Integration of RS/GIS in Assessing the National Great Green Wall Woodlots/Orchards in Katagum LGA, Bauchi State, Nigeria

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Abstract
The study is based on the premise that climate change and desertification have strong connection in the ecosystem. Because desertification affects climate change through the loss of fertile soil and corresponding vegetation, it also has important repercussions for the global climate system. Through the Great Green Wall (GGW) tree planting project initiatives, a lot has been achieved elsewhere hence this study. In Nigeria, the programme was introduced in Bauchi State (northern Nigeria) as one of the 11 front line states where desertification is observed. The study was conducted under the hypothetical assumption that the planting of Woodlots and Orchards can help checkmate and control the seeming desertification in the Katagum Local Government Area of Bauchi State, Nigeria. Six woodlots and Orchards were identified and mapped using the Google Earth image visualization platform and the spatial extent of change were determined in hectare (Ha) using the digitizing tool in the software. Except Dugunde (which reduced from 2,499.65 to 2,265.96 Ha), the rest increased within the period under review. Dagoro increased from 371.45 Ha to 372.91 Ha, followed by Dangazau (324.02 to 328.05 Ha), Gambaki (1,154.04 to 1.167.07 Ha), Dugunde 2 (469.42 to 537.74 Ha), and Dugunde 3 (719.58 to 749.61). The Orchard and Woodlots' growth is understandable because of continuous watering and tending of the vegetation over the years. From sampled questionnaires, the study further reveals that the Woodlots and Orchards are very effective mechanism in controlling desertification in the Northern State. The study shows that the locals are satisfied with the project and are ready to support the programme because it provided employment for them, and also helps to preserve the environment and tree species. The satisfaction with the use of woodlots and orchards for desertification is found to be generally moderate and highly significant to the programmes' goal.

Keywords: *Desertification, Great Green Wall, RS/GIS, Woodlots/Orchards*

1. Introduction

Environmental issues are almost inherently discursive, characterized as they are by 'a complex and continuous struggle over the definition of the meaning of the environmental problem itself' (Hajer 1995). Climate change, growing political instability, and increasing enclosures of large expanses of land are some of the changes and environmental issues with far-reaching consequences for those who make their living in the drylands (García, *et al.*, 2023). In simplest term, desertification means evolution from viable to non-viable

land (McDonald, Gann, Jonson and Dixon, 2016). In its global and practical meaning, it implies a set of actions, the consequence of which is the degradation of the vegetation cover, the soils and socio-economic conditions. In any ecosystem, the concept of desertification should indeed be approached through the notion of irreversibility, meaning that rehabilitation within one human generation is unlikely (Mainguet and Silva, 1998). Proven by field observations, air photographs and satellite image analysis (Bello, Irabor and Bello, 2017), the simplest and most useful definition of desertification rejects the simplistic perception of growing deserts, but refers to transformation of vegetated productive land into unproductive land and more precisely to the appearance of desert like landscapes and specific surface dynamics in semi-arid and dry sub-humid ecosystems.

Forests and trees support sustainable agriculture, stabilize soils and climate, regulate water flows, give shade and shelter. It also provides a habitat for pollinators and the natural predators of agricultural pests and contribute to the food security and income for hundreds of millions of people (Azare, *et al.*, 2020). On the other hand, desertification reduces the quantity and quality of environmental resources; hence' the need to evaluate sustainable tree planting programme of the National Agency for Great Green Wall (NAGGW) using Remote Sensing (RS) and Geographic Information Technology (GIT) for the identification, capture, storage, retrieval, manipulation, analysis and presentation of information on Geo-reference Geospatial data such as the Woodlot and Orchards of the NAGGW in the Katagum Local Government Area (LGA) of Bauchi State, Nigeria.

Change in the drylands (arid lands) is happening in an overwhelming manner (García, *et al.*, 2023), as seen in Katagum. This change in terms of reduction in vegetation thereby giving rise to aridity results in desertification. In literature, desertification is defined as land degradation in arid, semi-arid, and dry sub-humid areas resulting from many factors, including climatic variations and human activities (United Nations Convention to Combat Desertification (UNCCD), 1994). Going by the definition of the United Nations, the word "desertification" is restricted to dry lands (Mainguet and Da Silva, 1998). This means that in Africa, the areas affected are the arid (rainfall R5150 mm yr71), semiarid (1505R5 600 mm yr71) and dry sub humid (6005R5800 mm yr71) ecosystems, where rehabilitation is the most difficult and socio-economic impacts are the most severe (Vogt, Safriel, Von Maltitz, Sokona, Zougmore, Bastin and Hill, 2011). Desertification is regarded as a social problem, involving people at all stages, as a cause, and as victims as well of lower agricultural return and increasing poverty (Azare et al., 2020). There are many factors that can contribute to desertification; these factors include soil, vegetation, climate, demographic and human activities., Each of these factors has different variables determining it (e.g. population size, arable land and livestock size) (Bello, Irabor and Bello, 2017). The global concern about desertification started in earnest in 1977 when the United Nations Conference on Desertification convened in Nairobi, Kenya, and then came up with the United Nations Plan of Action to Combat Desertification (PACD) (United Nations Environment Programme, Governing Council (UN, 1995). It was formalized in 1992 at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro (the Earth Summit), with the development of a Convention to Combat Desertification (CCD) in those countries experiencing drought and/or desertification, particularly in Africa (UNCCD) (UN, 1995). The Convention was

adopted in June 1994 in Paris and entered into force on 26 December 1996. Nigeria signed the Convention on 8 July 1997.

It is important to note that complex human–environment interactions, coupled with biophysical, social, economic and political factors unique to any given location, render desertification difficult to map at a global scale (Cherlet *et al.* 2018). However, the recent regional attempt in Africa to address desertification in a more coherent manner is the Great Green Wall for the Sahara and the Sahel Initiative (GGWSSI) (Bello, Irabor and Bello, 2017) (Figure 1). The "Great Green Wall" is an initiative to increase the amount of arable land in the Sahel as Eleven (11) nations are investing in projects as varied as agroforestry to sustainable development (Kappler, nd). The initiative was developed by the African Union (AU), through its New Partnership for Africa's Development (NEPAD). The project was originally conceived as a 15 km wide strip of greenery (of trees and bushes) of some 7,775 km long, from Dakar, Senegal, in the west to Djibouti in the Horn of Africa in the east. The belt is expected to pass through eleven countries (Burkina Faso, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan and Chad), and it embraces the circum-Sahara enclaves such as Cape Verde (Leighton, 2016; Berrahmouni, Tapsoba and Berte, 2014; Kappler, nd).

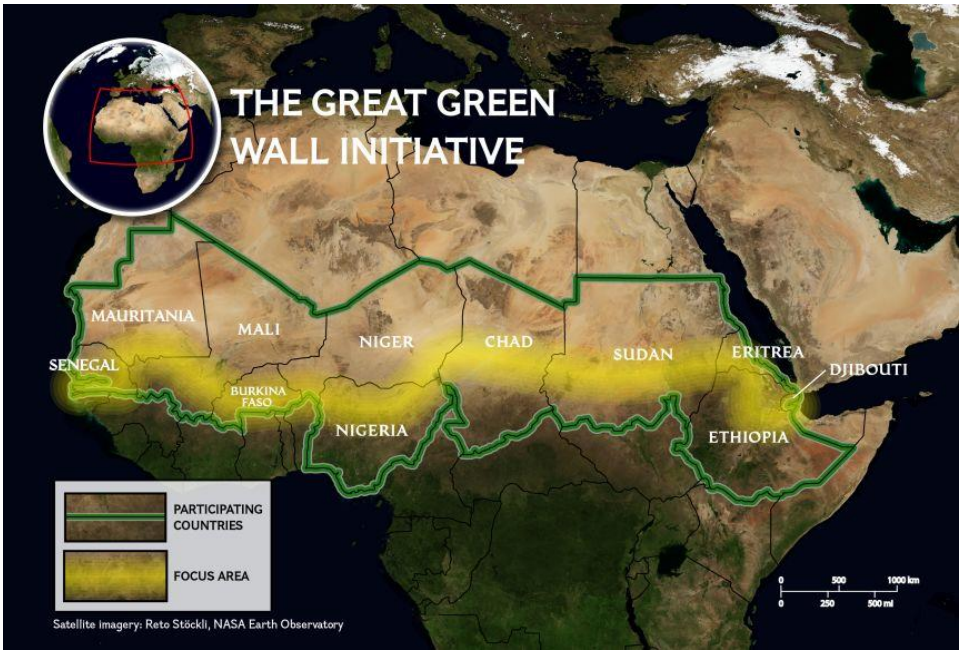

Figure 1. Great Green Wall Corridor showing Member Countries

Source: Kappler (nd), National Geographic,
https://education.nationalgeographic.org/resource/great-green-wall/

The National Agency for Great Green Wall (NAGGW) was established in line with the Great Green Wall Convention for the implementation of the Great Green Wall Programme in Nigeria with the head office in Abuja. The aim is to ensure environmental sustainability in the dry lands of Nigeria through afforestation/reforestation, mitigation of the negative impacts of climate change and improve the livelihoods of the affected people (Berrahmouni, Tapsoba and Berte, 2014). It is important to note that the NAGGW operate offices in each of the eleven (11) Front-line States in Nigeria to ensure proper execution and accomplishment of its mandate though proposed long ago as a way of mitigating environmental degradation occasioned by

desertification (Reenberg, 2012; Fang *et al.*, 2007). The Convention for the initiative was signed in Chad in 2010 (Vallée and Woodfine, 2015). The initiative has since then been recognized and supported internationally.

In terms of environmental challenge, Verstraete, Scholes and Smith (2009) opined that the cause of desertification include factors such as climate variation and human activities, and many scientists attributed desertification to where human forces steadily transforms the savannah wood land into human induced savannah. Gashu and Univerristy (2013) concluded that intermittent rainfall and the shortage of the rainy season are contributory factors to desertification as well as man's misuse of the soil as the chief culprit. Despite her rich renewable and non-renewable resources, poverty in Nigeria is widespread and rated among the world's worst. The poverty is directly linked to biodiversity loss and general environmental degradation because, rural livelihoods depend almost entirely on biodiversity. The region north of latitude 10^{o}N is generally regarded as the most desertification prone area of the country, and States within the region have often been described as desertification front-line states. They include Adamawa, Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara States (Bello *et al.*, 2017).

Visible signs of desertification in the sub-region include the gradual shift in vegetation from grasses, bushes and dotted trees to expansive areas of desert-like sand. Between the period of 1976/78 and 1993/95, sand dunes increased by approximately 17 % from 820 km^2 to 4,830 km^2 (FMEnv, 2012). Some villages and major access roads in most of the semi-arid areas have been buried under sand dunes in the extreme northern parts of Katsina, Sokoto, Jigawa, Borno and Yobe States (Medugu, 2009). In addition, many rivers and lakes like Lake Chad have silted, leading to rapid drying up of water bodies after the rains (Evans and Mohieldeen, 2002). Gully erosion, that hitherto was not a major threat, increased, threatening about 18,400 km^2 compared to only 122 km^2 in 1976/78 (FMEnv, 2012). Azare *et al.*, (2020) noted that with the country losing over 350,000 hectares of land yearly to desertification, it could not afford to watch while arable land is being lost to desert encroachment. Hence, the effect of the advancing Sahara Desert is more directly felt in the extreme northern parts of Nigeria, and this portion of the country extends from about latitude 12°N to the boundary of the Republic of Niger.

Furthermore, it has been estimated that between 50% and 75% of the 11 front-line States of Northern Nigeria are under severe threat. These States, with a population of about 35 million people account for about 35% of the country's total land area. The pressure of migrating human and livestock populations from these States are being absorbed by buffer States (Benue, Kaduna, Kogi, Kwara, Nasarawa, Niger, Plateau and Taraba) and FCT, to the south, resulting in an intensive use and degradation of the fragile and marginal ecosystems of these areas, even during years of normal rainfall (Bello *et al.*, 2017). The pressure point buffer states are reported to have about 10% to 15% of their land areas threatened by desertification. It is estimated that the country, on the whole, is currently losing about 351,000 hectares of its landmass to desert conditions annually, and such conditions are estimated to be advancing southwards at the rate of about 0.6 km per year (Azare *et al.*, 2020)

In literature, several studies were carried out on the success and failure of previous desertification programmes such as Seely (1998) on the Summer Desertification Programme (SDP) of the Desert Research Foundation of Namibi; Amiraslani and Dragovich (2010) on participatory approaches to combating desertification in Iran; Seely, Ward and Wassenaar

(2014) on effort of Gobabeb Research and Training Centre and Desert Research Foundation of Namibia (DRFN); and Jiang (2016) on Great Green Wall in China. Another set of studies were also carried out on the GGWP in some countries, like those of O'Connor and Ford (2014) in Senegal; Parungo, Li, Li, Yang and Harris (1994) on Gobi dust storms and the Great Green Wall, China; Tan and Li (2015) in china; and Niang, Sagna, Ndiaye, Thiaw, Diallo, Akpo, and Gueye (2014) in Sahel. From the foregoing, literature reveals that desertification leads to the destruction of vulnerable ecosystem which forms the basis of living of inhabitants of the semi-arid zone. It is mainly caused by overpopulation and ecosystem interactions (Abahussain, Abdu, Al-Zubari, El-Deen, and Abdul-Raheem, 2002). Thus, Mainguet and Da Silva (1998) noted that the perception of the causes of desertification has shifted from blaming colonization to climate change and finally to the traditional land-use systems.

From the above introductory background, problem statement and reviewed literature on the broad subject matter, this study is, therefore, aimed at assessing the effectiveness of woodlots and orchards used in the NAGGW programme to combat desertification in Katagum LGA in Bauchi State, Nigeria. This is with a view to identify areas of weakness and suggest solutions. The specific objectives of the study, therefore, are to (i) map and examine the spatial spread of woodlot and orchards in Katagum LGA, (ii) evaluate the strategies and procedure impact of woodlots and orchards used in the NAGGW projects for combating desertification in the study area, (iii) examine the effectiveness of using woodlots and orchards in combating desertification in Katagum LGA, and (iv) assess the level of stakeholders' satisfaction with the woodlots and orchards strategies used in combating desertification in the study area.

2. Study Area Description

This study was carried using the woodlots and orchards projects located in Dugunde (Madara District) Bulkachuwa, Dagaro (Chinade District), Dargazau, and Gambaki also in (Madara District) in Katagum LGA of Bauchi State. The study sites are divided into four (4) section by the National Agency for Great Green Wall (NAGGW) (Figures 2).

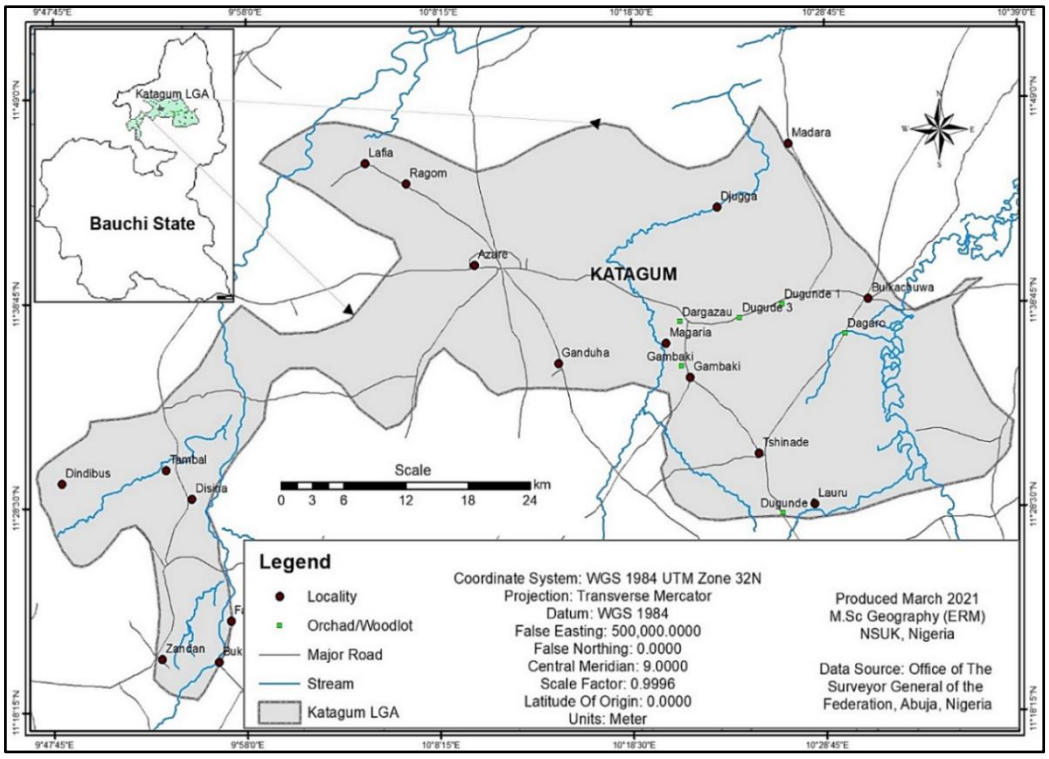

Figure 2: Katagum LGA Showing the Locations of the Orchards and Woodlots

Source: Fieldwork (2023)

The total number of hectares in Dugunde was 20 according to the Agency. The Dugunde 1 and 2 project is approximately 10 hectares of woodlots and has a few surviving plants. The site was beaten up to ensure that all the areas have been planted 3m x 3m spacing using neem seedlings. The remaining 10 hectares of woodlots used in Dugunde 3 and 4 have been planted same as Dugunde 1 and 2. About 60% of the beaten up carried out survived with an average height of 40cm - 50cm. After the planting, signpost was constructed and erected as specified for ease of identification and monitoring. The vegetation of the areas consists of economic trees such as neem tree, baobab, and many slumbers. The rainy season in the areas starts from May-June and ends between October and November, where the coldest months is December-January and the hottest month is February-May. The vegetation types as described above are conditioned by the prevailing climatic factors, which in turn determine the amount of rainfall received in the area. For instance, the rainfall in Bauchi State ranges between 1,300 millimetres (51 in) per annum in the south and only 700 millimetres (28 in) per annum in the extreme north. This pattern is because, in the West Africa sub-region, rains generally come from the south as they are carried by the south westerlies. There is, therefore, a progressive dryness towards the north, culminating in the desert condition in the far north.

In addition to rainfall, the study area is relatively flat and the entire State is watered by a number of rivers. Katagum is located in Bauchi State. Bauchi State has a total of 55 tribal groups in which Gerawa, Sayawa, Jarawa, Kirfawa, Turawa Bolewa, Karekare, Kanuri, Fa'awa, Butawa, Warjawa, Zulawa, Boyawa MBadawa. Fulani are the main tribes. This means that they have backgrounds, occupational patterns, beliefs and many other things that form part of the existence of the people of the state. Socio-economically, agriculture is one of the biggest activities in the area. The major crops production grown in the areas include; Millet, Sorghum, Cowpea, Groundnut, and Cassava, the community also heavily practice livestock rearing of

both larger and small ruminant, some few members in the community partake in petty trading and other service business; maybe full or part time. They are also engaged in other non-agricultural activities such as Tailoring, Carpentry, Barbing, and women are normally engaged in local processing such as pop (kunun samiya/kamu), roasted groundnut, groundnut oil extraction, and local grain processing, etc. Thus, the preservation of the vegetation through the planting of orchards and woodlots are geared towards improving the ecosystem of Katagum Local Government Area (LGA). The level of effects of these woodlots/orchards in the studied LGA formed the basis of this study.

2.1 Research Methodology

Research designed is key to a successful study (Saunders, Lewis and Thornhill, 2012). This study used remote sensing (RS) images in Google Earth Pro web platform and delineated the spatial extent of each woodlot/orchard using the Geographic Information System (GIS) *Tool* in the software. Secondly, questionnaire was used to gather information on the prevailing woodlot/orchard management system and the general satisfaction with the approach. Details of the systematic methodology adopted in this study is discussed further.

Population in this study includes all stakeholders directly involved in the National Great Green Wall Projects in Katagum, the study area. The stakeholders includes the household heads, farmers' association and NAGGW staffs that answered the questionnaire for the study. Sample frame refers to complete list of all units in the population under study, and it determines the structure of inquiries (Olaseni, 2004). The total populations of these particular areas according to National Population Commission (NPC, 1991, Census) is 1,038,518 (estimated to 2,596,378 for year 2022) in Gambaki, Dugunde, Dargazau, Dagaro, and Bulkachuwa towns which are all under two districts (Madara and Chinade) of Katagum LGA, Bauchi State, Nigeria and there are hamlets under each town as shown in Table 1. Also, the 2018 National Agency for Great Green Wall template indicates that there are 51,852 staffs (both ad-hoc and permanent staff), but only forty (40) staffs from relevant departments were involved in the projects. Thus, the study sample frame consists of 1,038,518.4 which is equivalent to 393 sample size of household heads, Eighty (80) farmers and forty (40) staff of National Agency for Great Green Wall. Note that the sampling approach (Table 1) beer in mind that calculation of sampling fraction from each village should be proportionate with population of the Districts and Sample frame and sample size of the study area.

It should be noted that in this study, Krejcie and Morgan's (1970) table of determining sampling size was adopted. This is in tandem with the work of Creswell (2002). Table 1 indicates that for the study area population of 1,038,518, a sample size of 393 was used as the minimum while the total number of farmers involved in the projects was eighty (80). Also, in the case of staffs of NAGGW, the total number of staff involved in the projects was forty (40). Therefore, to avoid problem of poor response, the sample size adopted for the study was 393 household heads.

Table 1: Sampling Approach

/N	District/ Town, village	No. of Hamlets	Sample frame of population	No. of farmers involved in GGW projects	No. of GGW Staffs involved in the projects	Sample Size Of Household heads	No. of respondents in each Village Town/hamlets
i.	Gambaki (Madara)	9	242,883.2	16	8	379	42
ii.	Dugunde (Madara)	5	32,928	20	8	379	76
iii.	Dargazau (Madara)	3	306,654.4	14	8	379	126
iv.	Bulkachuwa (Chinade)	4	423,281.6	18	8	380	95
v.	Dagaro Chinade town)	7	32,771.2	12	8	379	54
		28	***1,038,518.4***	***80***	***40***		***393***

Source: *Fieldwork (2023)*

The study deployed three sets of questionnaires, each for Agency (NAGGW staff), Farmers and Household heads as instrument for the data collection. The *Google Earth Pro* satellite image visualization platform was used to identify and examine the spatial extent of woodlots/orchard; first, by using the *historical* image tool to compare the spatial extent in 2003 and 2023. The identified woodlots/orchards boundaries over the years were carefully digitized and the spatial extent of each woodlot/orchard was calculated using the *calculation tool* in hectare (Ha). Structured Questionnaire was designed and sampled to elicit relevant information to get the right feedback on the use of woodlots/orchards to combat desertification in the study area.

The questionnaire was divided into four sub-sections; section: one: Demographic characteristics of respondents with twenty-seven (27) sub-questions. section two: centered on assessment of NAGGW projects effectiveness of woodlots and orchards used (Table 2). Section three: zeroed in on the strategies used in combating desertification. Section Four: focuses on community satisfaction with NAGGW program.

Table 2: Effective Response assessment criteria

Descriptors	Descriptors	Implementation (Practice)	Mean Interval
Very high	Highly satisfied	Always practiced	4.21-5.00
High	Satisfied	Often practiced	3.41-4.20
Moderate	Moderate	Moderately practiced	2.61-3.40
Low	Dissatisfied	Little practiced	1.81-2.60
Very low	Highly dissatisfied	Not practiced	1.00-1.80

In the Assessment of the Effectiveness and satisfaction of the use of Woodlots and Orchards for controlling Desertification in the study area, A 5-point likert scale was used all through the study with dissimilar constructs having different scale descriptors. Therefore, the ranks were numbered between level one (1) (maximum level) to level five (5) (lowest level). This study adapted the mean score decision interval based on the instrument of Black (2019) from which the following interval resolutions were reached Based on Table 2, the study constructs are assessed descriptively using mean ranking.

3 Results and Discussion

3.1 The Spatial Extent and usefulness of Woodlot and Orchards in Katagum LGA

As shown in Figures 3 to 9, it is evident that all the woodlots and Orchards have increased within the period under review with the exception of Dugunde 1 from 2,499.65 Ha to 2,265.96 Ha. Thus, Dagaro increased from 371.45 Ha to 372.91 Ha, Dangazau (324.02 to 328.05 Ha), Gambaki (1,154.04 to 1,167.07 Ha), Dugunde 2 (469.42 to 537.74 Ha), and Dugunde 3 (719.58 to 749.61Ha).

The general observed growth in the woodlots and orchards is understandable because of continuous watering and tending of the vegetation over the years. Nevertheless, coupled with reduction in soil quality, the effect of climate change resulting in high temperature cannot be left out in describing the very slow pace of plant growth in the study area.

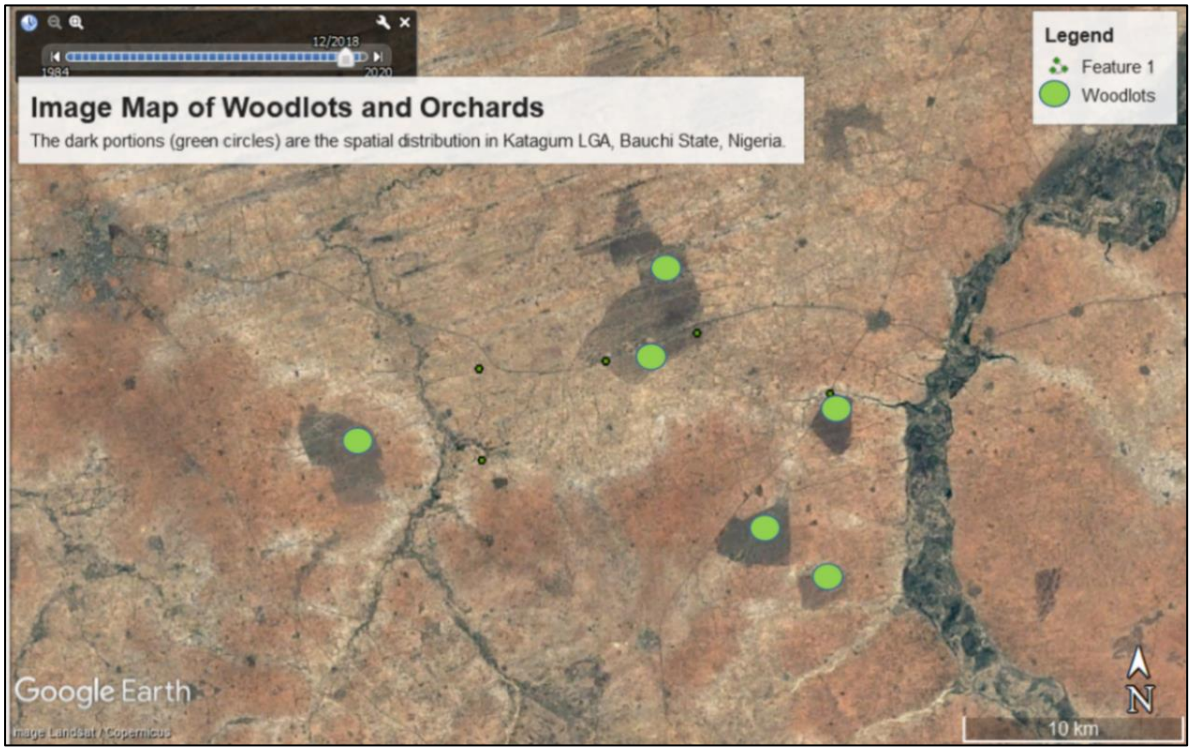

Figure 3: Satellite Image map showing the Locations of the Orchards/Woodlots in Katagum LGA, Bauchi State.

Source: Extracted from Google Earth Pro Satellite Image

3.2 Strategies and Impact of woodlots and orchards used in NAGGW Desertification Control in Katagum

Assessing the spatial spread viz-a-viz the usefulness of the woodlots and orchards as strategies in combating desertification in the study area reveals that community tree nursery has increased as well as training and participation of farmers which invariably increases productivity of the people.

These and others as shown in Table 4 are ranked **"high"** in terms of strategies and procedure impact. Conversely, procurement of *Gum Arabic* seedlings and improved fruit tree seedlings ranked the least as moderate with Mean value of 3.0909 and Standard Deviation of .86790 hence ranked 17 out of 17 of impact rating, though with Moderate remarks as strategy effect on combating desertification in the study area.

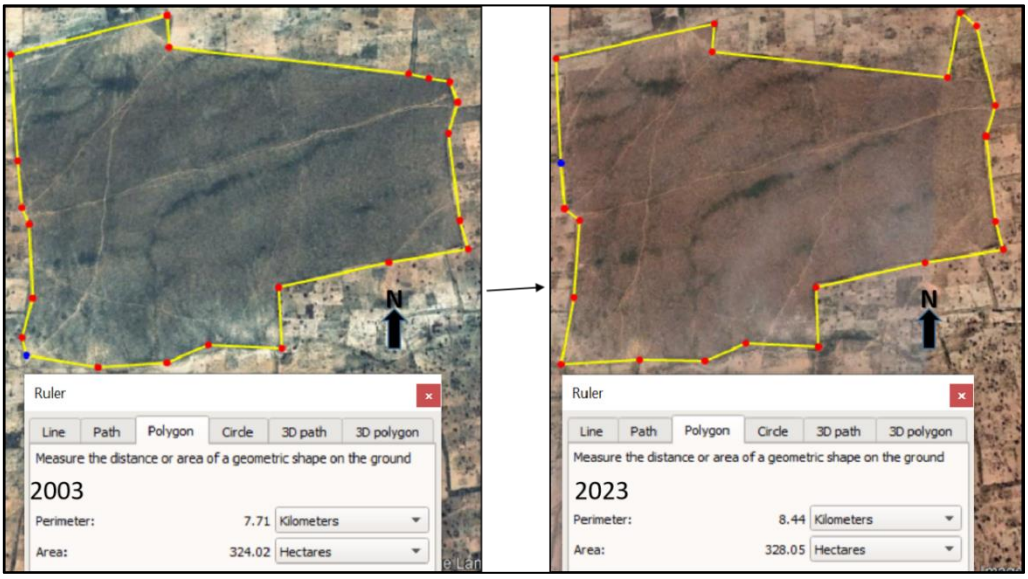

Figure 4: Image Map of Dangazau Woodlot and Orchard landcover change (2003-2023)

Source: Extracted from Google Earth Pro Satellite Image

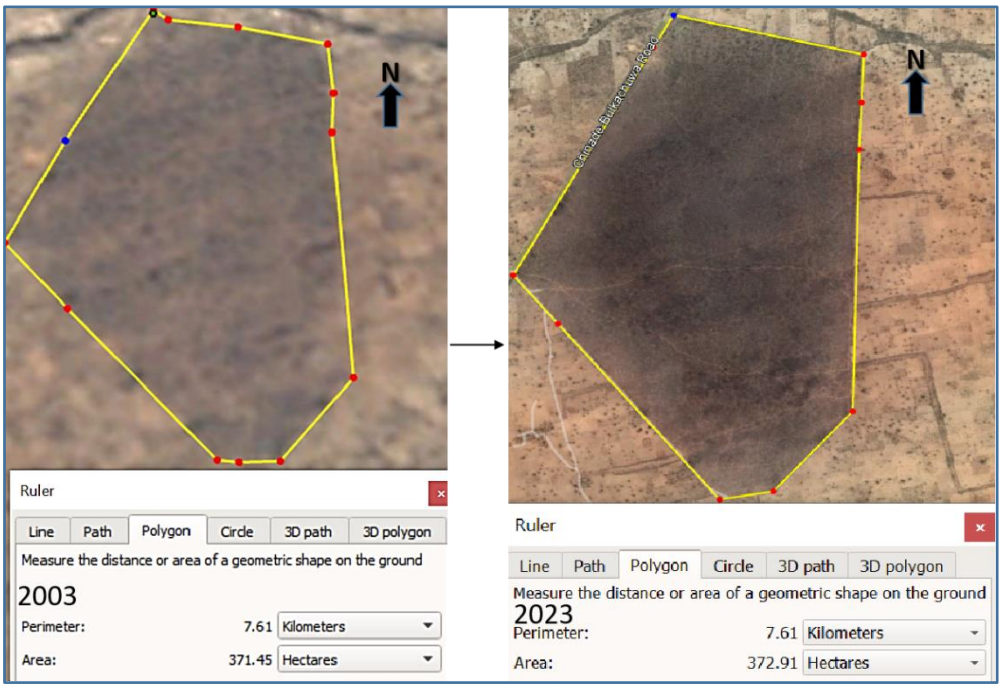

Figure 5: Image Map of Dagaro Woodlot and Orchard landcover change (2003-2023)

As shown in Table 4, the study generally revealed that the statistics ranges from a high mean value of 4.1818 to the low mean value of 3.0909. It can be perceived from Table 4 that provision of community tree nurseries has the highest mean value of 4.1818, followed by training and participation of farmers in the farm's natural regeneration project with a mean

value of 3.7727, provision of community orchards with a mean value of 3.6364, provision of shelter belt with a mean value of 3.5455 are noteworthy.

Implicitly, the results in Table 4 further indicates that majority of the strategies and procedures of using woodlots and orchards in National Agency for Great Green Wall (NAGGW) projects for combating desertification in the study area are effective and their impacts are highly significant. This is in line with the mean score decision interval proposed by Black (2019).

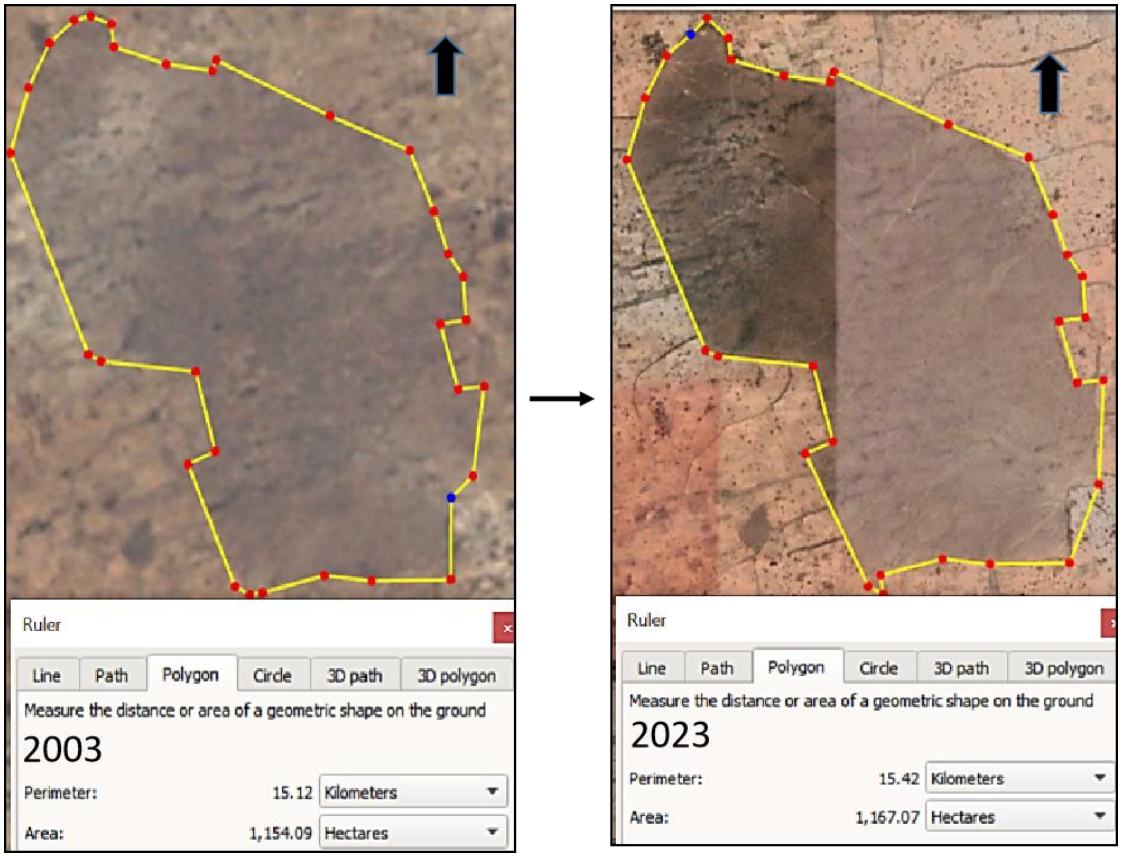

Figure 6: Image Map of Gambaki Woodlot and Orchard cover change (2003-2023)

Source: Extracted from Google Earth Pro Satellite Image

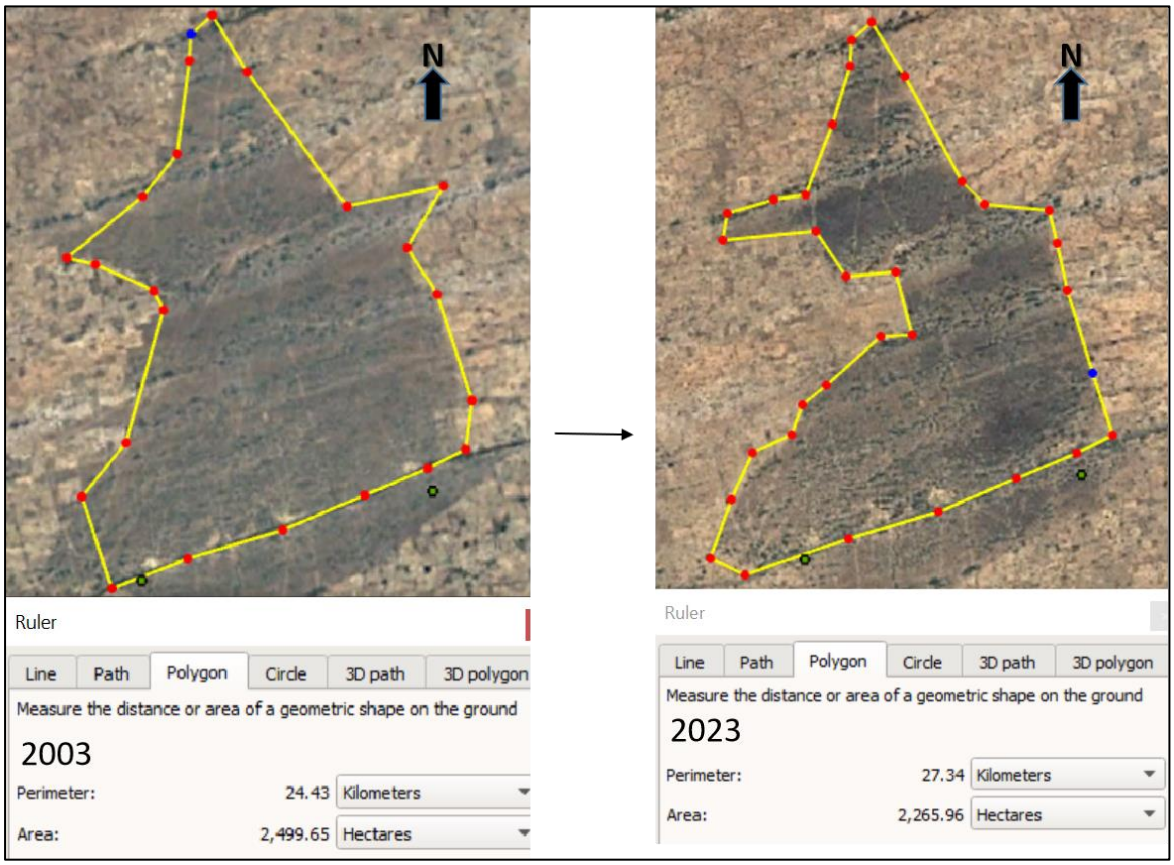

Figure 7: Image Map of Dugunde 1 Woodlot and Orchard cover change (2003-2023).

Source: Extracted from Google Earth Pro Satellite Image

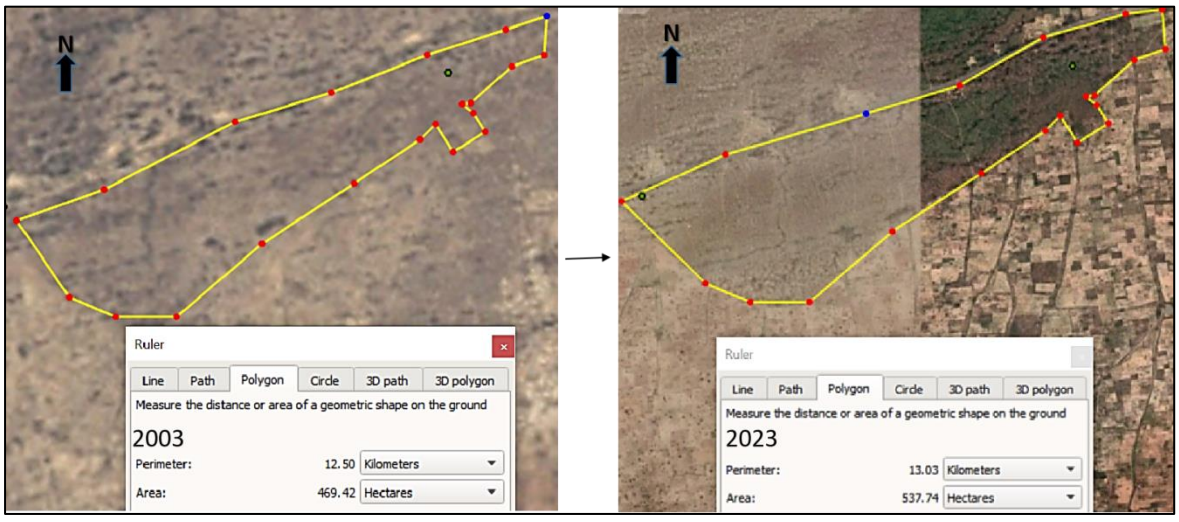

Figure 8: Image Map of Dugunde 2 Woodlot and Orchard cover change (2003-2023)

Source: Extracted from Google Earth Pro Satellite Image

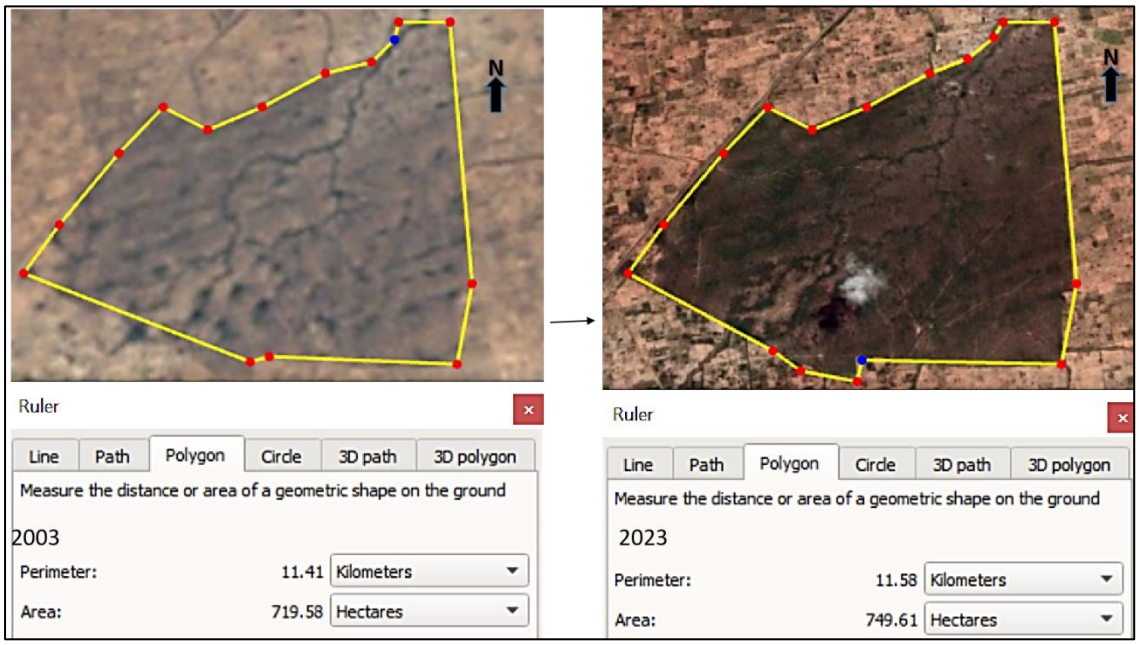

Figure 9: Image Map of Dugunde 3 Woodlot and Orchard cover change (2003-2023)

Source: Extracted from Google Earth Pro Satellite Image

Table 4: Strategies and procedures of woodlots and orchards used in NAGGW

	Strategies and procedures	Mean	Std. Deviation	Rank	Remark
i.	Provision of community tree nurseries	4.1818	.90692	1	High
ii.	Training and participation of farmers in the farm natural regeneration project	3.7727	.61193	2	High
iii.	Provision of community orchards	3.6364	.72673	3	High
iv.	Provision of shelter belt	3.5455	.96250	4	High
v.	Community youth participation in planting and other related activities	3.5455	.85786	5	High
vi.	Construction of solar powered boreholes	3.5455	.91168	6	High
vii.	Fencing of shelter belts, woodlots and orchards	3.5455	1.05683	7	High
viii.	Provision of community woodlots	3.5000	1.01183	8	High
ix.	Establishment of vegetable garden	3.5000	.96362	9	High
x.	Provision of water for irrigation and domestic uses	3.5000	.85912	10	High
xi.	Production of assorted forest and fruit tree seedlings	3.4545	.85786	11	High

xii.	Provision of solar and wind powered boreholes to ameliorate the impact of desertification	3.4545	.91168	12	High
xiii.	Baseline survey and engineering design of run-off and flood water harvesting structure	3.4545	.85786	13	High
xiv.	Formation of community based associations to manage the field investments.	3.4091	.79637	14	Moderate
xv.	Procurement and distribution of improved woodstoves, solar cookers, and solar lanterns	3.3636	.95346	15	Moderate
xvi.	Training of youths in fabrication of improved woodstoves and digesters	3.2727	.88273	16	Moderate
xvii.	Procurement of gum Arabic seedlings and improves fruit tree seedlings	3.0909	.86790	17	Moderate

Source: Fieldwork, (2023)

3.3 The effectiveness of using woodlots and orchards in combating desertification in Katagum LGA

As shown in Table 5, the study reveals that woodlots and orchards used in combating desertification is very effective as revealed in their positive effects in the study area. Thus, the effectiveness include provision of solar and wind powered boreholes to ameliorate the impact of desertification and provision of community tree nurseries with mean of 4.5000 and 4.4545 respectively, with standard deviations of .96362 and .80043 hence, they are rated very high and ranked first and second as the most effective impact of using the woodlots and orchards for combating desertification in Katagum LGA. In general, results tabulated in Table 5 shows that the mean value of effectiveness ranges from a very high mean value of 4.5000 to a low mean value of 3.2273. Details of other effectiveness of the desertification control measures are tabulated in Table 5.

Table 5: Effectiveness of woodlots and orchards used in the NAGGW projects

	Effectiveness	Mean	Std. Deviation	Rank	Remark
a.	Provision of solar and wind powered boreholes to ameliorate the impact of desertification	4.5000	.96362	1	Very high
b.	Provision of community tree nurseries	4.4545	.80043	2	Very high
c.	Community youth participation in planting and other related activities	4.0000	.61721	3	High
d.	Provision of shelterbelt	3.8182	1.05272	4	High
e.	Construction of solar powered boreholes	3.8182	.85280	5	High

f.	Training and participation of farmers in the farm natural regeneration project	3.7273	.70250	6	High
g.	Provision of community orchards	3.7273	.88273	7	High
h.	Procurement and distribution of improved woodstoves, solar cookers, and solar lanterns	3.6818	.77989	8	High
i.	Procurement of gum Arabic seedlings and improves fruit tree seedlings	3.6364	1.21677	9	High
j.	Establishment of vegetable garden	3.5455	1.10096	10	High
k.	Baseline survey and engineering design of run-off and flood water harvesting structure	3.5455	.59580	11	High
l.	Training of youths in fabrication of improved woodstoves and digesters	3.5000	1.33631	12	High
m.	Production of assorted forest and fruit tree seedlings	3.4545	.85786	13	High
n.	Provision of water for irrigation and domestic uses	3.4545	.85786	14	High
o.	Fencing of shelterbelts, woodlots and orchards	3.4091	.85407	15	Moderate
p.	Formation of community based associations to manage the field investments.	3.3182	.99457	16	Moderate
q.	Provision of community woodlots	3.2273	1.30683	17	Moderate

Source: Fieldwork (2023)

Statistically, Table 6 shows the regression analysis for the effects of the strategies and procedures on the effectiveness of woodlots and orchards used in the NAGGW projects in combating desertification in the study area. The result reveals that coefficient of determination (r^2) value indicates how much the variance in the dependent variable of the effectiveness of woodlots and orchards used in NAGGW projects is explained. The $r^2 = .228$, f (1, 192) = 56.824, p<.005. This means that the independent variable of strategies and procedures influences the effectiveness of woodlots and orchards used in NAGGW projects by 22.8% medium effect size, with significant effect at p< .005. The analysis returned a P-value of .000 (which is less than .005) which indicates that there is statistically significant effects of strategies and procedures used in the effectiveness of woodlots and orchards used in NAGGW projects.

Table 6: Effects of strategies and procedures of the effectiveness of using woodlots and orchards in the NAGGW projects in Katagun LGA, ABauchi State

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F	df1	df2	Sig. F Change

1	.478	.228	.224	.56776	.228	56.824	1	192	.000

a. Predictors: (Constant), strategies and procedures
b. Dependent Variable: effectiveness

3.4 The level of stakeholders' satisfaction with the woodlots and orchards strategies used in combating desertification in the study area

Result of the Descriptive statistics based on mean ranking carried out to explore the level of stakeholders' satisfaction with the strategies used in combating desertification in the study area is tabulated in Table 7. The results showed the *ranking*, *mean* and *standard deviation* for each item considered. The result further shows that the mean value ranges from a high mean value of 3.4323 to a low mean value of 2.7394. It can be perceived from Table 7 that the level of stakeholders' satisfaction with the combating strategies in the study area based on afforestation is high with the highest mean value of 3.4323, followed by practice of irrigation with a mean value of 3.2604, communication strategies with a mean value of 3.1604, GGW website sustaining radio and television jingle in English, Hausa, Fulfulde and Kanuri with a mean value of 3.1458, capacity building, advocacy and awareness creation with a mean value of 3.1064, training youth in various skills and trade such as carpentry, welding, bee keeping and computer maintenance with a mean value of 3.0417, establishment of dams, river basins and fadama projects with a mean value of 3.0052. Similarly, land rehabilitation and resource management has a mean value of 2.9891, provision of alternative sources of energy to reduce dependency on fuel wood and deforestation with a mean value of 2.9787, employment generation with a mean value of 2.9786, Encouraging local farmers to protect and conserve trees and shrubs growing naturally on their farms with a mean value of 2.9574, promotion of sustainable livelihoods to reduce dependency on the fragile lands has mean value 2.9358, among others. The study shows that majority of the stakeholders are moderately satisfied with the strategies used in combating desertification in Katagum LGA, Bauchi State. This is expected as it is positively in accordance with the mean score decision interval recommended by Black (2019).

Table 7: Stakeholders' satisfaction with the combating strategies

	Stakeholders' satisfaction	Mean	Std. Deviation	Rank	Remark
i.	Afforestation	3.4323	1.25735	1	High
ii.	Practice of irrigation	3.2604	1.04057	2	Moderate
iii.	Communication strategies	3.1604	1.07054	3	Moderate
iv.	GGW website sustaining radio and television jingle in English, Hausa, Fulfulde and Kanuri	3.1458	1.10561	4	Moderate
v.	Capacity building, advocacy and awareness creation	3.1064	1.00226	5	Moderate
vi.	Training youth in various skills and trade such as carpentry, welding, bee keeping and computer maintenance	3.0417	1.07652	6	Moderate

vii.	Establishment of dams, river basins and fadama projects	3.0052	1.11280	7	Moderate
viii.	Land rehabilitation and resource management	2.9891	1.11043	8	Moderate
ix.	Provision of alternative sources of energy to reduce dependency on fuel wood and deforestation	2.9787	.98674	9	Moderate
x.	Employment generation	2.9786	1.17380	10	Moderate
xi.	Encouraging local farmers to protect and conserve trees and shrubs growing naturally on their farms	2.9574	1.04723	11	Moderate
xii.	Promotion of sustainable livelihoods to reduce dependency on the fragile lands	2.9358	1.12722	12	Moderate
xiii.	Enhancement of human livelihood activities	2.9149	.96744	13	Moderate
xiv.	Provision of support to communities to raise seedlings for planting	2.9058	1.10651	14	Moderate
xv.	Rural infrastructure	2.8930	1.13325	15	Moderate
xvi.	Provision of support infrastructure	2.8925	1.02267	16	Moderate
xvii.	*Promotion of dry land agricultural technology*	*2.7394*	*1.15222*	*17*	*Moderate*

Source: Fieldwork, 2022

4. Summary And Conclusion

This study was conducted under the hypothetical assumption that the planting of Woodlots and Orchards can help checkmate and control the seeming desertification in the Katagum Local Government Area of Bauchi State, Nigeria. Based on the set objectives, Six woodlots and Orchards were mapped and their spatial distribution shows that they are concentrated almost within the same area in the State. Nevertheless, the study also shows that the Woodlots and Orchards are very effective mechanism in controlling desertification in the Northern State with particular instance to Katagum LGA. In specific, it revealed that all the studied woodlots increased with the exception of Dogoro which decreased from 371.45 Ha to 372.91 Ha between 2003 and 2023. The Woodlots and Orchards that increased within the 2003 and 2023 period under review as evidenced from the image analysis include Dangazau from 324.02 to 328.05 Ha, Gambaki (1,154.04 to 1.167.07 Ha), Dugunde (2,499.65 to 265.96 Ha), Dugunde 2 (469.42 to 537.74 Ha), and Dugunde 3 (719.58 to 749.61). The growth is understandable because of continuous watering and tending of the vegetation over the years. The study also further revealed that the people are highly satisfied with the project and they readily support it since it creates employment and also helps to preserve the environment especially notable tree species.

The implications of the findings in the study is that in order to reduce or control desertification in Katagum LGA of Bauchi State, and in the entire front-line states in Nigeria in general, the development of Woodlots and Orchards have proven to be very sustainable and effective in

controlling desertification and reducing land degradation; hence' the need to sustain it. Therefore, it has also become very important to note that all efforts should be geared towards improving the project by NAGGW and the local people with a view to preventing or reducing environmental decay and thus improving the ecosystem dynamics for human habitation. It is envisioned that with the above measures put in place, exotic and medicinal trees for the preservation of life and sustainable growth would have been preserved.

Based on the findings from this study, the following are specifically recommended for improved development of the Woodlots and Orchards in the study area:

i. There should be continuous monitoring of the programme especially in the implementation and sustainability of the project.

ii. The Government through the NGGWP office should ensure that the local people are carried along in all the project implementation phases so as to continually sustain by-ins, create employment and reduce conflict and criminalities in the area.

iii. More woodlots and orchards should be developed to control desertification in other front-line states.

iv. More research should be carried out by the NAGGW office to identify new draught resistant tree species for the woodlots and orchards especially those that can grow very fast and spread within limited time.

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