Open Access Library Journal
2019, Volume 6, e5750
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Landcover Change of Gashaka Gumti National Park within 21 Years Window (1991 to 2011) Using Satellite Imageries

Ibrahim Ahamed Umar[1], Zacharia Buba Yaduma[2], Ephraim Edward Dishan[2], Joyrose Enebuse Adaeze[2]

[1]Adamawa State Ministry of Environment, Yola, Nigeria
[2]Department of Forestry and Wildlife Management, Modibbo Adama University of Technology, Yola, Nigeria
Email: zachariaby@yahoo.com, zachariaby@gmail.com

How to cite this paper: Umar, I.A., Yaduma, Z.B., Dishan, E.E. and Adaeze, J.E. (2019) Landcover Change of Gashaka Gumti National Park within 21 Years Window (1991 to 2011) Using Satellite Imageries. *Open Access Library Journal*, **6**: e5750.
https://doi.org/10.4236/oalib.1105750

Received: September 2, 2019
Accepted: September 23, 2019
Published: September 26, 2019

Abstract

The study was conducted at Gashaka Gumti National Park to assess the land cover changes of Gashaka Gumti National Park within 21 years window (1991 to 2011) using satellite imageries. Results showed that in 1991, 2001 and 2011, Guinea Savannah covered 41% (2762.01 km^2), 38% (2565.01 km^2) and 36% (2449.23 km^2) of the land area respectively. Derived Savannah covered 31% (2086.85 km^2), 33% (2185.41 km^2) and 31% (2072.39 km^2) respectively in the stated years. Montane Forest covered 12% (775.28 km^2), 12% (822.02 km^2) and 14% (941.11 km^2) respectively in the years under consideration. For Gallery Forest, 16%, 17% and 19% were recorded for the stated years respectively. This indicated that Guinea Savannah decreased by 7.13% (−197 km^2), Derived Savanna, Montane Forest and Gallery Forest increased by 4.72% (+98.56 km^2), 6.03% (+46.74 km^2) and 4.67% (+51.7 km^2) respectively between 1991 and 2011. Between 2001 and 2011, Guinea Savanna and Derived savanna decreased by 4.51% (−115.78 km^2) and 5.17% (−113.02 km^2), respectively, while Montane and Gallery forests increased by 14.49% (+119.09 km^2) and 9.47% (+109.71 km^2) respectively. The changes recorded were considered marginal. Similarly, the temperature and rainfall dynamics established in the study were not of such magnitude that could negatively impact on the landcover classes.

Subject Areas

Biodiversity

Keywords

Landcover Changes, Gashaka Gumti National Park, Satellite Imageries

1. Introduction

Landcover originally referred to the kind and state of vegetation, such as forest and grass cover, but it has broadened in subsequent usage to include human structure such as buildings or pavements and other aspect of the natural environment such as soil type, biodiversity as well as surface and groundwater [1]. Landcover change has been described as the most significant impacts of anthropogenic disturbance to the environment [2]. In essence both land use and landcover, changes are products of prevailing interacting natural and anthropogenic processes by human activities. Land use and landcover change and land degradation are driven by the same set of proximate and underlying factors central to environmental processes [3]. The increasing concern for the management of natural resources in recent times has been necessitated by the increasing demographic pressures and its associated man-made activities which have led to serious environmental stress and ecological instability. In the last 300 years, the impacts of land use and landcover change have increasingly assumed significant to threatening proportions [4]. Expectedly, it is humans and not natural agents which bring about these changes and which is responsible for their magnitude and severity. Of course, these changes have been found to be more profound in developing countries due to the high propensity of the population growth rate and subsequent resource over-exploitation [5]. The impacts of these environmental problems are serious both in the short term and in the long term. In the short-term food security, human and wildlife vulnerability, health and safety are at stake, while in the long term the viability of the earth is being threatened [4]. Concerns about landcover change emerged in the research agenda on world environmental change several decades ago with the realization that land surface processes influence climate [6]. A much broader range of impacts of land use and landcover change on ecosystem goods and services were further identified. The primary concern of impacts is on biodiversity worldwide [7], soil degradation [8] and the ability of biological systems to support human needs [9]. Landcover changes also determine, in part, the vulnerability of places and people to climatic, economic or sociopolitical perturbations.

During the 20th Century, land use changes have emerged as a "World" phenomenon [10]. Land use and landcover changes at international, national and local levels have characterized human-environment relationship. One major consequence of land use and landcover change recorganized at the world level are loss of biodiversity and change in ecosystem functioning. The rate of biodiversity loss has been accelerating rapidly throughout the industrial era. According to FAO [11] the Global Biodiversity Assessment indicated that species are now becoming extinct at 1.000 - 10.000 times the natural rate.

As reported by Vitousek [12], land use and landcover change are key drivers of ecosystem changes worldwide and has significant implications for many international policy issues. In particular, land use and landcover change in tropical regions are of major concern due to the widespread and rapid changes in the distribution and characteristics of tropical forest [13]. However, changes in land use and landcover have become recognized over the last 15 years as important global environmental changes in their own right [1]. There is a growing concern worldwide, over the destruction and eventual disappearance of valuable fauna and flora species in the tropical forests. Milne [14] observed that renewable natural resources such as forest are continuously depleting. He further observed that the rate of depletion varies from place to place. In some places it is at large-scale while in others it is at small scale. In all cases it results from timber exploitation, lopping of trees for animal feed, fuel wood collection, expansion of agricultural land areas, urbanization, industrialization as well as road construction. Natural phenomena such as increasing temperature and reduction in rainfall have also taken their toll on flora and fauna [15]. Tim [16] reported that the annual bush meat harvest from African tropical forests may now exceed one million tons. He further stated that exploitation of flora and fauna resources are extended to protected areas. Gashaka Gumti National Park, a biodiversity hot spot occupying a land area of about 6731 km^2 lies within the tropical region of Africa. A review of past studies in the park indicated that there has been no study on lancover change detection in the park using remote sensing techniques. Landcover change detection in terms of magnitude of the change, rate of the change, spatial distribution of the change types, change trajectories of landcover types and accuracy assessment of landcover changes is only possible through the use of remote sensing techniques which, has not been carried out since the inception of the park in 1991.

Lambin *et al.* [17] observed that remote sensing and geographic information system are essential in documenting the actual change in landcover of a given ecosystem. Result of the review of past studies indicates that change detection in landcover using satellites imageries has not been done in GGNP hence, actual change in vegetation cover is yet to be determined. There is also dearth of information on the interaction between landcover types and natural phenomenon such as rainfall and temperature. Besides, while information exists on the presence of anthropogenic activities in the park, its effect on landcover types, and fauna abundance have not been determined. The dearth of information implies that whatever programme that has been put in place before now for the management of the park resource will not yield the desired result.

Studying land use and landcover dynamics is essential in order to examine various ecological and developmental consequences of land use change over a space of time. This makes land use and landcover mapping and change detection relevant inputs into decision-making for implementing appropriate policy responses. Change detection as defined by [18], is a process of identifying differences in the state of an object or phenomenon by observing it at different times. Land use and landcover change detection allows for the identification of major processes of change and, by inference, the characterization of land use dynamics. This study was to assess the landcover change of Gashaka Gumti National Park within 21 years' window (1991 to 2011) using satellite imageries.

2. Materials and Methods

2.1. The Study Area

Gashaka Gumti National Park is located in the North Eastern region of Nigeria, covering an area of about 6731 sq·km^2. It is the largest National Park in the country. It lies between Latitudes 6˚55' and 8˚05' North and between Longitude 11˚11' and 12˚13' east [19]. The Park's name is derived from two of the regions oldest and most historic settlements, Gashaka village in Taraba State and Gumti village in Adamawa State. The Park was created by the Federal Government of Nigeria Decree No. 36 of 1991 by merging of Gashaka Game Reserve with Gumti Game Reserve [19]. The park, like any other park in Nigeria, was established as a protected area for the purpose of nature conservation, recreation, ecotourism, scientific and medical research and to promote art, craft and cultural value of the indigenous people surrounding the park [20]. The Gashaka Gumti climate is broadly characteristic of the savanna woodland zone. However, the climate differs from most other central habitats because of its prolonged and marked dry season. It is not unusual to have no rain at all for up to three months. The rainy season begins in March or early April and ends in mid-November. Rainfall ranges from 1200 mm in the North to 3000 mm in the South of the Park [19]. The high rainfall is aided by the mountains of the area since humidity from the Atlantic is forced up into higher elevations, cools down and condenses to rain-bearing clouds. This, in turn allows the growth of moist forests. **Figure 1** shows Map of Nigeria showing Gashaka Gumti National Park—National Space Research and Development Agency.

2.2. Assessment of Landcover Change 1991 to 2011

2.2.1. Data Collection and Equipment

The type of data used in this study included land use and landcover map, Aerial photograph, landsat TM, landsat ETM, Landsat ETM+, population figure, temperature, rainfall and wildlife population records and vegetation inventory (**Table 2**).

2.2.2. Remotely Sensed Data

The remotely sensed data used for this study include satellite data. The researcher obtained three satellites data of the same time interval of ten years for good comparison and easy analysis. The data obtained were land sat thematic mapper Landsat TM 1991, landsat ETM, 2001 and landsat ETM+ 2011 and other reference imageries. Landsat TM 1991, landsat ETM, 2001 and landsat ETM+ 2011 were used for the deriviations and analysis of the land surface temperature. All the three images were used for the assessment of change in land cover time. Bands 4, 3, 2, of all images were used in classification process because land covers are sensitive to these bands. Since 2011 was the most recent image, it was in addition used in the identification and analysis of land cover change. All the images were acquired from the National Space Research and Development Agency (NASRDA) Abuja.

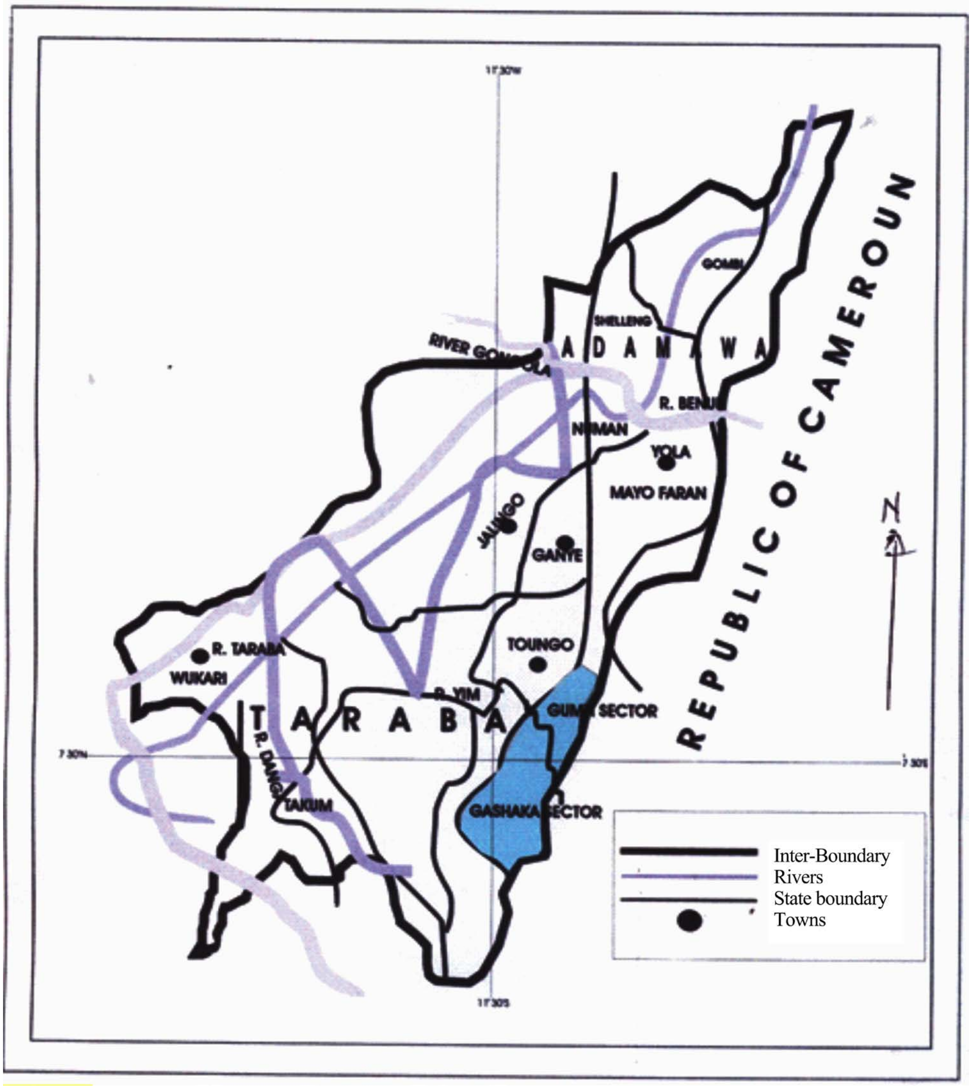

Figure 1. Map of Nigeria showing Gashaka Gumti National Park. Source: National space research and development agency (2010).

2.3. Use of Global Positioning System and Ground Truthing

Before the pre-processing and classification of satellites imageries began, an extensive field survey was performed throughout the study area using Global Positioning System (GPS) equipment and a digital camera cannon power shot (A2300). A Germin 12 hand-held GPS is an efficient GIS data collection tool which allows users to compile their own data sets directly from the field as part of "ground truthing". Ground truth survey were considered essential component for the determination of accuracy assessment for classification of satellite imageries. The field survey was conducted in order to obtain accurate location for each landcover class, which was used in the classification scheme as well as for the creation of training sites and for signature generation. Various land covers were identified on the ground; their coordinates recorded and subsequently used to trace the same points on the images. These were then identified in the image as

Guinea savanna, Derived savanna, Montane Forest and Gallery Forest respectively. Field work exercises were conducted during both the dry and rainy seasons between January to March 2013, September-November 2014 and November to December 2015. The field work was conducted so as to increase the researcher's understanding of the patterns and characters of land cover change in the study area during different seasons. Preliminary image classification and Red Green Blue (RGB) composited image of the study area printed to indicate target areas to be surveyed depending on the accessibility of each site. Data were collected from different sites depending on the different land cover type in the area. Each site was marked with the aid of Global Positioning System (GPS) technology, as explained above to allow for further integration with the spatial data in GIS and image classification system. In order to verify the selection of the pure land cover change type in the area, field verification was carried out in January 2015 based on the result of end member's fractions. *Geographical information system* (*GIS*) *software*: The Geographical Information System (GIS) software used in this study included Integrated Land Water and Information System (ILWIS) (version 3.1, Arc GIS 9.3.1) and Earth Resources. Data Analysis System (ERDAS images) Version 9.2 packages, ILWIS and ArcGIS, GIS package were used for geo-referencing and digitizing of maps. Erdas imagine was used to perform "Hard classifier" and soft classier' change detection and land surface temperature derivation. Statistical analysis and presentation was carried out using maximum likelihood algorithm.

2.4. Image Preprocessing

Image processing and analysis was performed using a variety of software package. National Space Research and development Agency (NASRDA) Abuja were the consulting units for this work. This is because they are equipped with most of the materials needed for data analysis in this work. Four cloud free Landsat scenes covering the study area were obtained in tagged image file format (TIFF) and analyzed in this study. Integrated Land Water and Information System (ILWIS 3.1) Arc GIS 9.3.1 and ERDAS Imagine) 9.2 packages were used to perform all the necessary GIS operation on the images. The images were first imported into ERDAS imageries band by band from TIFF format. Later on, they were layer-stacked and re-projected to WGS84 North UTM zones 33. Areas of interest (AOI) were subsetted from the main scenes. Each of the three GIS software was utilized in this work. Preprocessing or editing of satellite images prior to images classification and change detection analysis was done. This was because most of the images used are products of different sensors and they have different resolution. The 1991, 2001 and 2011 images were captured by TM, ETM and ETM+ sensor respectively with 30 m resolution. Because of this, images editing was necessary and was done in the following order georeferenced resampling and rectification. Georeferenced or reprojection was done through the data pre/Reprojected images subroutine.

2.5. Landcover Change Detection

The change detection algorithm employed for detection of land cover was images differencing. Images differencing is probably the most widely applied change detection algorithm [18] [21]. It involved subtracting one date of imagery from a second date that has been precisely registered to the first. In ERDAS images GIS operation, change detection was carried out through the interpreter/utilities/ changes DETECTION.

"Subroutine Highlight Changes as percentage" and "increase and decrease more than 10" (they are designated procedures). With these, the output file (change images) would produce a four class thematic images, typically divided into five categories of Decreased, some Decreased, Unchanged, some Increased and increased. Percentage change in the pixel value of land cover was then computed using RASTER Attributed/ edit/ computer statIStics subroutine and values were compared for the period involved. For instance, to detect areas of change in landcover between 1991 and 2011, a classified 1991 image was subtracted from the classified 2001 images. This resulted to the change in map and a table containing statistics of change in cover type.

Area of no change map and a table containing statistics of change in cover types, areas of no change retained pixel values of zero, while an area of changes has values of one. In the same vein, classified 2001 image was subtracted from classified 2011 images to get difference in landcover variable between those periods. The change in image and table (which provides a statistic of change in the landcover) was jointly used to identify and assess the extent of change in land cover. Percentages cover and land use defined was then computed for each period and compared. Further, a change statistical table was also use in the analysis of change in the variables contained in the images.

3. Result and Discussion

3.1. Landcover Change of Gashaka Gumti National Park between 1991 and 2001, 2001 and 2011 in Percentage

Table 1 and **Figures 2-4** present landcover classes change from 1991 to 2011. The result indicates that in 1991 Guinea Savannah covered and area of 2762.01 km^2 (41%), in 2001 the landcover reduced to 2565.01 km^2 (38%) and in 2011 to 2449.23 km^2 (36%). In 1991 Derived Savannah had 2086.85 km^2 (31%), in 2001 it increased to 2185.41 km^2 (33%) and in 2011 it decreased to 2072.39 km^2 (31%). In 1991 Montane Forest had 775.28 km^2 (12%) and increased in 2001 to 822.02 km^2 (12%) and further increased in 2011 to 941.11 km^2 (14%). In 1991 the Gallery Forest had landcover of 1106.86 km^2 (16%), in 2001 it increased to 1158.56 km^2 (17%) and then increased further in 2011 to 1268.27 km^2 (19%).

The landcover change of the major vegetation types studied between 1991 and 2001 is presented in **Table 2**.

While there was a decrease of (−197 km^2, 7.13%) in landcover in the Guinea Savanna between 1991 and 2001, those of Derived Savanna (+98.56 km^2; 4.72%)

Montane Forest (+46.74 km^2; 6.03%) and Gallery Forest (+51.7 km^2; 4.67%,) increased between 1991 and 2001.

Table 1. Assessment of Landcover Change of GGNP from 1991 to 2011 using Satellites Imageries.

Year	1991		2001		2011	
Landcover Classes	Sq. Km^2	%	Sq. Km^2	%	Sq. Km^2	%
Guinea Savannah	2762.01	41	2565.01	38	2449.23	36
Derived Savannah	2086.85	31	2185.41	33	2072.39	31
Montane Forest	775.28	12	822.02	12	941.11	14
Gallery Forest	1106.86	16	1158.56	17	1268.27	19
Total	6731	100	6731	100	6731	100

Source: Field Survey, (2015).

Table 2. Difference of Landcover Change of GGNP between1991 and 2001 in Percentage.

Landcover Class	Area (Km^2) 1991	Area(Km^2) 2001	Difference	%	Remarks
Guinea Savanna	2762.01	2565.01	−197	7.13	Decreased
Derived Savanna	2086.85	2185.41	+98.56	4.72	Increased
Montane Forest	775.28	822.02	+46.74	6.03	Increased
Gallery Forest	1106.86	1158.56	+51.7	4.67	Increased

Source: Field Survey, (2015).

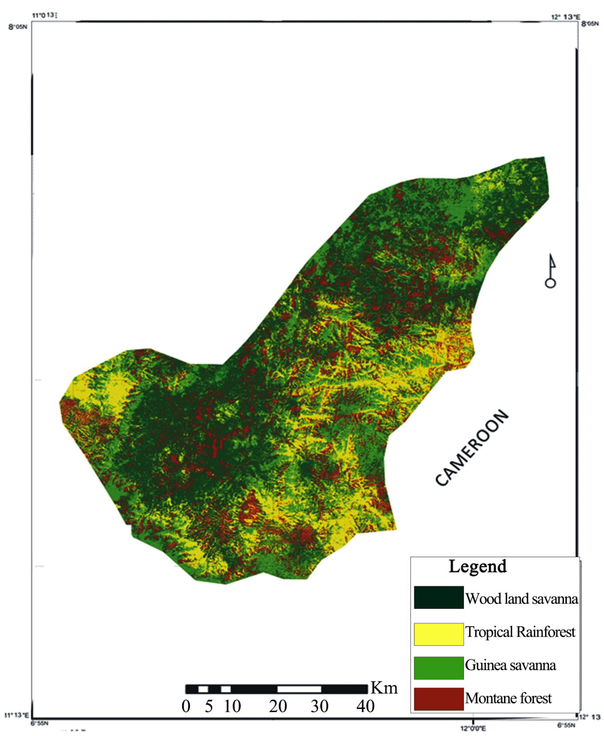

Figure 2. Classified vegetation of gashaka gumti national park 1991. Source: Field Survey, (2015).

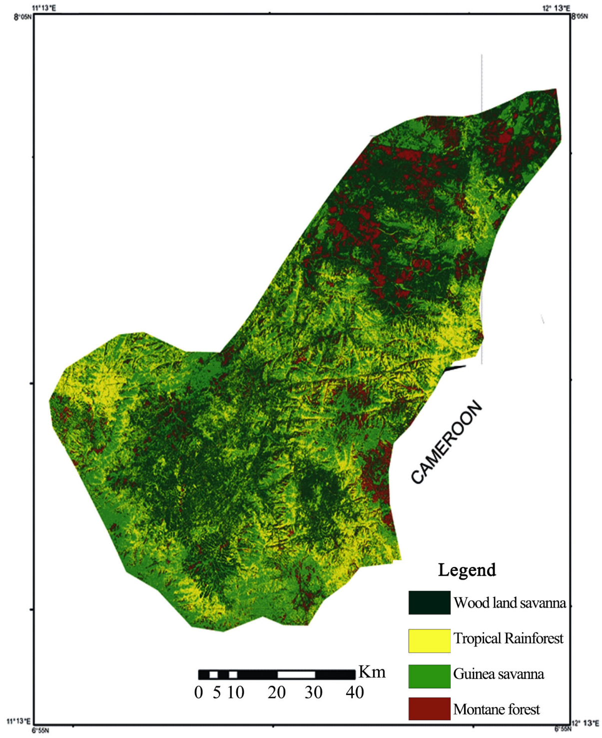

Figure 3. Classified vegetation of gashaka gumti national park 2001. Source: Field Survey, (2015).

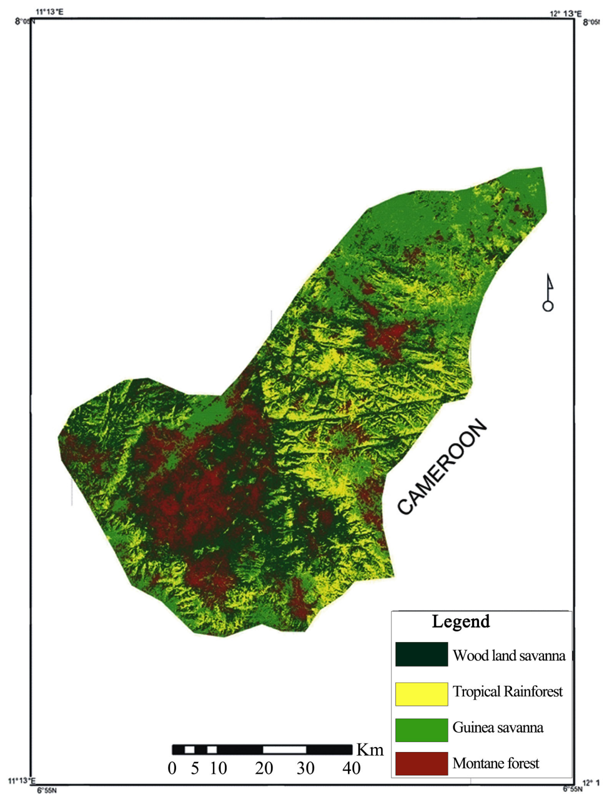

Figure 4. Classified vegetation of gashaka gumti national park. 2011. Source: Field Survey, (2015).

The landcover change of the major vegetation types studied between 2001 and 2011 is presented in Table 3.

There was a decrease in landcover in Guinea Savanna (−115.78 km^2 4.51%), and Derived savanna (−113.02 km^2; 5.17%), those of Montane Forest (+119.09 km^2 14.49%) and Gallery Forest (+109.71 km^2; 9.47%) recorded an increase between 2001 and 2011.

3.2. Changes in Landcover Classes between 1991 and 2011 in Gashaka Gumti National Park

Four landcover classes were identified and studied. They include Guinea savanna, Derived savanna, Montane forest and Gallery forest as presented in Figure 5. Supervised image classification technique studies of 1991 and 2001 imageries indicated changes in landcover classes. While the Guinea savanna, Derived savanna decreased in size, the Montane forest and Gallery forest increased in size. The findings on rainfall and temperature pattern over the same period showed that there was increase in the amount of rainfall and temperature. The increase in rainfall and slight increase in minimum and maximum temperatures could only bring about the regeneration and development of the vegetation as reported in an earlier study by [22] in the park. Therefore, the decrease in sizes of the Guinea and derived savanna may be attributed to landcover change and climatic factors, other factors like the anthropogenic activites which were observed from the study to be prevalent in some parts of the park could have been responsible. This observation agrees with that of [23] who investigated the effect of anthropogenic factors on wildlife resources of the park and found them to be serious decimating factors.

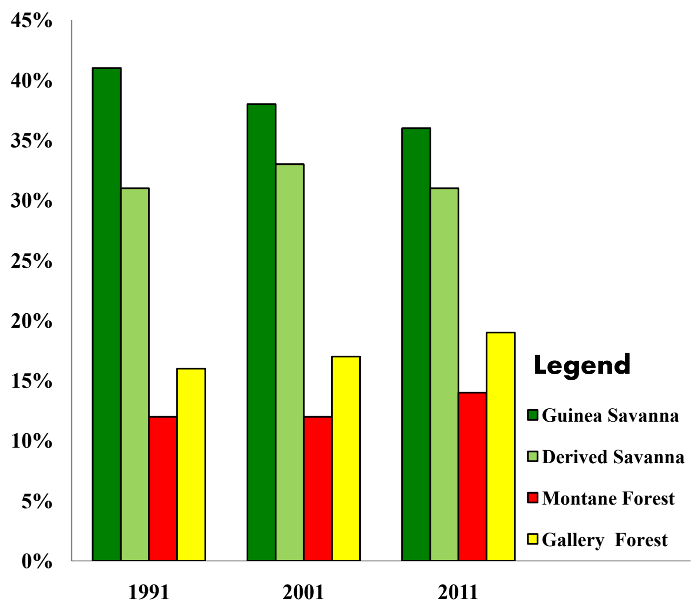

Figure 5. Landcover classes of Gashaka Gumti National Park 1991 to 2011. Source: Field Survey, (2015).

Table 3. Difference in Landcover Change of GGNP between 2001 and 2011 in Percentage.

Landcover Class	Area (km^2) 2001	Area (km^2) 2011	Difference	Percentage (%)	Remarks
Guinea Savanna	2565.01	2449.23	−115.78	4.51	Decreased
Derived Savanna	2185.41	2072.39	−113.02	5.17	Decreased
Montane Forest	822.02	941.11	+119.09	14.49	Increased
Gallery Forest	1158. 56	1268.27	+109.71	9.47	Increased

Source: Field Survey, (2015).

Further classification techniques studies of the imageries between 2001 and 2011 revealed a decrease in the size of both Guinea Savanna, Derived Savanna while those of the Montane Forest and Gallery Forest continued to increase in size. The decrease in the Guinea savanna, Derived savanna vegetation is not unexpected. This may not be unconnected with the high incident of anthropogenic activities such as deforestation, resulting from expansion of Agricultural land areas into the park and lopping of trees for livestock feed as well as fuel wood harvesting. An earlier survey by [24] aimed at determining the effect of anthropogenic factors on biological resources agrees with the findings of this study. The concentration of the above anthropogenic activities on the savanna habitats suggests that the savanna vegetation provides the desirable woody plant species for livestock feed hence their lopping for animal feed and their use for fuel wood. The soil, the terrain and the vegetation are also easy to manipulate for farming operations. These observations agree with that of [25] who reported on the threat factors affecting the rangeland of Adamawa State.

4. Conclusions and Recommendation

This study has sufficiently unveiled the current status of landcover classes and the major wildlife resources of Gashaka Gumti National Park. The findings indicated that while the savanna vegetation decreased in size those of the forest vegetation increased in size. However, the changes may be considered to be marginal. The study also established that the temperature and rainfall dynamics were not at such magnitude that could negatively impact on the lancover classes. The investigation revealed that the major causes of the decrease of the Guinea and Derived savanna vegetation were anthropogenic activities. Such anthropogenic activities include expansion of farm land into protected areas, expansion of settlements into the park, bush burning, fuel-wood collection and lopping of browse plants. Furthermore, the study also revealed that the park conservation programmes in terms of provision of social amenities/ infrastructure and surveillance strategies as well as complementary support from the Non-governmental organizations (NGOs) and the neighboring state governments helped reduce the incidence of anthropogenic activities in the study area.

It is therefore recommended that, involvement of the people particularly those living inside and around the conservation area will guarantee the success of the project and programme. The people should be encouraged to practice Agro-forestry as well as Taungya system of farming and incentives given to them when necessary. When local people are not involved, their actions tend to conflict with the goals of the conservation programmes.

The late burning which is currently prevalent in the Guinea and Derived Savanna vegetation of the park should be discouraged while early burning be encouraged.

Protection measures should be stepped up in the savanna area of the park because of its accessibility and higher value for agriculture, grazing, settlement, fuel wood harvesting and susceptibility to fire.

Currently, patrol staffs (rangers) though effective are overstretched hence the recommendation for the employment of more personnel for greater effective surveillance.

Creation of job opportunities for enclaves and support zone dwellers as economic empowerment by the park management and the Non-Governmental Organization (NGOs) should be encouraged.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Turner, B.L. (2002) Towards Integrated Land-Change Science: Advances in 1.5 Decades of Sustained International Research on Land-Use and Land Cover. In: Steffen, W., Jager, J., Carson, D.J. and Bradhsaw, C., Eds., *Challenges of a Changing Earth*, Springer, Berlin, 21-25. https://doi.org/10.1007/978-3-642-19016-2_3

[2] Roberts, D.A., Basitta, G.T., Pereria, S.L.G., Waller, E.K. and Nelson, B.W. (1998) Change Identification Using Multi-Temporal Spectral Mixture Analysis-Applications in Eastern Amazon. In: Lunetham, R.S. and Elvidge, C.D., Eds., *Remote Sensing and* 21 *Change Detection, Environmental Monitoring Methods and Applications*, Sleeping Beer Press Inc.

[3] Tiwari, M.K. and Saxena, A. (2011) Change Detection of Land Use/Landcover Pattern in an Around Mandideep and Obedullaganj Area, Using Remote Sensing and GIS. *International Journal of Technology and Engineering System*, **2**, 342-350.

[4] Briassoulis, H. (1999) Analysis of Land Use Change: Theoretical and Modelling Approaches. The Web Book of Regional Science, Regional Research Institute, West Virginia University, Morgantown.

[5] Bliss, P. and Moritz, R. (2004) Monitoring Habitat Quality in Protected Areas. Biodiversity Action Plan—Natural Resources, Msg: 5634.

[6] Sagan, C., Toon, O.B. and Pollack, J.B. (1999) Anthropogenic Albedo Changes and the Earth's Climate. *Science*, **206**, 1363-1368. https://doi.org/10.1126/science.206.4425.1363

[7] Sala, O.E., Chapin, F.S., Armesto, J.J., Berlow, E., Bloomfield, J., *et al.* (2000) Biodiversity-Global Biodiversity Scenarios for the Year 2100. *Science*, **287**, 1770-1774.

[8] Trimble, S.W. and Crosson, O. (2000) Land Use US Soil Erosion Rates: Myth and Reality. *Science*, **289**, 248-250. https://doi.org/10.1126/science.289.5477.248

[9] Vitousek, P.M., Mooney, H.A., Lubchenco, J. and Meldo, J.M. (1997) Human Do-

mination of Earth's Ecosystems. *Science*, **277**, 494-499.
https://doi.org/10.1126/science.277.5325.494

[10] Ramankutty, N., Archard, F., Aves, D., Tunner II, B.L., Defries, R., Goldewijk, K.K., Groumich, L. and Reid, R.S. (2005) Global Changes in Landcover Update News Letter of the International Human Dimensions Programme on Global Environmental Change. 032005, 4-5.

[11] FAO (1997) State of the World Forest: Food and Agricultural Organization of the United Nation. Rome.

[12] Vitousek, P.M. (1992) Global Environmental Change: An Introduction. *Annual Review of Ecology and Systematics*, **23**, 1-14.
https://doi.org/10.1146/annurev.es.23.110192.000245

[13] Jean, H. and Achard, F. (1997) A New Approach for Tropical Forest Area Monitoring Using Multiple Spatial Resolution Satellite Sensor Imagery. *International Journal of Remote Sensing*, **18**, 2455-2461. https://doi.org/10.1080/014311697217729

[14] Milne, A.K. (1998) Change Detection Analysis Using Landsat Imagery: A Review of Methodology. *Proc-IGARSS*, Edinburgh, 541-554.

[15] Ascher, W. (2001) Coping with Complexity and Organizational Interests in Natural Resource Management. *Ecosystem*, **4**, 742-757.
https://doi.org/10.1007/s10021-001-0043-y

[16] Tim, P. (2009) Regeneration and Environment: Socio Economic Welbeing of Local Communities.

[17] Lambin, E.F., Geist, H. and Lepers, E. (2003) Dynamics of Land Use and Cover Change in Tropical Regions. *Annual Review of Environment and Resources*, **28**, 205-241. https://doi.org/10.1146/annurev.energy.28.050302.105459

[18] Singh, A. (1999) Review Article: Digital Change Detection Remotely Sensed Data. *International Journal of Remote Sensing*, **10**, 898-1003.
https://doi.org/10.1080/01431168908903939

[19] Dunn, A. (1999) Gashaka Gumti National Park: A Guide Book. National Park Service, Abuja, 1-7.

[20] Marguba, B. (2002) Nigeria National Parks Their Significance and Potentials to the Nation. *The Magazine of the Nigeria National Parks*, **1**, 7-10.

[21] Bottomley, B.R. (1999) Mapping Rural Land Used and Land Cover Change in Carsroll Country, Arkansas Utilizing Multi-Temporal Land Sat Thermatic Mapper Satellites Imagery. http://www.uark.edulocal/brandon_thesis/

[22] Akinsoji, A. (1996) Vegetation Types and Ethonobotanical Studies of Gashaka Gumti National Park, Nigeria. Unpublished Report Prepared for the Federal Ministry of Agriculture, Water Resources, and Rural Development Nigeria, Nigerian Conservation Foundation and WWF-UK, 79.

[23] Dunn, A. (1993) A Training Manual of Survey and Sampling Techniques for Census of Large Mammals in Tropical Forests. Report Prepared for Worldwide Fund for Nature, Gland, 1-20.

[24] Dishan, E.E., Umar, I.A., Bashir, A. and Kwaga, B.T. (2009) Assessment of Population Pressure on Forest Vegetation in Greater Yola Adamawa State, Nigerian. *Journal of Tropical Agriculture*, **11**, 205-208.

[25] Dishi, K. (2014) Evaluation of the Ecological Health of Some Adamawa State Range Land Nigeria. Unpublished PhD Thesis, Modibbo Adama University of Technology, Yola.