	Akampa	4,000 sq.km
3	Gashaka-Gumti	Adamawa/Taraba	Serti	6,731 sq.km
4	Kamuku	Kaduna	BirninGwari	1,121 sq.km
5	Kainji Lake	Kwara/Niger	New Bussa	5,382 sq.km
6	Okomu	Edo	Arakhuan-Udo	202.24 sq.km
7	Old Oyo	Oyo	Oyo	2,512 sq.km
Estimated Total Conservation Area				22,206.24 sq.km

118

119

Figure 1: Location of National Parks and Game Reserves

Source: NCF, [8]

Materials and Methods

123 **Location and Size:** Gashaka-Gumti National Park (GGNP) is located in the mountainous region

124 of north-eastern Nigeria, adjacent to the international border with Cameroon, and immediately to

125 the north of Mambilla Plateau [13]. It is the largest and most scenic of all the seven National

126 Parks in Nigeria. This conservation area lies between latitude 6° 55' and 8° 05' north, and

127 longitude $11^o11'$ and $12^o13'$ east (Figure 2) and covers a total area of 6,731 sq.km [14]. Located

128 in Adamawa and Taraba States, the Park is contiguous with Faro and TchabalMbado National

129 Parks in the Republic of Cameroon [15].

130 **Figure 2**: Map of the Study Area

131 The Park experiences varying pleasant weather conditions, depending on one's location within

132 the Park [16]. These range from tropical dry humid, tropical moist humid in the lowlands to sub-

133 tropical highland weather on the high plateau around Chappal Waddi, Sabere and Fillinga [13].

134 In fact, the hidden corner of West Africa that is Gashaka-Gumti National Park is surely one of

135 Africa's best places [17]

136 [18] observed that Gashaka-Gumti National Park (GGNP) consists of Savannah, dry deciduous

137 woodland, freshwater swamp vegetation, lowland gallery forest, mountain forest riparian forest

138 and cold mountain grassland. The Park is divided into two sectors; the Northern Gumti and

139 Southern Gashaka. The northern Gumti sector is characterized by tall grassland, trees with

140 usually short boles and broad leaves [19]. In southern Gashaka sector, moist guinea savannah

141 predominates. The climate is broadly characteristic of guinea savannah zone which is an

142 intermediate between the humid wet climate of the forest zone and hot dry climate of Sudan and

143 Sahel savannah [14]. Rainfall commences in April and lasts to late November with a yearly

144 approximate rainfall ranging from 300mm to 1200mm and dry season usually last from

145 December to March [19]

146 The altitude ranges from about 457 meters (1,499 ft) in the northern flatter corner of the park, up

147 to 2,419 meters (7,936 feet) at Chappal Waddi (Mountain of death). Nigeria's highest mountain

148 in the park's southern sections [20]. It is an important water catchment for the Benue River.

149 There is abundant river flow even during the markedly dry season. Enclaves for local Fulani

150 pastoralists exist within the park boundary that allows for farming and grazing [17]

151 In terms of vegetation, the multiple regions of the Gashaka Gumti National Park lead to its

152 diversity of wildlife. In the Northeastern area of the park, it is relatively flat allowing for savanna

153 woodlands. In particular, these woodlands are the Sudan Guinea savanna woodlands, covered in

154 coarse, tall grasses and fringing forests with some striking vegetation, such as the intense red

155 leaves of *Brachystegia eurycoma* and the great white flowers of *Berlinia grandiflora*. Lions,

156 African elephants, African buffalo, waterbuck, and many more animals are housed here. As you

157 move east, the highlands, specifically the montane grasslands and shrublands, occur within the

158 mountainous regions of the park [18]. The canopy of the montane forest is rarely closed,

159 allowing for rich vegetation on the highland floor. The tallest trees are often stragglers, like the

160 ficus and other species of fig. Within and near the highlands, vast lowland rainforests, tropical

161 and subtropical moist broadleaf forests, begin to take over [18]. The rainforests are dense, hot,

162 and humid. The forest vegetation is dominated by woody species, mainly tall trees. This region

163 contains many different species ranging from chimpanzees to leopards to giant forest hogs,
164 creating the most diverse variety of species in this particular biome [9]. The park is officially
165 labeled as one of Africa's "Important Bird Areas" with more than 500 species found here. In
166 regards to species adaptations, plants have long tap roots that descend far into the ground
167 reaching the deep water tables of the savanna biome. In the woodlands area of Gashaka National
168 Park trees have thick bark which aides in wildfire protection [8]. Additionally, the trunks of these
169 trees store water during the dry season as well as their leaves that fall during the dry season that
170 occurs over the winter months to conserve water. The grasses in the savanna biome also hold
171 adaptations to avoid overgrazing of the diverse animal culture of the national park. Some of these
172 adaptations include sharp or bitter tasting grasses for some animals to deter depletion of the
173 grasslands biome [18]. Many animals that live in the savanna have long legs or wings that allow
174 migrations to be accomplished easier; while others have the ability to burrow through adaptation
175 to access cooler temperatures or raise their young underground [8]. Aside from climate, other
176 factors that influence the vegetation and wildlife of Gashaka-Gumti National Park are
177 environmental hazards, deforestation, urbanization, poachers from the Cameroonian border, and
178 human activities, such as a yearly burning that has turned the once semi-deciduous forest into a
179 grassy woodland. Some of the animals that are impacted by the illegal poaching are chimpanzees
180 and other species of monkeys, which is why the Gashaka Primate Project was created. The
181 project helps to contain the monkey populations and stop the system of illegal poaching [8].

182 Geologically, The Gashaka-Gumti National Park is approximately two-thirds of Nigeria's land,
183 which places it within the middle of the African Plate. Since it is not located near a fault line,
184 major earthquakes do not occur here. At times, some tremors can be felt and this can be due to
185 the close proximity to the mostly inactive Ifewara fault line which is linked into the Atlantic
186 Fracture System. The land that Gashaka-Gumti is located on and it's underlain by the pre-
187 Cambrian Basement Complex. The pre-Cambrian Basement Complex and the Ifewara fault line
188 have previously contributed to the movement and formation of geology and landforms in the
189 area. The only hazard that affects the national park is landslides [21]. This geologic hazard
190 occurs because of the sedimentary rocks that are in the area. The sedimentary rocks in the region
191 are known to be mineralized with lead and zinc. The pre-Cambrian Basin also is considered the
192 "oldest, crystalline, solid foundation in the country" and contains the igneous and metamorphic
193 rock. The sedimentary rock is found in the basins that separate the basement complex landmass.

194 The hazard of landslides and the main type of rock is defined as sedimentary, which leads to
195 erosion and weathering of landforms within the park [21]

196 The Northern Section of Gashaka-Gumti is characterized by flat woodlands and grasslands,
197 while the Southern portion of the park is characterized by mountains and deep slopes [21]. The
198 mountainous region of Gashaka-Gumti National Park provides an optimal landform of the
199 forested slopes for the local watershed, which pours into the Taraba River. This waterway is the
200 major tributary to the second largest river in Nigeria, the Benue. The rich vegetation along the
201 slopes of the mountains that allows a "trickle-down" effect to occur with rain is vital to the
202 mainstay of these rivers. Without the slow movement of water through this watershed, the dry
203 season would cause detrimental issues to the river water levels due to the vast evaporation that
204 occurs during this time [15]. Different landforms that contain liquid water, such as swamps,
205 rivers, and lakes each support their own unique communities of plants and animals. For example,
206 rivers provide havens for several varieties of fish, otters, hippos, and crocodiles. Inferring from
207 common clues of glacial impact and residue, Gashaka-Gumti National Park seems to hold certain
208 characteristics of glacial impacts. For instance, the National Park is characterized by flowing 'V'
209 shaped valleys and waterfalls, which allude to similar themes of a glacial presence at one point in
210 the history of the region. Furthermore, these rugged terrains, steep slopes and plunging valleys,
211 Gashaka-Gumti's iconic characteristics could also be attributed to wind erosion. This correlates
212 with the region's relationship with the Sahara Desert. Erosion also occurs from heavy rains
213 during the wet season [21]

214 **Methods:** The dataset used for the study are satellite imageries from United State Geological
215 survey (USGS) website. Other data include administrative maps, as well as topographical data of
216 the study area. The data used in this study are multi-temporal satellite images which include:
217 Landsat Thematic Mapper (TM), Landsat Enhanced Thematic Mapper plus (ETM+) and Landsat
218 Operational Land Imager (OLI). These images were extracted for the study area on; 1987, 2000
219 and, 2014 with path 186/185 and, and row 055/054 respectively. The images were mosaic to
220 cover the study Area. This provided the spatial database on which the classification of land cover
221 was carried out. The Landsat imageries were downloaded from the official website
222 http//www.earthexplorer.usgs.gov. All sensors have a spatial resolution of 30m (Table 2 and 3).
223 The primary data was collected from the field through the measurement of vegetation parameters

on the physical attribute of land cover types namely, Farmland (edge), Build-up area, dense forest, savannah, and Bare surface. Addition ground reference data were collected with observations for the 'unsupervised' classification. The number of stands of each species found in a quadrat measuring 10 meters by 10 meters were observed and counted.

The study area was delineated using the clipping method in IDRISI software tool, identifiable from the scanned and georeferenced 1: 500,000 Topographic maps covering the study area. From the topographic map, the contour and drainage networks were extracted and populated with their various features and other values respectively using onscreen digitization process and saved into the work used to clip (sub-map). ArcGIS 10.3 and IDRISI selva were used in this study.

Table 2: Characteristics of Data Used

S/N	Type	Format	Scale Resolution	Date/Source
1	Topography	Analogue	1:500,000	**1991**
2	Demographic Data	Analogue		**NPC, 2006**
3	Administrative Map	Analogue	1:500,000	**Administrative Office, GGNP Serti, Taraba State**

Table 3: Characteristic of Satellite Image Data

S/N	Data type	Form	Path/Row	Data Acquisition	Scale-Resolution	Source-Website.
1	Landsat image-MSS	Digital	186/055, 186/054 185/054	1987	30m	USGS
2	Landsat image-TM	Digital	186/055, 86/054 185/054	2000	30m	USGS
3	Landsat image-LDCM	Digital	186/055, 186/054 185/054	2014	30m	USGS

237 **Image Processing**

238 The images were pre-processed to correct the spectral variation resulting from sensor differences

239 before the study area is extracted from each dataset. False Color Composite (FCC) was created

240 using near-infrared, red and green Bands (432,432 and 654) for each of the images respectively

241 as reported by Gonzalez et al., [22]. The selection of Band combination was done to enhance our

242 ability to clearly distinguish vegetation types from non-vegetated land use. The pattern of change

243 is determined using the post-classification comparison method proposed by Babb et al., [23]. The

244 coordinates of some location were obtained using Global Positioning System (GPS) to identify

245 plant species density in the study area (GGNP).

246 **Table 4: The selected training sites (dominant land cover types in the study area)**

S/N	Training sample	Description
1	Build-up area	The area occupied by people for habitation
2	Dense Forest	Area cover with undisturbed forest
3	Riparian forest	Forest cover under which is full of water bodies or rivers.
4	Savannah	Area of open land that is cover with grass and woodland
5	Bare Surface	Area of empty space
6	Farmland	Area occupied with anthropogenic activities such as farming.

247

248 **Post-Classification Comparison**

249 Many methods such as Image overlay, change vector analysis, principal component analysis,

250 image rationing, change detection in forest cover, post classification comparison and Image

251 overlay was used in this research. In this technique, images of different dates were classified and

252 labeled individually. Using supervised classification, the classified Images were then compared

253 and the forest edge areas extracted and are determined using IDRISI software. Post-classification

254 comparison was used to detect dense forest from other classes and changes detection in general

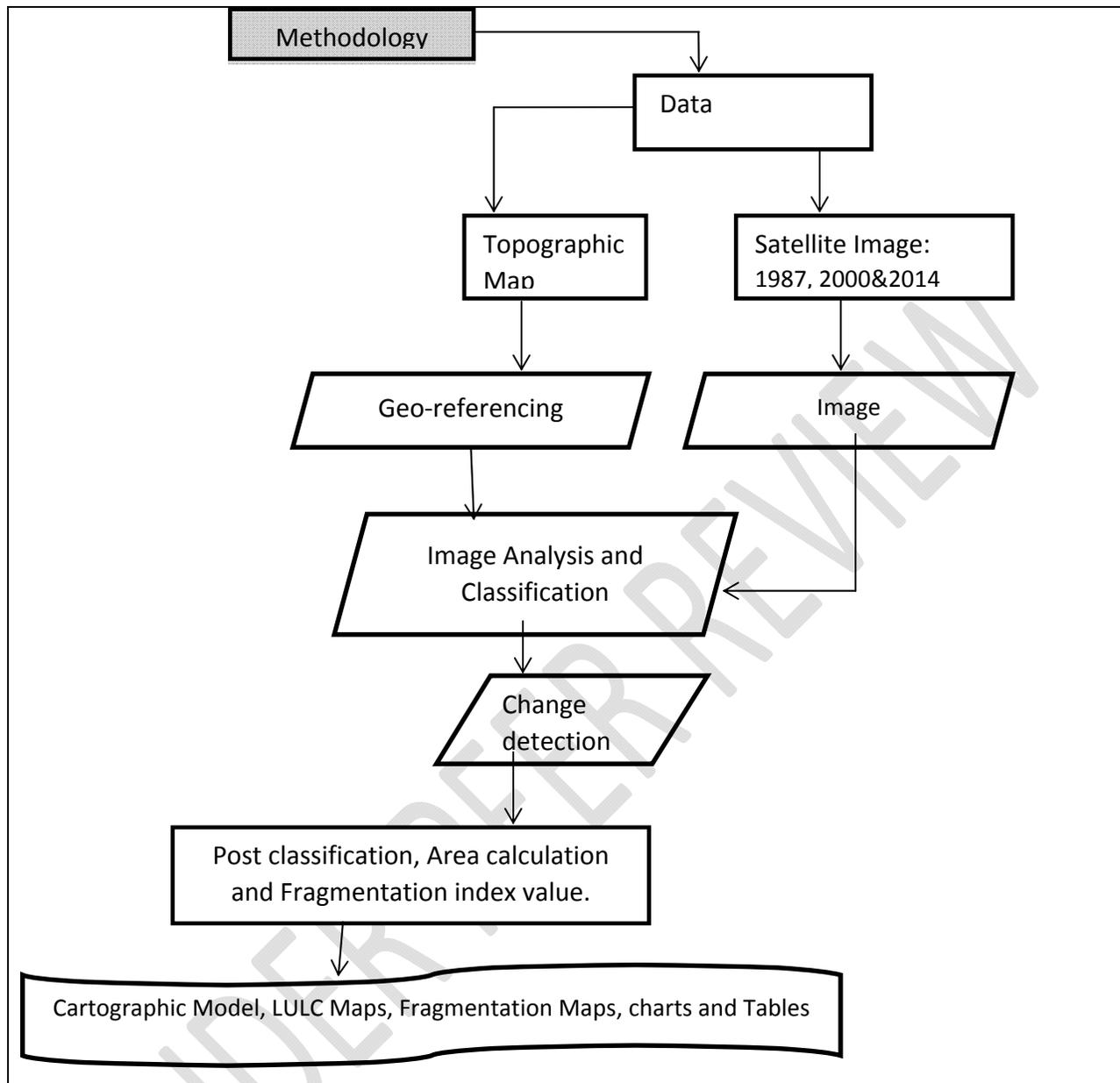255 Land Use. Figure 3 shows the flow diagram of the study.

256

257

258

259

260

Figure 3: Flow diagram for the procedures of a land transformation of GGNP.

261

262

263

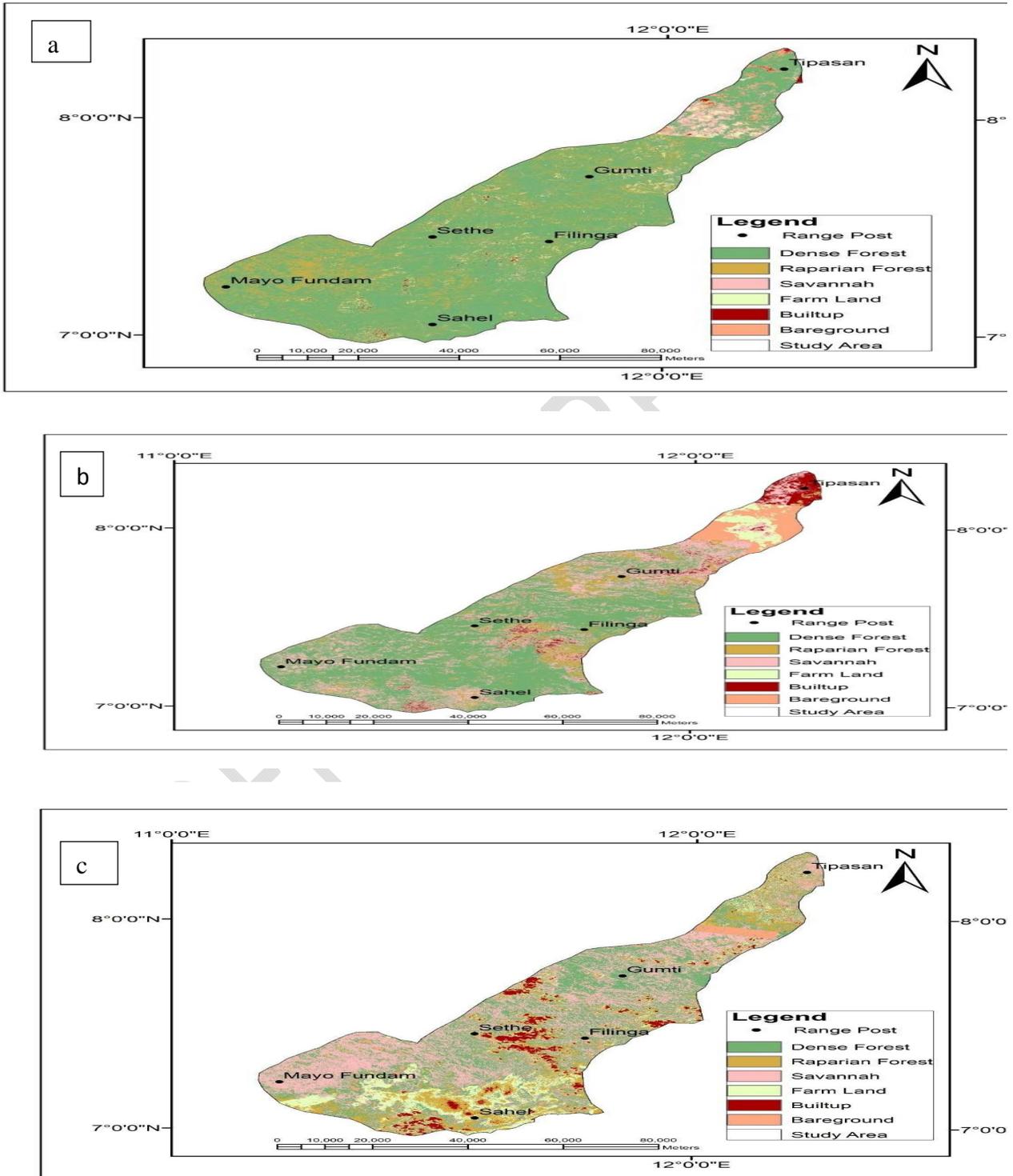264

265

266

RESULTS AND DISCUSSION

Landscape/Land Cover Types within GGNP

Fig 4: **Classified Image of Landsat Images of (a) 1987, (b) 2000 and (c) 2014**

Fig 4 a,b and c shows the maps from the supervised classification. There are six (6) LULC classes distinguished after the classification for 1987, 2000 and 2014. These classes include dense forest, riparian forest, savannah, built-up, bare ground, and farmland. Fig 4a shows that most of the park is covered by dense forest, while few build-up areas were located around Tipasan range post, this is also reflected by the numerous farmlands that are found within that area. According to the National Park Service Act (Section 29) on the demarcation of National Parks, settlements were not supposed to be located within the park as it's been noted in this image. In figure 4b, it can be observed that there is a significant transformation in the spatial distribution of the land use/land cover types located in the Gashaka-Gumti National Park. Worthy of note is the transformation of the once dense forest areas to savanna vegetation type covered by grassland and bare ground. There is also a gradual disappearance of riparian forest in the area. Increase in the built-up areas which has become more obvious in the Tipasan range post and also around Sethe and Filinga range posts, leading to cutting down of more trees for fuelwood, buildings and also to pave way for farmlands, which has resulted in the loss of the once dense forested areas. In 2014 as presented in Fig 4c, it can be observed that virtually most of the dense forest areas have been transformed into another landcover/land use type. There is a shift in the built-up areas from Tipasan range post towards Sethe, Filinga, and Sahel range posts.

Trend and Rate of Land Transformation of GGNP

Table 5: Analysis of the Dynamic Pattern of Land Transformation in GGNP

S/N	Classes of Forest	Transformation in the Area in Years (Hectares)					
		1987	% change	2000	% change	2014	% change
1	Dense forest	367500	5.45	343,300	5.1	107,600	1.59
2	Riparian	21300	0.316	16,000	0.23	11,000	0.16
3	Savannah	81260	1.2	62,100	0.92	183,800	2.73
4	Farmland	34400	0.51	90700	1.34	269,000	3.99
5	Built-up	4476	0.66	11,070	0.16	109,300	1.62
6	Bare ground	55685	5.27	67450	0.10	1107	0.023
	Total	**564621**		**590620**		**379407**	

Table 6: Image Overlay and Change Detection

S/N	LULC	Rate of change detection for Image overlay (Hectares)			
		1987/2000	% change	2000/2014	% change
1	Dense forest	-24200	3.60	-235700	35.02
2	Riparian forest	-5300	0.79	-5000	0.74
3	Savanna	-19160	2.75	121700	18.08
4	Farmland	56300	8.36	63800	9.48
5	Built-up area	6594	0.98	1400	0.21
6	Bare ground	11785	1.75	-66343	9.86

Figure 4.a, b and c are the supervised classifications for 1987, 2000 and 2014 images of GGNP indicating the land-use. The analysis indicated that dense forest which occupied 367,500 hectares at 62.2% of the total area of the park (Table 5) in 1987 has been converted into farmland and built-up area. This reduced the dense forest to 343, 300 hectares by the year 2000 and 107, 600 hectares in 2014 respectively. The significant decrease of the dense forest in the study area during the period of study and the increase of farmland and built-up was as a result of the anthropogenic disturbances by the farmers living within the park whose source of livelihood is farming and collection of forest fruits. The riparian forest i.e. forest along water axis of the

302 Taraba River, decreased from 21,300 hectares in 1987 at 3.6% to16, 000 hectares in 2000 at

303 2.7% and further to11, 000 hectares (1.8%) by 2014. The cause of these decreases was the

304 conversion of the forest to agricultural land (fig.4.a, b, c). Savannah vegetation was also found in

305 the study area but it is concentrated in the northern part of the study area and occupied a total

306 area of 81,260 hectares at 13% in 1987, reduced to 62,100 hectares at 10.5% in 2000 and

307 increased to 183,800 hectares at 31.1% of the total area in 2014. The significant change from

308 1987 to 2000 was due to the conversion of the riparian forest land into agricultural land and

309 built-up land as the population of the farmers increased. It was also reported that there was

310 massive illegal logging in the study area by the youths from 2013 to 2014 [24]. This may be the

311 reason for the increase of Savannah land covers in 2014 and the decrease in both dense forest

312 and riparian forest.

313 The farmland covered an area of 34,400 hectares at 5.8% in 1987 and it was found mostly

314 around the northern part and few areas within the range post of the GGNP. It increased to 90,

315 700 hectares at 15.3% of the total area in 2000 and further increased to 269, 000 hectares at

316 45.5% in 2014. The increase in the farmland is as results of an increase in population in the area.

317 It was also reported during the oral interview that the increase in the population was a result of

318 the insurgences cases in part of the Northeastern states (Borno, Yobe, and Adamawa) that led to

319 the massive immigration of farmers to the GGNP area.

320 The built-up area occupied a total area of 4,476 hectares at 7.5% in 1987. It is found around the

321 range post are and very pronounced in the northern part of the park. The built-up kept increasing

322 to 11,070 hectares at 1.81% in 2000 and decreased to10.930 hectares at1.85% in 2014.

323 Significantly, as the number of immigrants increased from 1987 to 2000, it also led to an

324 increase of the built-up areas. But the reverse is the case with 2000 and 2014. The reason for this

325 change was that there was information that the insurgents were shifting their base towards the

326 park to hide from security forces and some of the people living within the area became afraid and

327 deserted their houses and resettled in the nearby towns and villages that are outside the park,

328 leaving their houses to grow outgrown by bushes and became savannah in 2014.

329 The bare ground occupied 55,685.4% hectares from the total area of the GGNP in 1987. It

330 increased to 67,450 hectares at11.4% in 2000 and reduced to1107 hectares at 01.8 in 2014. The

331 increase of the bare ground from 1987 to 2000 was as a result of illegal grazing in the park in the

332 northern part of the park. The information received during the field survey was that there was a
333 fire disaster in the northern part of the park during the period under study in which the area was
334 rendered bare. It might be concluded here that natural disaster was also responsible for the
335 increase of the bare ground in the park. The decrease of the bare ground to 1107 hectares in 2014
336 might have some socio-economic significance. As the immigrants increase, the numbers of
337 farmers also increased in which some of the bare ground was converted to agricultural land

338 **CONCLUSION**

339 At present, global natural habitats face an immense crisis that has overtaking previous records.
340 Specifically, habitat destruction in Nigeria national parks is more pervasive for 'wholesale
341 extinction' of biodiversity. Identifying and delineating such 'key biodiversity area' is therefore
342 important for prioritizing conservation planning. Outcomes of such study generate valuable data
343 which is important for regions like this particularly in the northeastern states of Nigeria.

344 The result indicated that Dense Forest which occupies 62.2% of the total area of the parkin1987
345 have been converted into farmland and buildup land so that the total area other dense forest has
346 now reduced in 2000 and subsequently reduced again in 2014. It was revealed that significant
347 decrease of the dense forest in the study area during the period under study and the increase of
348 farmland and built up was as a result of the anthropogenic disturbances by the farmers living
349 within the area in searching for food to survive during needs. The riparian forest (forest along
350 waterside) was also decreased by 3.6% to 2.7% in the year 2000 and finally reduced to 1.8%in
351 2014. The cause of these decreases was the conversion of the forest to agricultural land.

352 Gashaka-Gumti National Park is thought to be the key plant species diversity area, but many
353 parts of the park have become less capable to perform that role and thus suffering to protect
354 valuable flora (plant species) and fauna within their legislative boundaries in particular and their
355 surrounding ecosystems in general. In this study, the relationship between the forest covers and
356 its associated LULC classes were investigated and various thematic maps were developed. The
357 main LULC types identified in the study are Dense forest, Savannah, Agricultural land bare
358 soil/sand, and built-up. It was observed that vegetation has changed remarkably from the period
359 1987-2014. This decrease in vegetation has caused higher forest fragmentation in the area as a
360 result of anthropogenic activities.

Based on the result of the study, the following suggestions are made:

i. More comprehensive and continuous study of land use and land cover and its harmful effects may provide necessary information to examine the efficiency of the existing protected area systems as well as to identify potential areas for systematic conservation planning.

ii. Further analysis of these studies is needed to better explain the impact of the factors on forest cover change considering other factors such as rainfall, soil moisture, etc., and the study could reach a higher accuracy for forest cover change detection.

iii. Performing multi-sensor data classification using neural networks by a combination of ancillary data (i.e. elevation and aspect) with the Landsat image data would improve the classification result and produce higher accuracy than the use of Landsat image data only.

References

[1] Adams, M., and Sibanda, S. Land Tenure Reform and Rural Livelihoods. *Agriculture and Technology Journal*, (1995), *1*, 15-35.

[2] Reed, R. A., Johnson-Barnard, J., and Baker, W. L. Spatial characterization and conservation prioritization in tropical evergreen forests of Western *Ghats, Tamil Nadu using geoinformatics*. Dissertation published, Bharathidasan University, India.1996.

[3] FAO. A preliminary survey of the forest animals of Gashaka Gumti National Park, Nigeria. Unpublished report for WWF-UK and the Conservation Foundation. Contract reference, 2002.

[4] ITTO. Guidelines for the restoration, management and rehabilitation of degraded and secondary tropical forests. *ITTO Policy Development Series No. 13. Yokohama, Japan,* 2002

[5] Ackley H. Andean forest fragmentation and the presentativeness of protected natural areas in the eastern Andes, Colombia. *Biological Conservation,* 2001, *113, 245–256.*

[6] Dauda D. S., Ebeiyamba O. E and Aluko O. E. Spatio-Temporal Assessment of Baissa Forest Disturbance in Taraba State Nigeria. Accepted in 2016 by Journal of Environment and Earth Science, 2015, ISSN (Paper) 2224-3216 ISSN (Online) 2225-0948.

[7] FAO. Report on an expedition to Sardauna Province, North-Eastern State 20th March -10th April, 1970. Ife University Herbarium Bulletin No. 6. 2009**.**

[8] Nigeria Conservation Foundation (NCF, 2016) https://ncfnigeria.org/

[9] Nigeria Conservation Foundation (NCF, 2015) https://ncfnigeria.org/

[10] Parker, M., and Nally, R. Synthesis of remote sensing approaches for forest carbon estimation: Reporting to the Kyoto Protocol. *Environmental Science and Policy 8(2): 161-178 satellite data. Science 227: 369-375,* 2002.

[11] Ali, R. and Pai, A. Human use areas in the Kalakad–Mundanthurai Tiger: A*nalysis of Management Strategies and Good Practices*. South Africa: 1-34. 2001.

[12] Gardner, R. H., & Urban, D. L. Neutral Models for Testing Landscape of Gashaka-Gumti National Park, Nigeria. *PhD Thesis* University of Surrey, 2007.

[13] Baldus R, Kibonde B and Siege L. Seeking conservation partnership in the Selous Game Reserve, Tanzania. Parks, 2003, 13(1):50–61.

[14] Nformi, B.U. *The Influence of Environmental Factors and Food Trees on the Nesting Programmes in Gashaka-Gumti National Park, Nigeria*. M.Sc. Thesis. Federal University of Technology, Yola, 2002.

[15] Warren Y., Higham J.P., Maclarnon A.M., Ross C. Crop-raiding and Commensalism in Olive Baboons: The Costs and Benefits of Living with Humans. In: Sommer V., Ross C. (eds) Primates of Gashaka. Developments in Primatology: Progress and Prospects, vol 35. Springer, New York, NY, 2011. DOI https://doi.org/10.1007/978-1-4419-7403-7_8

[16] Barrow, E., and Fabricius, C. Wildlife conservation initiatives in Nigeria. In Wildlife Conservation in *assessing limitations based on detailed field observations, Landsat ETM+, and textural analysis. Remote Sensing of Environment,* 2002, *80 (3)483-496*

[17] Distefano, E. *Human Wildlife Conflict Worldwide: Collection of case studies*. Cambridge University Press, 2010.

[18] Bornil J. Forest fragmentation: causes, ecological impacts and implications for landscape management. In *Landscape Ecology inForest Management and Conservation: Challenges and Solutions for Global Change*, Li C, Lafortezza R, Chen J, (eds). HEP-Springer: New York; 1999, 273-296.

[19] Gawaisa. S. Population Dynamics of mammals in the Savanna Zones and Management hypotheses. *Landscape Ecology*, 2001, *22*(1), 15-29.

[20] Brokaw N and Busing R. T. Niche versus chance and tree diversity in forest gaps *Trends Ecol. Evol.,* 2000, 15(5): 183-188

[21] Igwe, O. The geotechnical characteristics of landslides on the sedimentary and metamorphic terrains of South-East Nigeria, West Africa, *Geoenvironmental Disasters* 2015, 1-14, DOI 10.1186/s40677-014-0008-z

[22] Gonzalez, L., Vallet, V. and Yamamoto, H. Global 15-Meter Mosaic Derived from Simulated True-Color ASTER Imagery. *Remote Sens.* **2019**, *11*(4), 441; doi:10.3390/rs11040441

[23] Babb, B., Moore, F & Peterson, M. Optimized Satellite Image Compression and Reconstruction via Evolution Strategies. Proceedings of SPIE, the International Society of Optical Engineering, 2009, vol 7347, pg 2

[24] Ogunwusi A. A. & Ibrahim H. D. Impact of Unmitigated Rosewood Exploitation in Nigeria, Journal of Resources Development and Management, 2017, Vol.33, 9-15.

APPENDIX

IMAGES

A. GATE OF GNNP

444

445   **B: BUILT-UP AREA**

Gashaka Gumti National Park

446

C. DENSE FOREST

447

448 **D: DEFORESTED AREA**

449

450

451 **E: CULTIVATED AREA**

452

453 **F: BARE AREA**

454

455 **G: RIPARIAN FOREST**

456

457