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AN EXAMINATION OF THE SOCIO-ENVIRONMENTAL EFFECTS OF DEFORESTATION IN ZAMFARA STATE FOREST RESERVES, NIGERIA

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ABSTRACT
As one of the oldest and most obviously degraded forest reserve in Zamfara State, Marbe Forest was selected as a case study to determine the magnitude, causes and effects of deforestation in Zamfara State. Interview and questionnaire survey were employed to determine factors causing deforestation. Satellite Imagery analysis was employed to determine the magnitude of deforestation in the forest. Land use and land cover analyses of satellite imageries covering the periods 1980 (Landsat MSS) and 2015 (QUICKBIRD) using ERDAS IMAGINE and Arc GIS 9.3 software showed that forest vegetation had the highest percentage decline rate of 91.25% over a 35 year period. The factors responsible for the menace of deforestation in the forest were found to be the indiscriminate destruction of forest for agricultural expansion by the government, encroachment by illegal timber and fuel wood collectors and insecurity. General findings of the research reveal that the menace brought about by deforestation in the area has been enormous and unprecedented. The research concluded that, Marbe Forest Reserve no longer possess the basic characteristics of a forest, let alone a forest reserve. Unchecked deforestation over the years has deprived the forest of its tree resources; and with the current trend, the forest may no longer exist in the next five to ten years. The research recommends that concerted efforts be made by the government to reclaim the deforested area and measures including reforestation and strict surveillance be initiated to replace the lost natural habitat and prevent it from further degradation.

Keywords: *Agricultural Expansion, Land Cover, Land Use, Encroachment, Satellite Imagery, Magnitude.*

INTRODUCTION

The concept of deforestation covers activities that range from bringing down a few trees to the destruction of a whole vegetation community (Abdulazeez, 2014). The menace has become so rampant and destructive that its contemporary meaning often refers to a phenomenon usually explained as the significant reduction of vegetation cover from thick to light forest or from light forest to an open or bare land. It can also be from heavy or light forest to Savannah or grassland and from Savannah to open or isolated land (van Kooten and Bulte, 2000; Abdulazeez, 2014). According to Myers (1994), deforestation is primarily a concern for the developing countries of the tropics as it is shrinking areas of the tropical forests, causing loss of biodiversity and enhancing the greenhouse effect.

The motive behind deforestation differs from countries to countries. FAO (2000) identified the main causes of deforestation to include: clearance for agriculture; exploration for charcoal; firewood and other domestic uses; urban and industrial expansion; socio-political purposes; timber logging; road construction; accidental or deliberate burning of forest and so on. In some areas, notably in Savannah regions, forest clearance has contributed immensely to an extension of grassland in lands where forest formerly occurred. Chakravarty *et al* (2011) observed that, some of the most severe and devastating environmental challenges are either caused or accelerated by artificial vegetation removal all over the world. It is evident that the whole world is facing an environmental crisis on account of heavy deforestation.

Every year about 6.1 million hectares of tropical moist forests are destroyed (Husain, 1989). Cote d'ivoire and Nigeria annually lose about 5.2 per cent of their forests. If the present rate of deforestation of 6.1 million hectares per year were to continue indefinitely, the tropical moist forests would be completely cleared in 170 years (Omiyale, 2001). Within the past 20 years, an estimated 43.48% of the total forest ecosystem has been lost through human activities (Omiyale, 2001).

Different measures have been put in place to remedy or to combat the consequences of deforestation. The major one among them is the establishment of forest reserves. Sections or the whole of natural forests can be turned into reserves by strictly preventing deforestation in the area often through legislations and strong enforcement of such legislations. In some cases such areas could be fully or partially fenced and security operatives deployed to prevent encroachment. Alternatively, large areas of bare lands, which had hitherto little or no vegetation cover, could be earmarked for massive afforestation and subsequently turned into reserves (Abdulazeez, 2015).

Despite having one of the highest deforestation rates in the world, Nigeria is still one of the leading African countries in terms of forest reserve establishment (Forega, 2014; Abdulazeez, 2015). However, forest reserves in developing countries like Nigeria are facing serious challenges resulting from lack of adequate legislations' enforcement and protection from encroachment. In some cases, the government which ought to protect the reserves end up destroying the reserves themselves. Some forest reserves through government action are cleared for agriculture and settlements or for other purposes. Through these, the aims of the forest reserves have been seriously defeated.

The issue of indiscriminate destruction of vegetation resources is not new in Nigeria and so is its study. What is relatively new however is the extension of such destructions into reserves which ideally are meant to be conserved and protected. The rationale behind this research originated from the consistent and indiscriminate destruction of vegetation resources in Zamfara State, not only in open forests but also in reserves and protected areas such as Marbe, Kuyambana and Zamfara Forest Reserves.

These reserves were created to serve as solutions to the destruction of forest resources. Such destructions which were previously carried out illegally have now been institutionalized with governments clearing official forest reserves to make way for agricultural expansion.

MATERIALS AND METHODS

Study Area

Marbe Forest Reserve is shared between Tsafe and Gusau Local Government Areas of Zamfara State. The forest reserve lies between latitudes 11° 25[I] to 11° 42 [I] North and Longitudes 6° 20 [I] to 6° 34 [I] East (Fig 1). It is situated about 30 kilometres south of Gusau town on the left and right hand side of the tarred road from Gusau to Magami (Kaltho, 1997).

The forest reserve covers approximately 347.32 square kilometres. The reserve is bounded in the west by the tarred road from Wanke to Danjibga village and by feeder roads linking Kwaren-Ganuwa through Sami-naka, Nassarawa, Tsauri (Marbe) and Tofa, all in the southern part. It is also bounded in the North by a feeder road from Nassarawa (in Katsina state) to Kuyambana; and in the East by the tarred road from Magami to Kuyambana reserves. Two major streams form part of the boundary. These natural boundaries are Gagagare and Zamfara streams in the West (Zamfara Forestry Department, 2015).

Marbe Forest Reserve lies within the tropical hinterland climatic belt of Nigeria. It is characterised by alternating wet and dry seasons coded as '*Aw*' by Koppen's Classification (that is tropical rainy climate with dry season in winter) (Abdulazeez, 2005).

Generally, the land use characteristics of the study area include forestry, farming, grazing, quarrying, hunting and gathering. These activities form important part of the economy of the villages in the area.

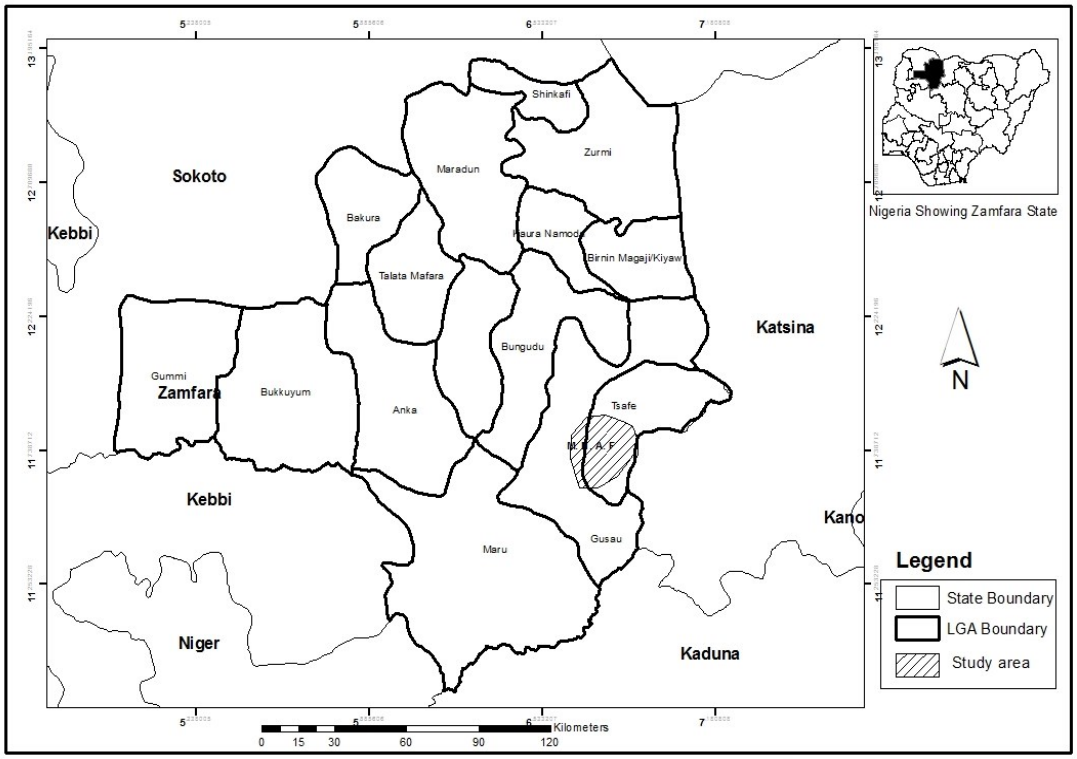

Fig 1: Map of Zamfara State showing Marbe Forest Reserve
Source: (Cartographic Analysis, 2014)

Land Use and Land Cover Analysis

The magnitude of deforestation over a 35 year period (1980-2015) was determined through data collected from Zamfara state forestry officials and comparing satellite imageries. Data collection methods involved questionnaire survey for villagers around the forest and interviews for forestry officials and other stakeholders.

Two satellite imageries covering the periods 1980 (LANDSAT) and 2015 (QUICKBIRD) were obtained and processed using ERDAS IMAGINE and Arc GIS 9.3 software for analysis of land use and land cover changes over a 35 year period. Since the focus of the land cover analysis was on vegetation, the NDVI (Normalized Difference Vegetation Index) was used in extraction by supervised classification based on Maximum Likelihood Classifier (MLC). This was done for individual separate imagery for 1980 and 2015.

Questionnaire Survey

The questionnaire was used to determine the factors, causes and consequences of deforestation from the perspectives of village residents who have been living for many years around Marbe Forest Reserve. The sampling frame for this survey includes the settlements in the area as follows: Marbe, Saminaka, Dogon Daji, Nassarawa, Konkonba, Tofa and Dan Jibga. Base on the approximate number of households (1007) in the study area, one hundred (100) respondents were captured by the questionnaire survey using systematic sampling procedure on household basis (Table 1). This was achieved by obtaining household data of the villages from Tsafe local government population office. The houses of each village were segmented into a group of 8 to 12, from which one respondent was selected from the 1st household of each group.

Table 1: Questionnaire Survey sampling for respondents in settlements surrounding Marbe Forest

SN	VILLAGES	APPROX. HOUSEHOLDS	NO. OF RESPONDENTS
1	Marbe	121	12
2	Saminaka	91	9
3	Dogon Daji	113	11
4	Nassarawa	153	15
5	Konkonba	131	13
6	Tofa	187	19
7	Dan Jibga	211	21

Source Fieldwork, 2015

Key Informant Survey

In an attempt to source data from various stakeholders who are directly or indirectly connected to the activities going on in the Marbe forest reserve in Zamfara State, interviews were prepared for five forestry staff (both admin and field workers) to investigate the factors among other aspect of anthropogenic causes that brought about the menace of deforestation in Marbe forest reserve.

RESULTS AND DISCUSSIONS

Socio-economic Characteristics of Respondents

The average age of the respondents is 45 years with a range of between 30 to 70 years, 91% of which are married or once were. In terms of gender, 85% are males while 15% are females with a combined literacy percentage of roughly 29%. By occupation, 74% are farmers or animal rearers or both; 26% are either firewood gatherers, commercial loggers, small scale enterprising housewives or jobless.

The Menace of Deforestation in Marbe Forest between 1980 to 2015

Land cover analysis using satellite images revealed that forest vegetation which covered 317 km^2 representing 91.25% of the study area (347.32km^2) in 1980, has decreased to 34.72 km^2 representing 10% in 2015, which means 282.28 km^2 of the forest area have been lost within the thirty five years interval.

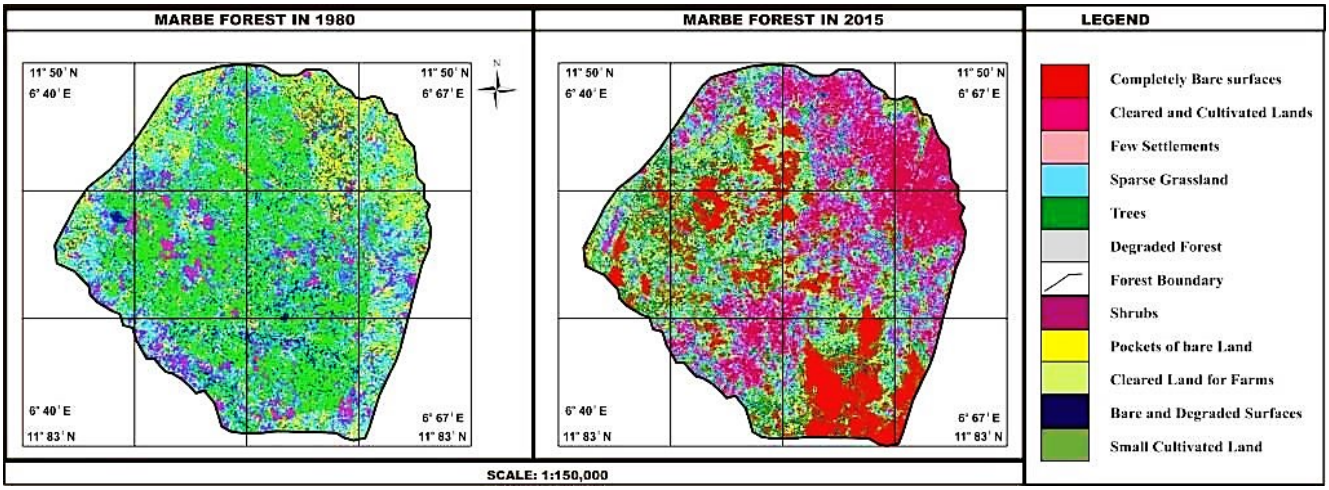

Fig 2: Maps of Marbe Forest Reserve showing magnitude of deoferastation

Source: Fieldwork, 2015

Table 2: Land use and Land cover changes of 1980 and 2015 in Marbe Forest

LAND USE AND FOREST STATUS	1980		2015	
	AREA (Km^2)	AREA (%)	AREA (Km^2)	AREA (%)
Agriculture	2.0	0.58	250	72
Settlement	2.5	0.72	7.27	2.09
Bare Surface	20.75	5.97	40.0	11.5
Forest Vegetation	317	91.25	34.72	10
Grazing land	5.07	1.46	15.33	4.41
Total	**347.32 km^2**	**100**	**347.32 km^2**	**100**

Source: Fieldwork, 2015

All the land use and land cover classes except forest vegetation increased in their spatial coverage. Forest vegetation had 282.28 km^2 of magnitude of change, which is 282.28 km^2 of the total forest vegetation area in 1980 which had changed to other land use classes in 2015. Table 2 shows among the existing land use/cover classes of 1980, forest vegetation already had the highest percentage change of 91.25% between 1980 and 2015. Most importantly, this reveals that forest vegetation is the only land use class that recorded negative changes of -91.25%. If the situation is unchecked, the forest would be absolutely and completely cleared in the near future.

Table 3: The magnitudes and proportion of change in Land use and Land cover of 1980 and 2015 in Marbe Forest

LAND USE & FOREST STATUS	1980 AREA (Km^2)	2015 AREA (Km^2)	Magnitude of change	Percentage of change (%)	Annual rate of change (Km^2)	REMARK
Agriculture	2.0	250	248	43.93	(+) 7.29	Increase
Settlement	2.5	7.27	4.77	0.85	(+) 0.14	Increase
Bare Surface	20.75	40.0	19.25	3.41	(+) 0.56	Increase
Forest Vegetation	317	34.72	282.28	50	(-) 8.30	Decrease
Grazing land	5.07	15.33	10.26	1.82	(+) 0.30	Increase
Total	**347.32**	**347.32**	**564.56**	**100**	**16.6**	

Source: Fieldwork, 2015

In terms of land use, Table 3 shows that agriculture had a massive increase over the 35-year period, increasing from 2km^2 in 1980 to 250 km^2 in 2015 with an annual rate of change of 7.29 km^2. This shows that agriculture virtually accounts for the most significant change and decline of forest vegetation. Furthermore, when the forest reserve was densely covered by trees in 1980, there was no room for grazing as little grasses existed, however by 2015 grassland has evolved from cleared forest land and constitutes about 15.33km^2 of total land.

The total magnitude of change from one land cover component to another and from one land use activity to another over the 35 year period in Marbe Forest amounts to 564.56 km^2. This means that if all changes do not occur on one another and happened separately, the area of the forest reserve would have increased to 564.56 km^2 from 347.32 km^2.

History of forest clearing in Marbe Forest Reserve

Interviews with forestry officials revealed that Marbe forest has long been serving as a hideout for armed robbers, and travellers along the road passing by the forest were always in danger. In 2001, the Zamfara State Government ordered that all trees one kilometre from the main road should be removed throughout the length of the forest close to the main road so that the armed robbers would not have places to hide. This opened the gates to other unauthorized people to engage in massive deforestation especially settlers of nearby villagers.

Factors Responsible for Deforestation

The origin of deforestation in Marbe Forest reserve, which has been in existence since the days of the Old Sokoto State, began due to many reasons. One of the primary factors that opened the floodgates of deforestation in the forest according to forestry officials was lack of proper and adequate protection of the reserve by both the government and the community.

Subsequently, different factors led to deforestation, degradation and eventual decline or collapse of the forest. Such factors from villagers' perspectives include but are not limited to security, grazing, energy and fuel as well as agriculture. Many of the settlers of nearby villages close to Marbe Forest have advanced different reasons for deforestation activities in the forest.

Table 4: Causes of forest clearing as identified by respondents

CAUSES	RESPONDENTS BY VILLAGES							
	Marbe	**Saminaka**	**Dogon Daji**	**Nassarawa**	**Konkonba**	**Tofa**	**Dan Jibga**	**Total**
Agricultural expansion	6	4	6	8	8	9	9	50
Poverty	0	1	0	1	1	2	0	5
Commercial fuel wood	2	1	2	2	1	3	4	15
Political	1	1	0	1	0	1	2	6
Security	2	2	3	2	3	2	5	19
No response	1	0	0	1	0	2	1	5
Total	**12**	**9**	**11**	**15**	**13**	**19**	**21**	**100**

Source: Field Survey, 2015

From Table 4, agricultural expansion alone accounted for 50% of deforestation in Marbe Forest Reserve, with security coming a distant second accounting for 19%. This corroborates with information from officials of Zamfara Forestry Department. According to the department, in 2001, the Zamfara State government embarked on massive deforestation of the forest reserve to pave way for agriculture. It started by clearing 5,000 hectares of forest land. Since then the state government made it a practice and went ahead to clear several thousand hectares of land every two years for agricultural expansion as shown in Table 5.

Table 5: Allocation of hectares of forest land for agricultural expansion in Marbe

YEAR	**2001**	**2003**	**2005**	**2007**	**2010**	**TOTAL**
Number of Hectares of forest lost	5,000	5,000	7,000	3,500	4,500	**25,000**
Percentage Loss	14.4%	14.4%	20.2%	10.1%	13.0%	**72.0%**

Source: Zamfara Forestry Department Officials (Key Informant Survey, 2015)

The year 2005 was the most devastating year for Marbe forest reserve when 7000 hectares of land were cleared for agricultural expansion. In total, 25,000 hectares of forest land were cleared for agriculture from 2001 to 2010. Many forestry stakeholders in Zamfara State believe that the genesis of deforestation in Marbe reserve was the demand for fuel wood. Even when deforestation was relatively unknown in the forest, a handful of forest trees were under occasional attack from tree cutters. Today, fuel wood extraction is second only to agriculture as the source of destruction of the Marbe Forest.

The high demand of wood as construction material to build houses in the emerging Zamfara capital of Gusau heaped a lot of pressure on the forest resources of the reserve.

Effects of Deforestation in Marbe Forest

Although, there is environmentally no justification for the indiscriminate destruction of trees, but the effects of deforestation in the Marbe Forest is seen from both positive and negative perspectives among villagers of Marbe Forest areas. Even though they admit the negative effects of deforestation, many villagers still believe that deforestation have brought more positive than negative consequences as shown in Figure 3.

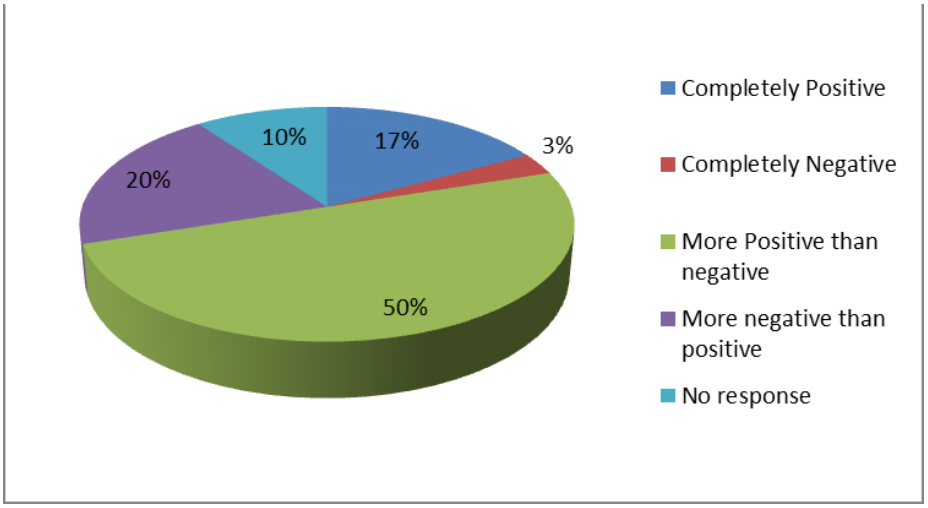

Fig 3: Villagers' Perception on deforestation in Marbe Forest Reserve
Source: Field Survey, 2015

Positive Effects
According to some respondents (90%) as captured in Table 6, when the forest reserve was densely populated with trees, grassland was virtually absent. With the continuous deforestation of the forest, grazing land now exists and many herdsmen come from afar with their animals especially during the rainy season to exploit this grassland. They however explained that, this has brought two other negative effects. First it has brought about the concentration of Fulani herdsman in the forest, some of which are accused of cattle rustling thereby constituting security threat. Secondly, many animals including camels grazing the forest have seriously constituted a problem to tree regrowth in the forest. They trample and eat up young tree regrowth which would have probably grown to full capacity.

Table 6: Some Perceived Positive Benefits of Deforestation

BENEFITS	RESPONDENTS BY VILLAGES							
	Marbe	Saminaka	Dogon Daji	Nassarawa	Konkonba	Tofa	Dan Jibga	Total
Increased Farming	6	4	6	7	8	7	7	45
Available Grazing Land	2	2	1	3	1	5	5	19
Employment Opportunities	2	1	1	3	1	3	4	15
Improved security	1	1	2	1	1	3	2	11
No response	1	1	1	1	2	1	3	10
Total	**12**	**9**	**11**	**15**	**13**	**19**	**21**	**100**

Source: Questionnaire Survey, 2015

According to 11% of the respondents (Table 6), deforestation in Marbe Forest has helped curbed armed robbery which bedevilled the road linking the forest about 10 to 15 years ago. Deforestation has made the forest more accessible and open thereby reducing travellers armed robbery nightmare which hitherto occurred almost on daily basis.

45% of the respondent's claimed that deforestation in the forest has increase accessibility to land for agriculture. The conversion of 25,000 of Marbe forest to agricultural land have according to Zamfara State Ministry of Agriculture provided direct and indirect jobs for more than 3,000 people. Fuel wood entrepreneurs have not been left behind, as villagers and settlers around the forest estimated the number of beneficiaries in the Marbe fuel wood business at more than 500 people and 15% of the respondents in Table 6 believe that it has contributed to the reduction of the level of unemployment.

Negative Effects
Key Informant Survey with forest officials and interviews with local people revealed that deforestation decreased the number of plants and wild animals, increased soil erosion, and contributed to the occurrence of gullies and debris flow. This further led to lower agriculture productivity, and contributes to an increase in the number of environmental problems.

a) Loss of Specie Diversity and Biodiversity

33% of respondents in Table 7 admitted that many trees in Marbe forest that were available 10 to 15 years ago have now become extinct. Trees of edible, economic and medicinal value have been gradually lost to deforestation (Plates II and III). Participatory interaction with forest users and interviews with local people revealed that deforestation decreased the number of plants and wild animals.

Table 7: Some Negative Effects of Deforestation

Effects	RESPONDENTS BY VILLAGES							
	Marbe	**Saminaka**	**Dogon Daji**	**Nassarawa**	**Konkonba**	**Tofa**	**Dan Jibga**	**Total**
Loss of important trees	5	3	4	5	4	6	6	33
Soil erosion	3	3	2	4	3	5	5	25
Land degradation & desertification	2	1	2	3	3	3	4	18
Others	1	1	2	2	1	4	3	14
No response	1	1	1	1	2	1	3	10
Total	**12**	**9**	**11**	**15**	**13**	**19**	**21**	**100**

Source: Field Survey, 2015

b) Soil Erosion

25% of the respondents believe that deforestation has increased soil erosion and contributed to the occurrence of gullies and debris (Plate I) which further leads to the occurrence of shallow infertile soils in sections of the forest. This results in lower agriculture productivity.

Plate I: Gully erosion attacking sections of the forest near Tofa Village

c) Land Degradation

Although this research was conducted during the dry season, but farmers interviewed have complain of low agricultural output from a significant part of the forest land cleared for agriculture. They heavily depend on fertilizer to support their crops due to infertility of the soil. In the course of field work, the researcher(s) noticed a lot of abandoned land with evidence of previous cultivation.

d) Other Effects

Based on observation, deforestation in the area results in soil erosion that is associated with perennial domestic water scarcity of Gusau town. As a result of the destruction of many trees in the area, erosion and siltation of water channels becomes obvious.

Plate II: Cleared cultivated land in Tofa village with multiple tree stumps

Plate III: Piles of firewood in Tashar Mai lena, transported out of Marbe Forest, 2015.

CONCLUSION AND RECOMMENDATIONS

The magnitude and rate of deforestation in Marbe forest reserve in the last 35 to 36 years have not only been alarming but monumental as well. With the current trend, the forest may no longer exist completely in the next five to ten years.

The major cause of this has been agricultural activities (both small scale and large scale) which have been on-going in the forest for more than 30 years. This suggests that, protection of the forest from encroachment have been largely poor over the years. On the other hand, the Zamfara State Government had allocated 25,000 hectares of Marbe Forest land between the year 2001 to 2010 for large scale agriculture.

The best way out of this quagmire is the education and orientation of all stakeholders by environmentalist on the effects of deforestation. Reforestation of degraded areas is suggested in order to speed up the process of rehabilitation and regeneration of the forest. This entails more annual tree planting and providing tree seedlings to farmers to encourage agroforestry or better still, to encourage them to plant two trees where one is felled. This will enhance forest resource management and reduce indiscriminate exploitation of the forest resources. The forest management unit should integrate surveillance/monitoring for forest protection by involving stakeholders such as community groups, officers and workers of government agencies and security guards as forest security 'watch dogs'.

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