



UNIVERSITI PUTRA MALAYSIA

***ANTHROPOLOGICAL INTERFERENCE ON THE VEGETATION OF
WASSANIYA FOREST RESERVE IN SOKOTO, NIGERIA***

ATIKU MUHAMMAD

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**ANTHROPOLOGICAL INTERFERENCE ON THE VEGETATION OF
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By

ATIKU MUHAMMAD

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in
fulfillment of the Requirements for the Degree of Doctor of Philosophy**

November 2017

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DEDICATION

This work is dedicated to the memory of my Father Alhaji Abubakar Ango Tela who departed this world on 15th May 2016, may Allah forgive him and reward him with Jannatul Firdaus, amen. It is also dedicated to my Mother Hajiya Aishatu Bint Musa Zauj Abubakar who is never tired of guiding and supporting me. It is dedicated to my wife Zainab bint Umar who is ever tolerating me and cooperating. It is also dedicated to the memory of my sons Anas and Ahmad and my daughters Khadijat, Hafsat and Aminat who died at their early stage in life. Lastly, it is dedicated to all of you who are ready to seek for the truth and work for it.



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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By

ATIKU MUHAMMAD

November 2017

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Faculty : Forestry

A forest inventory was carried out to investigate the anthropological interference on the vegetation of Wassaniya Forest Reserve in Sokoto state of northwestern Nigeria. Two approaches were employed. Firstly Landsat Multispectral Scanner (MSS) of 1986 (17-07-1986) and Landsat 8 Operational Land Imager Thermal Infrared Sensor (OLI-TIRS) of 2015 (0-07-2015) were used to capture images of the respective time of the same study area. The image data were analyzed within Idrisi Taiga environment using Markov change analysis. The Land Use Land Cover (LULC) changes of both dates 1986 and 2015 were detected to gain an insight into the changes in LULC and to make predictions for the future (2030). Secondly, a participatory rural approach was conducted using inclusion and exclusion criteria by administering questionnaires within twelve communities residing around the study area. A multi-stage random sampling technique was adopted for selecting 120 respondents, from three (3) villages out of two (2) districts each in two local government areas of Sokoto State. Result shows that out of the 1,396 individual trees encountered, 46 species were identified belonging to 19 family groups. Fabaceae has the highest number of species with 13, while *Guiera senegalensis* and *Combretum micranthum* recorded the highest number of frequency of occurrence which is 575 and 410 respectively. *Acacia nilotica* and *Fareitia apondanthera* were among the least with only one (1) representation. *Parkia biglobosa* has the highest diameter at breast height (200cm), tree height (48m) and basal area (2.11m³). smallest DBH was recorded by *Annona senegalensis* (14cm), while the smallest tree height was recorded by *Fareitia apondanthera* (4m) and the lowest basal area was recorded by *Acacia nilotica* (0.02m³). The highest above ground biomass estimated was recorded by *Mitragyna inermis* (5,379 kg) and the lowest was from *Grewia mollis* (25 kg). With regards to LULC study, the maximum likelihood classification revealed an accuracy of 86.25%. The results reveal eight different (LULC) vegetation types based on different conditions and other site characteristics; dense forest, scrubland, shrubby area, open grassland, and farmland. Others are dense forest (partly scrubland), dense forest (partly open grassland) and scrubland (partly open grassland). Change detection between the vegetation types

has indicated that dense forest has deteriorated in favor of farmland with a net loss of 100.59ha. It also shows that farmland has increased from 2,061 ha in 1986 to 7,336.53ha in 2015 which indicates a wide reduction of the forested area due to the pressure mounted by agricultural activities. Further predictions by 2030 reveal that farmland will increase by 11.88%. Results from participatory rural appraisal, showed that 39% of the respondents were youth and 80% of them are polygamous which could be the reason why they have large families as 82% of the respondents has 6-20 members. Their level of education was very low, with only 32% attaining primary education. They have a low level of income because 71% (of the respondents) gain less than USD 157 per month. Their consumption of staple food by far exceeds their production, of which out of 43.4% that consume 1120 bags of staple food, only 13% were able to produce enough food while the remaining 20.4% have to embark on other secondary occupations in order to feed their families. The secondary occupations includes; collection and selling of fuelwood (where 78% of the respondent uses wood and charcoal as fuel), illegal hunter, seller of non-timber forest products, herder of livestock, carver and blacksmith. All this invariably explain the dependency of the rural inhabitants on the forest reserve, which in turn are responsible for forest degradation, deforestation, and desertification. It is therefore recommended that these local communities are given environmental education on the importance of forest conservation, and empower to carry-out environmental-related programs, so that they are able to strengthen their livelihood. The dwindling forest reserves shall be enriched, and some of the farmlands shall be converted into forest plantations in order to reduce the total dependency on the forest reserve.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

GANGGUAN ANTROPOLOGI TERHADAP VEGETASI DI KAWASAN HUTAN SIMPAN WASSANIYA DI SOKOTO, NIGERIA

Oleh

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Inventori hutan telah dijalankan bagi tujuan penyelidikan ke atas gangguan antropologi terhadap tumbuhan di kawasan Hutan Simpan Wassaniya, Sokoto yang terletak di Barat Daya Nigeria. Dua kaedah telah digunakan iaitu pertamanya, Imej Multispectral Landsat (MSS) 1986 dan Imej Landsat 8 Thermal Infrared Thermal Land (OLI-TIRS) pada tahun 2015 telah digunakan bagi pengimejan semula di kawasan kajian pada masa yang ditetapkan. Data imej telah dianalisis di dalam persekitaran Idrisi Taga dengan menggunakan kaedah Markov. Perubahan gunatanah (LULC) pada tarikh 1986 dan 2015 telah dikesan bagi mendapat kefahaman tentang perubahan pada LULC dan penganggaran dapat dibuat pada tahun akan datang (2030). Kedua, satu pendekatan yang telah digunakan di luar bandar iaitu teknik kemasukan dan pengecualian dalam menjalankan soal selidik ke atas dua belas komuniti-komuniti yang terdapat di sekitar kawasan kajian. Teknik pensampelan secara rawak ini dilakukan dengan beberapa peringkat yang terdiri daripada 120 responden dari tiga (3) jenis buah kampung daripada setiap dua (2) buah daerah di dalam dua kawasan kerajaan Negeri Sokoto. Keputusan mendapati bahawa sebanyak 1,396 individu pokok, 46 spesies telah dikenalpasti terdiri daripada 19 kumpulan keluarga. Fabaceae merupakan spesies yang tertinggi bilangannya (13), sementara *Guiera senegalensis* dan *Combretum micratum* telah direkodkan sebanyak 575 dan 410 individu, masing-masing. *Acacia nilotica* dan *Faretia apodanthera* adalah antara spesies yang telah dikenalpasti dengan sekurang-kurangnya satu individu sahaja. Sebatang pokok *Parkia biglobosa* mencatatkan diameter pokok (DBH) yang terbesar dengan 200cm, dengan ketinggian 48m dan keluasan pangkal 2.11m³. DBH terkecil telah dipamerkan oleh *Annona senegalensis* dengan 14cm, sementara ketinggian pokok yang paling kecil adalah *Faretia apodanthera* (4m), dan luas pangkal yang terendah telah dicatatkan bagi *Acacia nilotica* dengan 0.02m³. Biomass tertinggi dirakamkan oleh *Mitragyna inermis* (5,379 kg) dan yang paling rendah adalah dari *Grewia mollis* (25 kg). Sementara itu bagi kajian LULC, ketepatan pengelasan kebolehjadian maksimum adalah 86.25%. Kajian mendedahkan terdapat lapan (8) jenis

vegetasi gunatanah (LULC) yang berbeza berdasarkan syarat-syarat dan ciri-ciri kawasan lain. Lapan vegetasi tersebut adalah: hutan tebal, tanah belukar, kawasan belukar, kawasan terbuka padang rumput, dan tanah ladang. Lain-lain adalah hutan tebal (sebahagiannya tanah belukar, hutan tebal (sebahagiannya padang rumput terbuka) dan tanah belukar (sebahagiannya padang rumput terbuka). Pengesanan pertukaran di antara jenis pertumbuhan menunjukkan bahawa hutan yang padat telah merosot kepada kawasan ladang dengan kerugian sebanyak 100.59 ha. Ini menunjukkan bahawa kawasan ladang telah bertambah dari 2,061 ha pada tahun 1986 kepada 7,336.53 ha pada tahun 2015 yang menunjukkan penurunan keluasan kawasan hutan adalah disebabkan oleh aktiviti pertanian. Ramalan pada tahun 2030 menunjukkan bahawa kawasan pertanian akan meningkat sebanyak 11.88%. Keputusan yang diperolehi dari penilaian luar bandar menunjukkan 39% adalah merupakan responden dari golongan muda dan 80% merupakan mereka yang berpoligami, yang menyebabkan mereka mempunyai bilangan keluarga yang besar, seperti 82% (dari responden) mempunyai 6 hingga 20 ahli keluarga. Taraf pendidikan mereka adalah sangat rendah, dengan hanya 32% menerima pendidikan di peringkat rendah. Mereka juga mempunyai sumber pendapatan yang rendah kerana 71% dari penduduk mempunyai pendapatan yang lebih rendah daripada USD 157 setiap bulan. Penggunaan makanan mereka adalah jauh lebih tinggi dari pengeluaran seharian mereka, di mana 43.4% yang menggunakan 11 hingga 20 buah beg, hanya 13% sahaja mampu memberikan sumber makanan yang cukup, manakala 20.4% terpaksa menjalankan pekerjaan sekunder untuk menampung keperluan makanan keluarga mereka. Pekerjaan sekunder mereka termasuklah mengumpul dan menjual kayu api (dimana 78%) responden menggunakan kayu dan kayu arang sebagai bahan bakar, pemburu haram, penjual hasil bukan kayu, pengembala haiwan ternakan, pengukir, dan tukang besi. Semua ini merupakan faktor yang menunjukkan kebergantungan penduduk luar bandar ke atas hutan simpan, yang telah menyebabkan kerosakan hutan, pembukaan hutan dan penggurunan. Oleh itu adalah disyorkan agar masyarakat tempatan diberikan pendidikan alam sekitar tentang pentingnya pemuliharaan hutan, dan diberikan kuasa untuk menjalankan program yang berkaitan dengan alam sekitar, supaya mereka dapat meningkatkan mata pencarian mereka. Keluasan kawasan hutan simpan yang semakin berkurang perlu diperkaya, dan beberapa kawasan tanah ladang ditukarkan kepada hutan ladang, agar dapat mengurangkan kebergantungan sepenuhnya terhadap sumber hutan simpan.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirements for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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CHAPTER 1

INTRODUCTION

1.1 General Background

There are three categories of protected forest in Nigeria, the Game Reserves, National Parks, and the Forest Reserves. Game Reserves and National Parks are owned and controlled by the Federal Government, while the Forest Reserves are under State government custody (McNeely, 1993). The study area, Wassaniya Forest Reserve, (WFR) falls within the third category of protected forest where existing poverty among local communities surrounding the protected areas and increase in population invariably increases the instantaneous human needs, making the area more susceptible to anthropological interference. Available records in the department of forestry show that Nigeria has a total of 1160 constituted forest reserves covering a total land area of 10,752,702 hectares which represents about 10% of the total land area (Akingbogun et al., 2012).

According to a report by the International Union for Conservation of Nature (IUCN) world database on protected areas, at present, there is almost one thousand (1,000) forest reserve in Nigeria (IUCN, 1987). Most of these forest reserves are seriously degraded with some not having any forest at all (Patricia et al., 2008; Akingbogun et al., 2012). Most of the protected areas lack adequate protection because of illegal logging, encroachment by farmers practicing shifting cultivation, uncontrolled grazing and browsing of livestock by herdsmen. Firewood collection and illegal poaching still continued in most areas, all of which is making the biodiversity crisis more complicated (Usman & Adefalu, 2010).

Wassaniya Forest Reserve is in Sokoto state of north-western Nigeria and it is surrounded by many villages, some of which includes: Bagida, Dayeji, Ginjo, Jimajimi, Kaurawal, Manu, Masallaci and Mulawa. Maraken-bori, Rafin-kubu, Tungar-noma, Tungar-filani, Tunni-gara, Wassaniya and 'Yartagimba (SSMEF, 2010). The population is mostly composed of rural communities which depend largely on agriculture, livestock and other minor business as local sources of their income. The people fall in the average income level, although a small number of households have a high-income level. Major occupations of men are farming and cattle rearing but they are engaged in secondary occupations which include a blacksmith, wood carving, thatching and selling of fuelwood that helps to augment for the primary occupations.

The main occupations of the women are household duties, groundnut cakes and other small artisanal works in their houses. Most of them cut and carry fuelwood, look after the cattle, and help their husbands in all operations connected with agriculture. Four

major tribes live in the area of the study. They are Hausa, Fulani, Arawa, and Zabarma (NPC, 2012). They possess the land which ranges from 1 to 20 ha per household. Hausa is widely understood but most of the people speak local languages. Some tribes have their own specific languages, which are spoken and understood by the members of that particular tribe only such as Fulani and Zabarma (NPC, 2012).

Wassaniya Forest Reserve is within the savanna forest zone of northern Nigeria. It should be noted that composition of vegetation within the forest reserves in Nigeria varies according to ecological classification. Forest reserves in the savanna regions of northern Nigeria may not necessarily have adequate timber resources like those in the lowland rainforest or the mangrove swampy areas of southern Nigeria (Ibrahim, 2008) but have short trees and grasses that are utilized in various forms. The vegetation zones in either the northern savannah or the southern rainforest and mangrove swamps have a peculiar floristic composition that is unique and plays vital roles in its communities as well as the environment (McNeely, 1993; Perkins et al., 1995). The reservation of land for forestry purposes was at its peak during colonial times. Efforts to increase the size of the reserves (forestry estate) since then have not been too successful (NFBR, 2001).

Forest and wildlife resources have abundant uses to human existence on earth, for example, 40% of world oxygen is produced by the tropical forest which also serves as a carbon sink. A total of 70% of Nigerians dwell in rural areas out of which 45% live and depend on forest products for livelihood (McNeely, 1993). It is estimated that the total area of reserved forest is about 10 million ha, which is equivalent to 10% of the total land area of Nigeria (Perkins et al., 1995). This means that 10% of land in Nigeria has been committed to forest reserves.

The bulk of the forestry products and services are obtained from the management of the forest reserves. Some of the major products include poles, sawn-wood, veneer and fuelwood. However, these products are still obtainable from "free areas" of the country (Ibrahim, 2008; McNeely, 1993; Perkins et al., 1995). The total area in free forest areas in Nigeria is 11,780,896 ha. Free areas are forested areas that are not under strict management by the State Forestry Department (SFD). However, permission to exploit trees from free areas still has to be obtained from SFDs. The free areas provide additional sources of forest products and services. In fact, they are considered to be very important for private forestry development. Some of the areas have been targeted as potentials forest establishment of plantations (Ibrahim, 2008; Perkins et al., 1995).

Forest reserves are greatly altered by human activities, such as indiscriminate felling of trees for agricultural production, fuelwood collection and local medications. Other uses include domestic utensils and overgrazing by livestock. These have led to the degradation of the forest under intensive pressure of exploitation (Adamu, 2005; Alonso, 2001; Bello, 2005). About 7.5 million hectares of forest globally and 3.8 million hectares of African forest are cleared each year, which is responsible for about 13000 km² of forest to disappear through forest clearing. If the trend continues then most of the

rainforest throughout West Africa could completely disappear by 2020 (Atiku et al., 2011; Jennifer & Shehu, 2010).

The motivation for high income from cash crops made farmers accept arable crop products, whereas forest conservation and the savannah ecosystem were neglected. There is high forest exploitation on the forest by host communities that are ignorant and do not think of the consequences of their actions who in most cases are marginalized in decision-making with regards to forest conservation (Osemeobo, 1991; Bello, 2005; Atiku et al., 2011). Commercial logging for timber, fuelwood, charcoal, raw materials for pulp and paper also contributes to the destruction of the fragile forest ecosystem that is hardly replaced.

The high frequency of felling of trees affects the coppicing ability of such forest and their conservation. Overgrazing by cattle in both rainy and dry season within the protected areas and uncontrolled bush burning in dry season had placed too much pressure on the forest reserves. This no doubt contributed immensely to the depletion and destruction of soil, minerals and forest biota within it (Osemeobo, 1991; Bello, 2005). The problem of increasing deforestation as a result of human interference necessitate the need to prevent the total destruction of forest in the country (Usman & Adefalu, 2010). Destruction of forests by man means destroying the ecosystem and the non-sustainable consumption pattern of our forest resources brought about a decline of world's forest reserves through large-scale felling of trees and deforestation of forested areas for the domestic and commercial purpose, in order to facilitate more civilization and urbanization (Ibrahim, 2008). This prompted the United Nations Commission on Environment and Development (UNCED) to make efforts through an awareness campaign and forest regeneration to halt the destruction done to the environment by man and his industrialization process.

Vegetation studies become more important because it provides data which can be used for comparisons with studies in other places or of the same place but at different times (Liman, 2010). Vegetation classification is also used to assist in making informed decisions on the habitat that is available for wildlife, as well as making informed decisions on fire policy and programs aimed at clearing alien plant species (Alexandridis et al., 2009). It may also provide data which may give detailed information about plant species abundance or may give a description of the structure of the vegetation. Such data can also be used for gradient analyses, measuring plant species diversity, the study of successional changes and measuring plant production of different ecosystems (Komiyaama, 2014; Rapinel et al., 2014; Hirata et al., 2013).

Many threatened vegetation species have been sporadically inventoried by field observations, but without exhaustive coverage (Rapinel et al., 2014). Satellite images appear to be a promising solution for natural vegetation mapping (Xie et al., 2008). Compared to field survey or aerial photography, recent satellite sensors provide images with a similar spatial resolution. Many studies have shown that the potential of Very

High Spatial Resolution (VHSR) sensors to map some vegetation communities (Alexandridis et al., 2009). For example, the potential of Quickbird images has been highlighted to map *Trapa natans*, *Phragmites australis* and *Lythrum salicaria* communities (Laba et al., 2008) and salt-marsh vegetation or to monitor bog vegetation in Hudson River, New York (Harris and Bryant, 2009). Another study has shown the benefit of IKONOS images for characterizing *Juncus acutiflorus* and *Juncus effuses* (Eastman, 2009; Eniolorunda, 2006; Rapinel et al., 2014). Other research carried out by (Ambursa, 2015; Laba et al., 2008; Waite, 2000) has pointed out the potential of VHSR images for mapping woody species in mangroves and the Mediterranean environments.

Participatory Rural Appraisal (PRA) method is important as a means of studying the human activities related to floristic changes in the forest (Mamoona, 2009). It is a method where the researcher may live and interact with the rural communities that are living very close to forest reserved areas for some time before later on administering questionnaires in some selected villages at the study area (Adamu, 2005; Bello, 2005). While interacting with them a lot of their live activities can be observed. A total number of respondents may be based on the village population, villages with higher population may be requested to have a larger number of questionnaires but the ration of which may not exceed 3:2 through multistage random sampling (Ambursa, 2015; Bello, 2005; Mamoona, 2009). The size of household, income, the level of education will be part of areas to be covered by the questionnaire.

Studies of this nature reveal ways by which forest conservation may be introduced and practiced by the local communities, the government may show more concerned so that all the stakeholders may be fully involved in forest conservation. The computing demands at all levels must be put together, such that in northern Nigeria, sustainable use of forest and forestry products may be achieved (Adamu, 2005; Bello, 2005).

1.2 Statement of the Problem

Nigeria had a total of 1,160 constituted forest reserves with an area of 10,752,702 ha (FORMECU, 1986). Unfortunately, most of these reserves are degraded due to either natural factors like the land depression, sheet or gully erosion, climate change which culminated in different changes to the landscape/land cover leading it to a desert-like condition or desertification (Ambursa, 2015) or to a large extent due to anthropogenic influences such as deforestation, improper-agriculture and overgrazing, bush burning, wood extraction for either fuel, or carving farm tools or timber collection among others.

Recently, all forest reserves were reported to have been degraded (CERAD, 2009). Wassaniya Forest Reserve has failed in its primary functions of forest production and environmental protection due to degradation by human activities. However, the extent of degradation in the study area is unknown, whereas such evidence is useful for effective forest management (Hayes & Sader, 2001). Thus, this study becomes necessary

to assess the extent of the degradation processes through its indicators in the study area, using *Remote Sensing* and *Geographic Information System* (RS/GIS), floristic composition assessment as well as participatory rural appraisals.

There was no record of any study previously carried out at Wassaniya Forest Reserve in order to investigate the floristic composition or the anthropological influence on the forest reserve. This study is the first attempt of research at Wassaniya Forest Reserve. Two approaches were employed in the study viz: Forest inventory and Participatory Rural Appraisal (PRA). In forest inventory, floristic composition and changes that had taken place in vegetation characteristics were evaluated, whereas the socio-demographic characteristics of people living around Wassaniya Forest Reserve and level of anthropological interference on the study site were found using Participatory rural appraisal. Changes found in vegetation characteristics are related to human activities, and it gives a clear picture of how anthropological influences affect the floristic composition of Wassaniya forest reserve.

1.3 Justification of the Study

The management objectives of Wassaniya Forest Reserve are primarily for forest production and environmental protection. Sound management strategies need to be put in place so as to achieve these objectives; such strategies require quantitative data on the dynamics of the vegetation. Wassaniya Forest Reserve is being degraded, but causes and to what extent has it been degraded is unknown. The ecological consequences of degradation of forest resources include a reduction in net primary production, alteration and loss of habitats, degradation of water and air quality and soil degradation among others (Alonso, 2001).

The socio-economic problems associated with forest degradation are food insecurity, poverty, social conflict and migration (Yelwa & Eniolorunda, 2012). To combat these menaces, policymakers should have information on vegetation damage covering a long time frame. This will allow us to come out with a working plan on the measures to be taken in order to arrest and reverse the process of degradation in the study area. Information on the degradation process is also necessary to adjust national policies that may directly or indirectly lead to convert the degradation of the environment (Ambursa, 2015). Countries are required to report on the state of their forests, including their efforts to tackle forest degradation, at the international level. Generally, the aim of managing any natural resource is to find a way to ensure its sustainability.

This study is important because it will allow us to understand why forest degradation is such a dangerous phenomenon. The study is also intended to provide to the user, data on the changes in the vegetation types, ie land uses and land classifications as well as the vegetation types in the study area. It may also reveal the extent of anthropological

interference on the floristic composition of the forest reserve as well as suggest ways by which they can be reduced.

1.4 Aim and Objectives of the Study

The main objective of this study is to assess the anthropological interference on the vegetation of Wassaniya Forest Reserve in Sokoto, a semi-arid zone of northwestern Nigeria.

The specific objectives of the study are:

- i. To determine the vegetation composition, growth and productivity parameters of tree species in Wassaniya Forest Reserve, and to estimate the above-ground biomass and carbon contents.
- ii. To determine the land use/vegetation types between 1986 to 2015, and to classify the study area into land use/land cover using landsat imagery of 1986 and 2015.
- iii. To study the relationship between socio-demographic characteristics of fringe communities and the land use and to identify the impacts of anthropogenic factors on the vegetative composition of Wassaniya Forest Reserve.

1.5 Limitations of the Study

This study covers the anthropological interference on the vegetation cover of Wassaniya Forest Reserve from 1986 to 2015 using Landsat data as well as participatory appraisal, with emphasis on woody floristic composition. The study did not cover shrubs, forbs, saplings and grasses. The study was not focused on the interference on the faunal components. The study is also limited to savannah zone of northern Nigeria as it was not carried out in the rainforest or the Mangrove swamps of the Southern parts of the country.

Parts of the limitations were centered on the difficulty in gaining the respondents attention due to time factor when most of them were engaged in farming activities and there is difficulty in reaching their domain at different villages due to the remoteness of the villages and lack of good roads. There was the unwillingness of some of the respondents to provide answers to the questionnaires due to fear as to whether our study is part of an investigation from the state government which may be tracking their activities for further prosecution. This has limited our enthusiasm in getting more number of respondents. We have to undertake group discussions after seeking patronage from the district and village heads. We also enlightened them on the purpose of our interviews before we now have their attention and willingness to participate and give the required information.

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