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Socio-Economic Impacts of Algae and Weed on Artisanal Fishing in Lagoon Coastal Water in Lagos State, Nigeria

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ABSTRACT
Artisanal fishing is one of the major sources of livelihood in Lagos particularly around and along coastal corridors. However, increasing algal bloom and weed infestation have become a huge threat to these fishing activities. It is on this premise that this study examines the socio-economic impacts of algal and weed infestation on artisanal fishing in the coastal waters of Lagos State, Nigeria. Data was obtained from administered questionnaire (75) and structured interview questions. The questionnaire was randomly distributed to selected Artisanal fishermen while the interview was extended to other stakeholders including fish sellers, transporters, and consumers. Focus group discussions (FGD) were also held among the fishermen within their community. The findings revealed that majority of artisanal fishermen are at their active age between 25 and 45 years old with years of fishing experience ranging between 5 and 30 years. Also, majority of respondent (85%) cited seasonal algal bloom and macrophyte infestation, such as presence of Pontederia crassipes (water hyacinth), as a major threat facing their operations and which has drastically reduced fishing output over the years. The seasonal blooms were majorly ascribed to inflow of fresh water from the catchments of the coastal waters and to a less extent, the polluting anthropogenic practices along coast. Furthermore, there was clear evidence that artisanal fishermen do not receive adequate support and extension services that can enhance their activities on better techniques and adaptive practices for sustainable fishing. The study established the links between seasonal eutrophication of coastal waters, decrease in coastal water quality, reduced fish catch and decreasing socioeconomic indices of artisanal fishermen. The study concluded that a holistic approach that combines governmental and non-governmental support with knowledge-sharing initiatives and awareness campaigns will not only help artisanal fishermen mitigate the immediate challenges posed by algae bloom and weed infestation but also contribute to the long-term sustainability of artisanal fishing activities.

Keywords: *Algal bloom, Eutrophication, Socio-Economics, Artisanal fishing, Lagoon.*

INTRODUCTION
Across the global, coastal farming is primarily recognized as one of the major activities that reduces poverty, not only in the rural coastal areas but also as feeders of coastal food to adjoining urban areas, which are usually characterized by high population densities (IPCC, 2007; Satterthwaite *et al.*, 2010; Enete and Amusa, 2010; Bjornlund *et al.*, 2020). The limited access to the socio-economic benefits in the urban areas also force rural residents to typically seek employment in other primary and informal sectors such as coastal artisanal farming (Birawa, 2006; Villegas *et al.*, 2012; Weng, 2015).

Among the various coastal farming, artisanal fishing is considered as the major socio-economic activity of inhabitants living around and along coastal areas (Okeowo *et. al.*, 2015; Aminu *et al.*, 2017; Mozumder *et al.*, 2018; Queiroz *et al.*, 2020). Although fishing is labour intensive, artisanal fishing nevertheless plays significant role in improving the livelihood and eliminating poverty in both rural and urban populace as it is characterized by low capital and operational cost, low application of modern technology, and mainly

based on the operation of hand crafted canoes on coastal waters including creeks, inland and inshore waters, and lagoons (Adedokun *et al.,* 2006; Brugère *et al.,* 2008; Akinwale 2011; Bolarinwa, 2014, Okeowo *et al*., 2015; Adesina and Ogunnowo, 2017; Adrew *et al.*, 2021). Despite the potentials of fishing to a nation's nutritional needs and economy, it has not been fully tapped in most African communities due to certain contemporary challenges, including the fact that the activities are mostly being carried out by small-scale fish farmers (Williams, 2006; Okeowo *et al.,* 2015). This has made the Nigeria's fishing sector to only contribute only 3 - 5% to national GDP (Okeowo *et al.,* 2015; Olaoye and Ojebiyi, 2018; NBS, 2019; Musa *et al.,* 2019). Challenges such as volumes of water, accessibility, algal bloom and weed infestation, anthropogenic activities as well as uncharted vessel routes, domestic and industrial effluents, land pollution etc have continued to militate against sustainable fishing (IPCC, 2007, Enete and Amusa, 2010). The limited access to the socio-economic benefits in the urban areas also force rural residents to typically seek employment in other primary and informal sectors such as coastal artisanal farming (Birawa, 2006; Villegas *et al.,* 2012; Weng, 2015).

Urban runoffs from densely populated coastal areas, the flow of domestic and industrial effluents, and atmospheric deposition to the lagoon coastal water have been major sources of pollutant nutrients into coastal waters (Olayinka *et al.,* 2016). Approximately 22% of the land mass of metropolitan Lagos, situated on the southern-most end of western Nigeria, consists of a web of creeks, rivers and lagoons, and because of its equatorial location, it experiences 50 to >700 mm of monthly rainfall during the wet season. Additionally, most highways in Lagos, which run parallel to these numerous creeks and canals or across them, also serve as sources of significant P transport to receiving waters during the wet season (Abayomi *et al.,* 2011).

The discharge of sewage-bearing rivers and streams, which flows through densely populated and industrialized catchments, into the Lagos Lagoon also contributes to the nutrient load of Lagos coastal waters (Oladosu *et al.,* 2020). Reported local sources of atmospheric N and P deposition to the Lagoon, including open-air waste burning, large-scale ammonia emission as well as industrial and tail-pipe emissions of particulate P and trace gases such as nitrogen dioxide, also adds to the dynamics of nutrient balance of Lagos coastal waters. In this respect, the Lagos water, especially its Lagoons system, has been described to be one of the highest P and N wet depositions in the world (Oladosu *et al.,* 2017). The continued delivery of nutrients to the Lagos Lagoon has largely resulted bottom-water hypoxia, due to oxygen depletion following the decomposition of algal blooms and weed infestation such as water hyacinth in large swathes of the water (Alo *et al.,* 2010; Alo *et al.,* 2014; Oladosu *et al.,* 2017). This has in turn drastically affected artisanal fishing in Lagos coastal water.

It is on the basis of the aforementioned that this study determined the relative perspective of artisanal fishermen on nutrient enrichment and eutrophication of Lagos coastal waters, and, examined its socio-economic impacts on artisanal fishermen and their communities.

MATERIALS AND METHODS

Study Area

The study was carried out along the stretch of Lagos State coastline which extends from the Epe to Badagry axes. The State which was created in 1967 by virtue of State Creation and Transitional Provisions under Decree 14 of 1967, is located at longitude 2º42'E & 3º22'E, and 6º22N & 6º42'N along the coastal plain of the Bight of Benin (Fig. 1). The state is on an expanse land area of about 3,577sqkm, including lagoons and other minor water bodies. Lagos is bounded by Ogun State to the north and east, to the west by the Republic of Benin, and to the south by the coast of the Atlantic. Tropical swamp (fresh water and mangrove) forest dominates the vegetation of the state with an annual rainfall which ranges between 1400mm and 1800mm sandwiching a short August break. The climate is characterized with two seasons namely the dry season which extend from November to March and wet season which extend from April to October, while the air temperature on the average ranges between 30ºC and 38ºC (Louche and Keep, 2002; Daejeon, 2004; Ayeni, 2017). The Lagos lagoon, Lekki lagoon, Yewa River and Ogun River are the prominent water bodies in the state, while other minor surface water bodies include but not

limited to Ologe lagoon, kuramo waters, Badagry creeks and Owu (Ayeni, 2017). The state is politically divided into 20 local government areas with a total population of about 9.01million in 2006. This accounted for about 6.44% of the Nigeria total population of 140.003million in the 2006 Census (NBS, 2007). Though the world population review estimated the Lagos State population at 15.388million as at early 2022 (World Population Review, 2022).

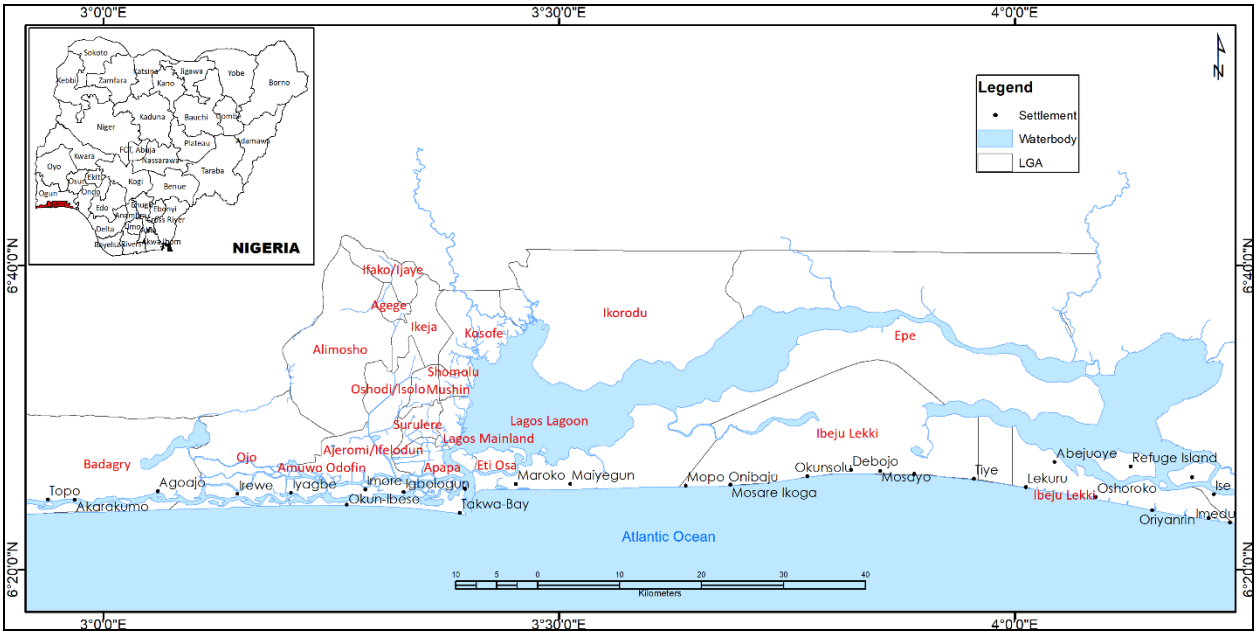


Figure 1: Lagos showing Coastal water

Methodology

For this study, a descriptive survey method was adopted to generate socioeconomics data that are relevant to achieve the study objectives. The instruments used comprise of pre-test, structured questionnaire and interview, focused group discussion as well as personal observations from the field. The questionnaire and interview were designed to target some selected artisanal fisher folks in the areas. Taking into consideration the overall population size and statistical considerations, a total of 75 questionnaire were randomly distributed to the fishermen along the study corridor with particular focus on Epe and Badagry towns fishing communities. The two (2) areas were selected based on a strategic thoughtful approach and geographic diversity such as the size of the communities, their proximity to urban centers, and cultural variations as well as consultations with local authorities, fisheries management associations, and communities' leaders that provide valuable insights into the significance of each location and the unique challenges faced by the communities. The structured interviews harnessed information from heads of coastal and leaders of fishermen association and fish seller, as well as some fish buyers. The interview questions included identification of fish species in the areas, gender and age group involved in the fishing activities, period and frequency of algal bloom and water hyacinth occurrence, impacts and challenges. The obtained data were complimented by field observations during monthly exercise, including types of fishing equipment and methods, identifications of locations of intense eutrophication, characteristics of catchment waters, the major stakeholders of the fishing communities, mechanism of fish catch marketing and the nature of adjoining landuse.

RESULTS AND DISCUSSION

Demographic Characteristics of Fishermen

Study Locations / Communities

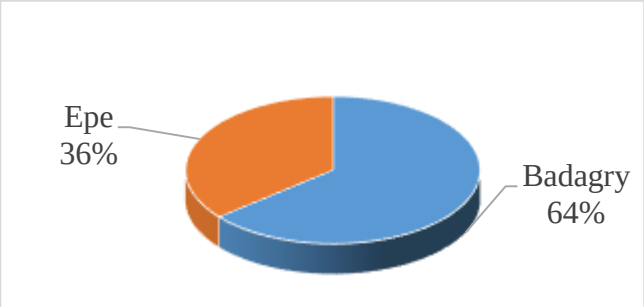


Fig. 2: Study Locations / Communities

The study focused on the socio-economic impact of water weed such as water hyacinth and algae and weed on artisanal fishing in the lagoon coastal waters of Lagos state. Of the 75 sampled respondents in the fishing communities of focus, 48 (64%) were from Badagry while 27 (36%) were in Epe as shown in Figure 2.

Gender of Respondents

The study showed that 62 (82.7%) of the respondents were male while 13(17.3%) were female (Figure 3). This invariably suggests that artisanal fishing is still largely a gender-based occupation due to the intensity of labour and attendant risks involved in the water-based endeavour. However, during the FGD session, the fishermen explained that there exists a clear division of labour in artisanal fishing practices, whereby, while the men do the fishing, the women undertake processing activities such as drying and smoking the of the fishes.

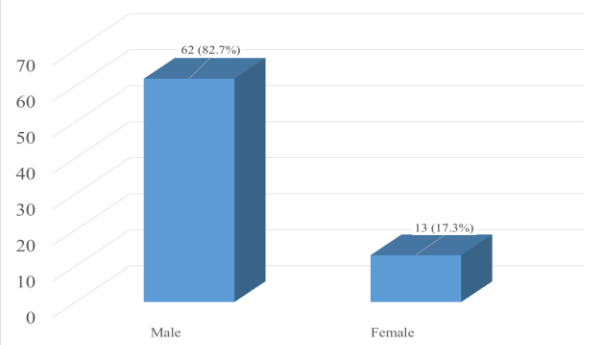


Figure 3: Gender of Respondents

The socio-economics characteristics generated from the study revealed that majority of the respondents are males. This is in line with the studies of Adeleke and Fagbenro (2013) and Adesina and Ogunnowo (2017) which informed that artisanal fishermen in Ondo water and Lagos State coastal areas respectively are dominated by active males. This is an indication fishing is mostly occupied by male folks.

Age of Respondents

As revealed in Figure 4, the highest age cohort was between 26 – 35 years (28.0%), while the lowest was less than 18 years (6.7%) which showed that there were more active fishermen aged 26–35.

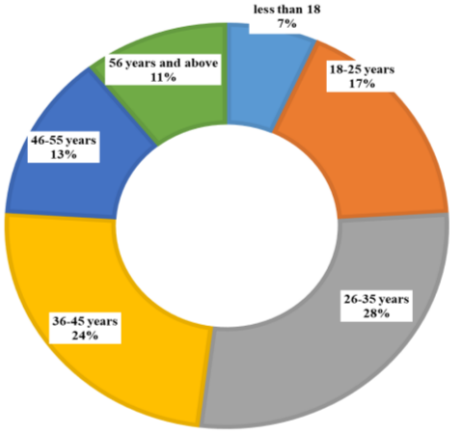


Figure 4: Age of respondents

In order words, artisanal fishing remains a major youth engagement and occupation in coastal communities due to the rigour and strength involved. The age bracket of majority of the respondents was within the age of 26 – 45 years, accounting for 52%. This corresponds with the studies of Siyanbola (2012) and Adesina and Ogunnowo (2017). The majority of age bracket in their studies was between the age of 34 and 48 years.

Marital Status and Size of Households of Respondents

The marital status of the respondents (Table 1) showed that 52 (69.3%) were married while 22 (29.3%) were single. Thus, indicating that artisanal fishing is mainly family centred and a major support system of economic well-being of coastal family units. Respondents with less than 5 per

household recorded 24.0% which is the least number of household members while 50.7% of the respondent have between 5 – 10 persons per household (Table 1). The large size of their households reinforces the notion that artisanal fishing is central to coastal fishing families. Majority of the respondents are married with average household size of between 5 and 10. The finding substantiates the studies of Rouf and Jenson (2001); Kumolu-Johnson and Ndimele, 2010 and Mozumder *et al.,* (2018) that observed large family size (between 5 and 10 persons) among the poor in rural coastal water areas.

Table 1: Marital status and household size

		Frequency	Percentage
Marital Status	Single	22	29.3
	Married	52	69.3
	widow	1	1.3
	Total	**75**	**100.0**
Household Size	less 5	18	24.0
	5-10	38	50.7
	Above 10	19	25.3
	Total	**75**	**100.0**

Level of Education

The study showed that the level of Education of the respondents varies with informal education accounted for the lowest (2.7%) while Senior School Education accounted for the highest (37.3%) and 22.7% had no education. This shows that a large portion of the fishermen have senior school certificate.

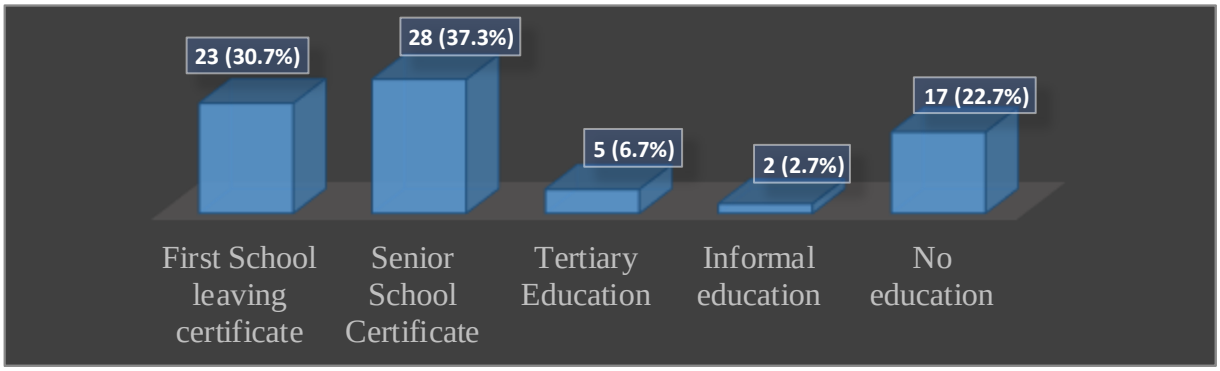


Figure 5: Level of Education of Respondents

The study showed that the level of education of the respondents varies The findings from this study showed that informal education accounted for 2.7%, senior school education accounted for 37.3% while 22.7% of respondents had no education. This is contrary to study by Adesinal and Ogunnowo (2017) which affirmed over 50% of the respondents had no education.

Fishing Characteristics

Fishing Job and Communities

About 86.7% of the respondents are full –time fishermen while 13.3% are part-time fishermen (Table 2). The part-time fishermen claimed they have alternative jobs e.g. teaching, sand mining, driving amongst others. This is line with the work of Mozumder *et al.,* (2018) where it was observed that majority of their respondent are full time fishermen that have boats and fishing gears as well as other tools for fishing.

Table 2: Fishing job and communities

		Frequency	Percentage
Fishing job	Full time	65	86.7
	Part-time	10	13.3
	Total	**75**	**100.0**
Fishing commu-nities	Akarakumo	25	33.3
	Ajido	18	24.0
	Badagry Oja	5	6.7
	Agbami Osa	27	36.0
	Total	**75**	**100.0**

The major fishing communities or villages of fishermen according to the respondents are Agbami Osa with 36.0% and Badagry Oja 6.7% with the highest and lowest respondents respectively (Table 2)

Fishing Households

The results in table 3 show that the number of fishing households in the communities are between a minimum of 100 (8.0%) and a maximum of over 300 (32.0%). These are function of the community's population. For example, in Badagry there is virtually no indigenous household that does not have representative in fishing. This is one of the socio-cultural characteristics of coastal fishermen and also indicates that artisanal fishing in Lagos coastal settlements is communal based, with community socio-economic values built around the fishing activities (Kumolu-Johnson and Ndimele, 2010; Okeowo et al., 2015).

Table 3: Number of fishing households in the sampled communities

Fishing households	Frequency	Percentage
over 100	6	8.0
over 200	21	28.0
over 300	24	32.0
over 500	6	8.0
over 2000	18	24.0
Total	**75**	**100.0**

Other minor Fishing communities

As revealed in table 4, most of the fishing communities have one or some other fishing communities around.

Table 4: Other minor Fishing communities

Other fishing communities	Frequency	Percentage (%)	Frequency	Percentage (%)
Ajido	16	21.3	3	4.0
Epe	11	14.7	10	13.3
Topo	8	10.7	12	16.0
Akarakumo	5	6.7	4	5.3
Ere Ise	5	6.7	1	1.3
Iworo	4	5.3	12	16.0
Ikeran	4	5.3	-	-
Igbo apawa	4	5.3	-	-
Mausa	3	4.0	5	6.7
Emino	2	2.7	5	6.7
Agonye	2	2.7	2	2.7
Orita	2	2.7	2	2.7
Itosun	2	2.7	2	2.7
Badagry	2	2.7	1	1.3
Abaketa	2	2.7	1	1.3
Take	1	1.3	5	6.7
Enuto	1	1.3	3	4.0
Apatuntun, Abaketa	1	1.3	3	4.0
Total	**75**	**100.0**	**74**	**98.7**

Years of Fishing, Type of Craft Used and Size of Catch

The respondents with more than 20 years fishing experience recorded the highest of 42.7% while the lowest of less than 5 years fishing experience was 9.3% (Table 5). This result shows that younger members of coastal fishing communities are no longer motivated to continue the tradition of fishing. As pointed out by the respondents, factors such as increasingly lower fish catch in recent years, exacerbated by eutrophication, pollution and structural impediments around fishing grounds, have made artisanal fishing unsustainable. The findings have emphasized that eutrophication, pollution and structural impediments around fishing grounds have had much negative impacts on fishing production (Cámara and Santero-Sánchez, 2019 and Haque *et al.,* 2021).

The most preferred craft for fishing by the respondents (Table 5) is the wooden/planked canoe (89.3%) and the least used craft for fishing is the half dug-out canoe (1.2%), indicating the subsistence nature of artisanal fishing. The finding supports the study by Emmanuel (2014) on Fishing crafts characteristics and preservation techniques which noted that wooden dugout canoes and planked canoe are the most used craft in Lagos coastal area. This has limited the capacity of the fishermen to navigate euthropied/weedy and unproductive fishing grounds to access deeper water for improved catch as the wooden boats are usually not strong enough to withstand stronger tides. Respondence (81.3%) said fish catches in the previous years were more and better (Table 5).

Table 5: Years of fishing, type of craft used and size of catch

		Frequency	**Percentage (%)**
Years of fishing	less than 5 years	7	9.3
	6-10 years	15	20.0
	11-15 years	11	14.7
	16-20 years	10	13.3
	more than 20 years	32	42.7
	Total	**75**	**100.0**
Type of craft used	Planked canoe	67	89.3
	Dug-out canoe	5	6.7
	Half dug-out canoe	1	1.3
	Steel boat	2	2.7
	Total	**75**	**100.0**
Size of catch from each fishing trip	less than 1kg	2	2.7
	Between 1kg-5kg	8	10.7
	between 6-10kg	21	28.0
	More than 10kg	10	13.3
	other	33	44.0
	Total	**74**	**98.7**

According to the respondents the least catch in each fishing trip is less than 1kg (2.7%) while the most is more than 10kg (44.0%) (Table 5), with 89.3% of the respondents saying the catches are wholly sold to support their household financially, while 14.7% and 40.0% said they are mainly for the community and storage purposes respectively (Figure 6). This study observed thus, the fish catches have drastically reduced over the years which also affirmed the study by Ajagbe et al. (2012).



Figure 6: What Fishermen Do With the Catch

Earnings from Fishing Monthly

The respondents indicated that the maximum amount of money earned monthly from fishing are between N25,000 – N100,000 and the minimum earned at 4.0% is less than N25,000 (Table 6). This shows that more fisherman at 90.6% earn between N25,000 - N100,000. This study shows that majority of the respondents (90.6%) earn between N25,000- N100,000 per months. This is contrary to the study of Anyanwu *et al.*, (2009) which revealed that majority of artisanal fishermen earn just about N20,000 per month as income. On the other hand, this result show that the artisanal fishing is profitable with earning of N25,000 – N100,000 (Abowei and Hart, 2008; Anene *et al.*, 2010; Okeowo *et al.*, 2015)

Table 6: Earnings from fishing monthly

Earnings from fishing monthly	**Frequency**	**Percentage (%)**
less than N25,000	3	4.0
N25,000 - N50,000	34	45.3
N50,001 - N100,000	34	45.3
N100,001 - N150,000	4	5.3
Total	**75**	**100.0**

Factors Responsible for Lesser Fish Catches

Indicated reasons for lesser catches were increased water transport, destruction of tradition, water pollution, changes in fishing practices and inferior fishing gear (Jallow *et al.*, 1999; Reo *et al.*, 2017; Adeleke *et al.*, 2021). But the most important reason for the lesser catches is water hyacinth and other vegetation growth as stated by 80.0% of respondent (Table 7). The finding from the study of Villamagn & Murphy (2010), and Nguyen et al., (2015) confirmed that water hyacinth Can limit species richness, reduce fisheries catchability and causes huge impacts to ecosystems functioning. According to majority of the respondents (76.0%), the causes of lesser fish catches is not limited to a particular type of fish while 24.0% respondents believe that less catch is limited to a particular type. In addition to the presence of water weeds, 86.7% of respondents also notice algal blooms in the waterways, while 13.3% do not observe this occurrence Table 7. The algal blooms according to 60.0% of the respondents, impacts the fishing activities Table 7.

Table 7: Factors responsible for less catches, algal on water way, and effect of algal blooms

		Frequency	Percentage (%)
If your catches are less, what do you think is responsible	Water Pollution	20	26.7
	Water hyacinth and other vegetation growth (eutrophication)	60	80.0
	Destruction of tradition	32	42.7
	Changed Fishing practices	11	14.7
	Inferior fishing gear	27	36.0
	Increased water transportation	37	49.3
	other reasons	1	1.3
Blooms (algal) on water ways	Yes	65	86.7
	No	10	13.3
	Total	**75**	**100.0**
Effect of algal blooms on fishing	Yes	45	60.0
	No	28	37.3
	Total	**73**	**97.3**

Causes of Eutrophication

Causes and Impacts of Eutrophication on Artisanal Fishing Activities

Studies have shown that algal bloom and water weeds including hyacinth negatively impact fishes and fishing activities. Deriving from this assertion, 74.7% of respondents agree with this while 25.3% do not believe that the water weeds impact fishing activities. Surface water impairments such as algal bloom, water hyacinth, water lettuce and other vegetation growth have impacted socio-economic activities of fishermen positively and negatively. The negative impacts include destruction of boat engines (84.0%), reduced fish catch (74.7%), reduced fish population (32.0%), noisome (88.0%), and has made boat transportation difficult (90.7%) (Table 8 and Figure 7). The positive impact mentioned by the respondents is an initial increase fish catch during the onset of rainfall and low tide when freshwater flows into coastal surface water. This finding supports to the studies of Adeleke *et al.*, (2021), and Adeleke & Fagbenro (2013) where they observed that pattern of climatic variables had positive and negative impacts on fisher folks and fish catch in the coastal areas of Nigeria. The variabilities not only affect fisher folks and fish catch but also have a profound impact on fishing infrastructure as fishing vessels get destroyed, loss of fishing gears and nets as well as deteriorating of equipment (Jallow *et al.*, 1999; Adeleke *et al.*, 2021)

The eutrophication of near shore Lagos coastal water, including the lagoon systems, according to the respondents (56.0%) are caused majorly by tidal drift from inland waters, 9.3% each attached the causes to improper disposal of domestic waste into the lagoon and the neglect of the water gods and/or deities, 6.7% believed that it is as a result of disposal of industrial waste into the water body while other unknown causes accounted for 5.3% (Fig. 6).

During the tidal drift episodes, the nutrient rich inflow water stimulates phytoplankton growth to make food plentiful for fishes and ensures higher fish catch and improved the size and quality of fish (Davies and Ugwumba, 2013; Abo-Taleb, 2019; Landrigan *et al.*, 2020). This period is also marked by increased and luxuriating flowering of water weeds including the water hyacinths (Akinyemiju, 1987; Ezama, 2019; Ayanda *et al.*, 2020). However, at high tides, when salinity of the water increases, the weeds start dying out and decomposing, resulting in decreasing dissolved oxygen (DO) and higher turbidity around the fishing grounds (Villamagna and Murphy, 2010; Makori *et al.*, 2017). Thus, leading to lower fish catch. Consequently, indicating that the effects of water weeds are more negative than positive for

the fishermen. The impact of eutrophication on the income of the artisanal fishermen was generally described as negative by 96.0% of the respondents (Figure 8), while 4.0% of the respondents felt it has had positive impact on their income. This shows that an adverse effect on fishing business of the respondents mostly prevails at particular period of the year while the algal bloom weed infestation subsist as it prevents water movement and fishing activities.

Table 8: Impact of water weeds on fishing activities

What are the effects of water weeds on fishing activities	Frequency	Percentage (%)
Reduce fish catch	56	74.7
Increase fish catch	27	36.0
Destroy boat engines	63	84.0
Reduce fish population	24	32.0
Make water smelly	66	88.0
Make boat transportation difficult	68	90.7
Reduce the size and quality of fish	25	33.3
Improves the size and quality of fish	42	56.0
Any other reason	2	2.7

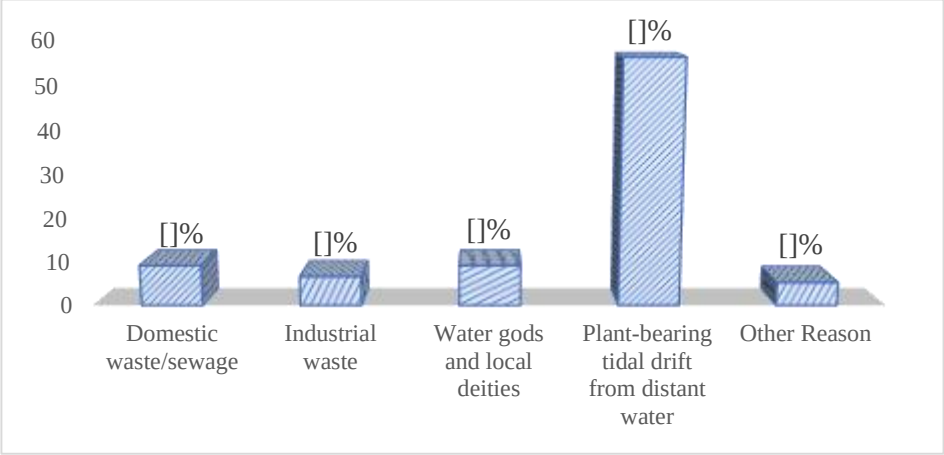


Figure 7: Cause/Source of plant growth in water

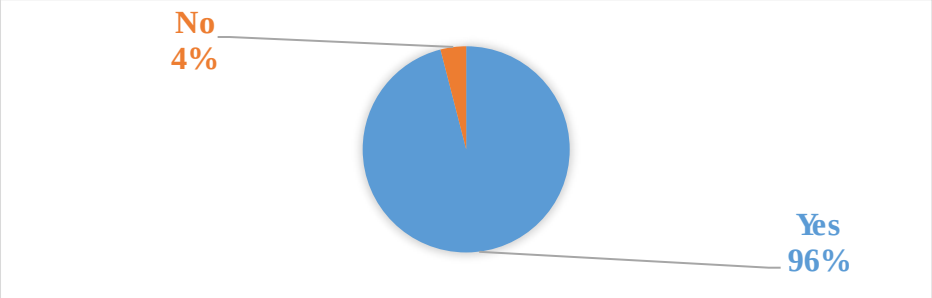


Figure 8: Impact of Water Weed on Respondents' Income from Fishing

Seasonality of Eutrophication in Lagos Coastal Waters

About 98.7% of the respondents believed that the water weeds impact on the Lagos lagoon is seasonal just as its occurrence and spread (Table 9). Majority (56.0%) of the sampled population believed that the month of August is their dominant period (Table 11), followed distantly by October-March at 25.3%. The weeds are least dominant in October (8.0%) and between

September and March (9.3%). The duration of each episode, according to the respondents, varies significantly. About 57.3% believe that the water weeds last for 9 months in a year while 6.7% opined that they last for just 3months respectively (Table 9). Also, signs of the eutrophication, according to the respondents, disappear from the water surface in April (56.0%) through September (28.0%) (Table 9). The study shows that eutrophication and its spread on the coastal fringes of Lagos is seasonal which conform with the studies of Oladosu *et al.* (2017), amd Malone and Alice (2020).

Table 9: Seasonality of impact of water weeds, time, duration, and disappearance

		Frequency	**Percentage (%)**
Seasonality of the impact	Yes	74	98.7
	No	1	1.3
	Total	**75**	**100.0**
Time of the year	August	42	56.0
	October	6	8.0
	October - March	19	25.3
	September - March	7	9.3
	Total	**74**	**98.7**
Duration	9 months	43	57.3
	3 months	5	6.7
	8 months	20	26.7
	6 months	7	9.3
	Total	**75**	**100.0**
Months of disappearance	April	42	56.0
	February	6	8.0
	April - September	21	28.0
	March - October	6	8.0
	Total	**75**	**100.0**

Possible Useful Applications of Water Weeds by Fishermen

Table 10: Are the water plants of good use to the fishermen

Are these water plants (water hyacinth) useful to you as a fisherman	**Frequency**	**Percentage (%)**
yes	19	25.3
No	55	73.3
If yes, for what	1	1.3
Total	**75**	**100.0**

Studies have shown that water weeds can be used as manure and other benefits to man (Ayanda *et al.*, 2020; Ilo *et al.*, 2020; Nega *et al.*, 2021), however, 73.3% of the respondents said that they do not see any usefulness in the water weeds, while 25.3% believe that water weed can be useful with adequate technology and knowhow (Table 10).

Local or Traditional Control of Eutrophication

A significant number of the fishermen (73%) believe that the water weeds cannot be controlled by traditional knowledge and practices since they are invasive species (Figure 9). This is contrary to the study carried out by Reo et al (2017) on control of invasive species in North America.

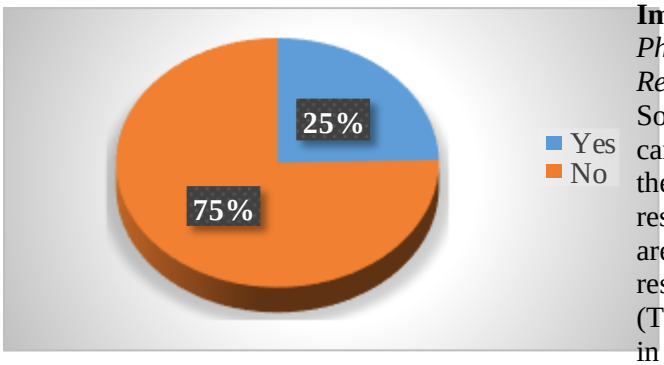


Figure 9: Control of Water Weeds with Traditional Knowledge

Table 11 shows that immediately after the water weeds disappear from the water body, 90.7 respondents believe that the water becomes clear; 88.0% believe they catch more fishes.

Table 11: What occurs when water plant disappears in the water?

Immediately after the plants disappears what happens in the water	**Frequency**	**Percent (%)**
The water becomes clear	68	90.7
The water becomes dirty	6	8.0
Total	**74**	**98.7**
The fish catches are more	66	88.0
The fish catches are less	8	10.7
Total	**74**	**98.7**

Impact of Eutrophication

Physical Problems Encountered by the Responsdents while Fishing in the Lagoon

Some physical factors hinder the fishermen in carrying out their fishing activities by restricting them access to favourable fishing sites and resulting in longer trips. Prominent among these are dead corpses in the lagoon (13.3%) which restricts them access to their favourite fishing sites (Table 12). Military restrictions (12.0%) to fishing in some potential fishing site and activities of commercial ferry operators (10.7%) disturbs the fishes and this in turn affects the quantity of fish catches.

Measures Taken to Protect Fishing Activities in Coastal Environment in Nigeria

The respondents opined those commercial ferries and dredging as well as water hyacinth are the dominant physical problems to their activities; thus advocating for thebregulatng or stopping of these activities. Precisely, 4% advocate for gthe stopping of commercial boat operators, 10.7% advocate for the control of water weeds such as water hyacinth (Table 13). However, 14.7% believe that stopping commercial boat operators and dredging would protect their trade, 9% prescribe that control of water weeds and regulation of water transport to specific routes would significantly improve their fishing business.

Table 12: Physical problems encountered by the respondents while fishing in the lagoon

What are the physical problems encountered while fishing in the lagoon	**Frequency**	**Percentage (%)**
Military restrictions to fishing in some areas in water body	2	2.7
Boat transportation disturbance	2	2.7
Dredging Activities	2	2.7
Climate change	1	1.3
Military restrictions to fishing in some areas in water body and boat transportation disturbance	9	12.0
Boat transportation disturbance and dredging activities	4	5.3
Dredging Activities and increase in fishermen population.	3	4.0
Boat transportation disturbance and climate change	1	1.3
Boat transportation disturbance and Sea Lion disturbance	8	10.7
Dead bodies seen in the water and Sea Lion disturbance	10	13.3
Boat transportation disturbance, Climate change and sea lion disturbance	2	2.7
Boat transportation disturbance, Climate change and Dead bodies in water	2	2.7
Boat transportation disturbance and Transmission of sea water	1	1.3
Total	**48**	**64.0**

Table 13: Measures taken to protect fishing activities in coastal environment in Nigeria

What can be done to protect fishing and fishing activities in your community and coastal environment in Nigeria?	**Frequency**	**Percentage (%)**
Stop commercial boat transportation	3	4.0
Stop Dredging	1	1.3
Stop disposing dirt into the water	1	1.3
Government should help control the water weed	8	10.7
Stop commercial boat transportation and stop dredging	11	14.7
Stop commercial boat transportation, Stop disposing dirt into the water and traditional rituals should be brought back	4	5.3
Government should control water weed and Regulate water transportation.	7	9.3
Stop commercial boat transportation, stop Dredging and allow water flow from Republic of Benin.	3	4.0
Stop commercial boat transportation, stop Dredging, allow water flow from Republic of Benin and Traditional rituals should be brought back.	3	4.0
Stop disposing dirt into the water	2	2.7
Stop commercial boat transportation and stop disposing dirt into water	1	1.3
Stop commercial boat transportation and empowerment of fishermen	2	2.7
Stop commercial boat transportation and Government should help to control water weed	1	1.3
Stop disposing dirt into water and Government should control water weed	1	1.3
Total	**71**	**94.7**

Reducing Impacts of Water Weed on Fishing

On the suggestion on how to reduce the impact of water weeds on water, a large proportion of respondent have no opinion on the issue (Table 14). About 16% opined that the regular or seasonal evacuation of the water weeds, 14.7% advocates for traditional solution, especially the sacrifice to the water gods would greatly help reduce the impact of the water weeds. In contrast to this opinion, 12% of the respondents argued for the use of modern technology in combating the issue. 6.7% of the respondents advocated for the community and fishermen voluntary sanitation of the lagoon and seasonal evacuation of the water weeds while 4% advised that the water weed problem should be tackled from the source because all other efforts have been ineffective. Combating water weed infestation necessitates an integrated strategy involving both mechanical and biological control methods. This includes installing floating barriers and employing tools like weed rakes for manual removal to restrict weed growth; introduction of aquatic animals that feed on water weeds, coupled with maintaining optimal nutrient levels and promoting beneficial vegetation, forms a comprehensive approach, and regular monitoring and the implementation of prompt control measures before infestation worsens.

Table 14: Suggestions to reduce impacts of water weed on fishing

What suggestion can you give to reduce the impacts of water weeds on your fishing	**Frequency**	**Percentage (%)**
No Idea	30	40.0
The source of weeds should be traced and removed	3	4.0
Sacrifice to water gods	11	14.7
Packing the water hyacinth from the lagoon	12	16.0
Organizing water sanitation by fishermen communities during hyacinth season	5	6.7
Control of water hyacinth with modern machines	9	12.0
Total	**70**	**93.3**

CONCLUSION

There is no doubt that artisanal fishing plays vital roles in poverty reduction, employment creation, provision of protein and beneficial nutrients, and also as sources of sustainable means of rural and urban livelihood. Nevertheless, the problems and challenges faced by artisanal farming are enormous and are not limited to algae bloom and weed infestation. In conclusion the study shows that artisanal fishermen do not receive adequate support and extension services that can expose their activities to better fishing techniques. Hence, there is a need for contributions and support from government bodies and non-governmental organizations (NGOs) to improve fishing practices and activities, as well as to manage the impact of algae bloom and weed infestation.

Also, relevant policies to guide and protect artisanal fishing as well as safe guarding their activities should put in place. Finally, there should database for all artisanal fishermen in the corridor for proper monitoring and orientation on how to cope with the impacts of algae boom and weed infestation.

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Assessment of Recreational Aquatic Facilities in Benin Metropolis, Nigeria

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ABSTRACT

Recreation is an important part of people's lives all over the world. Its facility takes multiple forms, whose provision is a crucial social service needed in an urban space. Public aquatic facility is an important example of a recreational facility that encompasses swimming pools and publicly accessed rivers for swimming. The quality of water, for recreational aquatic facilities in most African countries is cause for alarm. This paper aim to assess recreational aquatic facilities in Benin metropolis and adopted an experimental and cross sectional research methods. A river and ten hotel's aquatic facilities were randomly selected to assess their water quality. The standard microbial procedure was followed to isolate and observe important properties such as the pH, Temperature, Turbidity, Electric Conductivity (E.C), and Chlorine. Other include Total Coliform, Faecal Coliform, Escherichia coli, Staphylococcus Aureus, and Total Heterotrophic Bacteria Count (THBC). The outcome of the laboratory tested results were compared with the WHO Standards. The results showed that all the aquatic swimming samples met the standard temperature measure with the highest value at 29.3^{o}C. The Soft Touch Aquatic facility was the only sample to meet the Electric Conductivity standard at 1.5us/cm. As Staph, Aureus, and THBC also met the standards. Whereas, all the water samples for pH, Ogba River, and Soft Touch Aquatic facility for Chlorine standards did not meet the WHO statdards, only. The antibiotic resistance isolates discovered in the swimming facilities are likely transmitable to swimmers. Hence, users of aquatic facilities in Benin metropolis are at risk of contracting infectious diseases. The study recommentd an immediate and effective remedial policies and guidelines be put in place for for conformity with the required standards.

Keywords: *Aquatic, Recreational, Facilities, Quality, Water samples*

INTRODUCTION

Recreational facility provision is an important social service amenity that is needed in an urban environment. Recreation is an activity of leisure, either for relaxation or sports that is very crucial part of human biological or psychological wellness and well-being. Conceeptually, recreation is an activity that people value during their leisure time, and it is extremely multifaceted, encompassing physical, cognitive, emotional, and social components (Broadhurst, 2001 in Wash & Badaruddin, 2019). Recreational activities can be communal or individual, active or passive, outside or indoors, healthy or harmful, and extremely beneficial to the society (Ezeamaka & Oluwole, 2016). There are diffirent forms of aquatic recreational activities, the form that individuals partake in is based their interest and societal vogue (Saba and Tekpor, 2015). See Table 1 for examples of recreational facilities.

According to Duverge *et al., (*2017), aquatic centres are major community facilities that require a large amount of water and energy to operate. The recreational aquatic facility includes swimming pools, lap pools, water parks, etc. While public aquatic facilities are important for preserving and encouraging active lifestyles for better health and well-being, which are linked with disease outbreaks by QUIZLET Inc., and United States Access Board (Queensland Health, 2019).

Aquatic recreational facilities may transmit a great number of infectious diseases if not properly designed, constructed, operated, and maintained. In addition, chemicals utilised for water treatment and decontamination purposes at a facility may either, by their nature or after reaction with water constituents, present certain toxicological hazards to the users (Rigas *et al.,* 1998); in spite of the World Health Organization (WHO) established guidelines decreasing prevent the risk of diseases and infections.

Table 1: Type of recreational facilities

Type of Recreational Facility	**Type of Recreational Activities**
Multipurpose	Sports, social, and other recreational activities (Rock wall, juice bar, lounge, pool)
Aquatics	Aquatics sports and rec (Lap pool, waterparks)
Parks	Local, state, and national playgrounds (walking space, equipment, social) Nature Centers (botanical gardens and zoos) Campgrounds (private or public)
Outdoor Sports Facility	Courts, fields, tracks, etc.
Adventure Facilities	Climbing walls, challenge course, equestrian, Shooting with firing Positions
Senior Citizen Centers	Social, nutritional/health-related recreation, crafts
Youth Centers	Teen centers, scouts, boy, and Girls club
Art Centers	Visual performing arts, studios, exhibits, galleries
Coliseums/Auditorium	Private and public funding (concerts, conferences, trade shows)
Theme Parks/Resorts	Tourists' destinations (Six Flags, Disney)

Source: Adopted from QUIZLET Inc., and United States Access Board 2019

A number of researchers have investigated key aquatic recreational facilities. For instance, in Athens, Rigas *et al.,* (1998) examined a couple of pools to determine if they complied with DIN19643 standard, using the design and physicochemical parameters as an object of comparison. The result showed poor compliance with the DIN19643 standards when compared with all parameters investigated. The most critical parameters implicated in poor water quality were Redox potential, turbidity, and the appearance of certain opportunistic pathogens (Staphylococcus aureus and Pseudomonas aeruginosa). These were ascribed to the poor design of pools and the lack of adequate vocational training of the technical personnel operating the water treatment installations. Saba and Tekpor (2015), Yedeme *et al.,* (2017), and Ekopai *et al.,* (2017) also examined the microbial and physicochemical parameters of swimming pools to check whether they met the WHO water quality standard and the risk of infectious diseases. The result from Saba and Tekpor revealed that the swimming pools were below standards with regard to pH and turbidity. The antibiotic-resistant isolates found in the swimming pools can easily spread to swimmers. The result of Yedeme *et al.,* (2017) showed that the pH, residual chlorine, and temperature values of most of the swimming pools were within the acceptable limit. Regarding microbial quality, most swimming pools comply with the WHO standard.

Those swimming pools that did not comply with physicochemical and microbial standards were advised to improve due to the significant health implications. The results from Ekopai *et al.,* (2017) revealed that the heterotrophic bacterial load ranged from 0 to 6.35 105 cfu/ml, with a maximum of 6.35 105 cfu/ml and a minimum of 3 101 cfu/ml. The average TPC was highest at 6.19 105 cfu/ml and lowest at 5.07 103 cfu/ml. 30.8 percent of the pools had TPC levels within acceptable limits (5 102 cfu/ml), while 69.2 percent were highly contaminated and did not meet the Uganda National Water and Sewerage Corporation's recreational water quality standards for both treated (0 cfu/100mls) and untreated (10 cfu/100mls) water.

AlTuraifi *et al.,* (2019) studied the presence of bacterial pathogens and their antimicrobial susceptibility pattern in swimming pools (private and public pools) in Al-Ahsa. The survey sampled 11 private and 3 public recreational water facilities. Water samples were inoculated into nutrient broth and cultured for 24 hours in an aerobic environment. On blood and MacConkey agars, the overnight growth was plated out. Pure cultures of the bacteria samples were utilised for identification and antimicrobial susceptibility testing with the Vitek 2 compact automated system (BioMerieux, Marcy-l'Étoile, France). More possible pathogens were isolated from private pools than from public pools, with

Klebsiella pneumonia and Pseudomonas aeruginosa accounting for 50 and 43 percent of all isolates, respectively. Findings also revealed varying minimum inhibitory concentrations (MICs) showing that the isolates were of diverse strains. This investigation has uncovered a potential health risk related to the use of water recreation facilities. The presence of K. pneumonia and P. aeruginosa indicates a potential public health risk that should be investigated.

Currently, there is little information available regarding quality of aquatic facilities and the risks of infection or disease outbreaks in Nigeria. There is a possible high risk of infection owing to non-enforcement and non-compliance with regulations regarding the establishment of swimming pools and maintenance of recreational waters. As such, this paper assesses the recreational aquatic facilities in Benin metropolis.

The personnel who are tasked with job of taking care of the swimming pools have little or no knowledge of the importance of taking care of the pools to meet physiochemical and microbiological standards. Some tend to minimise the chemicals used for sanitising the pool or over chlorinate the pool due to their little knowledge of the quantity to apply; thus, contaminating the pool. This behaviour increases the possibility of exposing swimmers to the risk of disease infections; such as in in Benin City and related settings in Africa where swimmers are likely to gulp water during swimming. As such, this study examines the quality recreational aquatic facilities to determine whether they complied with the WHO standards. The key questions the study intend to address are: What are the levels of physiochemical parameters in recreational waters in Benin metropolis? Are there microbial properties in the recreational waters? Are there differences in the physiochemical and microbial properties of recreational water in the study areas?

MATERIALS AND METHODS

Study Area

Benin City is a metropolis that comprises the urbanized parts of Local Government Areas such as Egor, Ikpoba Okha, Oredo, Ovia North-East and Uhunmwunode that served as the Administrative Headquarters of Edo State, Nigeria. The metropolis is located within Latitude. 5 º35E and 5 º40E and Longitude. 6 º15N and 6 º25N. As a nodal town, it links the Northern part of the country through Benin-Auchi-Okene Road; the Southern through Benin-Lagos Road, East through Benin-Asaba Road; and Western parts through Benin-Ifon Road.

The city is drained by two principal river systems, Ikpoba River draining the eastern portion and the Ogba River draining the western part of the city (Odemerho, 1988). The city is both a commercial and industrial town. Benin City is characterised by a tropical climate with rainfall all year round. It is found in the equatorial climate belt (Koppen's Aw zone) with summer rains and winter dryness. Though there is hardly any month without an element of rainfall, rain concentrates between April and October (rainy season) while dry season prevails between November and March. The mean annual rainfall is constantly above 2000mm, with relative humidity above 70%. Temperature is high throughout the year, with an annual temperature of 28^0C (Ikhile *et al.*, 2003).

Benin metropolis has an abundance of water and it is drained by two major rivers (Ikpoba and Ogba) (Odemerho, 1988) and it has an average water table depth of 88m (Omorogieva & Imasuen, 2018). As such, the metropolis has the potential for recreational aquatic facilities that include:

1. Parks and Promenades: Cities can create parks and promenades along riverbanks, providing spaces for people to relax, walk, or engage in various activities.
2. Waterfront Development: Developments along the waterfront, such as restaurants, cafes, and shops, can enhance the recreational experience and attract both locals and tourists.
3. Water Sports: Water bodies offer opportunities for water sports such as kayaking, canoeing, paddle-boarding, and boating. Establishing rental services can encourage people to participate in these activities.
4. Water Parks: An amusement park that features water play areas such as swimming pools, water slides, splash pads, water playgrounds, and lazy rivers can be developed.
5. Fishing: If the water quality permits, fishing can be a popular recreational activity. Local authorities may regulate fishing to ensure sustainability.
6. Cruises and Boat Tours: Offering boat tours or cruises along the water body can be a great

way for people to experience the natural beauty of the area.

7. Events and Festivals: Cities can organize events and festivals by the water, such as music concerts, food festivals, or cultural celebrations, to attract people to the area.

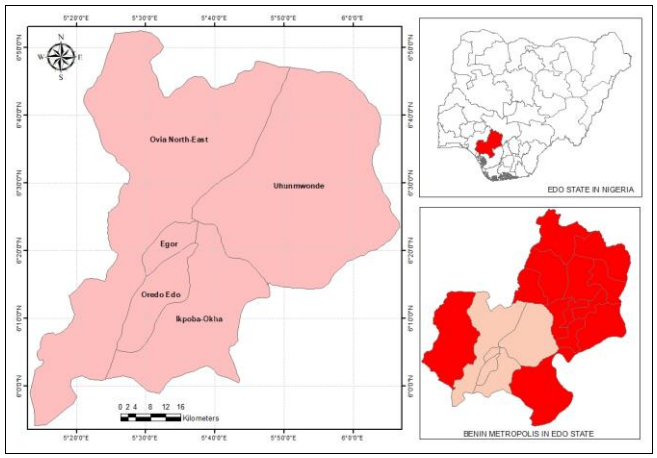


Figure 1: Edo state and Benin Metropolis
Source: Open Source Map, Modified by the Author 2023.

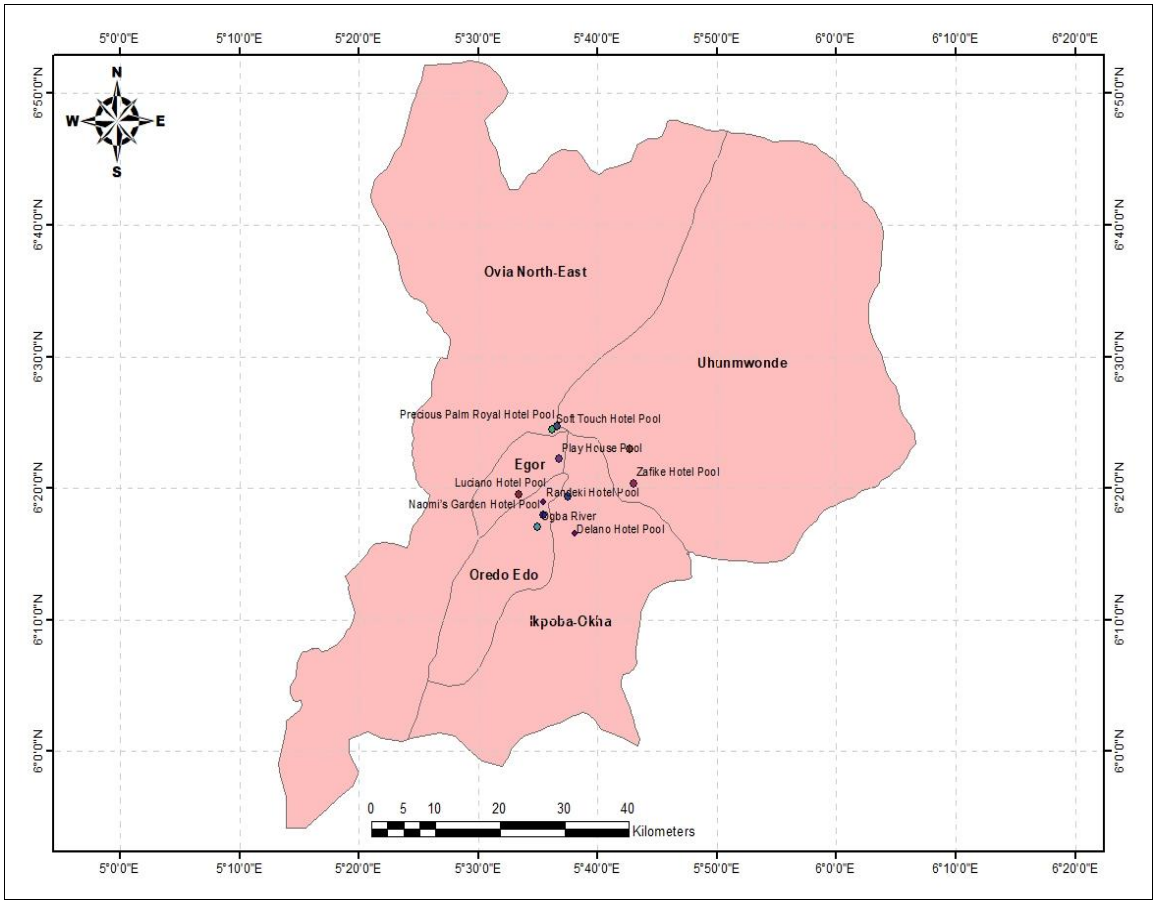


Figure 2: Benin Metropolis showing the Location of Sampled Recreational Water Points
Source: Open Source Map, Modified by the Author, 2023

Methodology

Water samples were collected from eleven (11) recreational water points (10 swimming pools and 1 river and subjected to a water quality test. Two recreational aquatic facilities were randomly selected from each of the LGAs using the lucky deep method. A total of 242 copies of questionnaire were distributed. Twenty-two (22) copies of questionnaire were distributed to on site users in each facility. Descriptive statistics (tables and charts) were used to analyse quantitative data while inferential statistics (Analysis of Variance ANOVA) was employed as a decision-making instrument for the processes. The goal was to see if there was enough evidence to "reject" or accept the stated hypothesis. The collected water samples from rivers and swimming pools were tested in a scientific laboratory and compared with the world Health Organisation Standard WHO for swimming pools. The WHO standard is a universally acceptable standard and as such, formed a solid foundation for comparison.

Table 2: Recreational aquatic facilities and location

S/N	LGA	Recreational Water Facility	Representative Code	GPS Coordinate of the Facilities
1	Egor	Play House Hotel	1	6º 22' 03.7''N 5º 37' 55.8'' E
		Luciano Hotel	2	6º 18' 56''N 5º 34' 10''E
2	Ikpoba-Okha	Water Phase Hotel	1	6º 20' 05''N 5º 36' 13''E
		Delano Hotel	2	6º 16 '40'' N 5º 38' 00'' E
3	Oredo	Randeki Hotel	1	6º 18' 42'' N 5º 36' 50'' E
		Naomi's Garden Hotel	2	6º 18' 10'' N 5º 36' 55'' E
		Ogba River	3	6º 17' 05'' N 5º 34' 56'' E
4	Ovia North-East	Soft Touch Hotel	1	6º 24' 10'' N 5º 36' 26'' E
		Precious Palm Royal Hotel	2	6º 24' 24.0'' N 5º 36' 18.4'' E
5	Uhunmwode	Zafike Hotel	1	6º 20' 05'' N 5º 36' 13'' E
		Rialto Resort	2	6º 22' 52'' N 5º 42' 38'' E

Source: Authors' Fieldwork, 2023

Preparation of laboratory aids supplies such as sampling glass bottles, DPD reagents and pH tablets, chlorine comparator, cotton with denatured alcohol, Portable Chlorine Colorimeter, and forceps to be used during water sample collecting. Technician in the Laboratory Shall collect water samples aseptically while maintaining adequate storage throughout shipment. Record required data in the monitoring sheet, such as collection time, residual chlorine, pH, and the name and particular address of the facility being collected. All water samples obtained will be taken to the laboratory as soon as feasible (within one hour) for bacteriological analysis. Each sample will be assigned a laboratory number, which will be recorded on the Bacteriological Worksheet. The best procedure indicated by the laboratory technician was used to assess water samples. The results were read and interpreted in accordance with WHO standards. See Figure 3 for the model summary by which the test was carried out.

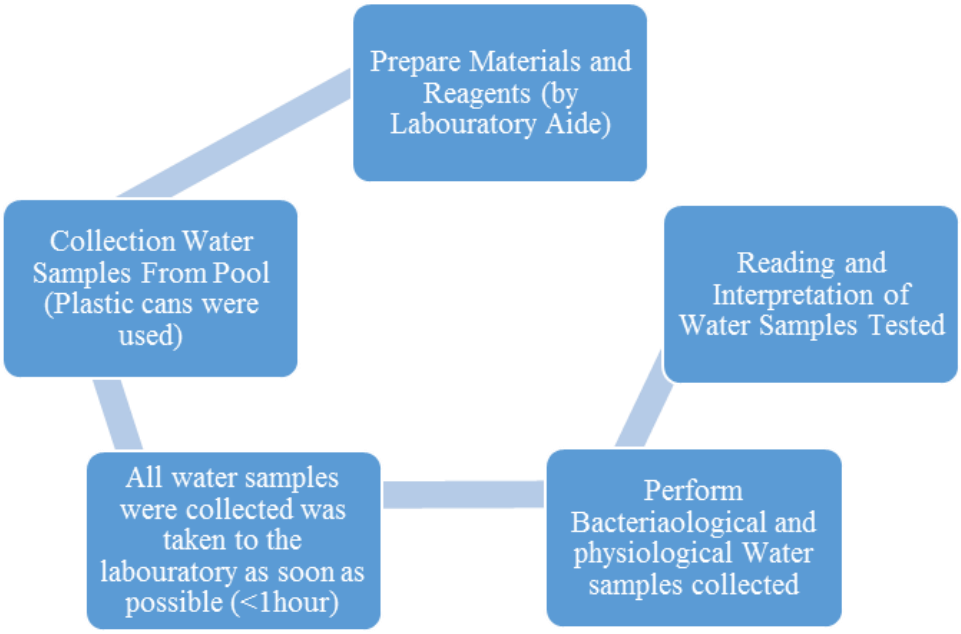


Figure 3: Model for Carrying out Water Quality Test
Source: Authors' Fieldwork, 2023

RESULTS AND DISCUSSION

Physiochemical and Microbial Characteristics of Water Samples

Table 3 shows results of physiochemical characteristics and microbial laboratory analyses on recreational water samples and the 2006 WHO water quality standards for swimming pools.

pH

The pH value of the swimming pool water samples ranged from 5.20 to 6.70 with Playhouse pool having the lowest at 5.20 while Water phase pool and Precious Palm Royal Pool have a joint-highest of 6.70, the rest of the pool values fall between the above-mentioned range while the Ogba River has a value of 6.30. Among all the tested pools and rivers, none had values ranging from 7.2 to 7.8 which is the recommended value by W.H.O. Thus, they all fall short of the standard.

Temperature

Table 2 shows that the temperature of the samples taken ranged from 28.8ºC to 29.3ºC with Randeki pool having the lowest value of 28.8ºC. Other pools fall within the aforementioned range. The Ogba River has the highest value of 29.3ºC. The temperature outcomes clearly reveal that all the swimming water samples in the study met the WHO standard limit of 26ºC to 30ºC.

Electric Conductivity

The electric conductivity in the study shows the value of the samples result ranged from 0.7us/cm as the lowest to 1.5us/cm as the highest for the hotel pools. River Ogba has a value of 0.9us/cm, majority (n=10) of the hotels' pool had a value of 0.8us/cm with only Soft Touch pool having the value of 1.5us/cm, which met the WHO Standard for swimming water of 1.5us/cm

Chlorine

The result in Tab 1 further shows that residual chlorine ranged from 0.42mg/l to 2.00 mg/l with River Ogba, accounting the lowest value at 0.42mg/l. and Zafike pool has, highest value of 2.00mg/l. The majority (n=9) of the swimming pool samples have a relatively decent amount of residual chlorine in their pool except Only Soft Touch pool has a value of 0.5mg/; that river Ogba short of the minimum standard set by WHO of 1-3mg/l residual chlorine. The Soft Touch swimming pool had no chlorine treatment, whose effect indicated the highest value of total coliform (98) and Staph Aureus (72).

Table 3: Laboratory test results for parameters of water sampled at the study points

Parameters	**Egor LGA**		**Ikpoba-Okha LGA**		**Oredo LGA**		**Ovia North-East LGA**			**Uhunmwode LGA**		**WHO Standard**
	1	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	
pH	5.20*	6.50*	6.70*	6.60*	6.10*	6.0*	6.30*	6.50*	6.70*	5.30*	6.50*	**7.2-7.8**
Temperature	28.9	29.3	29.2	29.1	28.8	29.1	29.3	29.3	29.3	29	29.1	**26-30^{o}c**
Electric Conductivity	0.9*	0.8*	0.8*	0.8*	0.7*	0.8*	0.9*	1.5	0.7*	0.8*	0.8*	**1.5 us/cm**
Chlorine	1.2	1.7	1.5	1.5	1.5	1.6	0.42*	0.50*	1.7	2	1.9	**1-3mg/l**
Turbidity	1.5*	1.3*	1.3*	1.2*	1.1*	1.3*	1.4*	1.6*	1.2*	1.6*	1.4*	**0.5 NTU**
Total Coliform	32*	30*	45*	54*	52*	60*	74*	98*	60*	41*	58*	**0.5 cfu/100ml**
Faecal Coliform	2*	15*	2*	4*	6*	3*	9*	8*	3*	3*	4*	**<1cfu/100ml**
E. Coliform	15*	15*	22*	21*	28*	25*	35*	35*	25*	18*	28*	**<1 cfu/100ml**
Staph. Aureus	18	19	28	30	35	36	55	72	36	26	37	**<100cfu/100ml**
THBC	125	121	122	133	130	132	140	168	132	119	199	**<200 cfu/1ml**

Source: Field Survey, 2023

* shows parametres and pools that failed to meet with WHO standard
Egor (1 = Play House Pool, 2 = Luciano Pool), Ikpoba-Okha (1 = Waterphase Pool, 2 = Delano Pool), Oredo (1 = Randeki Pool, 2 = Naomi Pool, 3 =Ogba River), Ovia North-East (1 = Soft Touch Pool, 2 = Precious Palm Royal Pool) and Uhunmwode (1 = Zafike Pool, 2 = Riato Pool)

Turbidity
The results in Table 1 further reveals that both Soft Touch and Zafike Pool both have 1.6NTU, the highest value followed by Play House Pool and Ogba River with values f 1.5NTU and 1.4NTU, respectively. Randeki Pool has the lowest value of 1.1NTU compared wth the 0.5NTU WHO standard. The turpidity outcome on the swimming pools and rivers failed to meet the required WHO standard of 0.5NTU.

Total Coliform
On the Total Coliform outcome in all the swimming pools and river, Soft Touch has the highest (98 CFU/100ml), followed by 74 CFU/100m in Ogba River and 60 CFU/100ml each for Naomi pool and precious Palm Royal Pool with the lowest values of 30 and 32cfu/100ml at Egor LGA pools. Sadly, the total Coliform counts did not meet the WHO standard of 0.5cfu/100ml.

Faecal Coliform
The study shows the various sample value of faecal coliform in which Luciano pool has the highest value at 15cfu/100ml, Playhouse pool, and Water Phase pool have the joint lowest value, the river Ogba has a value of 9cfu/100ml which the second-highest value, most of the pool had a value of 4cfu/100ml and below excluding Randeki and Soft Touch pools which have 6cfu/100ml and 8cfu/100ml respectively, from the result of the all the samples tested none met the standards set by WHO for feacal coliform in swimming waters which is <1cfu/100ml.

Escherichia Coli (E. Coli)
The swimming pool water and the river were checked for E. Coli. The samples tested show the presence of E. Coli, with River Ogba and Soft Touch pool having the joint highest of 35cfu/100ml and Playhouse and Luciano pools having a joint lowest of 15cfu/100ml. From the result, it can be seen that all samples fell short of WHO standards which are set at <1/100ml.

Staphylococcus Aureus (Staph. Aureus)
The swimming pool water tested for the presence or absence of Staph. Aureus shows that Soft Touch hotel has the highest value (72cfu/100ml), followed by river Ogba (55cfu/100ml) and the lowest in Playhouse (18cfu/100ml) The Staph Aureus test results on all aquatic recreational samples met the WHO standards set at <100cfu/100ml.

Total Heterotrophic Bacteria Count (Thbc)
The study shows that the THBC samples collected from all swimming waters ranged from 119cfu/1ml to 199cfu/1ml, with Zafike pool having the lowest sample value which is 119cfu/1ml and Railto pool having the highest sample value of 199cfu/1ml while the River Ogba has of 140cfu/1ml, the other pools fell within the above-stated ranges, therefore from the above sample results of swimming waters, it can be seen that al swimming waters samples met with the stated WHO standards which said to be <200cfu/1ml.

Hypothesis Testing
Ho: *There are no significant differences in the physiochemical and microbial properties of recreational water facilities in the study area*.

From Table 4, observing the pseudo value column, it can be observed that there were no significant differences in the microbial properties measured among the recreational aquatic facilities with pseudo value greater than the alpha value ($p>0.05$). Thus, the alternative hypothesis was rejected, while the null hypothesis was adopted, which means there is no significant spatial variability of water pollution and quality indicator across all swimming water facilities.

Table 4: ANOVA table

Variables	Sum of Squares	df	Mean Square	F	Sig.
Ph	Between Groups	1.145	4	0.286	1.001
	Within Groups	1.717	6	0.286	
	Total	2.862	10		
Temperature	Between Groups	0.100	4	0.025	0.846
	Within Groups	0.177	6	0.029	
	Total	0.276	10		
Electric	Between Groups	0.140	4	0.035	0.611
Conductivity	Within Groups	0.345	6	0.058	
	Total	0.485	10		
Turbidity	Between Groups	0.154	4	0.038	1.344
	Within Groups	0.172	6	0.029	
	Total	0.325	10		
Total Coliform	Between Groups	2571.909	4	642.977	3.334
	Within Groups	1157.000	6	192.833	
	Total	3728.909	10		
Faecal Coliform	Between Groups	44.136	4	11.034	0.545
	Within Groups	121.500	6	20.250	
	Total	165.636	10		
Escherichia Coli	Between Groups	272.879	4	68.220	1.653
	Within Groups	247.667	6	41.278	
	Total	520.545	10		
Staphylococcus	Between Groups	1365.182	4	341.295	1.833
Aureus	Within Groups	1117.000	6	186.167	
	Total	2482.182	10		
Total	Between Groups	792.409	4	198.102	.931
Heterotrophic	Within Groups	1276.500	6	212.750	
Bacteria Count	Total	2068.909	10		

Source: Authors' Field Survey, 2023

Health Related Issues with Recreational Water

Health-related issues were examined to determine health problems that relates to water quality of recreational and the frequency at which the water is been ingested by users.

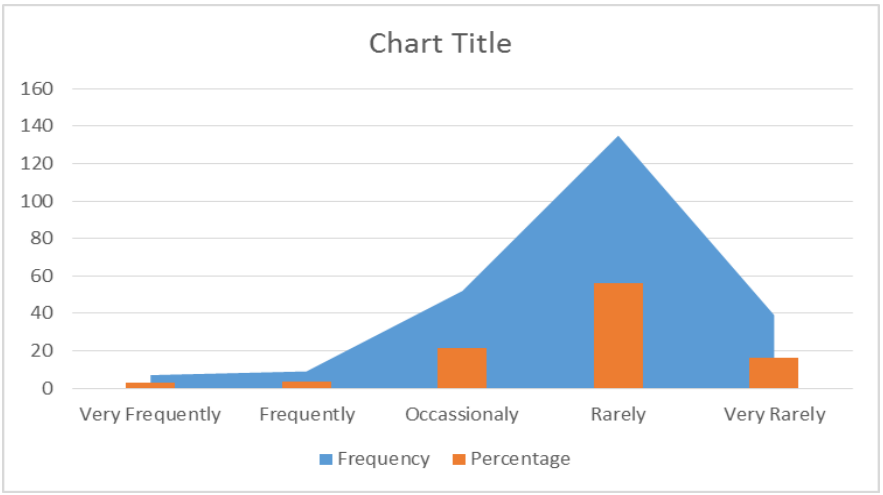


Figure 4: Regularity of the Ingestion of Recreational Waters in the Study Area

From Figure 4, it can be observed that only 2.9% (n=7) of the respondents said they very frequently ingest water while swimming. The majority (55.8%) (n=135) responded that they rarely ingest recreational water while swimming.

Irritation after the use of recreational water may occur. To this end, it was impossible to determine the proportion of recreational water users that have irritation after their activities. This proportion is shown in Figure 5.

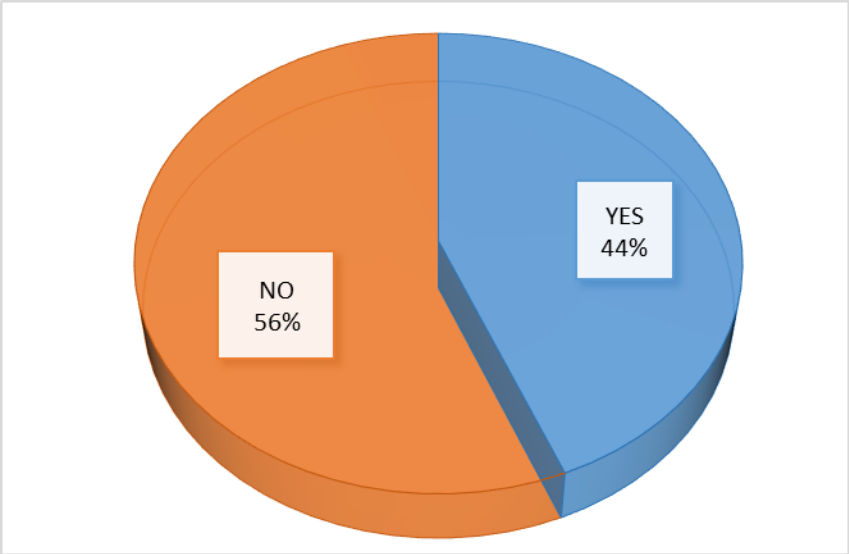


Figure 5: Irritation after the use of Recreational Waters among the Respondents

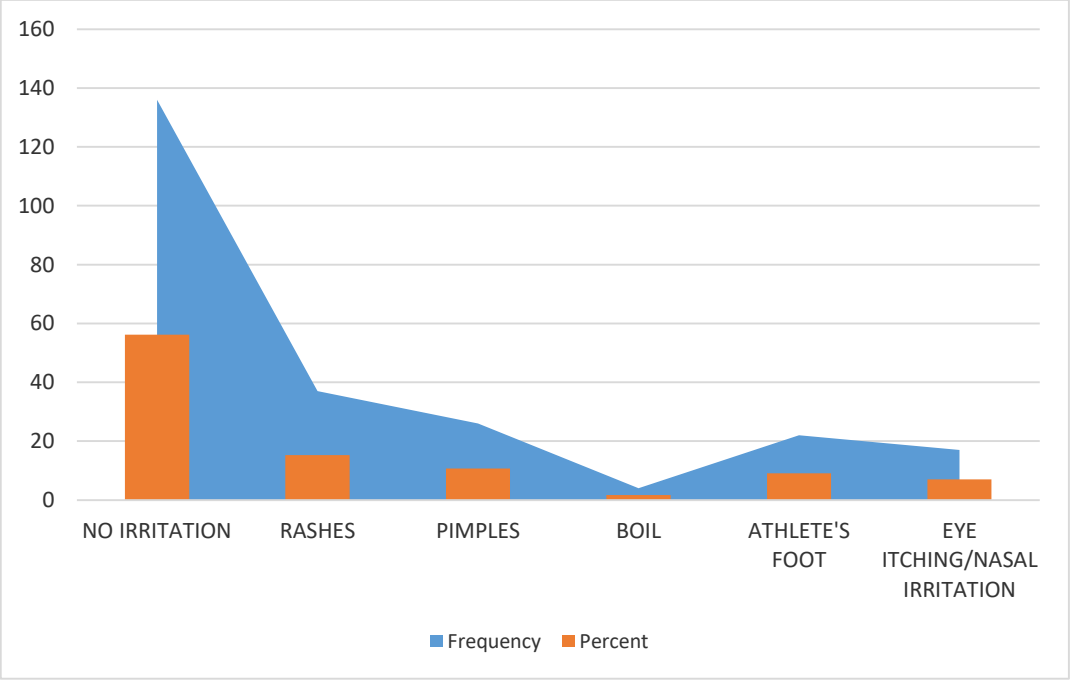


Figure 6: Irritation Type

Figure 5 depicts that 136 (56%) of the respondents agreed that they do not experience irritation after the usage of the recreational water while 106 (44%) declared that they do experience irritation after using the recreational water.

From Figure 6 it can be observed that respondents had different irritations after swimming, although 56.2% (n=136) of the respondents did not experience irritation after swimming, the most irritation experienced after swimming is rashes 15.3% (n=37), pimples 10.7% (n=26), athlete's foot 9.1% (n=22), itching/nasal irritation 7.0% (n=17), and boil 1.7% (n=4).

Discussion

The result of the pH level shows that all the swimming pools were quite acidic, and according to the Victoria State Government; Department of Health (2021), one may experience stings in the eyes when swimming in an acidic pool and rashes if the pH is higher than the 7.8 that is alkaline. This evidence implies swimmers are prone to experiencing stings in their eyes and on the skin due to the acidity of waters. Serafeim (2014), opined that in water whose temperatures is below 25^{o}C, Oxygen consumption increases at a faster rate, which results in a reduction in the mechanical ability of humans in cold water. Seeing that the temperature fell within the WHO range, no swimmer in any of these waters is likely to suffer from reduced mechanical ability or increased oxygen consumption. The result from the chlorine test implies that those who swim in soft touch pools were susceptible diseases infection and serious allergies. Water with high chlorine content can be harmful to the eyes because chlorine reaction with the mucous membrane of the cornea is highly acidic which can lead to burns (Al-Shami *et al.*, 2023). And burns that occur in the middle of the cornea can develop into an ulcer and then leave a scar inside (Al-Shami e*t al.*, 2023). For people who mostly swim, it can also result in scalp and skin redness (Al-Shami *et al.*, 2023). When ingested, it has been reported to be harmful to the heart organs, and the digestive system and also can lead to adverse reproductive effects, such as intrauterine growth retardation, low birth weight, and spontaneous abortion (Mohsen *et al*., 2016; Ward *et al.*, 2018*;* Harjan *et al.* 2019).

Although, Turbidity has minor health concern, however, its high presence can interfere with water treatment processes that allows medium growth of microbacterials that contaminants (US EPA, 2002). In the works of Vincent et al., 2009, they concluded that skin complaints may be significantly more likely to occur among swimmers exposed to waters with measured levels of total coliform, fecal coliform, E. coli, enterococci, and streptococci above the recommended cut-off points for these indicator organisms. Also, ingested coliform bacteria-infested water increases the chances of contracting a water-borne illness of the victim. This showed that people who swim in these waters will be susceptible to these bacterial infections leading to health issues. Staphylococcus aureus has long been known as one of the most vital bacteria that can cause disease in humans. When present in water, like a swimming pool, it can be harmful to humans when it comes in contact with their skin or is unpurposefully ingested. It is one of the leading causes of skin and soft tissue infections such as abscesses (boils), furuncles, and cellulitis. Although most staph infections are not serious, S. aureus can cause serious infections such as bloodstream infections, pneumonia, or bone and joint infections (Minnesota Department of Health, 2010). The result of the test shows that swimmers will not be prone to the health effects of Staphylococcus aureus in these sampled waters.

CONCLUSION

People frequently use recreational water facilities for enjoyment, fitness, fun, and therapeutic rehabilitation. The best outcome for them would be an improvement in their social and physical wellness. Instead, the majority of consumers experienced discomfort after swimming and had rashes. Although all swimming pools met temperature requirements, the study found that none of the swimming pools met the WHO standard. This may have been due to the time the sample was taken, as most hotels had a relatively moderate amount of chlorine, except for two swimming pools. The majority of swimming facilities were found to not generally adhere to WHO guidelines for swimming areas. Several recommendations have been put forward to address some of these issues.

To provide licenses to hotels that wish to have swimming pools, the Ministry of Culture and Tourism in Benin City should apply the standard index for safety as a criterion. In addition, the Ministry should routinely examine and implement safety measures for open swimming centers, as in

the case of the Ogba River. Hotels with swimming pools should hire professionals to assist them in maintaining the cleanliness of the pools, and the owners should carefully watch what happens around the pools. To ensure the safety and wellness of swimmers, all rivers and swimming pools should undergo thorough inspections regularly. The Ministry of Culture and Tourism can carry this out by appointing a committee to oversee operations. People should be informed about the advantages of using safety precautions before swimming in rivers or swimming pools since this can lessen swimmers' annoyance. It is difficult to determine if germs are resistant to the medications used to disinfect the pools or whether it is the lack of compliance with WHO criteria that causes the presence of pathogens in pools, hence further research on pathogens should be done.

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Assessment of the Suitability of University of Abuja, Faculty of Law Stream Water for Livestock Use in Mini Campus

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ABSTRACT

Poor water quality containing pathogens or contaminants are directly toxic to plants, livestock and human lives. This fact inspired this study, which assesses the quality of Faculty of Law stream water for livestock use. Water samples were collected from the Upstream, Midstream, and Downstream points of the perennial stream flowing along the Mini Campus of University of Abuja. The water samples were well stored and analyzed at the Laboratory of the Department of Chemistry, University of Abuja for selected physiochemical parameters. The water quality status were compared with the Nigerian Federal Ministry of Environment and the World Health Organization water quality standards for suitability of the stream in Mini Campus domestic and livestock uses. ANOVA Test was used to check the significant variation in the physiochemical parameters in the three stream water sample points. The study finding shows that the general appearance of the water quality deviated from being clear at the Upstream to being cloudy at the Midstream and Downstream. On the Physical properties, Temperature (26^{o}C, 32.8^{o}C and 29^{o}C) met the FME (<40^{o}C) water quality standard, but the values were above the WHO's. (22^{o}C). The pH values (7.9, 7.6 and 7.1), conductivity (151, 337 and 79) and TDS (138.1mg/l, 124.4mg/l and 152.6mg/l) concentration in the water samples were within the FME and WHO standards. The outcome on the chemical parameters reveals that, the content in chloride (38.6 mg/L, 35.2 mg/L, and 35.1 mg/L); DO (5.3 mg/L 5.9 mg/L, and 5.9 mg/L), BOD (.7 mg/L, 7.1 mg/L and 6.1 mg/L) and COD (61.2 mg/L, 51.2 mg/L and 44.5 mg/L) were within standard value limit set by the FME and WHO respectively. Hence, the study recommends chlorination and/or boiling of water sourced from the University of Abuja Faculty of Law stream to prevent health challenges on both humans and animals.

Key words: *Domestic and livestock, Physiochemical parameters, pH values, Turbidity, Conductivity, TDS concentration and TSS concentration.*

INTRODUCTION

The physical and chemical parameters are the basic quality characteristics for the identification of conditions for the control of diseases caused by pathogenic organisms, which have human origin. The organisms found in surface water include bacteria, fungi, algae, protozoa, plants, animals, and viruses. Some of these disease-causing organisms can only be observed microscopically (Dinka, 2018).

The notable microbial risks are associated with consumption of water that is contaminated with human or animal feces. Feces can carry pathogenic bacteria, protozoa, helminthes, and virus. Pathogens originating from feces are the main concerns in setting health-based targets for microbial safety (Dinka, 2018). The techniques for comprehensive bacteriological test are complex and time consuming. The two mostly used test methods to estimate the number of microorganism of coliform groups (*Escherichia coli and Aerobacteraerogenes*) include: total coliforms or *E. coli* (Davis, 2013).

Shortage of clean water for livestock affects the health, behaviour, and performance of cattle. Severe water restriction may decrease dry matter intake and cause a change in behaviour, such as increased aggression around the water trough and less lying; thus, livestock farmers are required to provide "proper and sufficient food and water" (Berhanu and Hailu, 2015).

Water for livestock can be sourced from surface water, such as streams and ponds, and/or groundwater, which may contain levels of dissolved salts, depending on the geology of the surrounding area, rainfall, vegetation and

topography. Human activities around the water sources will also influence the water quality (Berhanu and Hailu, 2015).The quality of the water is often usually contaminated from abiotic and biotic factors as a result of either dissolved nutrients or direct deposition of urine or faeces containing nutrients and possibly parasites (Esemuze and Adiaha, 2019).

Akpan-Idiok, *et. al.,* (2012) met the physiochemical properties guidelines for livestock and irrigation with slight traces of harmful heavy metals. Similarly, Ishaya, *et. al.,* (2016), established that River Usuma water quality for livestock consumption in Gwagwalada Town at the mid and downstream were safe. Studies have been undertaken to understand the water quality that assessed their used for livestock (cite three or more literature). However, these studies were carried out in different settings and some within Gwagwalada Town, no study has assessed the suitability of the water quality at the University of Abuja, Facility of Law Stream for livestock Mini-Campus use. Therefore, there is need for examining the University of Abuja Mini Campus stream for domestic animals' utilization. This study is set out to assess the physiochemical properties of the stream water from up and down stream sources of water at the University of Abuja Mini Campus stream using the World Health Organization (WHO) and the Federal Ministry of Environment (FMEnv) standards for potable drinking water, livestock watering, and their health implications.

MATERIALS AND METHODS

Study Area

The study setting consists of a perennial stream that dissected the Mini Campus of University of Abuja, flowing from Wuna Hill through University of Abuja Mini Campus in Gwagwalada. Gwagwalada on the other hand is a suburb of the Federal Capital Territory, Abuja. It is situated along Abuja-Lokoja road at about 55 kilometers away from FCT and centrally located between latitudes 8º 55'N and 9º 00'N and longitudes 7º 00'E and 7º 04'E (Ishaya, 2013). With a population of about 157,770 at the 2006 census, the region covers a total landmass of 1,043 km^2 out of the 8,000 km^2 of the total FCT land mass and located at the center of very fertile area with abundance of grasses (Ishaya, 2013).

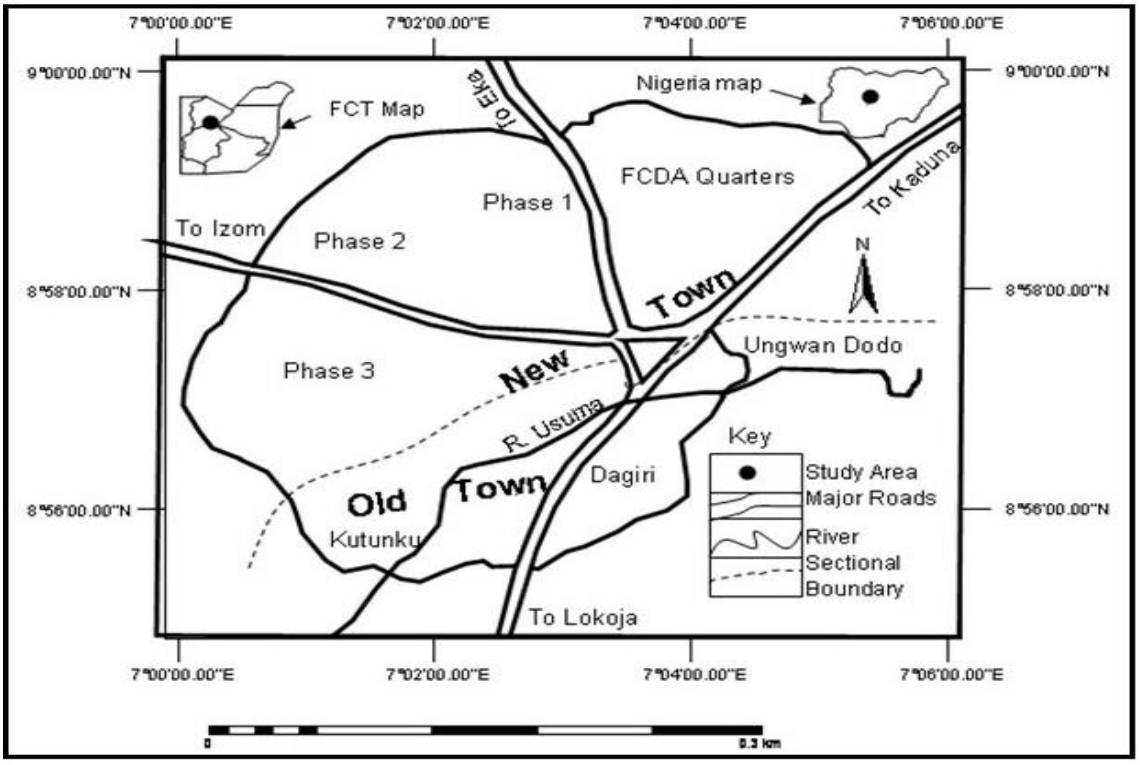


Figure 1: Gwagwalada Town, Abuja.
Source: Department of Geography and Environmental Management University of Abuja (2022).

University of Abuja shares a tropical sub-humid climate characterized by two distinct seasons, namely a wet and dry season (Balogun, 2001). The wet season lasts for seven months starting from April and ends in October. Its major elements have regimes that are transitional from those of the southern and northern part of the country. The area also records relative humidity of about 25% in the dry season of the year which often falls in the afternoon (Abuja Master Plan, 2000). During the day, temperature of Gwagwalada is generally high but falls sharply at night, with 17^{O}C maximum range. During the rainy season, the maximum temperature is lower due to dense cloud cover; Diurnal annual range is also much lower sometimes not more than 7^{O}C in July and August (Hassan, 2008).

In between these hills are extensive plains, the most important of which is the lku Gurara plains (Chup, 1998). The University soil is moist and poorly drained almost all year round and to a great extent support farming due to its various natures (Edicha and Mgbanyi, 2013). The most prominent of these include the Idon-Kasa range and Idon Bissa range northwest of Kuje and the Wuna range north of Gwagwalada (Chup, 1998).

Ishaya, *et. al.*, (2016), explains that the River Usuma around Gwagwalada is linked with the stream in the University, and it is quite shallow at almost all times of the year with exception during the peak of the rainy season and the river slope gradient also ranges between 2^{o}- 6^{o} although steeper in areas which have witnessed stream incision on rock outcrops and inselbergs. The drainage texture is coarse and valley density ranges between 1 and 2 km^2. Several mature profile rivers also drains the area westward to the River Usuma, such as River Itsu, running south to join River Gurara, which empties its content into River Niger (Balogun, 2001).

University of Abuja shares similar vegetation with Gwagwalada vegetation which falls within the Guinea Savanna Vegetation Zone of Nigeria. Trees such as A*ntirisern africana, Anthocleistanoblis, Ceibapentandra, Cola gigantea, Celtis spp., Chtorophora excels, Piptadenianum africanum, Lophira on alata, Temlinalia ivorensis, Triplochiton scleroxylon and Dracaena arborea* dominate the study area (GEHS, 2014). The dominant vegetation of in the area is classified into three savannah types, as follows: (a) **The Savanna Woodland;** are the most luxuriant of the three types of savannah species. They are found extensively in the more rugged and less accessible terrain. It occurs mostly on the Iku Gurara plains and surrounding hills. Common trees found in this region include; Afzelia Africana, shea butter tree (*Butyrospermus Paradoxium*) and African (*Copaihabalsom* tree *Daniela oliver*). The dominant grass elements include *Andropogon* and *Brachiavia Deflexa*. Some dominant tree species of the savannah woodlands yield high quality timber, e.g. *Anogeissus Leiocarpus*, *Daniela Oliveri*, *Khaya Senegalensis* and *pterocarpus Arenaceous* (Ishaya and Mashi, 2008). (b) **The Shrub Savanna;** are vegetations that occurs close to valley complexes usually bellow wooded ridges and hills (GEHS, 2014). The species found are the same as the park savannah type, trees appear in very scattered locations and shrubs provide the main foliage layer (Adekayi, 2008). Tree species found in shrub savannah include: *Anonas Senegalesis, Pilioostigmathonningii, Terminalia Macroptera, Terminalia Laxiflora, Afromosis Laxiflora* etc. It has more grasses than the park savannah (Dawan, 2000). ***(c)The Park or Grassy Savanna*;** Park savannah usually has a thicker and taller growth of grass and better marked horizontal separation between the foliage of the shrub layer and that of the tree layer (Hassan, 2008). According to Adakayi, (2000), the tree species found include: *Albizia, Zygia, Daniela Oliveri, Butyrospermus Paradoxum, Danielia, Oliveri* and African locust bean (*Parkia Biglobosia*). The shea butter tree (*butyrospermus paradoxium*) is the most widespread in this environment.

Methodology

A reconnaissance survey was carried out as pre-investigation on the study area in August 2021. The stream was delineated into three parts (up, mid, and downstream), and the points for water sampling were identified (see Figure 1). The research is designed to assess the quality of stream water based on the physiochemical properties that generated numerical primary data from laboratory test of water quality using the WHO and the Nigerian standards on the samples taken from perennial stream flowing through the University of Abuja Mini Campus.

The purposive sampling technique was adopted. The selection was considered necessary because irrigation farming is taking place along the stream even within the premises of the University. Upstream, Mid-stream, and Downstream were identified for sample collection along the perennial stream. Plastic bottles were pre-treated with dilute HNO_3 and thoroughly rinsed with distilled - deionized water for the collection of samples. All the sampled materials exposed to the samples and the sample containers were further painstakingly washed and rinsed with 1:1 nitric acid and distilled water.



Figure 2: Satellite Image of Water with Sampling Points.
Source: Author Field Work, 2022

The study adopted series of instruments and software packages for different purposes as presented in Table 1.

Table 1: Instruments adopted for stream water sample collection

Instruments	**Model**	**Use**
Global Positioning System	GPS map 60Cx	To obtain sampling points
Marker	Permanent Maker	Labeling samples
Notepad/Pen	40 leaves/bic	For writing
Deionized water	1Plastic bottle / 1litre	For washing plastic bottles used to take samples from sampling points.
Masking Tape	3-meter-long paper tape	For identification tag of samples
Neutralize $HN0_3$	1Plastic bottle / 1litre	To neutralize bottles used to take samples from sampling points.
Cooler/Cool box and Ice blocks	20 liters plastic box of cooler with Ice blocks.	To maintain the original temperature of the water and preserve the micro-biological components.
Plastic containers	Plastic bottles of 1 litre	To take samples of water from sample points
Google Earth	Google Pro-version	To develop imagery map
ArcGIS	ArcGIS 10.1	To produced study map

Source: Author Field Work, 2022

Three water samples were representatively collected from the stream. The samples were collected in nitric acid washed plastic bottles. The plastic bottles were further rinsed to reduce contamination. After the collection of water samples, a drop of nitric acid (not above 0.2%) was added in each as preservative. The samples were sealed, marked, and labeled accordingly in the plastic coolers containing ice block and transported to the laboratory for analysis.

Analysis

All the water samples were analyzed at Laboratory of the Department of Chemistry, University of Abuja. Physical parameters (pH, TDS, appearance, conductivity, turbidity, and TSS) and Chemical parameters (Calcium, Magnesium, Total Alkalinity, Total Hardness, Chloride, Sodium, Sulphate, and Bicarbonate), were analyzed. Quality assurance and control was performed according to the specification of American Public Health Association

A descriptive statistics, the Measures of Central Tendency was used to analyzed the results from the laboratory graphically and hused for comparison with the Nigerian and WHO Standard for Drinking Water Quality and livestock watering. The results from the three samples were also used to compare and evaluate the mean differences values using the One-way Analysis of Variance (ANOVA). This is check if the means of two or more groups are significantly different from each other and to control the errors so that the Type 1 error remains at 5%. The ANOVA analysis formula is expressed as:

$$\text{TSS} = \Sigma_i \Sigma_j \left(X_{ij} - X_{++}\right)^2$$

$$\text{BSS} = \sum_j n_j \left(X_{+j} - X_{++}\right)^2$$

$$\text{WSS} = \Sigma_j \Sigma_j \left(X_{ij} - X_{xj}\right)^2 = \sum_j \left(n_j - 1\right) s_j^2$$

Where:

TSS = Total Sum of Squares
BSS = Between Sum of squares
WSS= Within Sum of squares

RESULTS AND DISCUSSION

The laboratory test results of water samples collected from the Upstream, Midstream and Downstream are presented for first the physical properties and then, the chemical properties.

Physical Parameters

The physical parameters of the analyzed water samples are presented in Table 2.

Table 2: Physical parameters of Faculty of Law stream water of the University of Abuja

S/No	Parameters	Upstream	Midstream	Downstream	FME limit	WHO
1	General Appearance	Clear	Cloudy	Cloudy	Clear	Clear
2	Temp^{O}C	26	32.8	29	<40	22
3	pH	7.9	7.6	7.1	6 - 9	6.5 - 8.5
4	Conductivity (µs/Cm)	151	337	79	1000	1000
5	Turbidity (NTU)	17.1	26.2	16.3	5.0	10
6	T.D.S (mg/l)	138.1	124.4	152.6	500	500
7	T.S.S (mg/l)	290.2	190.4	151.1	25.0	25.0

NOTE: pH (Potential for hydrogen), T.D.S (Total Dissolved Solids) and TSS (Total Suspended Solids)
Source: Laboratory Analysis (2022).

Table 2 shows that, the general appearance has only upstream sampled water met the FME and WHO standard for domestic use and livestock farming. The Temperature of the stream water sampled points are all within the FME standard. However, the midstream and downstream samples recorded high temperature values above the WHO recommended limit of 22^{o}C respectively.

The term pH stands for "Potential for hydrogen." It is classified as one of the most important water quality parameters. Measurement of pH relates to the acidity or alkalinity of the water. The pH values of the Upstream (7.9), Midstream (7.6) and Downstream (7.1) all have

moderate pH level ranging between 6 to 9 for both FME and WHO standard limit that can support livestock farming and domestic use.

Electrical conductivity involves the tendency of water quality, to carry an electric current. The electric conductivity of the sampled water varies from 151µs/cm in the Upstream to 337µs/cm in the Midstream, and 79µs/cm in the Downstream, which are within the standard of the FME and WHO (1000µs/cm) for potable drinking water and livestock watering.

Table 2 shows that the concentration of Turbidity varies from 26.2NTU in the Midstream, 17.1NTU in the Upstream, and the Downstream, 16.3NTU, and D respectively all above the standard for good water quality set by the FME (5.0) and the WHO (10).

TDS are inorganic and small amounts of organic matters present as solution in water. The FME and WHO standard allowed the limits of TDS not exceed 500mg/L for drinking water. This study found the concentration of the properties at 152.6mg/l, 138.1mg/l, and 124.4mg/l at the Downstream, Upstream, and Midstream respectively.

The study further found the TSS concentration varied from 290.2mg/L in the Upstream to 190.2mg/L and 151.1mg/L in the Midstream and Downstream respectively. The values are far above the maximum standard limit of 25 mg/L each set by Federal Ministry of Environment FME and WHO.

Chemical Parameters

The result of chemical parameters of the sampled water is presented in Table 3.

Table 3 Chemical parameters of Faculty of Law stream water at the University of Abuja

S/No	Parameters	Upstream	Midstream	Downstream	FME limit	WHO
1	Hardness(mg/L)	123	104.1	102.2	200	-
2	Alkalinity(mg/L)	159.5	161.2	165.3	100	-
3	Chloride(mg/L)	38.6	35.2	35.1	250	200
4	DO(mg/L)	5.3	5.9	5.9	-	-
5	B.O.D(mg/L)	7.7	7.1	6.1	30	10
6	C.O.D(mg/L)	61.2	51.2	44.5	80	100

Source: Laboratory Analysis (2022).

Table 3 shows that, the hardness of the sampled stream sources are 123mg/l, 104.1mg/l and 102.2mg/l in the upstream, midstream and downstream respectively, while the alkalinity property found were to be 165.3 mg/L in Downstream, 159.6 mg/L in the Midstream, and 161.2 mg/L in the Upstream.

The Table also presents the concentration of chloride in the sampled water as it varies from 38.6 mg/L to 35.2 mg/L and 35.1 mg/L in the upstream, midstream and downstream respectively. The dissolved oxygen (DO) in the sampled water stood at 5.3 mg/L in the upstream sample, 5.9 mg/L in the midstream and downstream samples respectively. The concentration of BOD in the respective sampled water include: 7.7 mg/L, 7.1 mg/L and 6.1 mg/L. and the concentration of COD in the respective sampled water from the upstream (61.2 mg/L), midstream (51.2 mg/L) and downstream (44.5 mg/L).

This study postulated and tested hypothesis to understand whether there is no significant variation in the physical and chemical properties obtained from Upstream, Mid-stream and Downstream sources using the ANOVA to test for significant differences.

The analysis was based on 0.05% level of confidence, where, $P = \leq 0.05$ signifies statistical significance (see Table 4).

Table 4: Significant difference of physiochemical parameters of water samples

Source of Variation	**SS**	*Df*	*MS*	*F*	*P-value*	*F crit*
Physical Parameters						
Between Groups	7007.22	2	3503.61	0.321	0.731	3.682
Within Groups	163965.9	15	10931.06			
Total	170973.1	17				
Chemical Parameters						
Between Groups	2224.92	2	1112.46	0.072	0.931	3.555
Within Groups	277075.9	18	15393.1			
Total	279300.8	20				

*Significant p value: $p = \leq 0.05$
NOTE: degree of freedom (df), Mean Square (MS), and the F ratios. The outcome is stated as: F (2, 15) = 0.321, p = 0.73
Source: Authors Analysis (2022)

Table 4 shows that, there is no significant different in the physical properties of obtained from Upstream, Midstream, and Downstream stream water at the Faculty of Law of the University of Abuja at $p = \leq 0.05$ level F (2, 15) = 0.321, p = 0.731. For the chemical parameters, the outcome of the test *shows* that there is no significant difference in the chemical parameters at $p = \leq 0.05$ level for the three sample categories F (2, 18) = 0.072, p = 0.931. Given by the result, the postulated null hypothesis is upheld.

Discussion

The laboratory test results of water samples collected from the Upstream, Midstream and Downstream are discussed for first the physical parameters and then, the chemical parameters.

Physical Parameters

The implication is that animals exposed to the stream water at the mid-stream and downstream areas will experience internal body stress. Chilled drinking water (10°C to 25°C) reduced heat load by reducing body temperature and respiration rate in warmer days and has been shown to increase feed intake and milk production in dairy and livestock weight gains in beef cattle and water with high temperature (27°C to 32°C) (Schatz, 2012).

A sample is considered acidic if the pH is below 7.0. Meanwhile, it is alkaline if the pH is higher than 7.0. The result (7.9, 7.6 and 7.1), which indicates that the sampled water deviates slightly from neutral towards being alkaline falls within the standard limit for pH range, set by FME (6-9) and WHO (6.5-8.5). Water with acidic pH levels can corrode plumbing and leach metals such as Iron, Manganese, Copper, Lead, and Zinc are commonly found in acidic water. High level of these metals in drinking water places adults at risk of health problems such as cancer, stroke, kidney disease, memory problems, stomach cramps, vomiting, diarrhea, and high blood pressure among others (U.S. EPA, 2012). However, studies by Duressa, *et. al.,* (2019) stated that, the pH levels of cattle and has little influence on rumen pH.

The result implies that, the electric conductivity increase at the upstream and midstream respectively. This could be because of increase in human activities (irrigation farming) upstream and midstream of the sampled stream. Thus, the water current of the stream is high at the upstream and midstream respectively. Water with high conductivity leads to corrosion of metal surface in equipment such as boiler (Schatz and Gilbert, 2014).

Turbidity is the cloudiness of water due to variety of particles and is a key parameter in determining drinking water and the content of diseases causing organisms in water. Turbidity levels greater than the WHO acceptable limit renders water unsuitable for domestic and livestock watering. This is the case for the sampled water from upstream, midstream and downstream of the assessed stream. A high level of turbidity is often associated with harmful bacteria with potential effects on livestock (WHO and UNICEF, 2018; U.S EPA, 2012).

TDS in excess quantity is responsible for the wide spread of gastric human system, produce undesirable taste, gastrointestinal irritation and corrosion (Abaje, *et. al.*, 2009). In the case of the

sampled water, such effect is not expected to abound, considering the state of TDS concentration. Thus, the stream water is fit for livestock watering and domestic purpose.

Since various viruses and bacteria can be attached to and migrate along with the solid particles, the result depicts poor water quality for direct domestic uses and livestock watering. According to (Berhanu and Hailu, 2015) high TSS in water is toxic for animal consumption.

Chemical Parameters

The hardness of the sampled water met the standard limit of 200 mg/L, the alkalinity of the sampled water was above the FME standard of 100mg/l. Alkalinity is the capacity of water to neutralize acids and is attributed to compounds such as carbonate, bicarbonate, hydroxide, and some- times borate, silicate, and phosphate (Zhu, 2011). In contrast, when metals combine with anything other than alkalinity, it results to hardness.

These results are in line with the permissible limit of chloride concentration for livestock and domestic use. The concentration chlorides are harmless at low level, water high in sodium chloride gives drinking water, an unpleasant taste. The dissolved oxygen (DO) and the concentration of BOD were all within the FME (30) and the WHO (10) standard. The concentration of COD was within the FME (80 mg/L) and WHO (100 mg/L) standard for quality water. Unpolluted water typically have BOD values of 2 mg/L or less, whereas those receiving wastewaters may have values up to 10 mg/L or more (Kolawole, *et. al*., , 2011). Report shows that BOD and COD are responsible for odour and taste (Kolawole, *et. al*., 2011). Thus, the stream water is satisfactory for livestock watering and domestic usage.

The postulated null hypothesis is upheld and, that means, there is no significant difference in the physical properties of obtained samples from Upstream, Midstream, and Downstream stream water at the Faculty of Law of the University of Abuja at $p = \leq 0.05$ level $F(2, 15) = 0.321$, $p = 0.731$. Similarly for the chemical parameters, the outcome of the test shows that, there is no significant difference in the chemical parameters at $p = \leq 0.05$ level for the three sample categories $F(2, 18) = 0.072$, $p = 0.931$; in any case it simple explains that, the human activities around the stream has no major significance in the physiochemical properties of the water flow. The water can be adequately used for domestic and agricultural use with little monitoring and treatment (Ishaya, *et. al.*, 2016; Berhanu and Hailu, 2015; WHO, 2014; Schatz, 2012).

CONCLUSION

The general appearance of the upstream sampled water is clear, whereas the midstream and downstream sampled water are cloudy.

The upstream (26^{o}C), midstream (32.8^{o}C) and downstream (29^{o}C) samples recorded high temperature values which are within the FME (<40^{o}C) limit, but above the WHO recommended limit (22^{o}C).

The pH values (7.9, 7.6 and 7.1) and the conductivity (151, 337 and 79) of the sampled water from upstream, midstream and downstream are all within the WHO and FME standard.

The turbidity of the sampled water from the upstream (17.1NT), midstream (26.2NTU) and downstream (16.3NTU) exceeded the FME (5.0) and WHO (10) recommended standard.

The TDS concentration in the sampled water (138.1mg/l, 124.4mg/l and 152.6mg/l) are within the FME and WHO standard, while the concentration of TSS in the sampled water from upstream (290.2mg/L), midstream (190.2mg/L) and downstream (151.1mg/L) were higher than the limit set by WHO and FME (25mg/L).

The total hardness of the sampled water from the upstream (123mg/l), midstream (104.1mg/l) and downstream (102.2mg/l) were within the FME (200 mg/l) standard for good water quality. However, the alkalinity of the sampled water from the upstream, midstream and downstream (159.6 mg/L, 161.2 mg/L and 165.3 mg/L) are above the FME standard (100 mg/l).

The chloride content **(**38.6 mg/L to 35.2 mg/L and 35.1 mg/L), DO (5.3 mg/L 5.9 mg/L, and 5.9 mg/L), BOD (.7 mg/L, 7.1 mg/L and 6.1 mg/L) and COD (61.2 mg/L, 51.2 mg/L and 44.5 mg/L) are all within standard limit set by WHO and FME respectively.

Statistically, the physical parameters ($F = 0.321$, $d.f = 2$ and $P=0.731$) and chemical ($F = 0.072$, $d.f = 2$, $P = 0.931$) properties of the sampled water from upstream, midstream and downstream sources were not significantly different.

The study found no difference in the physical and chemical parameters of the Upstream, Midstream and Downstream water quality in University of Abuja Mini-Campus. However, the concentration of the physiochemical quality of the stream decreases downstream. This is due to the intensive activities taking place upstream (irrigation farming). The implication of the result is that, at downstream, the water quality is poor for domestic uses as well as livestock watering. However, in subjecting the water to either uses, it is expected to be pretreated prior to it usage.

Erosion control strategies through best farming practices should be employed by farmers to prevent downwash of chemicals from farmland into the stream. Runoff from the agricultural land directly into the stream is a concern to the aquatic and livestock life.

Aside the use for livestock, the water can be used for general cleaning and washing of facilities and conveniences. It is recommended that, pre-treatment either through chlorination or boiling should be considered to eliminate all cases of contamination of water collected from the stream for domestic use.

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An Assessment of the Quality of Water from Different Sources Used for Irrigation in Jos South LGA, Nigeria

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ABSTRACT

The study assessed the quality of surface water from three sources used for irrigation in Jos South LGA. A total of 12 samples were collected four each from household wastewater, industrial wastewater and mining ponds. They were assessed for their physical, chemical and biological properties using standard laboratory procedures. The results showed that of all the surface water sources selected, the Mining Ponds were the safest for use, as it contained less of the chemical and biological parameters tested for like Total Hardness, Sulphate, Fluoride, Nitrate, Total Dissolved Solids, Copper, Zinc, Sodium, Escherichia coli, Proteus mirabilis, Salmonella and Shigella which can be harmful to man, the soil and crops. The Household Wastewater had more of the biological parameters such as Escherichia coli, Proteus mirabilis, Salmonella and Shigella which can impact man negatively. The presence of these parameters in the Household Wastewater is most likely the result of the by-products of man's metabolic activities. The Industrial Wastewater had more of the chemical parameters present such as Total Hardness, Sulphate, Fluoride, Nitrate, Total Dissolved Solids, Copper, Zinc, and Sodium. On a general note, a number of the chemical parameters were below the standard set by WHO, NAFDAC and SON guidelines for water in use by man for consumption and irrigation farming, but the fear of continuous use and accumulation over the years can likely have negative consequences on man, the crops produced and the soil in use for that production. It is recommended that mining ponds which are abundant in the study area can be used maximally for irrigation farming by government committing to land preparation and constructing irrigation canals to cover areas that can be serviced by individual ponds. Also, bodies charged with maintaining environmental standards ensure that public water sources are not contaminated, open defecation by humans and animals alike be brought to the barest minimum and the general public be sensitized on thoroughly washing vegetables that are eaten raw before consumption.

Keywords: *Assessment, surface water, quality, chemical, biological*

INTRODUCTION

Water is a fundamental requirement for life on our planet. All of the Earth's organisms are composed mostly of water. About 60 percent of a tree is water by weight and humans are 50-60 percent water (Miller 1994). An average man is two-third water and would weigh only 13kg when completed without water (Ayoade 1998). Apart from the air that we breathe, water is the most important element to mankind. They can survive longer without food than without water. Dry air extracts 1.2kg of this substance from the human body daily and this must be replaced. Moreover, water is an integral part of the Earth's biogeochemical processes that create and sustain our environment (Sundaray et al. 2009). For instance, water cycles through the atmosphere modify day-to-day weather. Consequently, water is an essential resource for many human activities required to sustain our current society; agriculture, industry, and transportation are just a few of the myriad of human activities that require water (Narsimha et al, 2013)

The quality of water used across the globe is fast becoming an important area of discuss (UN/Water For Life Decade, 2005-2015 Report).

Water is one of the most important resources man has on the earth, the quantity is quite substantial but may not be in the required quality needed for man's uses which include municipal uses, agricultural uses, industrial uses and then for power generation, navigation and recreation. It has been observed that the quality of this resource has been on the decline due to some factors. The sources of water for any specific purpose are not as important as the suitability of that water for the specific purpose as the suitability can defeat the aim even when available but without the required quality for that use (Asiwaju-Bello and Akande, 2004). Water used for agriculture and most especially crop production needs to meet certain quality levels, in terms of physical, biological and chemical components, most especially the chemical and biological aspects. This is because rapidly declining surface and groundwater quality mostly used for irrigation especially in major urban centres in the developing world threatens human health and natural values (Cosgrove et al, 2000). Water quality is determined by the physical and chemical limnology of a reservoir (Sidnei et al, 1992) and includes all physical, chemical and biological factors of water that influences the beneficial use of water.

The quality of irrigation water has direct influence on the quality of the soil and the crops grown on this soil. Poor irrigation water quality has negative effects on crop productivity, crop product quality, and public health of consumers and the farmer who come in direct contact with the irrigation water (Qadir *et al*., 2007; Listkas *et al*., 2010; Muthana, 2011). Water quality related problems in irrigated agriculture include; salinity with salts in soil or water which reduce water availability to the crops to such an extent that yield is affected; water infiltration rate where relatively high sodium or low calcium content of soil or water reduces the rate at which irrigation water enters soil to such an extent that sufficient water cannot be supplied to the crop from one irrigation to the next; specific toxicity where certain ions (sodium, chloride, or boron) from soil or water accumulate in a sensitive crop to concentrations high enough to cause crop damage and reduce yields; and miscellaneous challenges characterized by excessive nutrients which reduce yield or quality; create unsightly deposits on fruit or foliage thereby reducing marketability of the crops and also excessive corrosion of equipment increasing cost of maintenance and repairs (FAO, 2019)

Irrigation is an agricultural practice designed to increase food production in the arid and semi-arid areas by supplementing the water supplied by precipitation. In Nigeria, the Guinea savanna region is known to have significant amount of rainfall but there are up five or six months of moisture deficit during which agricultural activities virtually stop hence the need for irrigation practices. Jos South is found in this area and is known for irrigation farming producing mostly vegetables of all kinds. The sources of water for the irrigation farming comes from the industrial waste water generated by manufacturing industries as well as densely populated areas with waste water affected by human use. There is therefore, need to assess the chemical and biological qualities of these waters to ensure they meet the standards set for irrigation farming.

MATERIALS AND METHODS

Study Area

Jos South LGA is located between latitude $9^0$38' and $9^0$47' and longitude $8^0$43'and $8^0$52' in the northern part of the Jos Plateau. The climate of the area is influenced by its position and altitude in relation to the general circulation pattern of wind in West Africa (Ati et al 2002). The climate is classified as Aw (Koppen) with alternate wet and dry seasons. The relatively higher altitude has moderated the temperature of the area. The mean minimum temperature is about 18^0 C while the mean maximum is about 26^0C with a mean annual of about 24^0C. Mean annual rainfall is 1,260mm. Vegetation is classified as Northern Guinea savanna characterized by tall grasses and open woodland. According to Macleod et al (1971), the geology of the area is dominated by Precambrian basement complex rocks (including migmatites, gneiss and older granites) and the Jurassic younger granites (biotite-granite). In some areas particularly around Vwang are found the Tertiary and Quaternary volcanic rocks (including basalts, pumice, lava flows and ash deposits). Three major rivers drain the waters of the study area. They are River Delimi, River N'gel and River Kaduna.

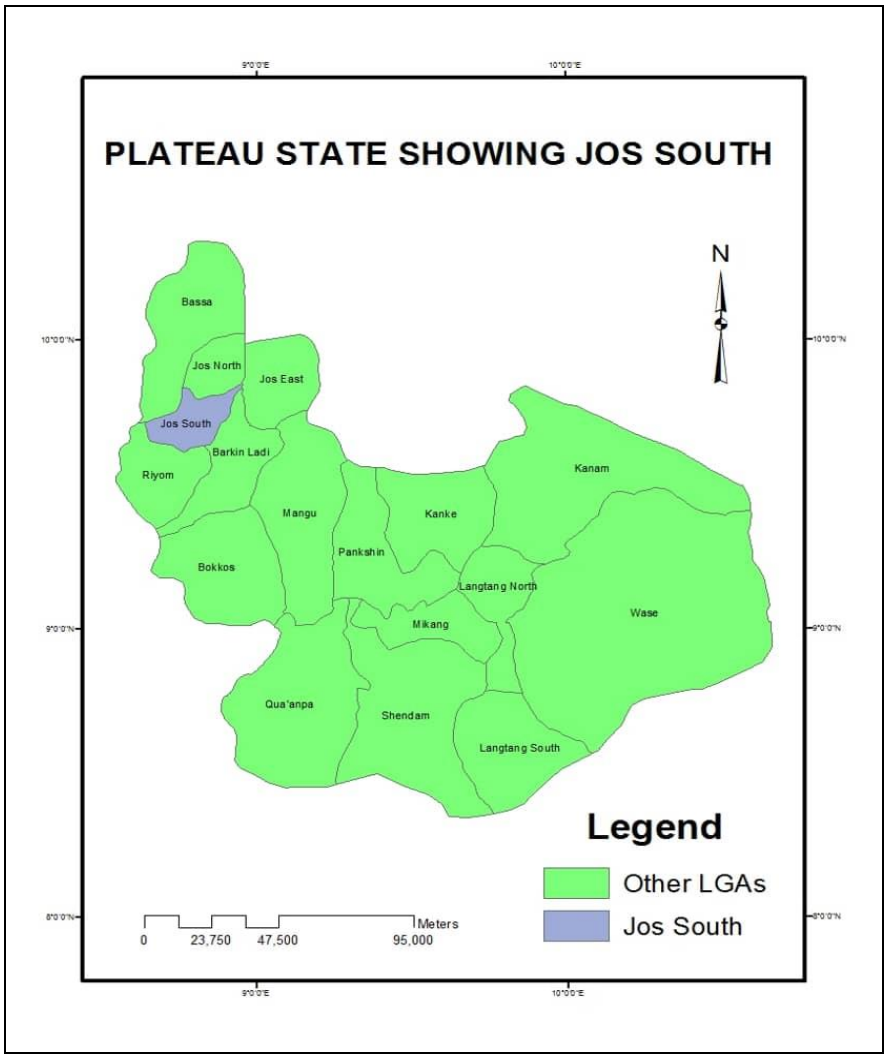


Figure 1: Plateau State Showing Jos South LGA (Study Area)
Source: National Center for Remote sensing Jos.

Methodology

For the purpose of this study, three major sources of water for irrigation were identified. They include industrial wastewater, household wastewater and water from mining ponds. 0Industrial waste water was collected at four points in Zaramaganda, household wastewater was collected at four points in Sparkling junction and mining pond water was collected from four ponds at Gura Top giving a total of 12 samples. The sampling procedure included the use of sterilized 750ml plastic bottles which were used for the collection of water samples. The caps of the sterilized bottles were removed after water had been extracted from the sample points and the bottles were rinsed with the source sample water before being filled leaving some space at the top for air. The bottles were covered immediately after filling. Provision was made for coolers containing ice for the storage of the water samples. This was so that a water temperature of at least 5^0C would be maintained to prevent excessive growth or death of bacteria. A pH meter was carried along so that the pH and temperature of each sample was determined at the point and time of collection.

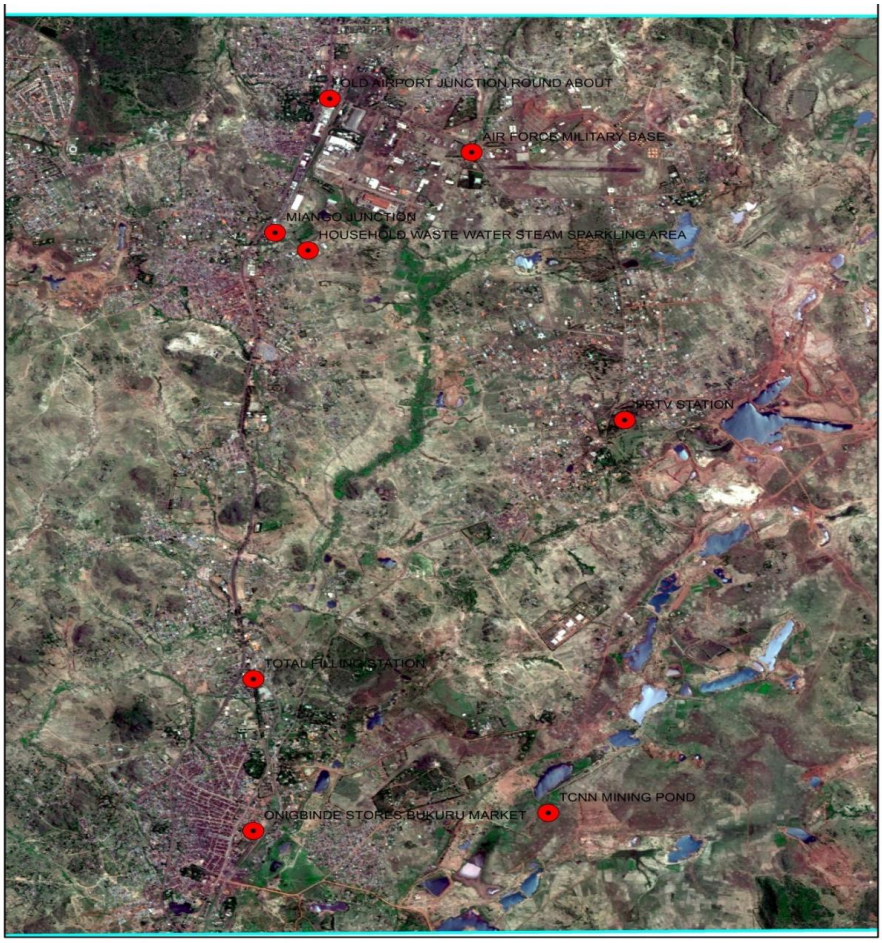


Figure 2: Satellite Image of the Study Area
Source: National Centre for Remote Sensing, Jos

The parameters determined included Physical Parameters like colour, turbidity, particulate matter and transparency. The chemical Parameters were pH, total hardness, total dissolved solids, dissolved carbon (IV) oxide, chloride, fluoride, nitrate, sulphates, free chloride, trace metals, copper, lead, zinc, iron, calcium, sodium, magnesium, aluminum and manganese. Biological parameters included *Coliform Count, Escherichia coli, Klebsiella aerogenes, Pseudomonas aeruginosa, Proteus mirabilis, Proteus vulgaris, Salmonella spp. and Shigella spp.*

RESULTS AND DISCUSSION

Physical Properties

The results of analysis for the physical parameters are contained in table 1. It showed that all samples from the three sources were colourless. Household wastewater and mine pond water exhibited no turbidity while industrial wastewater was turbid. In terms of transparency only mine pond water samples were completely clear. Sample HW1 was not clear while the remaining three household wastewater were clear. However, all the four samples of industrial wastewater were not clear. It is therefore not surprising that sample HW1 and all the industrial waste water samples contained particulate matter while HW2,3and 4 and all the samples of mine pond water did not contain particulate matter. Despite the different sources, all the samples were odourless. The values for pH did not vary much between the three sources. The range was between 6.56 and 6. 65 making them slightly acidic to neutral.

Table 1: Physical parameters

SAMPLING POINTS

	HW1	HW2	HW3	HW4	IW1	IW2	IW3	IW4	MP1	MP2	MP3	MP4			
PARAMETERS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**WHO**	**NAFDAC**	**SON**
Colour	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourless	Colourle	5	20	15
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	No Guideline	Odourless	Unobjectionable
Taste													No Guideline	Tasteless	Unobjectionable
Turbidity	Not Turbid	Not Turbid	Not Turbid	Not Turbid	Turbid	Turbid	Turbid	Turbid	Not Turbid	Not Turbid	Not Turbid	Not Turbid	15	25	5
Particulate Matter	Present	Absent	Absent	Absent	Present	Present	Present	Present	Absent	Absent	Absent	Absent			
pH	6.58	6.62	6.61	6.63	6.64	6.60	6.61	6.63	6.61	6,60	6.56	6.65	6.5-8.5	6.5-8.5	6.5-8.5

Table 2: Chemical parameters

SAMPLING POINTS

PARAMETERS	HW1 1	HW2 2	HW3 3	HW4 4	IW1 5	IW2 6	IW3 7	IW4 8	MP1 9	MP2 10	MP3 11	MP4 12	WHO	NAFDAC	SON
DCD (mg/l)													No guideline	50	-
Total Alkalinity (mg/l)	36.2	51.8	41.5	61.2	101	75.3	62.5	49.7	78.3	85.5	105.2	95.4	-	100	-
Chloride (mg/l)	16.19	75.30	68.91	112.5	128.6	95.70	105.5	69.90	55.82	78.60	96.72	100.30	250	250	250
Total Hardness (mg/l)	123	98.3	76.9	102.5	184.2	147.0	214.0	168.0	79.5	65.0	181.0	60.5	500	500	Not mentioned
Calcium Hardness (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	No guideline	50	150
Magnesium Hardness (mg/l)	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-
Sulphate (mg/l)	28.50	41.30	19.50	25.70	41.7	52.30	39.84	47.65	100.90	73.20	67.90	88.40	500	250	100
Fluoride (mg/l)	1.050	0.860	0.410	0.910	1.430	1.012	1.670	0.901	1.312	0,866	0.992	1.711	1.5	1.3	1.5
Nitrate (mg/l)	14.80	25.30	41.50	12.00	44.80	57.50	75.30	31.92	41.10	71.82	35.90	52.80	50	30	50
PVC est. in water	-	-	-	-	-	-	-	-	-	-	-	-	Negative	Negative	-
TDS (mg/l)	412	381	535	205	614	685	791	543	318	425	511	364	500	500	500
Free Chlorine (mg/l)	0.29	0.21	0.19	0.23	0.33	0.24	0.18	0.35	0.20	0.22	0.15	0.24	0.4	0.3	-
Copper (ppm)	0.009	0.113	0.081	0.050	1.003	0.982	0.018	0.931	0.054	0.008	1.024	0.985	2.0	2.0	1.0
Calcium (ppm)	1.800	1.414	0.941	0.719	0.897	0.996	1.670	1.852	0.353	0.319	0.707	0.868	200	75	Not mentioned
Lead (ppm)	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.01	0.01
Zinc (ppm)	0.085	0.902	1.332	0.223	1.852	1.040	0.095	0.115	1.203	0.921	0.083	0.988	3.0	5.0	3.0
Iron (ppm)	0.059	0.908	0.101	0.193	0.549	0.035	0.069	0.393	0.314	0.692	0.711	0.078	No guideline	0.30	0.30
Magnesium (ppm)	1.300	0.981	1.103	1.514	0.835	1.016	1.401	3.121	0.660	0.891	1.195	0.740	50	50	20
Manganese	0.057	0.015	0.071	0.016	0.057	0.027	0.090	0.023	0.029	0.039	0.051	0.048	0.5	0.5	0.2
Sodium	27.13	11.42	35.50	60.15	40.95	74.70	63.81	52.51	70.92	74.06	41.00	50.51	200	200	200

Note: ND Denotes Not Detected

Table 3: Biological parameters

SAMPLING POINTS														
PARAMETERS	**HW11**	**HW22**	**HW33**	**HW44**	**IW15**	**IW26**	**IW37**	**IW48**	**MP19**	**MP210**	**MP311**	**MP412**	**WHO**	**NAFDAC**	**SON**
Coliform (cfu/ml)	920	280	300	260	>1800	>1800	>1800	>1800	40	54	29	17	No guideline	1	1
E-coli count (cfu/ml)	120	150	130	130	32	90	43	38	-	20	-	-	0.00	0.00	0.00
K. aerogenes (cfu/ml)	210	60	90	40	410	440	380	510	-	-	19	-	0.00	0.00	0.00
P. vulgaris (cfu/ml)	-	-	-	-	960	750	690	710	-	-	-	-	0.00	0.00	0.00
P. mirabilis (cfu/ml)	360	30	40	50	-	-	-	-	-	-	-	-	0.00	0.00	0.00
P. aeruginosa (cfu/ml)	-	-	-	-	-	-	-	-	13	-	-	6	0.00	0.00	0.00
Salmonella	-	-	1+	1+	-	1+	-	-	-	-	-	-	0.00	0.00	0.00
Shigella	3+	3+	3+	3+	-	-	1+	1+	-	-	-	1+	0.00	0.00	0.00

Chemical properties

Data obtained for the chemical parameters are contained in table 2 and it revealed that total alkalinity was lowest in household wastewater with values ranging from 36.2 to 61.2 while it was higher for both industrial wastewater and mine pond water with ranges of 49.7 to 101.0 and 78.3 to 105.2 respectively. Only that of household wastewater was well within the standard limit set by NAFDAC at 100. Chloride content was highest and lowest for HW4 and HW1 respectively but for all the sources are within standard limits. Total hardness was highest for IW4 at 214.0mg/l but for all sources was within acceptable limit of 500mg/l. All values for sulphate were within standard limits. The nitrate content showed that all the samples except HW1 were above the 30mg/l limit set by NAFDAC. This can add to the nitrate content of the soils which is advantageous but at the wrong stage of growth it can delay maturation and can also stimulate growth of algae which can clog valves, pipelines and sprinklers (Ayers and Westcot, 1994). For fluoride only IW1, IW3 and MP1 had values above the 1.3mg/l limit for NAFDAC. However, the use of water at these points may not be safe as excess Fluoride affects soil fertility as well as can lead to enamel and skeletal fluorosis from prolonged exposure (WHO, 2010). All samples were found within the standards for sulphate.

Total dissolved solids content for most of the samples were above the 500mg/l limit. This property has effects on soils and plants, as a continuous buildup of Total Dissolved Solids in soils invariably means more salts in the soil. These salts absorb water that plant roots need fo uptake for their growth and development, increasing water stress and root dehydration, this is referred to as "*physiological drought*" which if not corrected can lead to reduced plant growth (Ayers and Westcot, 1994). Free chlorine content had only two samples above the 0.3mg/l limit of NAFDAC but below the 0.4mg/l of WHO. Chlorine is generally one of the most used disinfectants for both drinking and irrigation water, but research seems to connect it to certain ailments such as colorectal cancer (bladder cancer), asthma most especially in children and heart disease (WHO, 1996). For all the samples, the copper content was below the 2.0ppm limit. Similarly, the calcium contents were well below the 200ppm limit for WHO and 75ppm for NAFDAC. The zinc content for the three sources of water were all below the 3.0ppm limit for WHO and 5.0ppm for NAFDAC. Mine pond water had the highest iron content with MP1, MP2 and MP3 above the 0.30ppm limit set by NAFDAC and SON. Industrial wastewater also had two samples above the standard. This high content of iron can cause clogging of drip irrigation emitters and above 0.3 ppm may lead to iron rust stains and discoloration of foliage plants in overhead irrigation applications (FAO, 1996). Research has shown that the human body has no way of disposing excess iron. A common iron overload disorder is Hemochromatosis (Iron build up in tissues and organs). Overtime, untreated hemochromatosis increases risk of arthritis, cancer, liver problems, diabetes and heart failure (Arnarson, 2017). Magnesium content of all the samples were well below the 50ppm limit of WHO and NAFDAC and 20ppm of SON as to make their content insignificant. The manganese and sodium contents follow the same pattern as magnesium with all the values falling well below the WHO, NAFDAC and SON standards. The presence of lead was not detected in all the samples.

Biological properties

The *coliform* count is the representation of the bacteriological quantity and quality of a water source. HW had between 280 to 920, while IW had >1800, MP had a range of 17 to 54. The general standard by WHO, NAFDAC and SON is one (1) for any water source, but all these water sources had *coliforms* with the mining pond having the lowest quantity making it the safest source in terms of the presence of this form of bacteria. *Escherichia Coli (E. coli)* is the major specie of fecal *coliform* group found in any water source. HW had an *E. coli* count of 120-150. IW had 32- 90. MP1, MP3 and MP4 showed no presence of *E. coli* with only Sample Point MP2 showing about 20. These figures show that the highest presence of *E. coli* is in the Household Wastewater, and very minimal presence in some positions of Industrial Wastewater and even absent in the Mining Pond. For the places where they are present, they are all above the standard required by the WHO, NAFDAC and SON hence making these water sources most especially the Household Wastewater and Industrial Wastewater unsafe to use for farming. They are mostly a product of human and animal feces in water, meaning that the Sample Point in the Mining Pond water showing presence may have likely been contaminated by human and animal feces around that water source. Medical research has shown that E. coli is more likely to have health effect on the urinary and gastrointestinal tracts of humans. Symptoms of this intestinal infection include diarrhea, abdominal pain and fever. More severe cases can lead to bloody diarrhea, dehydration or even kidney failure making its presence in water used for irrigation unsafe for man (Healthline Newsletter, 2017).

K. aerogenes was found present in all the samples of household and industrial wastewater and only in MP3. *K. aerogenes* has been found in human gastrointestinal tract and does not usually cause disease to healthy individuals. It has been found to live in various wastes and the soil too. It is an outstanding Hydrogen producer (Wikipedia, 2017). The quantity of *K. aerogenes* present in all the water sources where it was present are above the required WHO, NAFDAC and SON standards. *Pseudomonas aeruginosa* was absent in HW1-4 and IW1-4. It only showed some presence in MP1 and MP4 but was absent at Sample Points for MP2 and MP3. Its presence in those Sample Points makes water at those points unsafe by WHO, NAFDAC and SON Standards which requires them to show no content. *Proteus mirabilis* was only found present in HW1, HW2, HW3 and HW4 in quantities of 360, 30, 40 and 50 respectively. It was absent in all the Industrial Wastewater and Mining Pond samples collected and tested. The quantities of *P. mirabilis* in the Household Wastewater as tested are above the WHO, NAFDAC and SON required standard which requires that there should be zero content. *Proteus vulgaris* was absent in HW1-4 and MP1-4. It was found present in IW1, IW2, IW3 and IW4 in quantities of 960, 750, 690 and 710 respectively. It mostly gets into water sources via human and animal feces. A reconnaissance survey of the Industrial Wastewater source showed that cattle graze and drink water at this source and in the process defecate in the water and may have likely been the major source of contamination of this water source with *P. vulgaris* asides human and other animal feces. The WHO, NAFDAC and SON standards require that there should be zero content of *P. vulgaris* in any water source in use by humans most especially for drinking.

Salmonella was absent in HW1 and HW2 but was found present in samples collected at points HW3 and HW4 (1+). It was also found present in IW2 (1+) but was absent in IW1, IW3 and IW4. It was absent in all the samples collected in the Mining Ponds represented by MP1, MP2, MP3 and MP4. Based on the WHO, NAFDAC and SON standards which require zero content for the sample points showing presence of salmonella, those waters are unsafe for use for irrigation of farms as *Salmonella* is the major causative agent of Typhoid fever with symptoms of diarrhea, headaches, fever, vomiting, nausea, blood in the stool, chills and abdominal cramps. This can adversely affect humans who eat vegetable crops produced using water contaminated with *Salmonella* as its effects are directly on the gastrointestinal tract of humans unlike *P. mirabilis, P. vulgaris and P. aeruginosa*. *Shigella* this was found in household wastewater in 3+, and also in some of the industrial and mine pond water samples. The presence of these bacteria in most especially the Household Wastewater makes it unsafe for use for irrigation and crop production by the WHO, NAFDAC and SON standards. *Shigella* affects the gastrointestinal system of humans with Shigellosis causing diarrhea, fever and stomach cramps, the diarrhea is often bloody. Severe infections of *Shigella* can lead to high fever and can be associated with seizures in children younger than two (2) years of age (Illinois Department of Public Health, 2017).

CONCLUSION

This study has shown that for irrigation purposes, perhaps water from mine ponds is the safest. The chemical parameters analysed seem to mostly fall below the standards given by the authorities but the danger lies in their ability to accumulate in the soils and plant tissues over long periods. The greatest danger posed is by the biological agents found in almost all the water sources studied. Though most of them affect the urinary tract of humans and are even found living in the gastrointestinal tract, there exists the possibility of inter-tract crossover. It is therefore not surprising that typhoid disease is ever present with us and the causative agent has been tracked to infection of water sources. It is thus recommended that mining ponds should be put to maximum use for irrigation by government committing to land preparation and construction of irrigation canals. Also, bodies charged with maintaining environmental standards to ensure that public water sources are not contaminated, open defecation by humans and animals alike be brought to the barest minimum and the general public be sensitized on thoroughly washing vegetables that are eaten raw before consumption.

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Evaluation of Irrigation Systems: Implication for Sustainable Agriculture in Southern Kaduna, Kaduna State

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ABSTRACT
This paper attempts an evaluation of the irrigation systems adopted by farmers in southern Kaduna for sustainable agriculture. The paper in particular identified the sources of irrigation water in the area; establish the irrigation system practiced in the study area; the type of irrigation scheme in southern Kaduna; and an evaluation of the irrigation system in southern Kaduna. The study made use of measurement, interview, and observation techniques in obtaining data from the field. Purposive sampling method was adopted during the study. Three interviews were conducted with key informants practicing irrigation across four communities in southern Kaduna – Ashafa, Saminaka, Kachia, and Gimi respectively. Questions were centered on the aim and objectives of the study, and a total of twelve farmers were interviewed, three from each location. Results revealed that in all the four locations where irrigated agriculture is practiced in southern Kaduna, farmers are using the same source of water, which is the river. Basin irrigation system in particular is the most common method adopted by farmers to water their crops. The study also established the fact that the irrigation scheme observed in southern Kaduna is farmer- owned. Furthermore, the source of funding and labour are taken care of completely by the farmers, implying no support of any kind by the government or non-governmental organizations, and tools used by farmers in the area are locally made among others. Hence, the study concluded that, irrigation system adopted by farmers in southern Kaduna is traditional and will not support sustainable agriculture in irrigation due to its negative impact on the soil, water, and the environment in general. Therefore, the study recommended the adoption of alternative sources of water in the study area, a shift from basin irrigation system to the introduction of drip and sprinkler irrigation systems by farmers in the area, and the need to introduce cash crops like rice among the irrigated crops in southern Kaduna instead of cultivating the same type of crops during the dry season.

Keywords: *Irrigation, Irrigation system, Sustainability, Water, Southern Kaduna*

INTRODUCTION
The artificial application of water for crop production is generally referred to as irrigation. It is a man-made technique of watering crops. Adamala (2016) defined irrigation as the skillful application of water for agricultural purposes through man-made systems to supply water requirements that are not fulfilled by rainfall. This implies that irrigation has to do with the delivery of water for growing plants by man rather than rainfall. Therefore, very key for the survival of crops when rainfall is insufficient.

Christopher, James and Gani (2022) defined irrigation as the non-natural application of water to land or soil to support the growing of food crops, maintenance of landscape and re-vegetation of disturbed soils in dry areas and during periods of inadequate rainfall. It is also seen as a means of improving crop production, fortification of plant against frost, overpowering of weed growth in grain field and prevention of consolidation (Synder & Melo-Abrue, 2005). This implies that irot only the application of water to soil for plantsbut also a means of encouraging sustainable agriculture for maximum food production.

Irrigation is indispensable today because it has better economic gains than rain fed agriculture, and also reduces the threats and uncertainties associated with rainfall farming. Rain fed farming depends exclusively on irregular rain received in an area during the rainy season which may lead to low yield and subsequently low income to farmers (Sanni *et al*, 2012). The development of irrigated agriculture has certainly boosted agricultural productivity, contributed to economic steadiness and made it possible to feed the world's growing population (Shanono *et al*., 2021). Furthermore, Li & Troy (2018) established that crops grow better through irrigation as crop yield is on the average of 2.3 times higher than the ones produced under rain fed production. This is because water is optimally applied by putting climatic conditions into consideration and thereby enhancing world's agricultural production and ensuring food sufficiency to the populace.

In Africa, irrigated agriculture has upgraded the standard of living of farmers. Mango *et al*. (2018) prove that agricultural income has tremendously improved farmers' adoption of small scale irrigation farming in South Africa. More economic proceeds have been witnessed on rice production on farmers partaking in irrigated agriculture in Ghana compared to their colleagues practicing rain fed production (Bidzakin *et al*, 2018).

Furthermore, in Nigeria similar studies by Tijani, Abba & Dandela (2022); Schuenemann *et al.*, [2018] and Olaniran *et al.* [2019] reveal that irrigated agriculture in rural areas of Nigeria have boosted domestic earnings of farmers leading to high purchasing power and safety of their livelihoods. If these are true, then there is need to encourage farmers to embrace irrigated agriculture so as to boost food production as well as improve standard of living which would help in eradicating poverty in Nigeria especially in southern Kaduna which is an agrarian community. Therefore, farmers need to recognize the importance of taking up friendly methods or systems of irrigating crops so that irrigated agriculture will be observed in a sustainable manner.

Sustainable irrigation system has to do with the usage of an appropriate method of applying water to crops in a controlled manner that will reduce land and water degradation for better nutrient and pesticides control in crop production (Davis *et al*., 2013). Irrigation may have a negative impact on water quality and/or quantity. Diversion of surface water for irrigation can reduce streamflow and water volume downstream in water bodies (Dean *et al*, 2021). Therefore, a sustainable irrigation system will seek to improve food production and farm profits while minimizing negative impacts on water resources and the environment.

The rural environment in Nigeria supports agriculture, but the level of agricultural production has been very low. This is because of over dependence on rain fed agriculture which has its consequences. Yet, agriculture remains the bedrock of the economy in Nigeria, as such the need to embrace irrigated agriculture to ensure food security and poverty alleviation of the populace.

In 2004, the Nigerian Investment Promotion Council (NIPC) reveal that only 5% of the cultivated land in Nigeria are irrigated, yet more than 10% of agricultural production comes from those fields. However, Adelodun & Choi (2018) observed that presently in Nigeria 45% of the total irrigation potential of 2 million hectares is under irrigation. This displays an improvement in respect to acceptance of this system of farming, as such the need to look into the types and systems of irrigation practiced in Nigeria, so as to make wise decisions as the country embraces irrigated agriculture most especially in southern Kaduna.

The food and agriculture organization of the United Nations [FAO-UN, 2014] classified irrigation schemes into three based on land mass. Hence 10,000 ha and above are classified as large irrigation schemes, 100 - 1000ha are medium irrigation schemes while less than 100ha are small irrigation schemes. In Nigeria irrigation schemes and project are also categorized into three. The first category is the public irrigation schemes. This is owned by the government and was introduced in the 1970's. It is run either by river basin and rural development authorities (RBRDAs) or states through agricultural development programs (ADPs). This led to the construction of large dams especially in the northern parts and middle belt of the country. The second category is the farmer - owned irrigation scheme. This is private and managed by the farmer. It is small scale and can be formal or informal. The third category is the flood plains (fadama) irrigation scheme. This is based on rain water harvesting. It is also referred to as the emerging irrigation system in Nigeria (FMWR and FAO-UN, 2015; Adekunle, Oladipo & Busari, 2015; Adelodun & Choi,2018). Any of these type of irrigation can be successful with a sustainable irrigation system.

Sustainable irrigation systems involve different methods of making water available to crops from different sources through various channels that will give good yield as well as protect the environment from destruction. This is needed in agriculture because of the irregularity of weather and climate. Bohle & Jones, (2022) defined irrigation systems as the implements required to provide water to plants. The system embraced has the device in providing water evenly to the plants. Therefore, farmers need to know which system is best for their operations in other to provide uniform distribution for the land and crops respectively. Furthermore, Bohle & Jones (2022) stated that irrigation systems are either gravity-driven or pressurized. The gravity-driven systems are also known as surface irrigation systems while pressurized systems are sprinklers or drip system.

Surface irrigation systems are suitable when water is in sufficient quantity. Uniform water supply is difficult when using this method, but can be improved with various approaches. This system encourages water loss and intensive labour, but uses less equipment. This system consists of water applied in furrows, basins, gated pipes, or flooded over the surface. While sprinkler irrigation on the other hand, has greater control over application rates, amounts and timing. They are less labour

intensive but requires specialized equipment and energy for pumping and water delivery. Sprinkler can be in-ground, stationary, portable, semi-portable, solid or mobile. Sprinkler irrigation systems are center-pivots, side-rolls, linear, travelling guns and booms. Drip irrigation systems have been identified to be the best. This is because they provide the best evenly and water use effectiveness, but is capital intensive. Drip system are made in such a way that they deliver water directly to the soil surrounding roots on a frequent basis. This system is productive but expensive due to the type of equipment needed. These imply that, any system chosen by a farmer determines the yield expected. if the best system is not employed, there is bound to be a lot of problems that may lead to poor yield.

In southern Kaduna, farmers are using the resources and equipment they can afford. They may not necessarily take heed of the effects of these to the immediate environment (where they are practicing irrigation), crop yield and income they will realize. If irrigated agriculture will thrive in Nigeria most especially in southern Kaduna, there is need to evaluate the systems of irrigation practiced in the area, so as to suggest effective ways of irrigating crops in the area to guarantee sustainable agriculture that will address food security as well as lessen the poverty level of the populace. Therefore, the aim of this study is to evaluate the irrigation systems adopted by farmers in southern Kaduna for sustainable agriculture. In particular, to; identify the sources of irrigation water in the study area, determine the types of irrigation farming practiced in the study area, and also evaluate the irrigation systems adopted by farmers in the areas.

MATERIALS AND METHODS

Study Area

Southern Kaduna is located between latitudes 9º 08' 00'' and 10º 04' 00'' of the Equator, and Longitudes 7º 15' 00'' and 7º 50' 00'' of the Greenwich Meridian (Soladeye, 1997, NIMET, 2017, & Bulus, 2021).

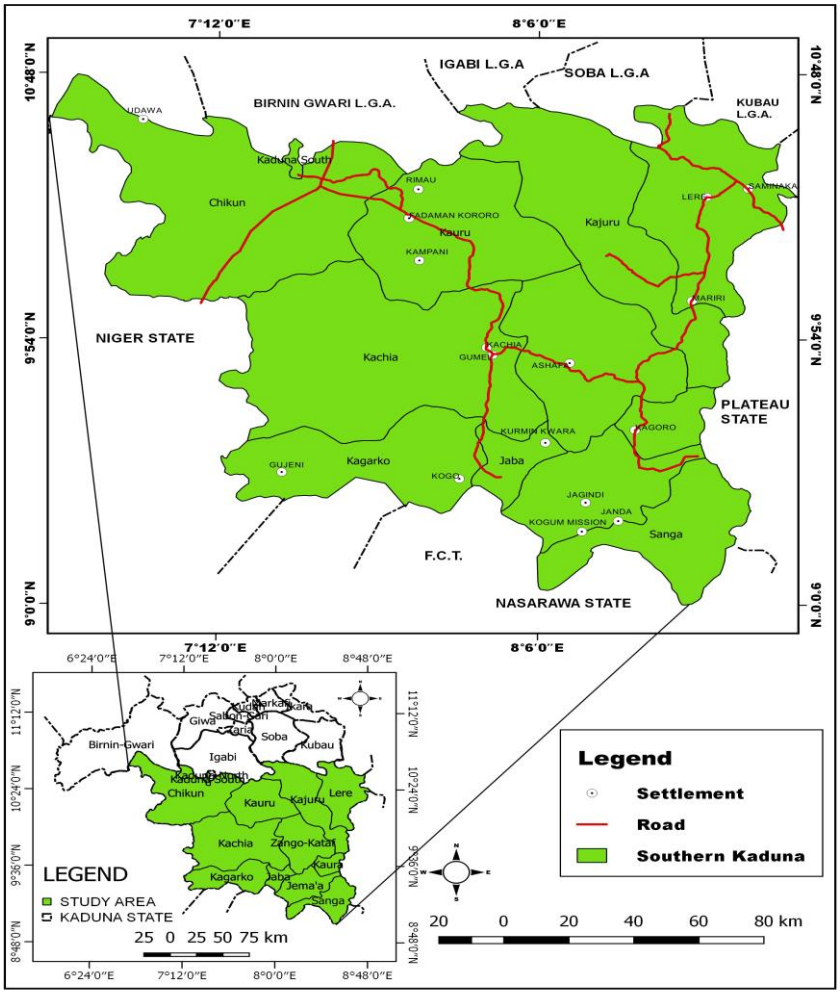


Figure 1: Southern Kaduna, Kaduna State
Source: Adopted from Kaduna State Administrative Map.

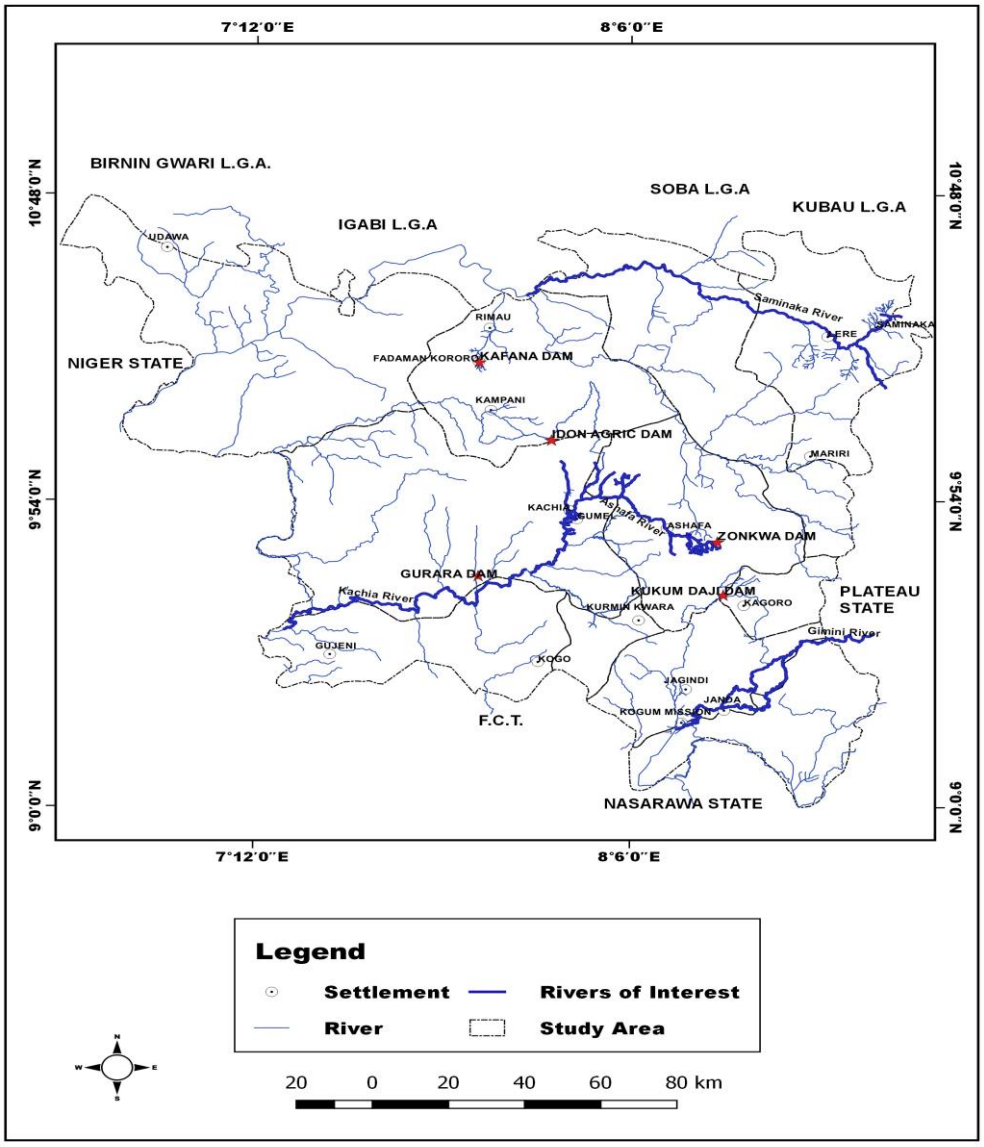


Figure 2: The Sampling Sites
Source: Adopted from Kaduna State Administrative Map.

The area is estimated to cover about 26,000km^2 (fig. 1). The area is characterized by Aw type of climate, classified by Koppen, that is, the tropical continental climate with two distinct seasons, wet and dry. The wet season begins in April and ends in October with the peak in August. While the dry season begins from November to March. These seasons are influenced by the tropical maritime and tropical continental air masses respectively. The mean annual rainfall ranges between 1,659.44mm – 1,800mm, this usually decrease to about 1,245.97mm in Kaduna (Abaje *et al*, 2010). The average minimum and maximum temperature are 15.1^{o}c and 35.18^{o}c, while relative humidity is about 62% (Ishaya & Abaje, 2008; Abaje *et al*, 2018). There is abundant sunshine in Southern Kaduna. The duration of sunshine at any given place is the function of its latitude and cloudiness (Aremu, 2014). The range is between 12.9 hours per day in the wet season, and 11.7 hours in the dry season. The study area is drained by rivers such as river Kaduna, Gurara, Gimi, Manchok, and Kachia among others. Most of the rivers take their source from the high lands of the Jos plateau, they are tributaries of the River Niger. Most of these tributaries are seasonal, that is they overflow their banks during the rainy season but reduced in volume or dry up during the dry season (Bonoh, 2012). The rivers have cataracts, rapids, falls and gorges.

Procedure and Methods of Data Collection

This study made use of interview and observation techniques in obtaining data from the field. At the observation phase, the variables noted include soil

type, irrigation system, types of crops irrigated, and irrigation type among others. Measurement of coordinates at each location was observed using a GPS. Purposive sampling method was adopted during the study, as this allowed the authors get relevant information from the group of interest that is farmers practicing irrigated agriculture at the interview phase. Three interviews were conducted with key informants who are farmers practicing irrigated agriculture across the four communities - Ashafa, Saminaka, Gimi and Kachia respectively. The questions were centered around the aim of this paper, which is to evaluate the irrigation systems adopted by farmers in southern kaduna. The questions were fifteen ranging from biodata, sources of water, irrigation systems, source of funding, and source of; labour among others. A total of twelve farmers were interviewed, three from each selected community (Kachia, Saminaka, Ashafa and Gimi). Information received from them and observations carried out are presented appropriately.

RESULTS AND DISCUSSION

Information on Irrigation Farmers

Investigation in the course of study shows that most of the irrigation farmers in southern kaduna are males who are married with wife /(wives) and children. Their ages range between 25 to 60 years, and are indigenes of their respective communities (Kachia, Saminaka, Gimi, and Ashafa). Furthermore, eighty percent (80%) of the farmers did not go to school, ten percent (10%) obtained primary or Islamic education, eight percent (8%) went to secondary school but some did not graduate. While two percent (2%) went to tertiary institution, and some of them did not graduate too. This implies that irrigated agriculture is dominated by the male folk in southern Kaduna. Women are not into this system of farming but are sometimes hired to weed the farms. More than eighty percent of these farmers belong to the active workforce group who are agile yet with little or no formal education. Only a few of them went through primary, secondary and tertiary institutions successfully.

Method of Water Application or Irrigation System

The study reveals that in all the four locations studied there is little or no difference in the method of applying water to crops. The common method adopted by farmers in this area is the surface irrigation system, basically, the basin irrigation system. Surface irrigation is the traditional method of applying water to crops. Water moves over and above the land by simple gravity flow in order to wet it and also infiltrate the soil. This method is used worldwide and water control is manual. Basin irrigation falls under this category.

Basin irrigation is the most common method adopted by farmers in southern Kaduna. The field is divided into small units which are surrounded by small levees or dikes to prevent run-off. The field is also divided into a number of terraced rectangular bays that are levelled and graded and have no significant slope plates (1 & 2). This method is not suitable for all crops and soils, but generally favored by moderate and slow intake soils, deep-rooted and closely spaced crops that are unaffected by standing water like rice for long periods. Water control is manual and it induces large variations in volumes of water applied per unit area. Under such situation, moisture distribution is uneven and deep percolation unavoidable (Adamala 2016). Other effects of this irrigation system include soil erosion, evaporation, pest and diseases, and poor yield amongst others (FAO, 2017; Adamala, 2016).

Most farmers in the area adopted this method because it is less expensive and affordable not knowing the disadvantages in using this system of irrigation. In all the locations studied, some of the deep rooted crops cultivated include cassava and potatoes. These are not in large quantities like vegetables and maize which may not thrive well based on this system. Rice, one of the crops that will do well using this system of irrigation is not cultivated by farmers in the area till the rainy season. Table one shows the irrigation system practiced in southern Kaduna and the structure involved.

Table 1 Irrigation systems in Southern Kaduna

Irrigation Site	Irrigation System	Structure
Gimi	Surface (Basin)	River Gimi as the only source of water
		Digging of shallow borehole/wells on river beds to yield water
Kachia	Surface (Basin)	Use of pump to divert water from the river
-+		Digging of shallow borehole/wells on river beds to yield water
Ashafa	Surface (Basin)	Use of pump to divert water from wells/boreholes on river beds
		Diversion of water from river to the farm.

Source: Authors' Fieldwork April, 2023.



Plate 1 Cultivated Terraced Rectangular Bays, Kachia.
Source: Authors' Fieldwork April, 2023.



Plate 2: Basin Irrigation System at Saminaka.
Source: Authors' Fieldwork April, 2023.

In 1998 Sivanappan proved that sprinkler and drip irrigation systems are more effective than surface irrigation systems in terms of water conveyance, application, usage and evaporation. This was subsequently supported by other authors such as, Adamala (2016), Adelodun & Choi (2018) and Dean, Martin, Heren & Hoffman (2021) among others. Therefore, there is need for farmers to upgrade in the aspect of the irrigation system they are using in southern Kaduna, so as to improve production as well as their standard of living at the same time conserving the environment.

Source of Irrigation Water in Southern Kaduna

The study further reveals that all the farmers get water from the same source in their different locations, which is the river. At the time of this study, all the rivers are almost dry. Patches of water were observed along the course of the rivers except for the Gimi river that is located in the southern part of the study area which has a good quantity of water downstream. This can be attributed to the presence of trees that are serving as water shed at that point and also the presence of rocks that may be storing water during the rainy season. The scarcity of water during the dry season in southern Kaduna do forced farmers to use the only available source, to the extent of digging shallow boreholes or tube wells on the river beds to pump water in order to irrigate the crops. This is shown on plate 3, and is not be a sustainable means of using these rivers, as it may have consequences that may not be observed immediately. Recent studies conducted by Iqbala, 2023; Prince, 2018; and Adekola, 2018 in different study areas outlined the effects of unregulated drilling of boreholes to groundwater resources, soil structure, and the environment in general. Therefore, drilling of tube wells or shallow boreholes on river beds should not be overlooked in order to use our rivers sustainably.



Plate 3: Shallow Tube-well on River bed, Saminaka
Source: Authors' Fieldwork April, 2023.

Type of Irrigation Schemes.

The type of irrigation practiced in southern Kaduna is the farmer - owned scheme as reveal by this study. It is private, managed by the farmers, small scale, and informal. Based on FAO-UN (2014) irrigation classification, southern Kaduna irrigation schemes fall in the third category based on land mass size. It is referred to as the small irrigation schemes. In this category, farmers cultivate less than 100ha of land for irrigation. In all the locations studied, most of farmers cultivate between two to four hectares of land. This is due to inadequate finance and water scarcity to expand production as stated by some of the farmers.

Source of Funding and Labour

During the interview session with the farmers, the researchers were able to establish that the farmers are responsible for funding their projects with no support or incentives from the local, state, or federal government. They are forced to take loans with high interest from cooperative associations in order to boost production through the purchase of herbicides, fertilizers, and pesticides among others to prevent their crops from pests and diseases infestation in their developmental stages. Furthermore, the study reveals that most of the farmers use members of their families as their source of labour. This is because of inadequate fund to pay laborers per day which will engulf a lot of money. However, some of the farmers do have laborers to assist them since their children are not with them, but schooling in other places.

Type of Tools Used

Tools used by farmers for cultivation as observed during the course of study include local hoes, cutlasses, iron and rubber buckets for fetching of water, and water hose among others. These are local farm implements used by the farmers for the cultivation of crops. This is because of inadequate fund for modern farm implements that will make their work easier. It is also among the reasons why farmers in the area cannot cultivate large expanse of land because of the intensive labour involved.

Irrigated Crops

These are the crops cultivated using an irrigation system to make water available to them. These crops include cereals such as maize, leguminous crops such as sweet potatoes, vegetables such as tomatoes, onions, garden egg, pepper, cabbage, and green leaves among others. Others include fruits such as bananas and plantains. Sugar cane which is a grass plant is also cultivated in large quantities in the study area during the dry season. These crops need different amount of water at different developmental stages in order to thrive well, as such the need for sustainable irrigation system to make water available to all the crops in the right proportion for better yield. These findings at the different irrigation sites are summarized on table two.

Table 2: Summary of observations carried out at irrigation sites

S/N	Irrigation Site	Location	River Width (M)	Farm Implement	Irrigation Type	Irrigated Crops	Source of Funding
1	Gimi River	Lat 9º 21' 52'' N Long 8º 16' 33''E	27	Hoes, cutlasses, buckets, water hose	Small Scale	Garden egg, okra, Sugarcane, Pepper, Cassava, Spinach, Banana, Maize,	Self – funding
2	Saminaka River	Lat 10º 26' 46''N Long 8º 39' 04''E	55	Hoes, Cutlasses, Buckets, Pump, Water hose	Small Scale	Potatoes, Okra, Jute, Tomatoes, Pepper Banana, Cassava, Spinach, Lettuce, Melon, Sugarcane, Pumpkin, Ugwu	Self – funding
3	Kachia River	Lat 9º 51' 51''N Long 7º 57' 26''E	40	Hoes, Cutlasses Pumps, Buckets Water hose	Small Scale	Sugarcane, Pepper, Onions, Maize,Okra, Spinach, Tomatoes, Garden egg, Ugwu, Banana	Self – Funding
4	Ashafa River	Lat 9º 41'14''N Long 8º 10' 57''E	13	Hoes, Cutlasses, Pumps, Water hose, Buckets	Small Scale	Pepper, Okra, Maize Garden egg, Banana, Sugarcane, Cassava, Tomatoes	Self – Funding

Source: Authors' Fieldwork April, 2023.

CONCLUSION

The study reveals that farmers practicing irrigated agriculture in southern Kaduna have only one source of water, the river. Water usually overflow river banks in the rainy season, but reduces or dry up during the dry season. This has led to scarcity of water during the dry season for irrigation. It is a set-back to irrigated agriculture in the area. Secondly, the farmer owned scheme is what is practiced in the area. Farmers cultivate between two to four hectares of land during the dry season due to financial constraint. Financial constraint has also led to the use of local farm implements by the farmers, as well as the use of domestic labour to maximize profit. Last but not the least is the irrigation system practiced in the area. This study reveals that farmers still use the traditional method of irrigation. That is, the surface irrigation system, the basin irrigation system in particular. Previous studies in other parts of the world reveal that this system is not that efficient as its disadvantages are more than the advantages. This system of irrigation favor particular type of crops which the farmers are not aware of, as such may be the reason for poor yield sometimes experienced by the farmers in the study area as rightly observed by Adamala (2016) and FAO (2017). The study further reveals that farmers drill boreholes or tube - wells on the river bed due to

scarcity of water to irrigate their crops. This can destroy the river system as it is not an appropriate means of coping with water scarcity. They are tempering with the natural system of the river which may affect it subsequently. The study also reveals the fact that this system of farming is dominated by males who belong to the work force population group in the study area. Finally, farmers cultivate almost the same type of crops in all the sites investigated. This is not healthy to the economy of the area. This is because there are no varieties of crops to attract consumers, and the available ones are all over the market at the same time which will make farmers to sell their goods at giveaway prices which will definitely affect the farmers profit at the end of the day.

Based on the findings of this study, we give the following recommendations;

a) The study reveals that farmers in southern Kaduna use rivers as the only source of water for irrigation. Hence, the need for the construction of earth dams or dams in the area to reserve water during the rainy season so as to check overdependence on rivers during the dry season. Other sources of water such wells and boreholes (groundwater) can be explored. The can be constructed within the farm area instead of drilling them on river beds, which can be detrimental to sustainable use of the rivers. The use of groundwater for irrigation have been very effective in boosting irrigated agriculture in the northern part of the country and the developed world. Non – governmental organizations, local government areas, state government and the federal government can come together and take up this project to boost agricultural production in the area and the country at large. This will also check the issue of digging borehole and wells on river beds in order to sustain the rivers in the area.
b) Farmers in the area are still using traditional system of watering plants. This system has proved to be ineffective hence, the need for farmers to shift from basin irrigation to either drip or sprinkler irrigation system. These systems are more effective but capital intensive. These systems have been embraced by developed countries to boost irrigated agriculture in their countries (Musa et al, 2021; Adamala, 2016; Adelodun and Choi, 2018). Moreover, since the equipment are expensive soft loans can be given to farmers to encourage them to embrace these systems of irrigation for a better tomorrow.
c) Farmers in the area need to upgrade from farmer – owned schemes which involved small scale farming to large irrigation schemes that deal with large hectares of land. This can be made possible if government at the three levels will help farmers with capital to acquire modern farm implements, incentives, and tractors that can cultivate large expanse of land to encourage them. This will help in checking the use of domestic labour which affects their productivity because of small hectares of land cultivated. This will also lead to the cultivation of different varieties of crop which will improve the standard of living of these farmers and the economy at large since this type of project is capital intensive.
d) There is need to introduce the cultivation of rice during the dry season. This crop will thrive well using the basin irrigation system. It will also add to the variety of crops irrigated in southern Kaduna. This will not only add to the standard of living of the farmers but will go a long way to complement the production of rice in rainy season as well as improve the economy of the study area and the nation at large.
e) Based on the biodata of farmers obtained in the course of study, women in southern Kaduna need to be encouraged to be part of this system of farming by providing farmlands and other agricultural incentives to boost production in the area. There is need to encourage those into agriculture to improve themselves education wise as this will help them produce better crops as well as inform them on sustainable use of their environment for the present and future generations.

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Analysis of Some Rainfall Parameters and Guinea Corn (Sorghum Bicolor (B) Moench) Yield in Katsina State, Nigeria

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ABSTRACT
Amount in rainfall and length of growing season directly or indirectly influences agriculture activities especially rain fed cultivation which serve as a source of income to farmers. This work examines some rainfall parameters and their relationship with Guinea Corn Yields in Katsina State, Nigeria. Secondary data of rainfall and Guinea corn yield were obtained from Nigerian Meteorological Agency Abuja and the State Agricultural Development Programme respectively for 30 years (1986 – 2015). The data were analyzed using simple descriptive statistics, correlation analysis was used to evaluate the relationship between selected rainfall parameters and Guinea Corn Yields. Finally, linear regression was used to assess the combine effect of the rainfall parameters on the yield of Guinea corn. Findings showed that only total annual rainfall exhibited a strong positive relationship with Guinea corn yield with a correlation coefficient r = 0.547. The result of the linear regression showed that 54% of the final yield of sorghum in Katsina state is attributed to the combine effect of the rainfall parameters under investigation. The research therefore concluded that total annual rainfall is very significant in the yield of sorghum and therefore recommended some soil moisture conservation techniques to enhance increased corn yield in the state.

Keywords: *Rainfall amount, Growing season, Relationship, Guinea corn, Yield, Rain fed.*

INTRODUCTION
Rainfall is one of the most important natural factors that determine the agricultural production in Nigeria, particularly rain fed agriculture in the northern part of Nigeria (Binbol and Zemba, 2007). The amount of rainfall extreme high or low received are very important for agriculture as well as the economy of an area. It is well established that rainfall is changing at both the global and the regional scales due to global warming (Kayano, 2008). As the moves to encourage agriculture to ensure food security continues to gain ground and acceptability, information on rainfall amount and its relationship with agriculture (Guinea corn) is vital for the design of water supply. Such information can also be beneficial in determining the best adapted plant species and the optimum time of seeding to reestablish vegetation on deteriorated rangelands. Much as long rainfall records are mostly available in many countries, little use is made for this information because of the unwieldy nature of the records (Mina and Sayedul, 2012). According to researches the current rainfall amount across the north-western part of the country has been a source of concern to the inhabitants, especially those who rely on it for their economic activities (Abaje et al, 2014).

Growing season according to Odekunle (2004) is defined as the period of the year during which rainfall distribution characteristics are suitable for crop germination and full development. It is the period of the year categorized as rainy or wet season. Walter (1967) also stated that the length of the growing season could be taken as the period between the onset and the cessation date which may be determined by calculating the number of days in between the onset date and the cessation date. Downward trend in the duration (length) of the growing season in some locations in northern Nigeria was observed by Ati, et al (2002).

Tantawi and Saleh (2013) carried out a research on the impacts of rainfall and growing season changes on food crops yield in Katsina, Northern Nigeria and revealed that considerable high variability in the number of days in between the onset date and the cessation date decreased over study period. They used data on yield of food crops (Millet, maize, Sorghum) to investigate the possible impacts of rainfall on food crops yield in the study area and pointed out that, there was no clear pattern shown for the trend in onset dates. If the present downward trend in onset dates continues, a statistically significant shift in growing season may be expected, and then the impacts on food crop yield will be very high but if the downward trend reduced the impact will be low, and further revealed that Sorghum yield was significantly correlated with onset and cessation dates, June, July, August and September rainfalls. It also correlated with annual rainfall and length of growing season. No significant

correlation between Sorghum yields with May, October rainfall.

Emmanuel and Ujoh (2013) investigated the effect of variability in rainfall characteristics on maize yield in Gboko, Nigeria. Findings revealed that the correlation between rain days and rainfall amount had positive relationship (r = 0.47 and r = 0.39, respectively) with maize yield. It was also observed that the rainfall characteristics jointly contributed 67.4% variations in the yield of maize per hectare. The results also revealed that number of rain days and annual rainfall amount have the strongest influence on maize yield per hectare in the study area.

Oruonye, *et al* (2016) in their research work on the effect of rainfall variability on maize yield in Gassol Local Government area in Taraba state, showed that rainfall is increasing, while onset is delayed and cessation is early. The study also showed that onsets of rainfalls are becoming more uncertain and unpredictable with dry spells after planting, it furher revealed that there is a low relationship between maize yield and total annual rainfall. A reliable estimation of the onset and cessation dates of the rain could help to maximise rainwater use by farmers if put into considerations. It observed based on the foregoing that there are no much studies on annual rainfall amounts, rain days and length of growing season and their relationship on Guinea corn (sorghum bicotor (L) moench) yields in Katsina State. Therefore, it is on this basis that this study seeks to examine in detailed the effect of annual rainfall amount, rain days and length of growing season on the yield of guinea corn in Katsina state for a period of 30 years.

MATERIALS AND METHODS

The Study Area

Katsina state is located in the north-western part of Nigeria. It is bounded by latitudes11º32N to 11º53N of the equator and longitude 7°19′E and 7°31'E, of the Greenwich Meridian (Fig 1). It is bounded in the north by Niger republic, in the east by Jigawa and Kano states, in the south by Kaduna state and in the west by Zamfara state. Katsina state has a total land mass of about 24,192km² (9.341sqmi) with a total population of about 8,682,529 million people according to 2023 population projection.

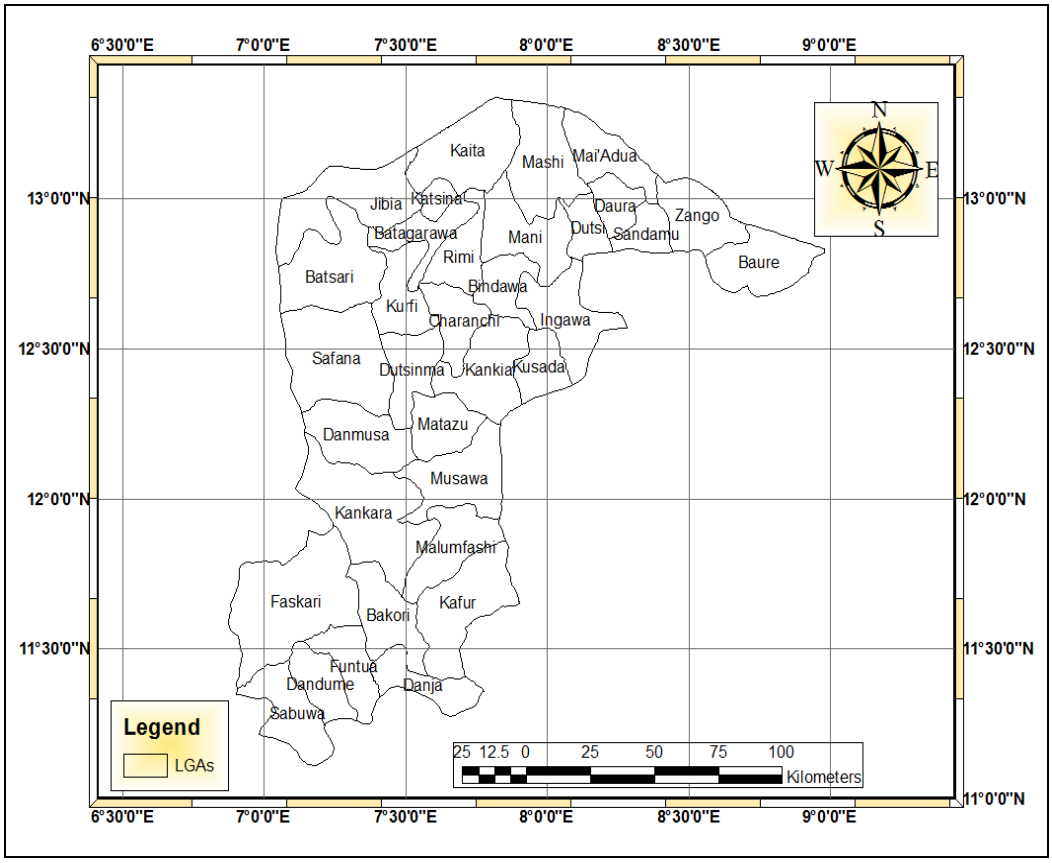


Figure 1. Katsina State, Nigeria

The climate is tropical characterized by wet and dry seasons. Maximum temperatures ranges between 29.0 – 38.0ºC while the Minimum temperature fluctuates between 18.0 - 27.0ºC

respectively. Harmattan season is well pronounce from November – February. Rainy season commences from April to September. The mean average rainfall ranges from 400 - 1300mm with maximum down pour in August. The vegetation cover of Katsina state consists largely of shrubs with some wooded savanna trees in the southern part of the state. Agriculture and livestock rearing forms the major occupation of the people.

Method of Data Collection

The research made use of secondary data obtained from the Nigerian meteorological services department (NiMet) in Katsina. Daily rainfall records for a period of 30 years (1986 – 2016 was abstracted from NiMet archive. The data was analyzed for parameters like length of rainy season, number of raindays per annum and total annual rainfall. Another secondary date in the form of annual yield of guinea corn was also obtained from the state agricultural development program (ADP) and national food reserve agency for a period of 30 years commensurate with the rainfall record. The total yield obtained was divided with total area cultivated to obtained yield in tons per hectare.

Method of Data Analysis

The daily rainfall record was summarized into monthly values from which the onset and cessation period for each year was calculated using Walter (1967) method. The length of rainy season (LRS) was then calculated as the number of days between the onset and cessation period. The daily rainfall data was further subjected to frequency count to establish the number of days rain actually falls in each year. A rainday for this study was determined using the NiMet standards of at least 0.25mm of rain recorded per day. Finally, the total daily rainfall occurring in the year was summed up to give the total annual rainfall.

Graphs and charts were used to plot the annual variability of parameters under observations. A trend line was imposed on each to establish the pattern of behavior over the study period. Product moment correlation analysis was used to established bivariate relationship between each parameter and the yield of sorghum. Finally the research used regression analysis to determine the combine effect of the parameters on the yield of sorghum.

RESULTS AND DISCUSSION

A descriptive statistics of all parameters under investigation is presented on table 1. Findings on table 1 shows that out of the 30 years period, the average rainfall stands at 594.21mm with the lowest being 262.60mm and 1310.20 being the maximum rainfall ever recorded. These occurred in 1993 and 2007 respectively. Other parameters summarized and presented on table 1 include length of rainy season (LRS), number of rain days (NoRD) and yield.

Table 1. Descriptive statistics of parameters studied

	N	Minimum	Maximum	Mean	Std. Deviation
AnnRF	30	262.60	1310.20	594.2100	223.72797
LRS	30	80	169	124.60	20.441
NoRD	30	32	90	45.67	10.213
Yield	30	.56	1.90	1.3580	.33403
Valid N (listwise)	30				

Trend Analysis of Rainfall Parameters and Yield of Sorghum

A trend analysis of rainfall in Katsina state for the study period shows that rainfall has been very variable. Rainfall values ranges from 262.60mm (lowest) in 1993 to 1310.20mm (highest) in 2007, however, the imposition of a regression trend line on the variable pattern shows that on the overall average rainfall for the 30 years period stands at 402.84mm. the regression equation generated reveals that over the 30 years under study, rainfall has been increasing steadily by about 12.35mm annually and this represents about 24% increased annually as explained by the coefficient of determination $r^2 = 0.236$ (see figure 2). In the same vein, trend analysis of other parameters used in the study shows tendencies towards increasing values. These are presented on figures 3, 4 and 5 respectively.

A cursory look at figure 3 shows the annual pattern of the length of rainy season (LRS) in Katsina over the study period (1987 – 2016). This period is also referred to climatologically as the hydrologic growing season (HGS) because it is the period between the established onset and cessation dates of the rainy season in any given year.

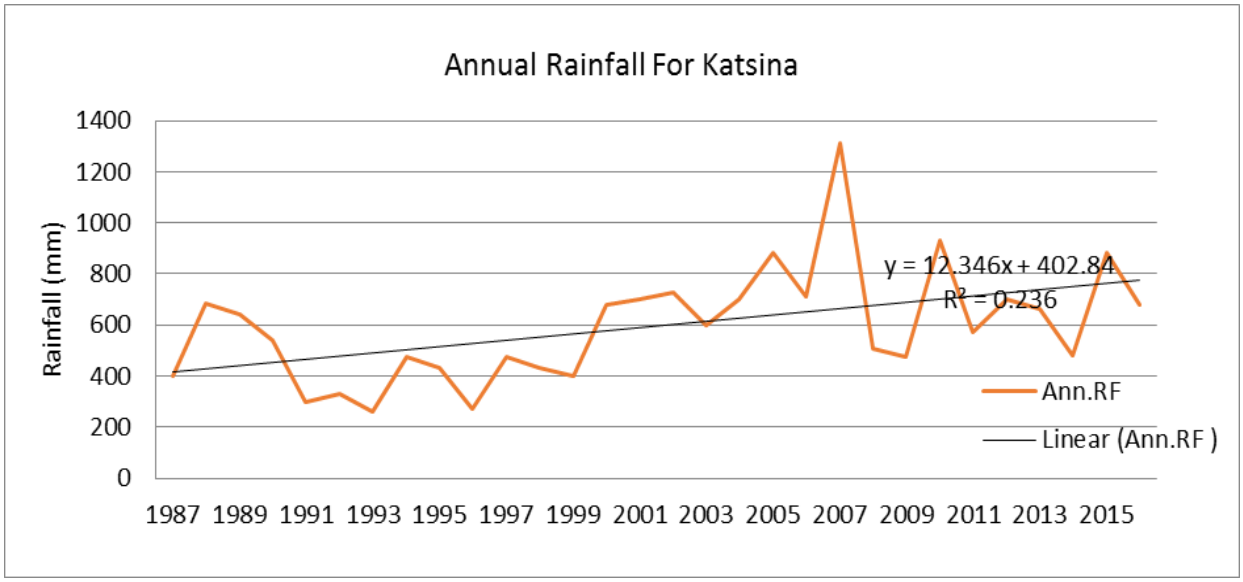


Figure 2. Trend of Total Annual Rainfall in Katsina.

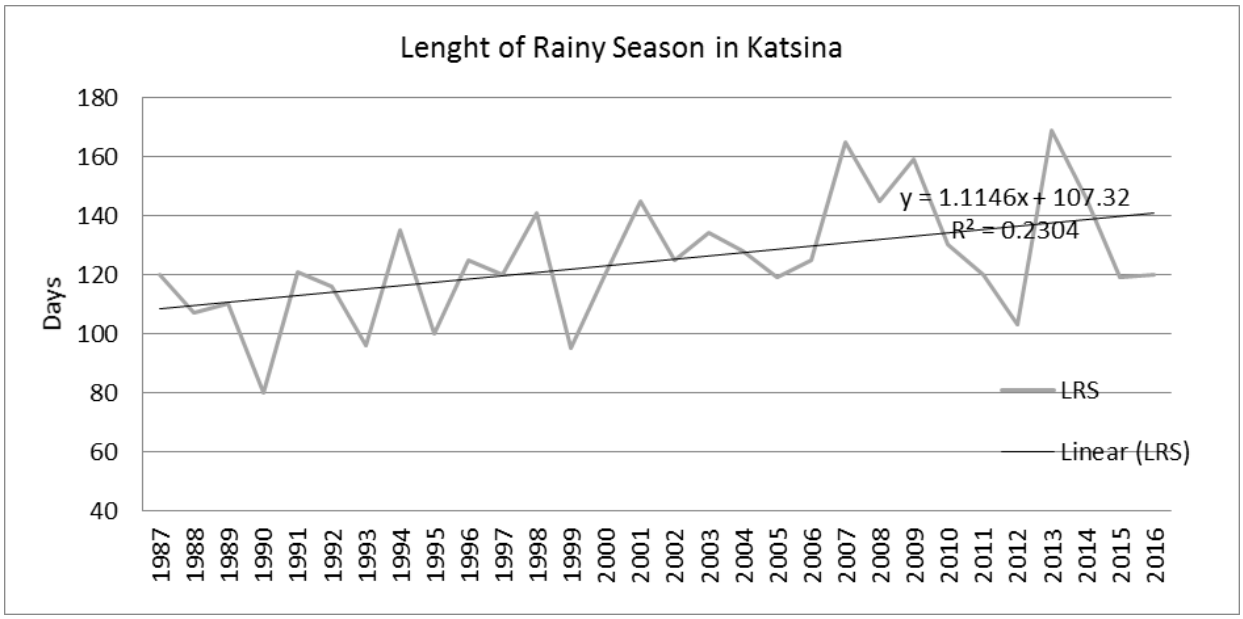


Figure 3. Trend of Growing Season or Length of Rainy Season

The calculated onset dates does not necessarily means the date a particular location receives its first rains but rather the date on which crop cultivation can be guaranteed because the location has received enough rainfall to support crop survival. Findings for Katsina state shows that the length of the hydrologic growing season is also highly variable, ranging from 80 to 169 days. However, the average for the study period and location is 107 ± 1day.

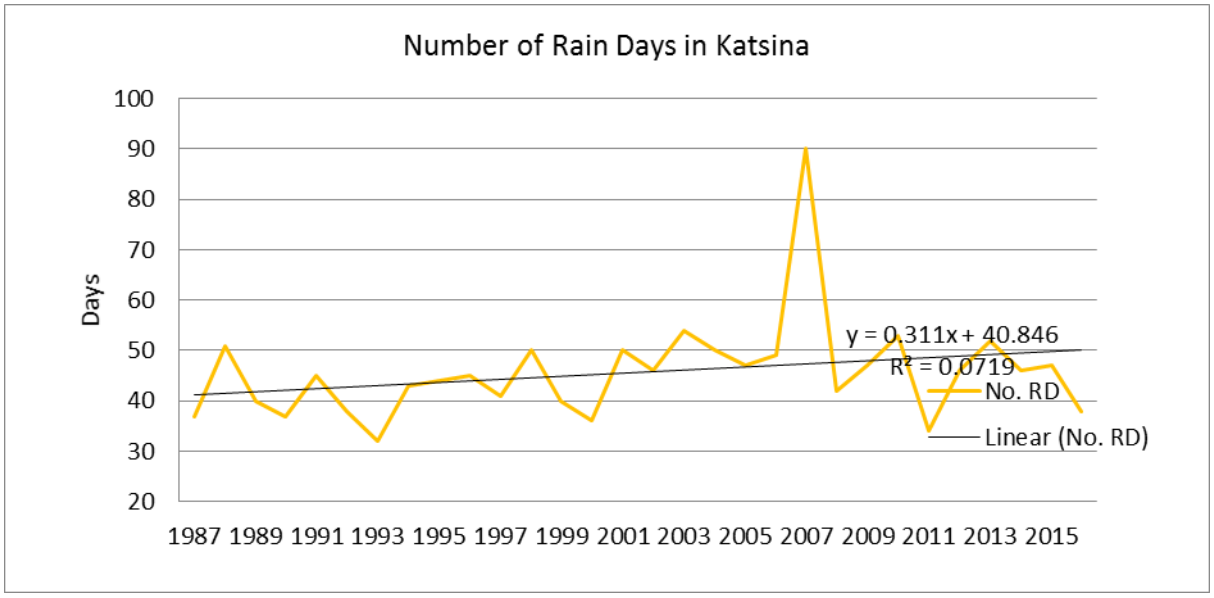


Figure 4. Trend of Number of Actual Rain Days in Katsina

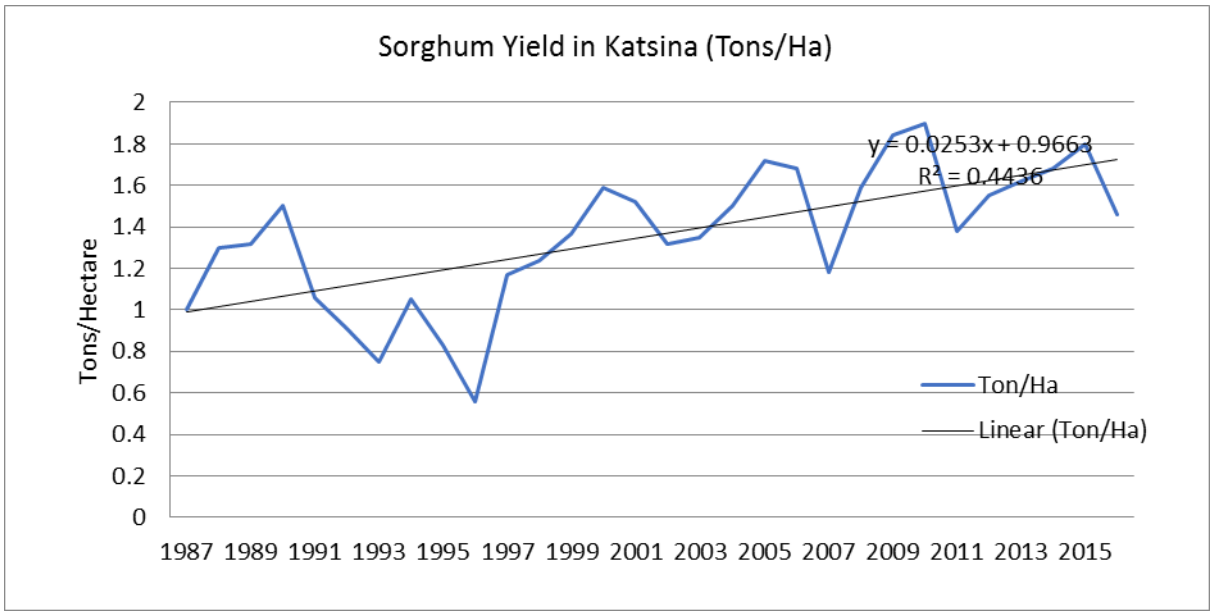


Figure 5. Trend of Guinea Corn Yield in Katsina State

The number of rain days signify the actual number of days rain falls in any particular location. This was also calculated for Katsina and result presented on fig. 4. Earlier analysis showed that the onset dates for Katsina is around June/July and the rains also ceased early around September. This makes the actual number of days rain fall in Katsina to range between 32 to 90 days in a year. However, the calculated average for the study period is 41 days (see fig. 4).

The average yield of guinea corn (sorghum) in tons/hectare within the study period for Katsina has equally been highly variable ranging between 0.56 to 1.90 tons/ha. However, mean yield observed for the study period stands at about 1.0 tons/ha with a possible annual increment of 0.03 tons/ha. It is this observed variability in rainfall parameters and yield in Kasina that necessitate the investigation of the relationship between rainfall amount and timing on the yield of guinea corn in Katsina state.

Relationship between Rainfall Parameters and Guinea Corn Yield in Katsina.

The Pearson product moment correlation analysis was used to test the relationship between identified rainfall parameters and the yield of sorghum, the finding is presented on table 2.

Table 2. Correlations between rainfall parameters and guinea corn yield in Katsina State

		AnnRF	LRS	NoRD	Yield
AnnRF	Pearson Correlation	1	.317	.704**	.547**
	Sig. (2-tailed)		.088	.000	.002
	N	30	30	30	30
LRS	Pearson Correlation	.317	1	.583**	.285
	Sig. (2-tailed)	.088		.001	.127
	N	30	30	30	30
NoRD	Pearson Correlation	.704**	.583**	1	.142
	Sig. (2-tailed)	.000	.001		.454
	N	30	30	30	30
Yield	Pearson Correlation	.547**	.285	.142	1
	Sig. (2-tailed)	.002	.127	.454	
	N	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

Findings on table 2 shows that all rainfall parameters tested exhibited positive relationship with the yield of sorghum in Katsina. However, number of rain days and growing season exhibited weak relationship. Only annual total rainfall showed a strong positive relationship with the final yield of sorghum in Katsina with a correlation coefficient r = 0.547. The relationship is significant at the 99% confidence level on the two tail test. This means that an increase in total annual rainfall will lead to a commensurate increase in the yield of guinea corn. This finding agrees with the work of Sawa (2002) and Ikpe (2014) who both observed that sorghum yield increases in Katsina as rainfall amount equally increases.

Results on table two further shows that a strong positive relationship exist between total annual rainfall and number of rain days (r = 0.704). this simply means as total annual rainfall increases so does the number of rain days. If the annual rainfall amount is small that the number of days the rain fell was equally small. There was also a strong positive correlation between the length of the growing season and the number of rain days with a correlation coefficient of r = 0.583. This means the longer the rainy season stretches, the more the number of days rain will fall (Olanrewaju and Fayemi, 2008).

Table 3. Combined effect of rainfall parameters

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.736[a]	.542	.489	.23869

a. Predictors: (Constant), NoRD, LRS, AnnRF

The research went further to analyze the combine effect of rainfall parameters on the yield of sorghum in Katsina. The yield of sorghum was the dependent variable while the rainfall parameters of number of rain days, length of rainy season and total annual rainfall were the independent variables. Result obtained is presented on table 3. Findings on table 3 shows that the combine effect of the rainfall parameters on the yield of sorghum exhibited a strong positive relationship with correlation coefficient r = 0.736. The coefficient of determination r2 shows that the combine effect of the rainfall parameters accounted for 54% of the yield of sorghum in Katsina state. The regression residue of 46% explained the contribution of other inputs into sorghum yield that were not considered in this current study such as soil fertility, cultural practices etc. this significant finding aggress with the works of Ikpe et al (2020) who examined trends in rainfall onset, cessation and length of growing season and its implication on sorghum yield in the same location and found out that each exhibited positive contribution.

CONCLUSION

A critical analysis of how three rainfall parameters; Number of rain days, length of rainy season and total annual rainfall contributes to the final yield of guinea corn (sorghum) in Katsina was undertaken. The use of bivariate analysis showed that while total annual rainfall had direct effect on the yield of guinea corn, it also affects the number of rain days and the number of rain days in turn affects the length of growing season. However, the use of regression

technique showed that jointly, the three rainfall parameters under investigation accounted for 54% to the final yield of guinea corn in Katsina. The research therefore concluded that because of high temperatures in Katsina, there is the need to encourage and intensify soil moisture conservation techniques such as mulching and zero tillage on large scale to guarantee guinea corn yield and help in ensuring food security in the state and country at large.

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Analysis of Farmers' Awareness and Adaptation Strategies to Climate Change in Kachia Local Government Area, Kaduna State, Nigeria

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ABSTRACT
The study analysed farmers' awareness and adaptation strategies to climate change in Kachia Local Government Area of Kaduna State, Nigeria. The study design involved the collection and analyses of rainfall and temperature from (1970 – 2021) for the area. The rainfall and temperature data were used to characterise the climate of the study area. Krejcie and Morgan's sampling techniques was used to purposively sampled 384 farmers. Structured questionnaire was administered on the sampled farmers. The data were analysed using trend line equations, mean score, standard deviation and Likert-type rating. The results of the analyses are presented in tables, percentages and charts. The results of the trend line equation showed an increase in total annual rainfall and increase in temperature within the period reviewed. The results show that 89% of the respondents were aware of climate change; 68% got their knowledge about climate change from radio. The farmers perceived effects of climate change in the study area was reflected in the gradual reduction of vegetative cover as observed by 84%; 62% observed that the changing climate has led to crop infestation and diseases by pest; 47% strongly agreed that there are incidences of flood after rainfall. The result further stated that planting of different varieties of crops was the most used adaptation strategies in the study area followed by mixed cropping and use of organic manure. Based on the findings of the study, major recommendations made include adequate provision of weather forecast records and climate related data for the farmers and encouraging farmers to participate in agricultural extension services which will educate them on the effects of climate change and viable adaptation strategies in the study area.

Keywords: *Awareness; Climate change; Farmers; Rainfall; Temperature*

INTRODUCTION
Climate change has continued to witness a growing worldwide awareness with large population areas in most developing nations left vulnerable to the extremities and anomalies caused by these changes (Intergovernmental Panel on Climate Change [IPCC, 2022]). Federal Ministry of Environment, (2003) reported that these climatic extremities appear in form of floods, drought, famine and heat waves in many areas, and have resulted to devastating effects on human existence, crop productivity and food security, with many households affected economically and health-wise.

Climate change is a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, which persists for an extended period typically decades or longer. Climate change, in the most general sense, encompasses all forms of climatic inconstancies (that is, any difference between the "long-term" statistics of the meteorological elements calculated for different periods but relating to the same area) regardless of their statistical nature or physical cause (IPCC, 2007). In other words, it is a long-term change in the statistical distribution of weather patterns over time that range from decades to millions of years. The change could be limited to a specific region or may occur across the globe. Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since 2000 (IPCC, 2021).

Adaptation to climate change is an adjustment made to human, ecological or physical system in response to vulnerability (Adger, et al., 2007). According to Oladipo (2008), adaptation to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. Adaptation, technically, is the appropriate way to deal with the unavoidable impacts of climate change. It is a mechanism to manage risks, adjust economic activity to reduce vulnerability and to improve business certainty.

Environmental awareness is the means by which we seek to understand environmental

phenomena in order to arrive at a better use of environmental resources and a more effective response to environmental hazards. The processes by which we arrive at these decisions include direct experience of the environment (through the senses of taste, touch, sight, hearing and smell) and indirect information from other people, science, and the mass media. The study of environmental perception and awareness has to encompass all these means of processing environmental information and to place the individual psychological processes of prediction, evaluation and explanation into a relevant social and political framework (Doss and Morris 2001).

Farmer's awareness of climate change issues influences the type of adaptation strategies they adopt. This awareness may mediate human interaction with the environment (Burton, et al., 2002). According to Raden-Fessenden and Heath (1987), people base their awareness upon their personal experiences, observations, knowledge and character. Human responses to environmental issues have been broadly categorized as cognitive (related to knowledge and understanding), affective (related to feelings, attitudes, and emotions), behavioural (related to changes in behaviour of the viewer), and physiological (biological or physical effects on the observer's body) (Zube, et al., 1982).

Awareness determines the social mental picture of climate change. It is reasonable to argue that the first step towards adaptation is the awareness of the problem. Farmers' ability to perceive climate change is a key precondition for their choice to adaptation. Farmers with little or no awareness of climate change may not be able to fully take advantage of the technical and economic opportunities around them since adoption of adaptation strategies only takes place after awareness.

Reports from previous studies on climate change awareness and adaptation (Ejeh 2014; Ikpe, 2021; Bambale, et al., 2022) has shown that a significant number of Nigerian farmers are aware of climate change issues, although, their sources of information and approaches to adaptation strategies differs. Previous results further show that some farmers got their information on climate change from personal observations, radio, television, schools and printed materials among others.

Are the farmers in Kachia Local Government Area (LGA) aware of climate change issues? If yes, what are their sources of information and what measures have they put in place to cope with the impact of the change? It is on this premise that this research seeks to examine farmer's awareness and adaptation strategies of climate change in Kachia LGA, Kaduna State. The aim of the study is to analyse the level of awareness and adaptation strategies of farmers to climate change in Kachia LGA of Kaduna State.

MATERIALS AND METHODS

Study Area

The study area is located between Latitudes 9° 33"N to 10° 11"N of the Equator and Longitudes 7° 10"E to 8° 08"E of Greenwich Meridian. Kachia LGA is bordered to the north by Kajuru and Chukun LGAs, to the east by Zango Kataf LGA, to the south by Jaba and Kagarko LGAs and to the West by Niger State (Fig. 1). The area consists of twelve (12) electoral wards (Agunu, Ankwa, Awon, Bishini, Dokwa, Gidan Tagwai, Gumel, Kachia, Kateri, Kurmin Musa, Kwaturu, Sabon Sarki (Ishaya, 2014).

The area lies within North central plateau, with a relief of between 712-742 meters characterised by outcrops of hills. The area is drained by numerous tributaries which include: Rivers Kachia, Ariko, Kurmin Taba, Nabiyu, Ungwa Pa River, among others. These drains into river Gurara. Most of the streams are seasonal (Rimau, 2011). The study area is characterized by Tropical Continental climate, with distinct dry and wet seasons. The dry season is between November and April, characterized by harmattan, while the wet season commences between April and May. The area experiences high mean annual rainfall of about 1525mm. Maximum temperature is about 28°C, recorded in March and April, just before the onset of rainfall with mean monthly minimum temperature of about 13°C occurring in December and January (Wendock, 1993). The area falls into the ferrugenous tropical soil classification, which is mainly derived from the weathering of basement complex rocks. The study area falls within the Guinea savanna vegetation belt. The appearances of vegetation however, changes with season.

Kachia LGA has an estimated population of about 368,853 (2023) using geometrical method of population projection at 3% growth rate from the 2006 National population census. The people of the area are of diverse tribes such as Jaba, Adara, Baju, Kuturmi, Koro, Hausa, Fulani, and Igbo. The main economic activity in Kachia is agriculture and the bulk of agricultural production is undertaken by small scale farmers (Rimau, 2011). The major crops cultivated are cereals, such as maize, sorghum, millet and cash crops like ginger. Also, it has an alluvial soil which encourages the cultivation of rice, sugarcane, cassava, yam, and cocoyam (Musa, 2004).

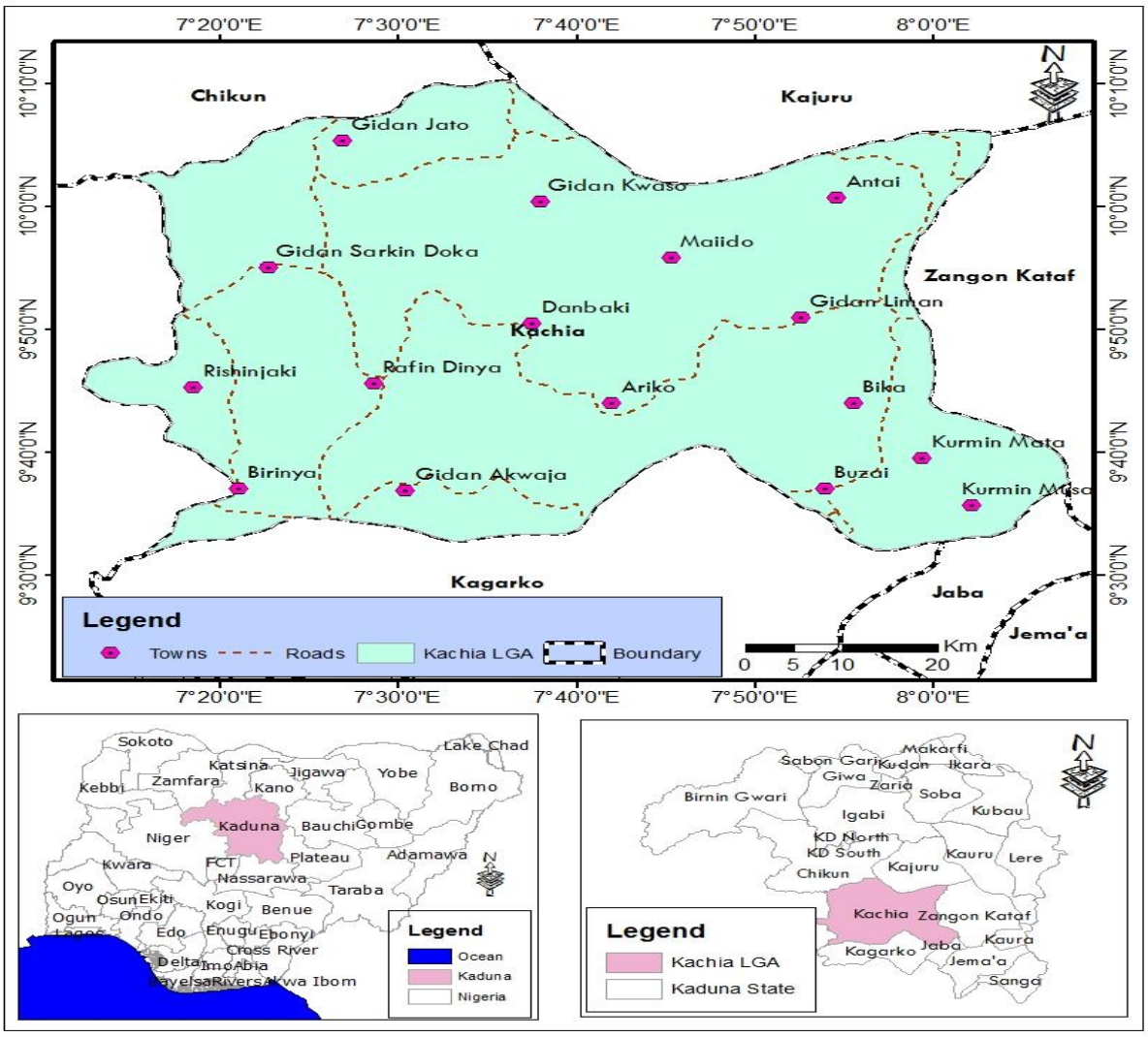


Figure 1: Kachia LGA, Kaduna State
Source: Adapted from the administrative map of Kaduna State.

Methods of Data Collection

Rainfall and temperature data (1970 – 2021) were collected from the Nigerian Meteorological Agency (NiMet). The data were used to characterise the climate of the study area. Krejcie and Morgan's (1970) method of determining sample size was employed to determine the sample size; a total of 384 respondents were sampled for questionnaire administration. The 384 questionnaires were distributed equally among the 12 wards for wants of actual population figures for the localities for proportional distribution. Thirty-two respondents were purposively sampled from each ward.

Methods of Data Analysis

Trendline equations were used to analyse the rainfall and temperature data (1970-2021). The data were used to characterize the climate of the study area. Descriptive statistics were used to analyze the socio-demographic data. The questionnaire uses Likert Rating Scale (LRS). The five-point LRS was assigned numerical values thus: SA (Strongly Agree) =5; A (Agree) =4; D (Disagree) =3, and SD (Strongly Disagree) =2 and U (Undecided) =1. Thus, 3.0 was the decision mean, implying that any mean score above 3.0 will be accepted as being significant. Mean score ($\overline{X}$) and Standard Deviation (SD) were used to present the results.

RESULTS AND DISCUSSION

Table 1 shows that 78% of the farmers are male, while 22% are female. Majority of the farmers (32%) are within the age bracket of 30 – 40; 28% were between the ages of 41 – 50 years; 15% are within the ages of 51 – 60 years; 19% were between 61 – 70 years and 6% were 71 years and above (Table 1). On the social status of the farmers, 53% were family heads; 3% were village Heads; 2% were community Heads and 42% are mere farmers. Majority of the farmers are married (74%); 13% are single; 9% are widowed and 4% are divorced.

Table 1: Demographic characteristics of the farmers

Distribution of Farmers by Sex		
Variable	**Respondents**	**Percentage**
Male	301	78
Female	83	22
Total	**384**	**100**
Distribution of the Farmers by Age		
Age	**Respondents**	**Percentage**
30 – 40	124	32
41 – 50	108	28
51 –60	57	15
61 – 70	72	19
71 & above	23	6
Total	**384**	**100**
Social Status of the Farmers		
Status	**Respondents**	**Percentage**
Community Head	6	2
Village Head	12	3
Family Head	205	53
Others	161	42
Total	**384**	**100**
Marital Status of the Farmers		
Marital Status	**Respondents**	**Percentage**
Married	284	74
Divorced	14	4
Single	50	13
Widowed	36	9
Total	**384**	**100**
Distribution of Farmers by Level of Education		
Level of Education	**Respondents**	**Percentage**
Primary	36	9
Secondary	184	48
Tertiary	40	10
Adult Education	32	8
Koranic	92	24
Total	**384**	**100**
Farmers' Years of Residency		
Years of Residency	**Respondents**	**Percentage**
1-10	10	3
11-20	201	52
21-30	111	29
>30	62	16
Total	**384**	**100**
Years of Farming Experience		
Years of Experience	**Respondents**	**Percentage**
1-10	37	10
11-20	178	46
21-30	117	30
>30	52	14
Total	**384**	**100**

Source: Field work, 2023

The educational level of the farmers is presented on Table 1. Majority of the farmers (48%) had secondary education; 9% had primary; 10% had tertiary; 8% had adult education while 24% had Koranic education. According to Enete et al., (2011), education has a positive and highly significant

relationship between the farmers' level of education with the level of investment in indigenous and emerging climate change adaptation practices. This is to be expected as educated farmers may better understand and process information provided by different sources regarding new farm technologies, thereby increasing their allocation and technical efficiency.

Fifty-two percent of the farmers had 11 – 20 years farming experience in the area; 46% had been farming in the area for 11 – 20 years, while 30% had been farming for about 21 – 30 years in the study area. The farming experience of farmers to a large extent affects their managerial know-how and decision-making. Besides, it influences the farmers understanding of climatic and weather conditions as well as socioeconomic policies and factors affecting farming.

The farmers' level of awareness of climate change and their sources of information are presented on Table 2. The result shows that 89% of the farmers are aware of climate change issues. On the sources of information, 68% of the respondents reported that they got their information from radio; 20% from television; 10% from newspaper and 2% from extension officers (Table 2).

Table 2: Farmers level of awareness of climate change and source of information

Farmers' Level of Awareness		
Level of Awareness	**Respondents**	**Percentage**
I am aware	339	89
I am unware	45	11
Total	**384**	**100**
Farmers' source of information on climate change		
Source of Information	**Respondents**	**Percentage**
Radio	261	68
Television	75	20
Newspaper	38	10
Extension officers	8	2
Other sources	2	0.5
Total	**384**	**100**

Source: Field work, 2023

Climatic characteristics of the study area

The Total Annual Rainfall (TAR) and temperature of the study area (1970-2021) were analysed and presented in Figures 2 and 3. Rainfall is the most variable of all climatic elements and determines the growing season in developing countries like Nigeria where agriculture is predominantly rain-fed. Almost every farmer is interested in what the expected rainfall would be, more than any other climatic elements as it determines the success or failure of crops. Timely and accurate weather forecasting and sharing are crucial to improve farming activities.

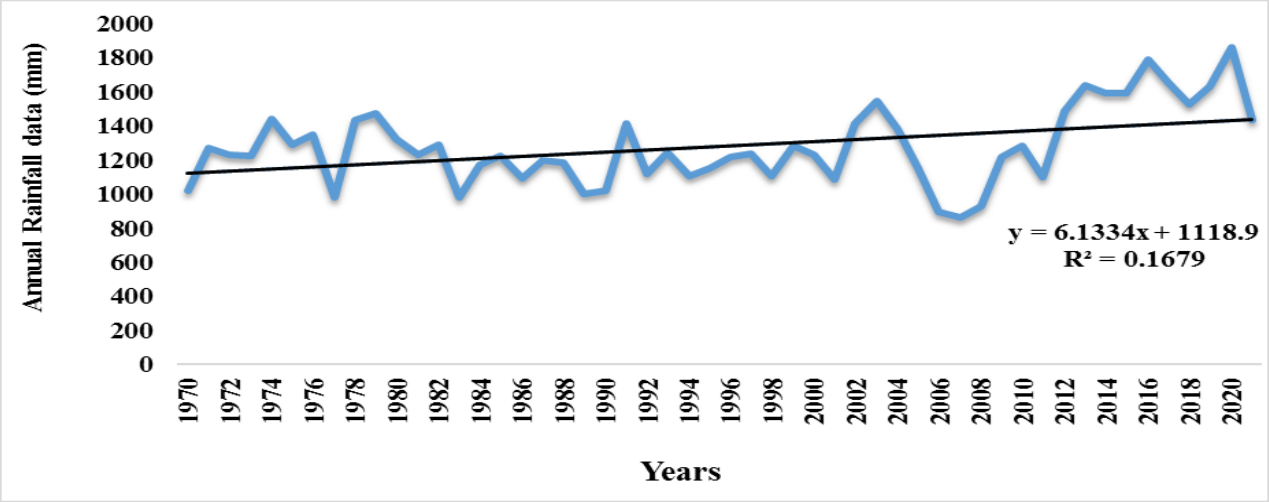


Figure 2: Trends in Total Annual Rainfall for the study area (1970 – 2021)
Source: NiMet (2022)

The trend shows a fluctuating, but increasing pattern in the TAR for the 51 years reviewed. That the TAR is increasing agree with the findings of Umar, et al., (2015) who stated that TAR is increasing in Sokoto State. According to Ayoade (2004), rainfall has more significant effect on inter-annual changes in crop yield in a tropical environment as it determines the supplies of water to plants. The regression equation generated by the trend line shows that TAR is on the increase and that it has the potential for further increase. The implication could result into soil erosion and flooding of farmlands.

Temperature plays a significant role in agriculture. In general, higher temperature is associated with higher radiation and higher water use. The average maximum and minimum temperature of the area is shown in Figure 3. The trend line equation for the average annual maximum and minimum temperature (1970-2021) shows increasing temperature (y = 0.0147x + 31.314 and y = -0.0153x + 20.771) respectively.

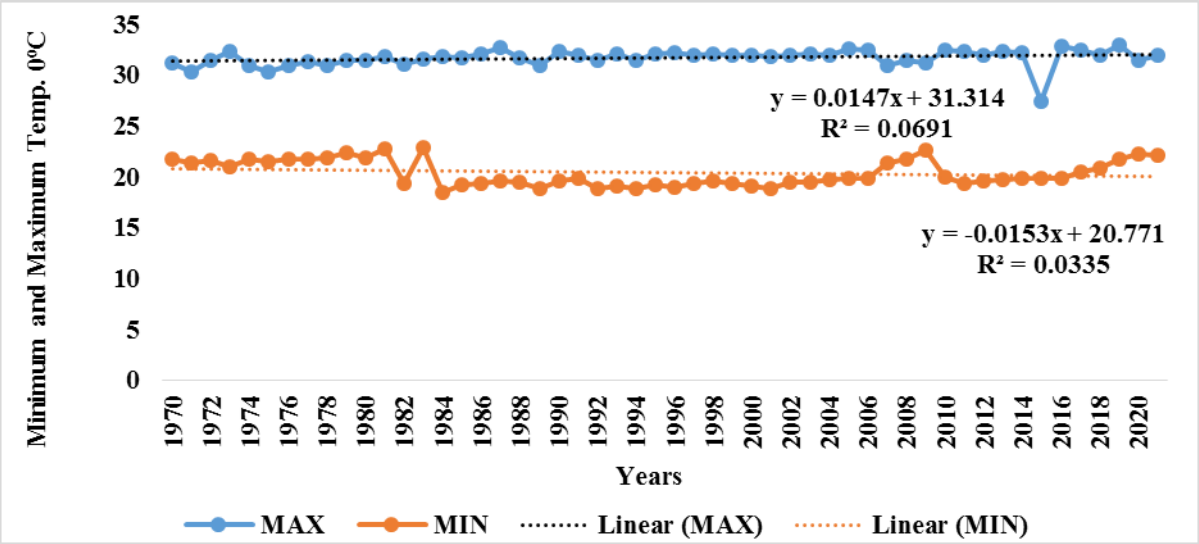


Figure 3: Trends in annual max. and min. temperature for the study area (1970 – 2021)
Source: NiMet (2022)

Farmers' awareness on rainfall and climate related issues

The farmers' awareness on rainfall and climate related issues were assessed and discussed. The farmers perceived that the green environment in the area is reducing as a result of climate variability as reflected in the mean value (4.2$\bar{x}$). The farmers also perceived that the dryness in the environment is increasing (3.2$\bar{x}$). The farmers reported increase in temperature (3.8$\bar{x}$), late onset of rainfall (3.6$\bar{x}$) and decrease in the total annual rainfall in the area (4.0$\bar{x}$). The fact that the farmers perceived late onset of rainfall in Kachia agrees with the study of Sawa, et al., (2014) who reported that crop farmers in Kano State perceived late onset and early cessation of rainfall as evidence of climate change in the area. The result further agrees with Umar, et al., (2015) who reported that 68% of crop farmers perceived early cessation of rainfall in Sokoto State as evidence of climate change.

Table 3: Farmers perception on rainfall and climate related issues

S/N	Perceptual Indicator	Mean ($\bar{x}$)	SD
1	The green environment in this village is reducing	4.2	2.04
2	The environment is increasingly becoming dry	3.2	1.78
3	Temperature is rising	3.8	1.94
4	Late onset of rainfall	3.6	1.89
5	Early cessation of rainfall	4.2	2.04
6	Total rainfall is decreasing every year	4.0	2.00

Source: Field work, 2023

***Significant Perception ($\bar{x} \geq 3.0$)**

The farmers' perception on rainfall and climate related issues were analysed and discussed. The farmers disagreed that the weather is becoming wetter every year. Table 4 also indicates that 33% of the farmers strongly agreed that the changing climate has led to crop infestation and diseases by pest; 29% agreed; 22% were undecided; 6% disagreed and 10% strongly disagreed that the changing climate has led to crop infestation and diseases by pest. The fact that majority of the farmers (62%) observed that the changing climate has led to crop infestation and diseases by pest concurs with the reports by Oladipo (2010) who stated that the direct effects of climate change on agriculture in Nigeria include the effects of pests and diseases on crop production.

The farmers perceived effects of climate change in the study area was also reflected in the gradual reduction of vegetative cover (84%); drying up of water bodies (87%); increasing cost of food crops (75%) and increased incidences of flood after rainfall (47%). The result of increased incidences of flood after rainfall agrees the findings of Ejeh (2014) who reported increased incidences of flood episodes especially in recent years. The farmers also perceived increasing incidences of agricultural droughts during the raining season as an effect of climate change in the study area (68%).

The result of drying up of water bodies aligns with the findings of Odjugo (2010), who reported that many rivers in Nigeria have been reported to have dried up or are becoming more seasonally navigable while Lake Chad shrunk in area from 22,902 Km^2 in 1963 to a mere 1304 Km^2in 2000 as evidence of climate change. This shows that what was left of Lake Chad in the year 2000 was just 5.7 per cent of 1963 size.

Table 4: Farmers perception on rainfall and climate related issues

S/N	Perceptual Indicator	Strongly Agreed (%)	Agreed (%)	Undecided (%)	Disagreed (%)	Strongly Disagreed (%)
1	The weather is becoming wetter every year	92 (24)	42 (11)	24 (6)	163 (43)	63 (16)
2	Climate change has led to increased crop infestation by pest and diseases	127 (33)	112 (29)	85 (22)	21 (6)	39 (10)
3	Gradual reduction ofvegetation cover	196 (51)	127 (33)	20 (5)	38 (10)	3 (1)
4	Gradual drying of water resources/bodies	159 (41)	175 (46)	17 (4)	25 (7)	8 (2)
5	Increasing cost of food crops	167 (44)	120 (31)	46 (12)	36 (9)	15 (4)
6	Crop yields have decreased with climate change	101 (26)	120 (31)	24 (6)	80 (21)	59 (15)
7	Climate change has led to the change in livelihood system	132 (34)	128 (33)	87 (23)	23 (6)	14 (4)
8	Increase incidences of floods during the rainy season	195 (41)	153 (6)	10 (4)	15 (44)	11 (5)
9	Increase incidences of drought during the rainy season	128 (33)	134 (35)	67 (18)	42 (11)	13 (3)

Source: Field work, 2023

Adaptation strategies in the study area

Climate change adaptation has been defined as the process of preparing for and adjusting proactively to climate change - both negative impacts as well as potential opportunities (World Bank, 2011). Through the enhancement of the adaptive capacities of local farmers, their resilience to climate change shocks can be strengthened. Planned adaptation could offer better strategy against climate change, but there is the need to identify local strategies for mainstreaming. Adeshina and Odekunle (2011) suggested that adaptation strategies may be entirely novel to an area or they may just be an improvement on what is previously well-known to a community.

Table 5 shows that the planting of different varieties of crops was the most used adaptation strategies. Mixed cropping, use of organic manure and mulching of crops to reduce water loss were 2nd, 3rd and 4th respectively, while planting of flood resistant crop was the least. This result corroborates the findings of Ikpe, et al., (2016) who reported that mixed cropping is the most viable adaptation strategy in Sokoto State, Nigeria.

Table 5: Farmers' adaptation strategies

S/N	Adaptation Strategies	Frequency	Percentage	Ranking
1	Planting of different varieties of same crops	290	84	1st
2	Planting of drought tolerant crops	203	59	7th
3	Planting of flood resistant/tolerant crop	174	50	12th
4	Planting of disease resistant/tolerant crop	216	62	5th
5	Changing the extent of input into crop production	206	59	7th
6	Changing the breed of livestock	188	54	11th
7	Mulching of crops to reduce water loss	235	68	4th
8	Planting of different crops (Mixed cropping)	245	71	2nd
9	Decreased use of chemical fertilizer	210	61	6th
10	Increase in use of Organic Manure	238	69	3rd
11	Agricultural Insurance of Enterprise	196	57	10th
12	Migration	204	59	9th

Note: ** Respondents provided multiple responses
Source: Field work, 2023

CONCLUSION

This study has examined farmers' awareness and farmers' adaptation strategies in Kachia LGA of Kaduna State, Nigeria. Results of the trend line regression showed increase in total annual rainfall. Increase in temperature was also observed. The farmers' perception of climatic characteristics of the study area was in line with climatic data records analysed. Farmers in the study area are aware of climate change. Radio is the main source of information on climate change in the area. The farmers adopt adaptation strategies such as planting of different varieties of crops, mixed cropping, use of organic manure and mulching which were perceived to be the most effective adaptation strategies in the study area.

Despite the challenges posed by climate change in the study area, there are possibilities for addressing the effects of climate change and assisting farmers to adapt to the effects of climate change. There is need for putting in place policies and programmes that will make the farmers to be proactive in the use of resources and at the same time adapting to climate change. Particularly the following have been recommended:

i. The Nigerian Meteorological Agency (NiMet) can do more in issuing seasonal forecasts of onset and cessation dates of rainy season. Considering the sensitivity of crop yields to these variables, farmers should be encouraged to avail themselves of these services and apply such information in crop production;

ii. Since 89% of the farmers are aware of climate change issues in the study area, and 68% got their information from the radio, more climate related issues should be discussed on radio programmes.

iii. More so, Agricultural Extension Officers (AEOs) should be deployed to guide farmers through routine visits, sensitization programmes on variability in rainfall characteristics and use of viable adaptation strategies in order to achieve improved and sustained crop yield.

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Soil Nutrient Status: Comparative Analysis for under Grass-land and Trees in University of Abuja, Mini Campus, Gwagwalada Abuja

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ABSTRACT

This study is aimed at comparing the soil nutrients status of soils under grassland and trees within University of Abuja, mini campus, with the view of identifying the suitability of the land use purposes of the sites in the University of Abuja; to achieve this, the sample points were identified, soil types under grassland and tree in the study areas were determined using world standard, soil nutrients were compared and the variations were accounted for. Using the line transect method, transect line of 30m long was used and at each end soil samples were collected at the depth of 0-15cm for top soil and 15-30cm for sub soil, making two (2) top soil and two (2) sub soil for grassland and tree land respectively. In total (8) samples were collected for the entire study area. Physio-chemical characteristics; (soil type, temperature, pH, permeability, moisture, porosity, bulk density, soil texture, organic matter, electrical conductivity, nitrate, sulphate, ammonium, potassium, magnesium). The results showed that, texture of soil samples on tree land was silt loam across the sampling points and grass land was sandy clay loam across the sampling points except for subsoil of point 2 with loamy sand. The values of bulk density on top and sub soil of tree land ≤ value of grassland. The topsoil of tree land recorded higher mean value of pH 6.25 while on subsoil tree land also recorded highest value of 5.45. The study concludes that soils under grass land are relatively more liable to soil compaction because of the high level of bulk density; which would hinder proper root growth. The relatively low levels of organic matter and CEC, particularly under grass land, would negatively affect crop yield and also increase the incidence of erosion and leaching of nutrients in the study area. This would further deplete the phosphorus in the soil and increase the chemical constraints of the cultivated lands. The study recommended that appropriate management practices should be adopted, such as contour cultivation and mulching to check erosion since the soils at grass land are at upper slopes which are prone to erosion.

Keywords: *Physiochemical parameters, Soil under grassland and Trees, Top soil and Sub soil.*

INTRODUCTION

The availability of nutrients influences every single aspect of an ecosystem, and it is a critical revamper of the responses of the ecosystem to global change (Yusufu, 2017). Grasses are the most cost-effective provender of ruminants. Grassland is a community of natural plants, with the election of grass species (Ravikumar, 2013).

Nitrogen shortage lowers grass coverage, determining the quality and quantity of fodder and the carrying capacity of the territory. In grasslands of high diversity, lots of species remain ungrazed making them appear as weeds in the field (Tilahun, 2007). In both developed and developing countries, many millions of livestock farmers, pastoralist and ranchers depend so much on grasslands and conserved products such as hay and silage (Shehu, Jibrin and Samndi, 2015). Grasslands are surprisingly diverse and difficult to define. Although grasses and other grass like plants are the dominant vegetation in all grasslands, grasslands also include a diverse assemblage of other plant life forms that contribute to their species richness and diversity. Many grasslands also support a diverse animal community, including some of the richest species in grazing food webs on the planet (Jimoh, *et. al.*, 2016)

Trees can play important roles in national economies, ecosystems, and international efforts for sustainability - and in many places they already do. At the local level, people have long relied on trees in various land-use settings for food security, income, and biological diversity (Areo and Magaji, 2017).
Several studies have reflected on soil variation and nutrient status, some of which include; Akhabue, Chima and Eguakun (2020) who evaluated the growth Performance and soil quality of two age sequences of Gmelina-arborea plantation in University of Port Harcourt, Nigeria. The study was evaluated based on tree growth variables and above-ground carbon stored. Asadu and Odugu (2020) also compared the characteristics of soils of isolated forests and adjacent grasslands in Nsukka area of Enugu state, Nigeria. The study used auger borings to collect soil samples from depth of (0-20 and 20-40cm) from each vegetation type per location giving a total of 12 auger samples while two profiles pit each were dug, described and sampled. In all, 24 samples were collected processed, analyzed and results subjected to statistical analysis. Among all

of these studies, none has been able to examine the comparative assessment of soil nutrients status under grassland and trees from different area in the mini campus. Based on this aim, the following objectives are to be pursued: to identify sample points location, determine the soil types under grassland and trees in the study area, compare the nutrients in the soil under the grassland and trees in the study area, account for the variations of the soil under grassland and soil under tree and suggest alternative land use for sites.

MATERIALS AND METHODS

Study Area

The study area is the University of Abuja Mini campus. Mini Campus of University of Abuja is located in Gwagwalada town of Gwagwalada Area Council of the Federal Capital Territory, Abuja. It is situated along Abuja-Lokoja road at about 55 kilometers away from FCT and located between latitudes 8º 55'N and 9º 00'N and longitudes 7º 00'E and 7º 04'E (Ishaya, 2013). With a population of about 157,770 at the 2006 census, the region covers a total landmass of 1,043 km^2 out of the 8,000 km^2 of the total FCT land mass and located at the center of very fertile area with abundance of grasses (Ishaya, 2013).

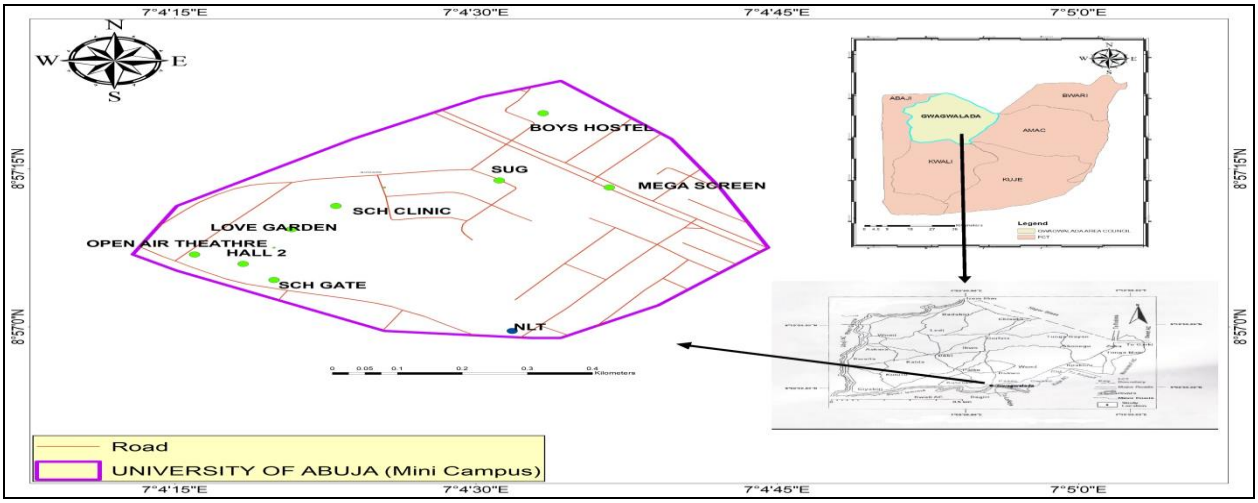


Figure 1: University of Abuja showing the study area (NLT).
Source: GIS Lab, Department of Geography and Environmental Management (2022).

Soil in University of Abuja shows a high level of variability, is predominantly occupied by tropical ferruginous soils but alluvial soils are commonly found in the valleys of the main river (River Usuma) and other streams within the study area (Balogun, 2001).

University of Abuja is located within the Northern boundary of the Guinea Savanna. The vegetation shows a slight level of variability comprising shrub savanna vegetation type that covers, the Iku – Gurara plains where the study area is located except for the dominance of riparian vegetation on the flood plains of River Gurara and Usuma (Balogun, 2001 and Areo, 2021(b)). The vegetation is dominated by species of plants such as Danulio Oliver, Albizia Zygia, Shea butter tree Butrospermum paradoxium and African Locust bean. Parkia clappertoniana, Terminatia pilisotigma, Amona, Nauclea and Bombax contratum are the dominant shrubs found within the area (Areo, 2021(a); Ishaya, *et. al.*, 2009).

Research Design

The study is anchored on the concept of Soil Quality; Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation. Seybold *et al,* (2018) explained that, soils vary naturally in their capacity to function. This concept encompasses two distinct but interconnected parts: inherent quality and dynamic quality. Characteristics, such as texture, mineralogy, etc., are innate soil properties determined by the factors of soil formation—climate, topography, vegetation, parent material, and time. Collectively, these properties determine the inherent quality of a soil. A loamy soil will have a higher water holding capacity than a sandy soil; thus, the loamy soil has a higher inherent soil quality (Seybold, *et. al.*, 2018).

Sources of Data

The source of data for this research is primary and secondary. The sources of data were employed to analyze all necessary empirical investigation. The secondary data include data from Google earth map showing location where soil samples were collected as presented in Figure 1

Instrumentation

The study adopted series of instrument and software packages (See table 1).

Table 1: Adopted instruments

S/N	Instrument	Model	Purpose
1	Soil Augar	-	Soil collection
2	Foil Paper	-	Soil collection
3	Masking Tape	-	Labeling soil samples
4	Marker	Permanent marker	Marking the soil samples
5	Global Positioning System	GPSmap 60Cx	To obtain sampling points
6	Notepad/pen	40 leaves/bic	For writing
7	Tape rule	Fibre 100ft	For measuring sample plot
8	Google earth	Mobile software	To develop sampling point map
9	ArcGIS	ArcGis 10.1	To produce study map

Source: Authors Fieldwork (2022)

Sampling Frame, Sample Size and Sampling Procedure

Mini campus constitutes the sample frame for this research. The area is dissected into two plots of land to investigate the variation in soil nutrients; Law Faculty in Mini campus (grass land) and Geography Garden near Geo Block (tree land).

Using the line transect method, transect line of 30m long was used and at each end, soil samples were collected at the depth of 0-15cm for top soil and 15-30cm for sub soil, making two (2) top soil and two (2) subsoil for grassland and tree land respectively. In total (8) samples were collected for the entire study area.

Table 2: Sampling points

POINT	LATITUDE	LONGITUDE	ELEVATION (M)
	Transect 1 (NLT)		
1	N8^0 57’ 2.27’’	E 7^0 4’ 29.72’’	198
2	N8^0 57’ 2.151’’	E 7^0 4’ 30.26’’	198
	Transect two (ENV. Garden)		
3	N8^0 57’ 3.811’’	E 7^0 4’ 19.60’’	181
4	N8^0 57’ 3.998’’	E 7^0 4’ 18.762’’	181

Source: Authors Fieldwork (2022).



Figure 2: Sampling Points
Source: Adapted from Goggle Earth (2022)

Laboratory Analysis
Some important physio-chemical characteristics; (soil type, temperature, pH, permeability, moisture, porosity, bulk density, soil texture, organic matter, electrical conductivity, nitrate, sulphate, ammonium, potassium, magnesium).

Physical Properties
Soil pH
A glass of electrode PH meter is used in 1:1 soil/water ratio suspension to determine the soil PH, the same PH meter is used in a 1:25 soil/CaCl ratio in separate soil suspension. The electrode of PH is inserted into partially settled suspension and PH of each suspension measured.

Organic matter
This is determined using 1 walkey (Walkley and Black, 1934), wet oxidation method, the method measures active or decomposable organic matter in the soil, fifty grams of soil sample weighed into 500ml conical flask 100ml of potassium dichromate vii (k2 cr 207) and Wml of concentrated tetra-oxosulphate vi acid (H_2SO_4) is added using graduated cylinder. The mixture of soil and reagents is swung for 1 minute and the flask containing the mixture is allowed to rest for 30 minutes. Ten mls of distilled water is added and titrated with 10ml of ferrous sulphate until color changes to black. The organic carbon is calculated using the formula:

$$Oc = Mek2\ Cr2\ 07 - MeFeSO_4 \times 0.003 \times 100 \times f$$

Where**:**
f = correlation factor; 1.33
Me = Normality of solution xml of solution used.
% organic matter = % organic carbon × 1.726 (Jou, 1983).

Particle Size Distribution:
The proportion of sand, silt and clay particles in soil determine particles size distribution. The Bouyouces (1935) hydrometer method is used for the analysis.
Distilled water and neutral sodium hexametaphosphate (calgon) is the major reagent (IITA, 1979). The results are calculated using the formula below:

$$Sand = 100.0 - (Hi\ to\ 2)\ (Ti - 68) - 2.0)\ 2\ clay - (H2 - 0.2\ (T2 - 68) - 2.0)\ 2$$

$$SiH - 1OO - (\%\ sand + clay)\ (I)$$

Where:
Hi is the hydrometer reading at 40 seconds.
T1 is the temperature reading at 3 hours
T2 is the temperature reading at 3 hours
The textural names of the analyzed soil samples are determined using textural triangle.

Bulk Density
This is the ratio of the mass to the bulk volume of the unit of measurement in grams per cubic centimetre. The method used in bulk density is the core method.

The samples were weighed while wet, is oven dried at 105°c for 24 hours cooled and re weighed. The bulk density is calculated for the formula below:

$$BD = M/V \quad (2)$$

Where:
BD is the bulk density.
M is the mass of oven dry soil in gram; V is the Volume of the core.

Soil Porosity
It was calculated as the fraction of total volume not occupied by soil solid assuming a particle density of 2.65Mg M^{-3} (Danielson and Sutherland, 1986) using the formula below:

$$P = \frac{1 - P_b}{P_s}$$

Where:
p= soil porosity
Pb=bulk density
Ps = particle density= 2.65 Mg m^{-3}

Chemical Properties
Nitrate
Nitrate – Nitrogen in Soil Samples
The Brucine Colorimetric method in accordance with CAEM and USEPA 352.1 was used to determine the nitrate-nitrogen (NO_3^--N) content of soil samples. NO_3^- was calculated as follows:

$$\text{mg } (NO_3^-) \text{ from calibration graph Volume of extractant } NO_3^- (\text{mg/kg}) = \frac{\text{Volume of extract (ml)}}{\text{Sample weight (g)}}$$

Potassium and Magnesium
Determination of K, and Mg were extracted from the soil with 1N neutral ammonium acetate solution.

Method of Data Analysis
The data obtained were analyzed using inferential and descriptive statistics. Descriptive statistically used include measures of central tendency such as mean, standard deviation and variance presented on

tables. Inferential statistics involved student-t- Test was used to test the hypotheses.

Student t- test was used to determine the variations between samples from grass land and tree land.

Student T-test formula:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{(\sigma_1^2/N_1) + \sigma_2^2/N_2}}$$

Where:

$\bar{x}_1$ = mean variable one

$\bar{x}_2$ = mean variable two

σ_1^2 = square of standard deviation of variable one

σ_2^2 = square of standard deviation of variable two

N_1 = total number of values in variable one

N_2 = total number of values in variable two

RESULTS AND DISCUSSION

Soil types under Grassland and Trees in the Study Areas

Soil Texture on Tree Land

The particle size distribution of auger and profile samples at 0-15 and 15-30 cm (depths), A and Bt Horizons across the two points as influenced by the vegetation type are summarized in Figure 3. Generally, the texture of auger soil samples on tree land was silt loam across the sampling points. The average silt fraction of the tree land at 0-15cm depth was 63.73% and 69.28% respectively. However, the fraction decreased with depth since the value recorded decreased to 53.84% and 59.54% in the 15-30cm depth.

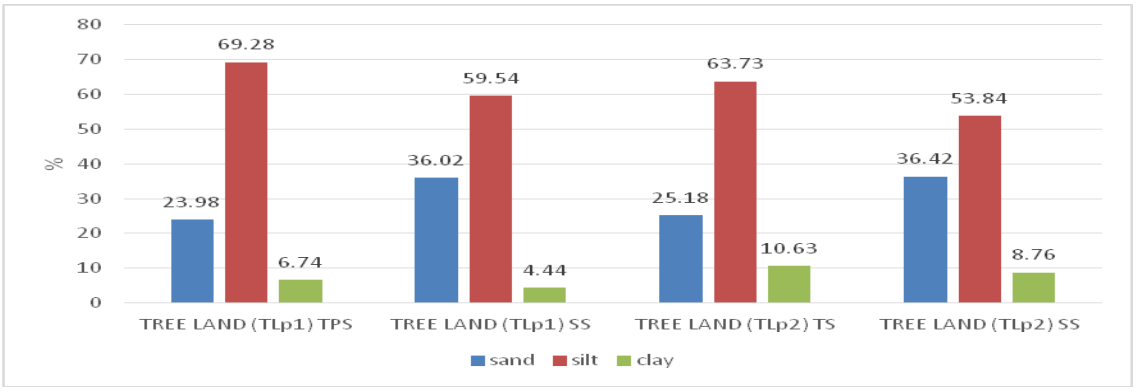


Figure 3: Soil Texture on the Tree Land
Source: Field Work, 2022.

Soil Texture on Grass Land

Figure 4 shows the texture of auger soil samples on grass land was sandy clay loam across the sampling points except for subsoil of point 2 with loamy sand. The average clay fraction of the grass land at 0-15cm depth was 54.28% and 70.12% respectively. However, the fraction decreased with depth since the value recorded decrease to 9.39% and 61.83% in the 15-30cm depth.

The decrease in clay content with depth could be attributed to argillation or clay lessivage. It could also be due to sorting of soil materials, clay migration or combination of both factors (Ojanuga, 2003). The silt content of the soils under tree land was on the average higher than that of the grassland, although their means were not significantly different. The percentage gravel of the soils on the average was minimal.

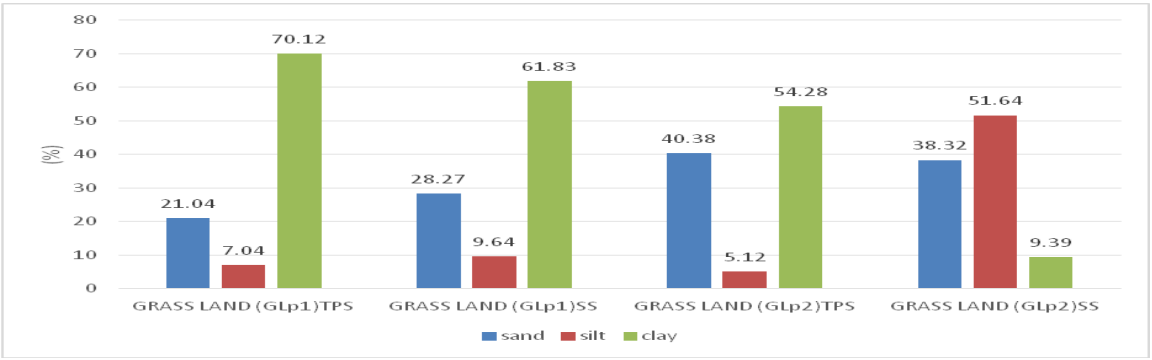


Figure 4: Soil Texture on the Grass Land
Source: Field Work, 2022.

Comparing Nutrient in the Soil under the Grassland and Soil under Trees in the Study Area.

Bulk Density

The measure of bulk density is required for the determination of soil compactness; it is also used as an indicator of aeration status and water infiltration capability. Figure 5 shows that topsoil of grass land recorded higher mean value of bulk density of 1.45g/cm^3 while on subsoil grass land also recorded highest value of 1.55g/cm$^{3.}$ The result shows that value of bulk density on top and sub soil of tree land ≤ value of grassland. Similar values were obtained in a study carried out in Zaria and the increase in clay with depth and decrease in organic carbon with depth was observed as factors responsible for increase in values of bulk density (Jimoh *et al.*, 2016). The findings of higher values of bulk density on grass land which is cultivated on compared to artificial vegetation in tree land corroborated that of Lal (1995) and Ekanade (1985); who studied bulk density of soil which had been converted from forest to cultivation arable and tree crops. The higher the bulk density of the soil, the higher the degree of compaction of the soil. The critical value of bulk density for restricting root growth varies with soil type (Hunt and Gikes, 1992) but in general, bulk density greater than 1.66 g/cm3 tends to restrict root growth (Mackenzie, Coughlan and Cresswell, 2002). So bulk density of both study area has tendency to restrict root growth.

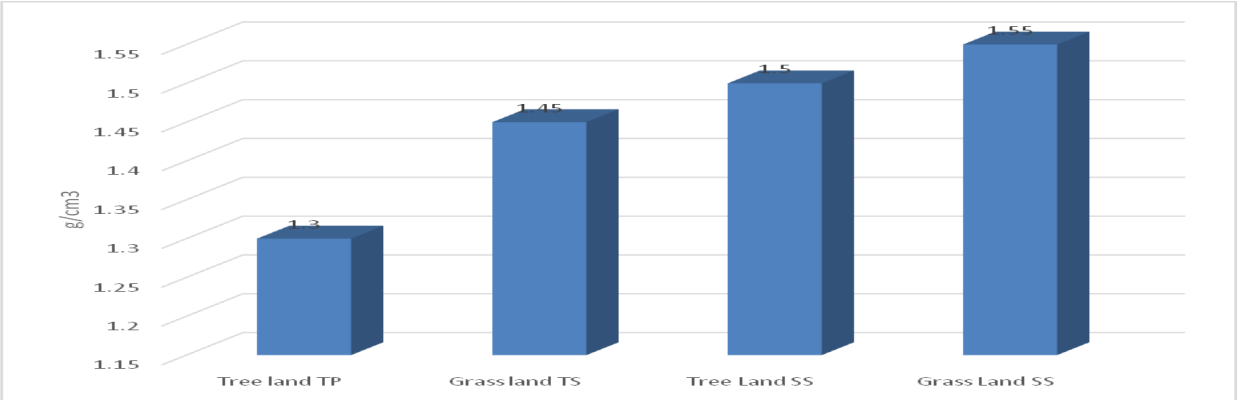


Figure 5: Bulk Density Recorded in the Study Area
Source: Field Work, 2022.

pH

Soil pH is a measure of the hydrogen ion concentration in the soil. It affects the solubility of nutrients in the soil solution and the absorption of nutrients elements by the roots of plants. The mean pH values at the top soil and subsoil in the study area were generally lower under grass land associated with maize cultivation compared to values under tree land. Figure 6 shows that topsoil of tree land recorded higher mean value of pH 6.25 while on subsoil tree land also recorded highest value of 5.45.

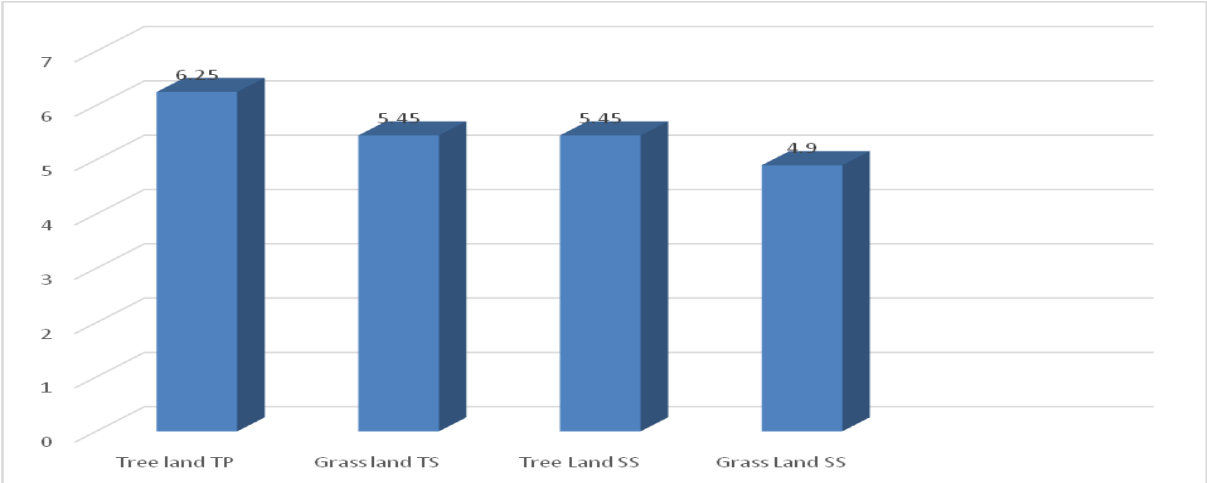


Figure 6: pH Recorded in the Study Area
Source: Field Work, 2022.

The soil in the study area is slightly acidic especially on grassland and with increasing soil depth, the level of acidity also increased. The use of inorganic fertilizer in the maize cultivation on grassland to boost productivity could be responsible for increased acidity in the subsoil. Many crops grow best when pH is close to neutral (pH 6 -7.5). It promotes the availability of plant nutrients for optimal yield. Also, bacteria that decompose soil organic matter are hindered in strong acidic soils (United States Department of Agriculture, 2011). Where pH is low, the nutrition, growth and yield of crops decreases negatively affecting crop production; for instance, the pH levels for optimum yield of maize and guinea corn was placed at 6.8 by Smith and Doran (1996). The pH level under grassland with maize in the study area, is lower than 6.8 and could affect the yield of the crops.

Organic Matter

Organic matter in soil protects the soil surface from rain drop impacts, resist wind action, and thus, greatly aid in erosion control (Yusufu, 2017). The grass land associated with maize cultivation had the lowest mean value (1.85 %) of organic matter at the top soil and (1.6 %) on sub soil. Figure 7 shows that topsoil of tree land recorded higher mean value of organic matter 5.2% while on subsoil tree land also recorded highest mean value of 3.1%.

The increase at the topsoil and subsoil might be due to soil organic matter incorporation from the decomposition from fallen leaves from the tree. Similar observations were made by Tilahun (2007) in the study of variability of soil nutrients. Comparatively the tree crops had higher mean values of organic matter (2.4% - 4.8%) while the highest value (6.3%) was under cultivation. The decrease observed under grassland (maize cultivation) is an indication that the values of organic carbon, which is used in the determination of organic matter, also decreased lowering the soil quality.

The rating of organic matter by Landon (1991) showed that it is very low when values are < 2%, low when it is 2-4%, medium when it is 4-10%, high when 10-20% and rated very high when it is above 20%. The organic matter in the soils of grass land studied, are rated very low to medium while tree land is rated medium. The result in the study area shows that soil organic matter was degraded after the opening up of natural vegetation for cultivation, be it tree plants or arable crops. The high difference between the values under tree land and grass land may have been brought on by insufficient inputs of organic substrate from the farming system, due to residue removal and lack of crop rotation. This corroborates previous reports of Duff. *et. al.*, (1995) and Tilahun (2007).

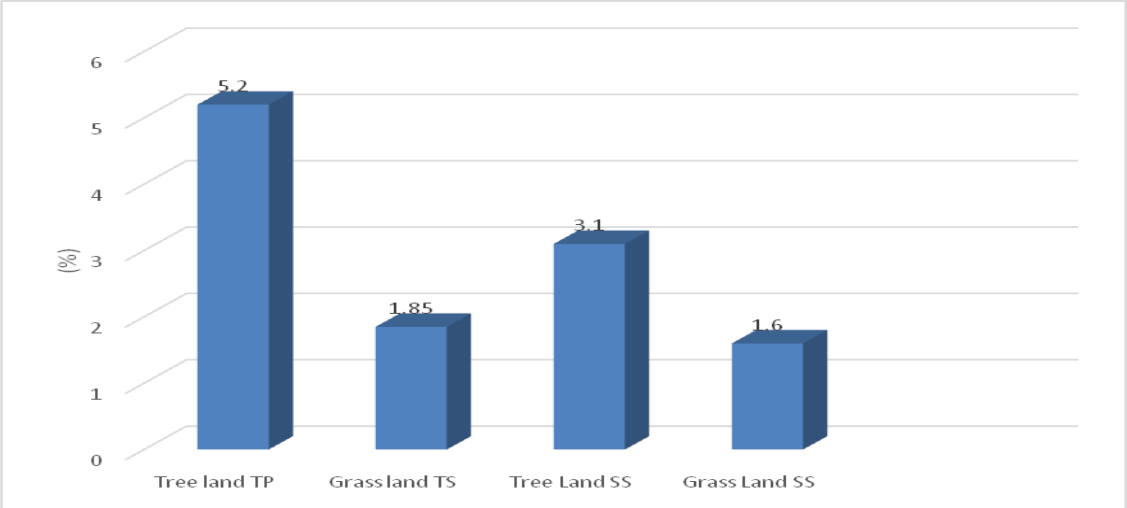


Figure 7: Organic Matter Recorded in the Study Area
Source: Field Work, 2022.

Available Phosphorus

Available phosphorus is crucial to agriculture because when it is lacking in the soils it limits the growth of both cultivated and uncultivated plants (Foth and Ellis, 1997). Figure 8 shows that topsoil of tree land recorded higher mean value of available phosphorus 6.25 while on subsoil tree land also recorded highest mean value of 4.05.

The value of phosphorus under grass land (associated with maize cultivation) was lower on top and subsoil. Landon (1991), categorized available soil phosphorus levels: values 15 mg/kg is rated high. The available phosphorus in the soils of the study area was generally low, since the phosphorus was less than 5 mg/kg in all the soil management systems except top soil of tree land. The low content

of phosphorus observed in the study area corroborates what some authors (Igwe, 2001; Mustapha and Udom, 2005; Shehu, Jibrin and Samndi, 2015) observed in their studies that availability of phosphorus under most soils in Nigeria declined as a result of crop harvest and erosion.

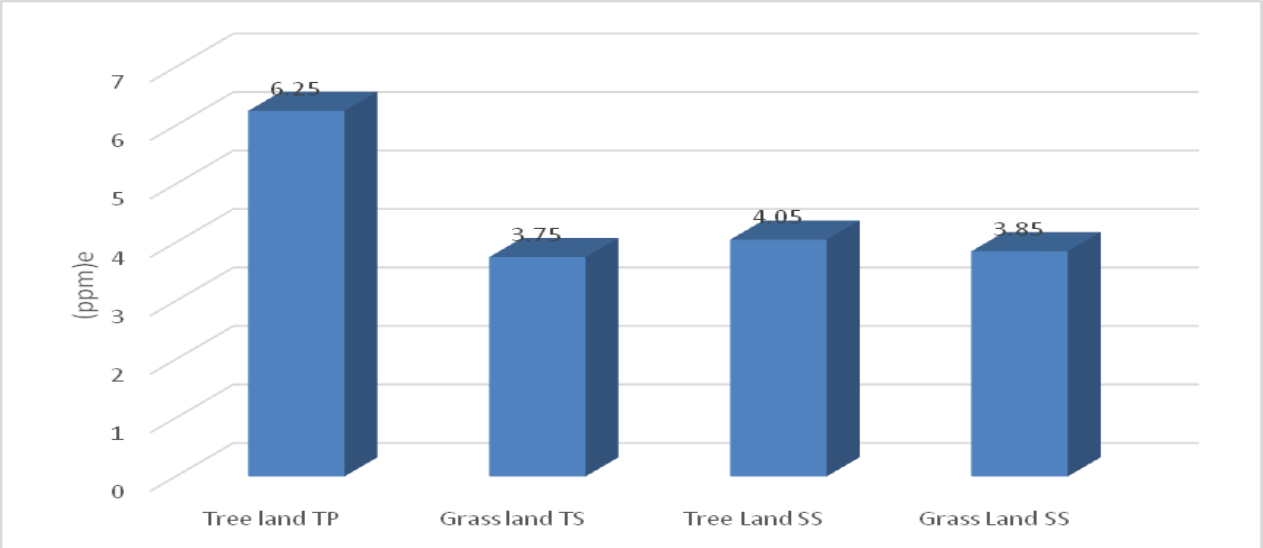


Figure 8: Available Phosphorus Recorded in the Study Area
Source: Field Work, 2022.

Total Nitrogen

Nitrogen is a macro-nutrient in the soil, which helps to regulate to a considerable extent the utilization of potassium, phosphorous and other soil constituents by most plants (Mesfin, 1998). Figure 9 shows that topsoil of tree land recorded higher of mean value of total nitrogen 1.25% while on subsoil tree land also recorded highest mean value of 1.05%.

The relatively low values observed under grass land were perhaps due to its low organic content and continuous tillage of the land. A similar idea was propagated by Tisdale *et al.*, (1995) when they noted that nitrogen content is lower in continuously and intensively cultivated and highly weathered soils of the humid and sub humid tropics due to leaching and low organic matter content. The considerable reduction of total nitrogen in the continuously cultivated fields could also be attributed to the rapid turnover (mineralization) of the organic substrates derived from crop residue (root biomass) whenever added following intensive cultivation (McDonagh, Thomsen and Magid, 2001). The lowest content of nitrogen (0.0245) observed for grass land may be attributed to its high utilization of nitrogen (FAO, 1995).

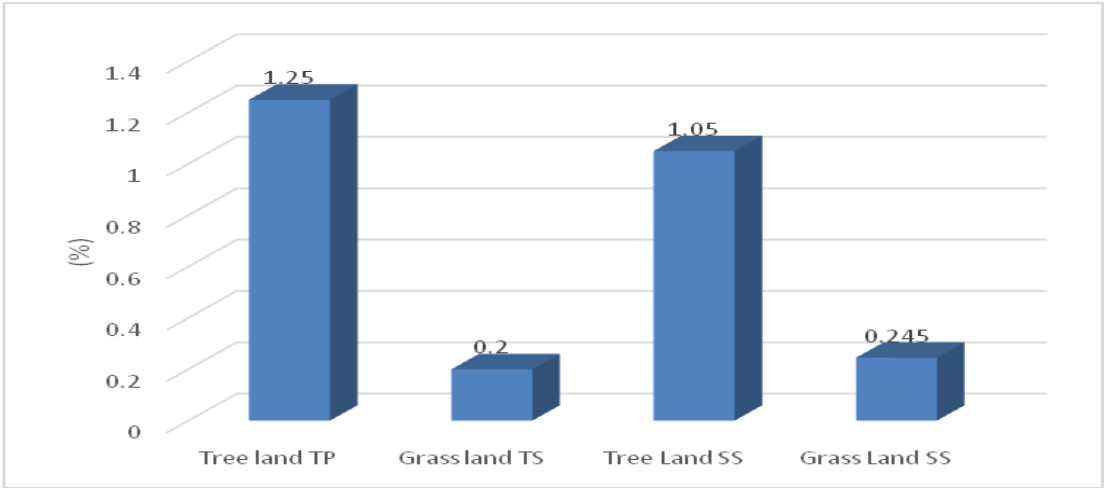


Figure 9 Total Nitrogen Recorded in the Study Area
Source: Field Work, 2022.

According to Landon (1991), the rating of total nitrogen > 1% is very high, 0.5-1% is high, 0.3-0.5% medium, 0.1-0.2% low, and < 0.1% as very low. In the study area, only tree land was categorized as very high at the top and subsoil wile grassland fell under low categorization. The continuous decline in the total nitrogen content of the soils is likely to affect the productivity and sustainability of soil as opined by Tilahun (2007).

Sodium

Exchangeable sodium affects the population, composition and activity of beneficial soil microorganisms directly through its toxicity effects. When it is high in soils it makes the soil sodic which affects soil fertility and productivity (Grime, 2001; Wakene, 2001). Figure 10 shows that topsoil of tree land recorded higher of mean value of sodium 0.65 cmol/kg while on subsoil tree land also recorded highest mean value of 0.4cmol/kg.

There was a decline of 0.1cmol/kg under all the land with increased depth at sub soil, these values according to United States Department of Agriculture (2011), is not high enough to make soils saline. High sodium content would adversely affect soil structure resulting in easy dispersal of soil particles. Excessive sodium levels can occur naturally or it can result from irrigation with high sodium water. In the study area, the levels of sodium fell within tolerable limits.

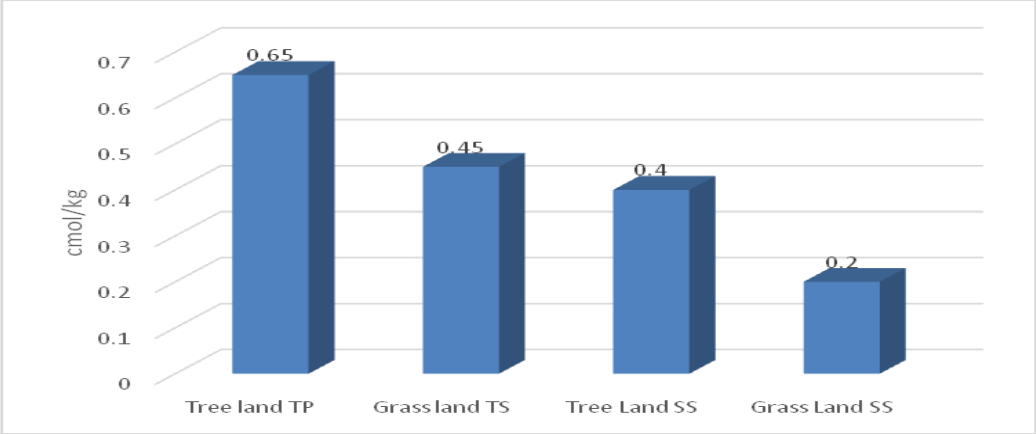


Figure 10 Sodium Recorded in the Study Area
Source: Field Work, 2022.

Potassium

Exchangeable Potassium influences plant productivity and one of the factors that affect the distribution of K + in soil is soil management practices (Wakene, 2001). Ravikumar and Somashekar (2013) developed a rating scale for exchangeable potassium, where values are categorized as low when it is < 0.1cmol/kg, medium when it is 0.1 -0.2cmol/kg and high when it is above 0.2cmol/kg. Figure 4.9 shows that topsoil of tree land recorded higher of mean value of potassium 0.9 cmol/kg while on subsoil tree land also recorded highest mean value of 0.9cmol/kg.

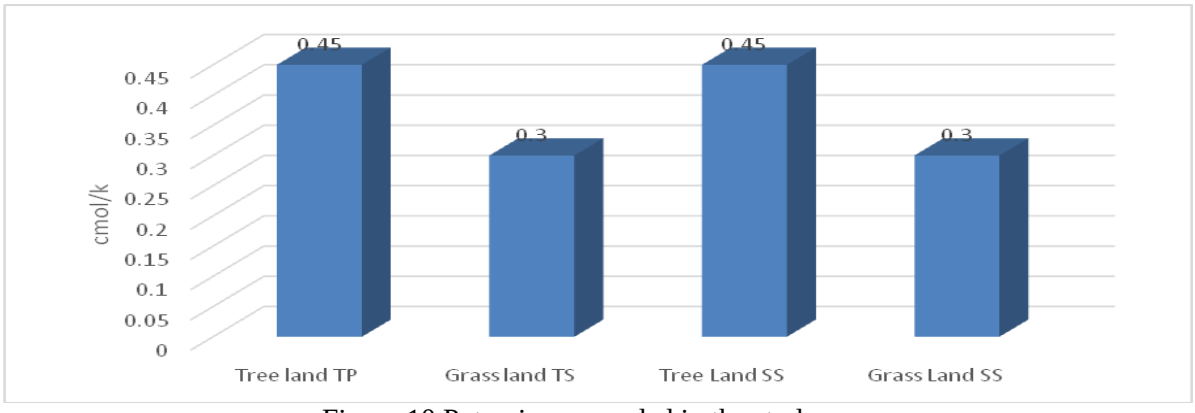


Figure 10 Potassium recorded in the study area
Source: Field Work, 2022.

Thus, they were rated as having high content of exchangeable potassium. Although there was a decline in the values observed on topsoil to subsoil, they still maintained the same high rating. The relatively high content of potassium recorded under tree land may be associated to the high pH value observed under the tree land (figure 6). Similar observations were reported by Mesfin (1998) of high potassium under high pH tropical soils.

Cation Exchange Capacity

Cation exchange capacity (CEC) of the soil affects its capacity to supply nutrient cations for plant growth (Brady and Weil, 2002). Figure 11 shows that topsoil of tree land recorded higher of mean value of cation exchange capacity 6.8 while on subsoil tree land also recorded highest mean value of 4.5.

Using the Esu (1991) categorization scale where CEC values were placed into three classes: high (> 12cmol/kg), medium (6- 12cmol/kg) and low (< 6cmol/kg). A medium scale rating was observed under top soil of tree land (6.8cmol/kg). The value recorded on grass land is low. The findings support Igwe (2001) who also observed decrease in soil cation exchange capacity following cultivation of lands. A general decline was recorded in the values of CEC at the top and subsoil for all the grass land studies (figure 11).

At the topsoil the relatively higher value of CEC under tree land revealed that the soil was less susceptible to cation nutrient loss through leaching, since CEC measures the soil ability to retain and supply nutrient ions called cations. The soils under arable grass land is more susceptible to nutrient loss, hence the relatively low CEC values. The topsoil organic matter was higher under tree land than under the grass land.

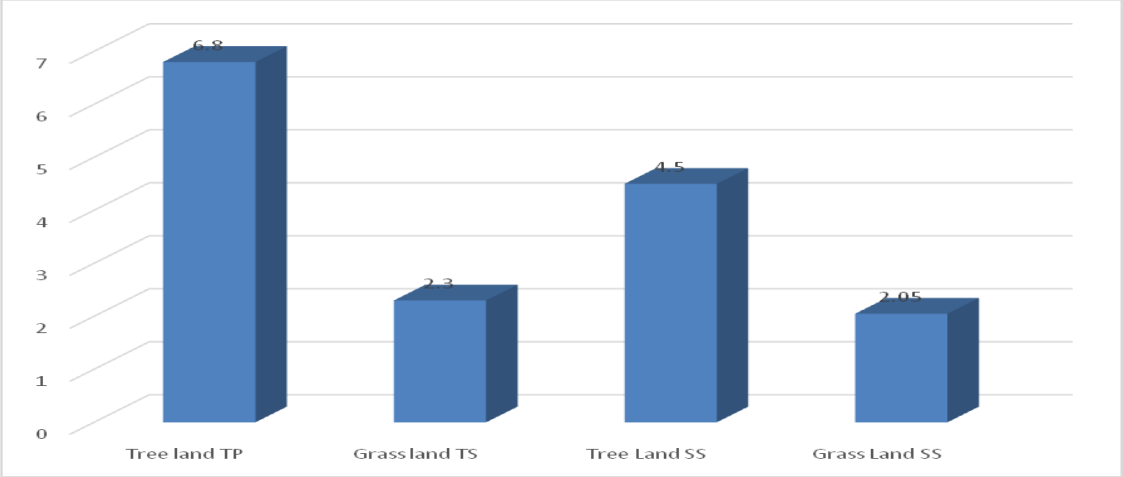


Figure 11 Cation Exchange Capacity recorded in the study area
Source: Field Work, 2022.

Variation of Soil under the Grass Land and Tree: Ho1: There is no significant difference between the soil nutrients under grass land and the soil under tree.

Table 4 Paired samples test

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	Df	Sig. (2-tailed)
Grassland – Tree land	-4.5512	4.9708	1.7574	-8.7070	-.3955	-2.590	7	1.89

Source: Authour's Computations, 2022.

From the analysis, the t-stat calculation is 2.590 while the table value at α=0.05 is 1.89. It then means that since the calculated value of 2.590 is higher than the table value 1.89, therefore the null hypothesis is rejected and the alternative hypothesis is accepted it concluded that there is significant

difference between the sol nutrient under grass land and the soil under tree in the study area. The grass land is associated with arable cultivation (maize) farming activities in the grassland has reduces nutrient capacity of the grass land while tree land retains its average nutrient capacity.

CONCLUSION

The study compared soil nutrients under grassland and trees in University of Abuja Mini Campus, Gwagwalada Area Council, Abuja. Summarily, the major findings of this study included the following:

i. The texture of auger soil samples on tree land was loamy sandy clay across the sampling points and grass land was clay sand loamy across the sampling points except for subsoil of point 2 with loamy sandy clay.
ii. The result shows that value of bulk density on top and sub soil of tree land ≤ value of grassland.
iii. The result shows that topsoil of tree land recorded higher mean value of pH 6.25 while on subsoil tree land also recorded highest value of 5.45.
iv. The grass land associated with maize cultivation had the lowest mean value (1.85 %) of organic matter at the top soil and (1.6 %) on sub soil.
v. The result shows that topsoil of tree land recorded higher of mean value of available phosphorus 6.25 while on subsoil tree land also recorded highest mean value of 4.05.
vi. Furthermore, the finding shows that topsoil of tree land recorded higher of mean value of total nitrogen 1.25% while on subsoil tree land also recorded highest mean value of 1.05%.
vii. The result shows that topsoil of tree land recorded higher of mean value of sodium 0.65 cmol/kg while on subsoil tree land also recorded highest mean value of 0.4cmol/kg.
viii. The result shows that topsoil of tree land recorded higher of mean value of potassium 0.9 cmol/kg while on subsoil tree land also recorded highest mean value of 0.9cmol/kg.
ix. More also, the finding shows that topsoil of tree land recorded higher of mean value of cation exchange capacity 6.8 while on subsoil tree land also recorded highest mean value of 4.5.

Statistically, there is significant difference between the soil nutrients under grass land and the soil under tree.

The study concludes that soil properties in the study area, despite having the same slope class and belonging to the same parent material, were influenced by soil management practices. Differences were observed in the values of all the soil properties analyzed, between tree land and grassland. Soils under grassland were the most affected because of the continual cropping associated with the land; compared to tree land. The implication of the finding shows that, soils under grassland are relatively more liable to soil compaction because of the high level of bulk density; which would hinder proper root growth. The relatively low levels of organic matter and CEC, particularly under grass land, would negatively affect crop yield and also increase the incidence of erosion and leaching of nutrients in the study area. This would further deplete the phosphorus in the soil and increase the chemical constraints of the cultivated lands.

The study further recommends the following:

To sustain occasional and continuous farming on grassland, that reduces the rate of soil nutrients in the grassland, gardeners and farmers in the grassland area should be encouraged to adopt soil fertility management practices, where they combine the use of crop residues (organic inputs), fertilizers and cropping systems such as crop rotation and agroforestry.

i. Appropriate management practices and soil conservation measures should be adopted; such can include contour cultivation, crop rotation and mulching to check erosion, improve soil nutrients at grass land and few upper slopes prone to erosion.
ii. Application of lime to reduce the acidity of the soils, especially that of tree land is also recommended after lime requirement test.
iii. Further studies are required to ascertain if, there could be significant variations in the evaluated parameters as the stands get older.

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Appendix I

ABUJA ENVIRONMENTAL PROTECTION BOARD
PLOT 776 CADASTRAL AO OFF Z. MAIMALARI STREET
CENTRAL BUSSINESS DISTRICT–ABUJA
PMB 152 GARKI
LABORATORY UNIT
CERTIFICATE OF ANALYSIS
Date sample collected: 01/12/2022
Date sample delivered to the Lab: 01/12/22,
Time sample received in the lab: 03:05pm

S/N ;'[p]]		TREE LAND (TLp1) TPS	TREE LAND (TLp1) SS	TREE LAND (TLp2) TS	TREE LAND (TLp2) SS	GRASS LAND (GLp1)TPS	GRASS LAND (GLp1)SS	GRASS LAND (GLp2)TPS	GRASS LAND (GLp2)SS
1	Soil texture (sand/silt/clay)	23.98 69.28 6.74	36.02 59.54 4.44	25.18 63.73 10.63	36.42 53.84 8.76	21.04 7.04 70.12	28.27 9.64 61.83	40.38 5.12 54.28	38.32 51.64 9.39
2	Bulk density g/cm3	1.3	1.4	1.3	1.6	1.5	1.6	1.4	1.5
2	pH	6.0	5.9	6.5	5.0	5.3	4.9	5.6	4.9
3	Organic matter %	6.0	4.1	4.4	2.1	2.5	1.6	1.2	1.6
4	Avail phosphorus (ppm)	6.9	4.1	5.6	4.0	3.6	3.6	3.9	4.1
5	Total Nitrogen %	2.2	1.3	0.3	0.8	0.3	0.4	0.1	0.09
6	Na+ cmol/kg	0.8	0.4	0.5	0.4	0.6	0.1	0.3	0.3
7	K + cmol/kg	0.4	0.6	0.5	0.3	0.4	0.3	0.2	0.3
	CEC	7.9	5.1	5.7	3.9	2.4	2.6	2.2	1.5

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The Effect of Temperature Variations on Physiological Comfort in Ibadan, Nigeria

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ABSTRACT

Among the very important factors affecting man's response and activities in the environment is temperature. The conditions both inside and outside vary considerably in time and space. This seriously affects human physiological comfort and workers' productivity. The secondary data (temperature parameters) collected from the Nigerian Meteorological Agency (NIMET) and primary data (structured questionnaire) of 220 copies administered to Ibadan residents, 215 were returned and used in the study. These data were analysed using Time series, regression and correlation analytical tools in Statistical Packages For Social Sciences (SPSS). Time series analysis revealed the trend and pattern of the various temperature parameters which include daily minimum, maximum and mean temperatures. On the other hand, simple descriptive analysis was used to describe the socio-demographic and socio-economic characteristics of the respondents while correlation analysis, cross-tabulation and Chi-square were used to show the relationship between temperature variations and physiological comfort. Time series analysis revealed that most variations tend towards an increasing trend in air temperature especially at minimum temperature levels with the coefficient of variability (CV) ranging between 13 and 21%. Correlation analysis revealed that there was a significant inverse relationship between temperature variation and physiological comfort ($r = -0.60$, $p<.01$). Cross-tabulation and chi-square analysis of the relationship between temperature and physiological comfort indicates that there was a significant relationship between temperature variation and physiological comfort ($X^2=189.65$, $df=16$, p .05). The study, therefore recommends adequate, regular and up-to-date records of climatic elements be properly compiled and kept. The government should take action in treating air pollution in the industrial areas and deforestation in the rural areas, hence the tree planting program will be embraced by citizens.

Keywords: *Temperature, Human physiological comfort, Time series analysis, Ibadan.*

INTRODUCTION

For quite a few decades, air temperatures have been on the rise globally, which could easily be attributed to the excessive emission of greenhouse gases into the environment. Consequently, the effect has been felt not only on the environment, and humans alone but also on the performance and productivity of individuals (Kjellstrom et al. 2016). Hence, the application of biometeorological indices to understand thermal comfort and its effect on human beings becomes very crucial (Telma et al., 2015). Richard (2022) noted that one of the core concepts of human biometeorology is the effective and practical assessment and forecasting of the thermal environment due to concerns about thermal comfort, discomfort, and health effects. In this context, the term 'thermal environment' encompasses both the atmospheric heat exchanges with the body (stress) and the body's physiological response (strain). This is due to the need for human beings to balance their heat budget in any climate to a state very close to thermal neutrality to optimize their comfort, performance, and health (Jendritzky et. al., 2006; Lai et al., 2020).

Human physiological comfort, health and efficiency especially at work are greatly affected by weather elements especially temperature which is the most noticeable element of weather and climate (Smith et al. 2014; Kjellstrom, et al. 2016). Its variability (i.e. temperature) is the crucial property which brings about comfort and discomfort.

Achieving thermal comfort is challenging because one would need to account for six factors such as: air temperature, radiant heat, relative humidity, moving air, physical exertion and clothing (Oke, 2011; Newton, 2021). More so, human variability i.e. variability between people e.g. different metabolic rates, level of physical fitness, medical conditions (including medication), acclimatisation, level of hydration, age, smoking and etc. makes achieving thermal comfort a challenge (Alberta Open Government Program, 2014). These factors all affect how people perceive their comfort levels, even if they are doing the same work in the same environment.

The body temperature of a healthy person varies within very narrow limits. The rectal temperature is usually 37ºC ±0.5ºC, and in the armpit it is 36.6ºC ±0.5ºC (Del Bene, 1990; Lim et al., 2008; Osilla et al., 2022). The temperature of the skin and subcutaneous tissue in the limbs is not only lower than the body temperature but also appears to vary over quite wide limits (28ºC ±15ºC) without any after-effects being noticed by a healthy person (Ronanovsky, 2014).

Heat exchange between the human body and the environment is governed by three factors namely radiation, convection and evaporation. Following Landsberg (1969), the bodily heat balance can be expressed by the following equation:

$$M – W ± R ± C - E = 0$$

This means that to maintain thermal equilibrium, the metabolic heat (M) created chemically within the human body and (W), which is the rate at which external work (force x distance) is being performed together with the heat gained or lost by radiation (R) and convection (C) and the heat lost by evaporation (E), must add up to zero.

If more heat is lost than produced the body temperature falls. This can be prevented by increasing the metabolism rate through muscular activity. Muscular activity may take place voluntarily through work or exercise or involuntarily through shivering. On the other hand, if more heat is produced than lost, the body temperature rises. To prevent overheating, the human body usually resorts to sweating and panting while there is an increase in the skin temperature.

Comfort can best be defined as a state of physical ease and freedom from pains or constraint (Oxford English Dictionary, 2018). It can also be defined as the easing or alleviation of a person's feelings of grief or distress (Lexicon English Dictionary, 2021). People feel uncomfortable when they are too hot or too cold, or when the air is odorous and stale. Positive comfort conditions are those that do not distract by causing unpleasant sensations of temperature, drafts, humidity, or other aspects of the environment. Ideally, in a properly conditioned space, people should not be aware of equipment noise, heat, or air motion.

Ibadan with its climatic characteristics is considered to be humid with high temperatures especially during the wet season (Ojo, 1977; Bello, 1997). As it were, humid air always causes discomfort. For example, in a hot, moist environment, the evaporation of sweat on the skin surface might be retained, leading to difficulty for the body to lose heat. And a man would be uncomfortable. While in a cold environment, the excessive moisture in the air would absorb heat from the skin and increase heat conduction of the clothes causing more discomfort in a wet, cold condition than in a dry, cold condition.

Based on thermal physiology principles it can be predicted that a high level of direct heat exposure in workers will affect their ability to continuously carry out work. Core body temperature needs to be maintained close to 37ºC in order for body systems to function properly. If the body temperature exceeds 38ºC heat strain will occur with exhaustion as one important effect for workers (Kelli, 2021).

Dehydration from sweating also contributes to heat exhaustion and more severe heat stroke effects. Heat exposure is thus an important factor in worker productivity (Jendritzky, et. al. 2006; Kelli, 2021). Climate change will increase heat exposure and this will be of particular importance in locations that are already hot during seasons of the year. Occupational health guidelines for protection against excessive heat effects proscribe an increasing length of rest periods during working hours with high heat exposure. Ibadan Metropolis cannot be an exception in the above corollary because the temperature characteristic is such that there is a considerable increase during the afternoon period when people are still actively at work and it is also when the maximum temperature is being obtained. Generally most of the workplaces in Ibadan are not air-conditioned (a situation that is capable of reducing the effect of high temperature) and as such, efficiency and productivity might be hampered. It is against this backdrop that this study seeks to examine the effect of temperature variation on the physiological comfort of Ibadan residents by achieving the following objectives: determining the temporal changes or variations of temperature over time, and establishing the relationship between temperature variations and physiological comfort of the residents in the study area.

MATERIALS AND METHODS

Study Area

Ibadan, the capital of Oyo state, was carved out from the former Western state or region of Nigeria on 3rd February 1976. The study area 'Ibadan' lies between latitude 7º 20'N, and 7º 28'N and longitude 3º 50' E and 3º 57'E. It has a land area of about 240km square and it is located at the transition zone between the forest and grassland areas of the country, Nigeria. The population of Ibadan was estimated at 3,874,908 (World Population Review, 2023). Ayeni (1994) also noted that "the population of Ibadan has continuously been on the increase and

these high rates of growth are due to implementations and inaccuracies of census estimates. There are eleven (11) Local Government Areas in Ibadan Metropolitan area consisting of five urban local governments in the city and six semi-urban local government areas in the less city. According to Ojo, (1977) the climate of Ibadan is dominated by the influence of three main wind currents, which are the tropical maritime (MT) air mass, the tropical continental (CT) air mass and the equatorial easterlies. The annual temperature ranges between 21.15 to 34.8 ^{o} C and the annual rainfall is about 1,467mm.

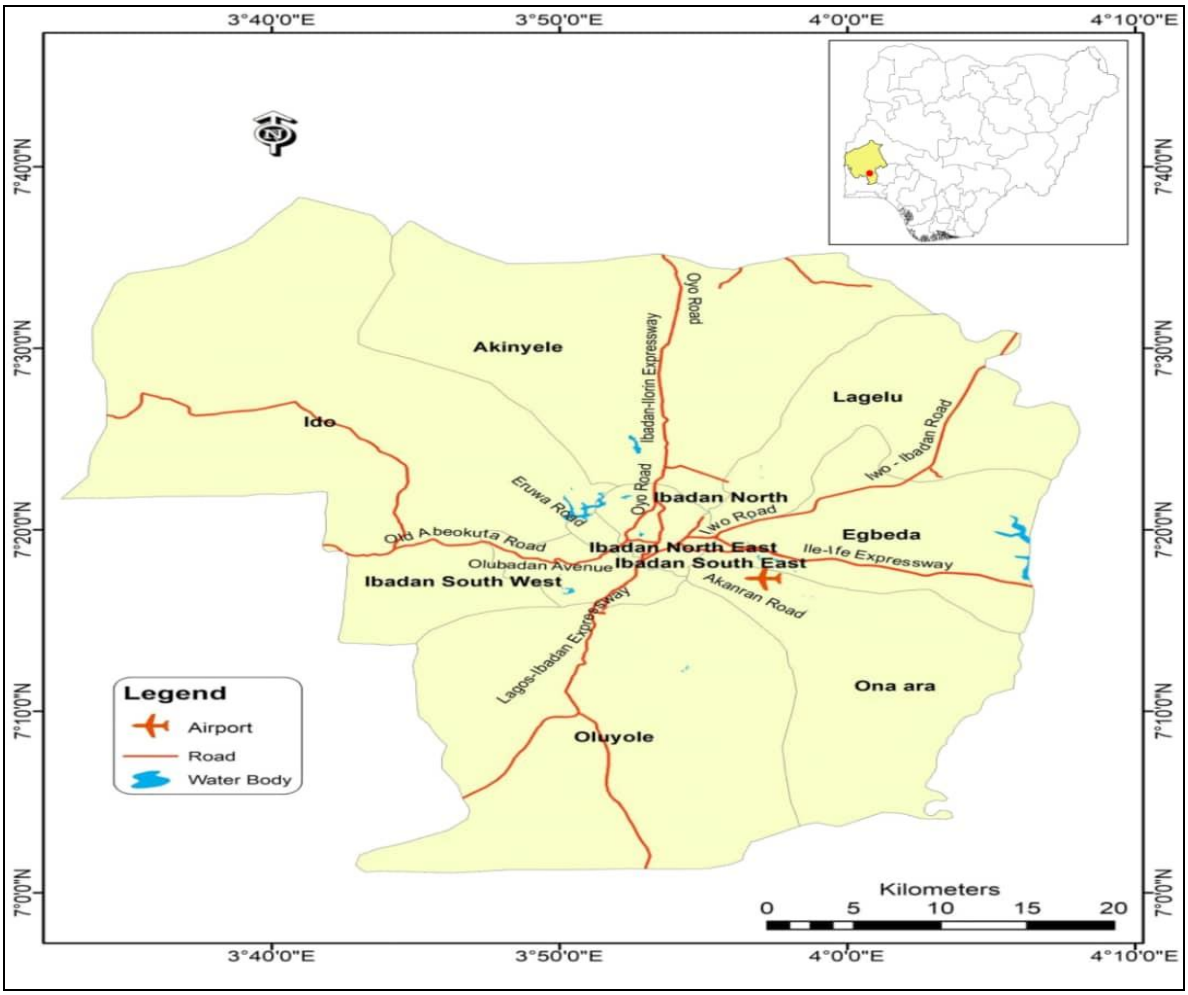


Figure 1. Ibadan Metropolis, Nigeria

Research Design, Population and Sample Size.
The research design adopted for this study was a survey design approach. The data were obtained through primary and secondary sources. The primary data were sourced from the field survey conducted through the administration of questionnaires to various respondents in the study area. This is attempted to complement the meteorological data (i.e. the maximum and minimum temperature data) collected from the Meteorological station. A questionnaire was designed to reflect the aim and objectives of the study and administered to 220 respondents. The set of questionnaires was directed to respondents both in their houses or offices. Data on age, marital status, number of households, and level of education and occupation of respondents were obtained. On the other hand, the secondary data spanning a period of thirty-four years were obtained from the Archives of the Nigerian Meteorological Agency (NIMET) Ibadan station. Specifically, minimum, maximum and mean daily air temperatures were obtained. These were used to demonstrate the extent to which temperature has varied over time.

Agbola and Olutubara (2004) identified the research population as the entire relevant cases or objects of interest in a study. The population for this study, therefore, comprised every Ibadan resident who has stayed for a minimum of ten years. More so, both indoor and outdoor work categories are considered worthy of completing this questionnaire. The following occupations are considered very important to this research: Construction Work, Traffic Police, Street Vendor, Bus/Taxi/Auto Driver,

Office Work, Students, Farming, and Craft/Artisan. These are the group of occupations which are believed to be vulnerable to heat stress as evidenced by Roy et al. (2011).

The proportion of the population considered as the sample size is quite plausible. Here, a total of two hundred and twenty (220) copies of questionnaires were administered to selected indoor and outdoor workers through stratified and purposive sampling techniques. Twenty copies of the questionnaires were distributed using stratified sampling techniques among the eleven (11) Local government areas of the metropolis, while the purposive sampling techniques were further used to target respondents from various occupations that are thought to be impacted by temperature variations. In this case, at least two (2) respondents from the same indoor or outdoor occupation in a local government area were considered. To justify the sample size, larger populations permit smaller sampling ratios for equally good samples (Yusuf, 2003). Neuman (1991) reiterated that as the population size grows, the returns in accuracy for sample size shrink.

Data Analysis

Both descriptive and inferential statistics were employed in analysing the data. Analysis of the socio-demographic characteristics of the respondents and the effect of temperature variations on human physiological comfort in the study area was carried out using both statistical methods. The frequency distribution of each of the socio-demographic characteristics of the respondents was extracted and analysed to identify patterns and trends in each variable. Time series analysis was used to determine temporal variation in the distribution of daily minimum, maximum and mean temperature in Ibadan between 1990 and 2023. Regression and correlation analysis were also used to examine the relationship between temperature variations and physiological comfort in Ibadan.

The Linear Regression Model that was employed as one of the inferential techniques in analysing the data goes thus:

$$y = b_0 + b_1x_1 + \varepsilon$$

Where, **y** = value of the dependent variable (Physiological Comfort), $\mathbf{b_0}$ = a constant value, $\mathbf{b_1}$ = the predictor coefficient, the slope of the regression line, $\mathbf{x_1}$ = the predictor variables or independent variables (Temperature Variation); **ε** = error term.

RESULTS AND DISCUSSION

Meteorological Data

Daily minimum and maximum temperature between 1990 and 2023 made up the data for this study, which was then projected through 2021 using a linear trend model. Time series analysis was used to show temporal variation/changes in daily maximum, minimum and mean temperature in Ibadan for the period under study.

Time Series or Trend Analysis

Data on daily minimum and maximum temperature from 1990 to 2023 are presented in Figure 2, 3 and 4. These Figures show that there has been a steady increase in temperature i.e. an upward or positive trend when analysed using trend analysis a statistical package under time series analysis.

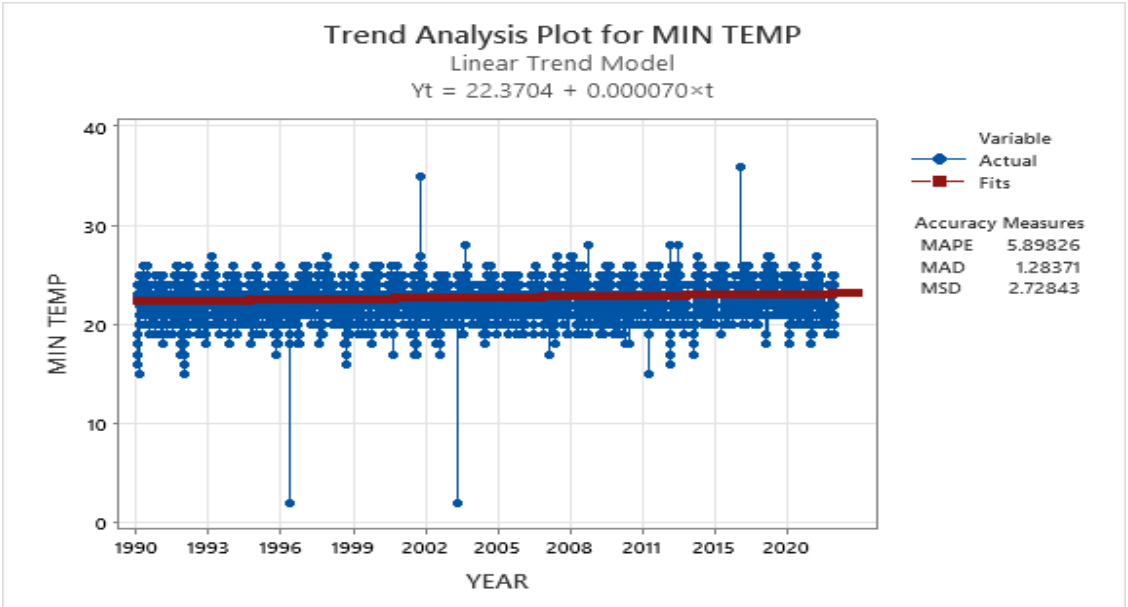


Figure 2: Linear Trend Analysis of Daily Minimum Temperature of Ibadan.

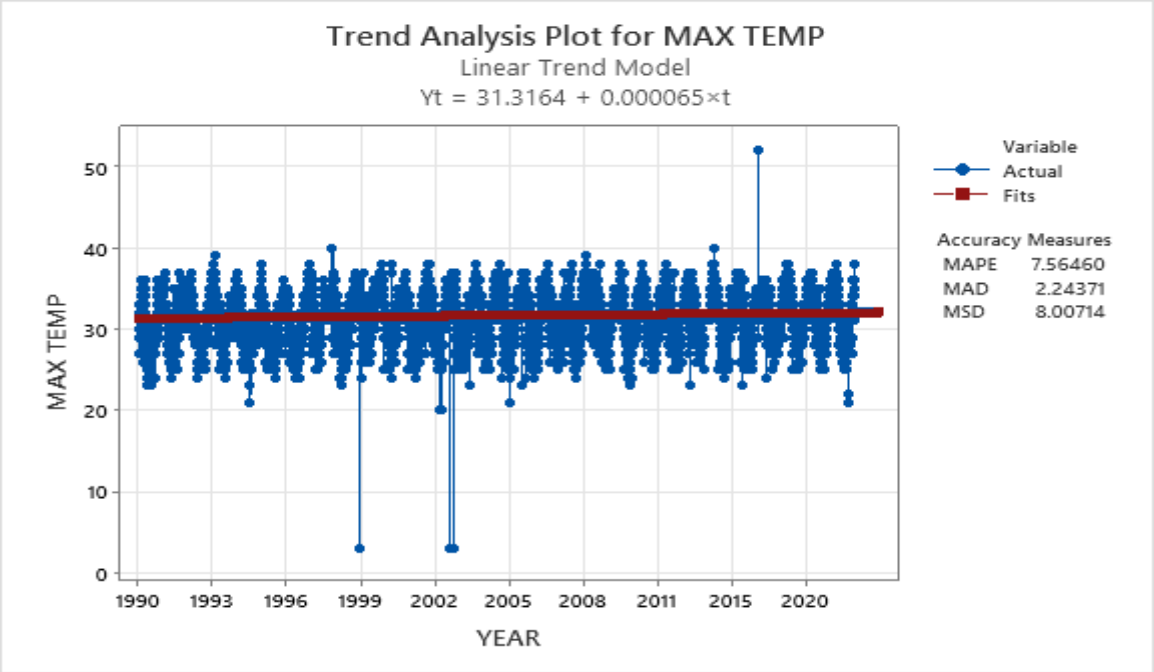


Figure 3: Linear Trend Analysis of Daily Maximum Temperature of Ibadan.

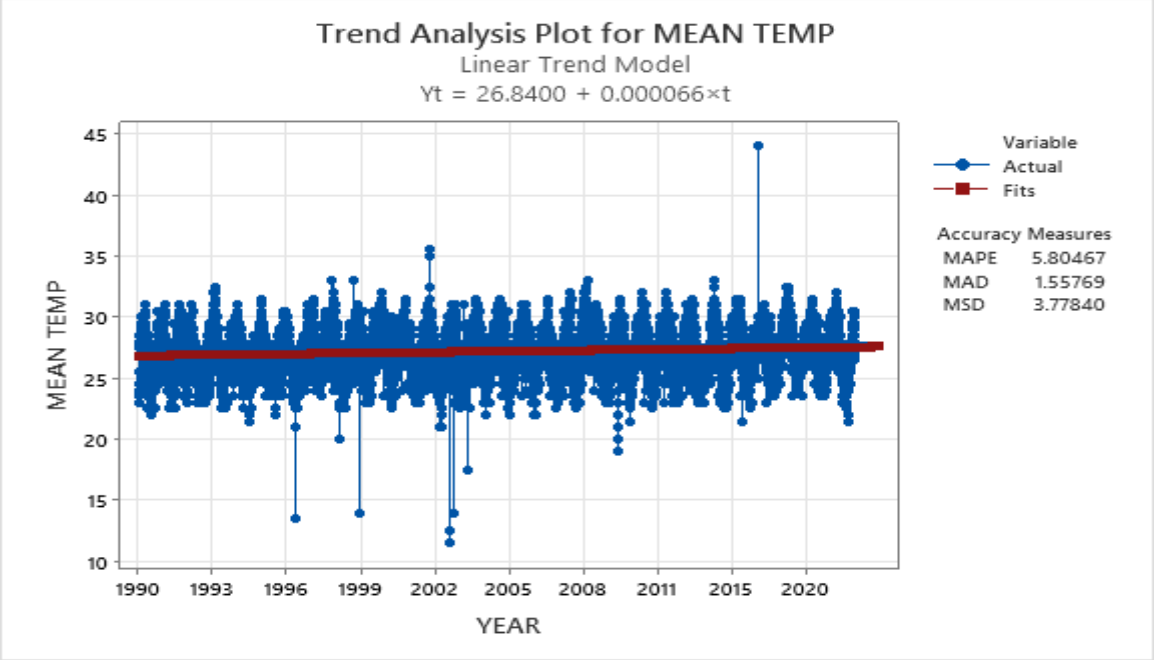


Figure 4: Linear Trend Analysis of Mean Daily Temperature of Ibadan.

The mean temperature of Ibadan daily did not deviate from the former i.e. minimum and maximum temperature data. An upward or positive trend was found on the linear trend model and on the graph it produces.

This also suggests consistently warmer days in the future. This could be said to be a result of excessive accumulation of greenhouse gases in the atmosphere.

Socio-demographic Characteristics of the Respondents

Table 1 shows that among respondents, males accounted for 57.7% while 42.3% were females. The mean age of the respondents was 34 years with the age range 31-40 years having the highest proportion. More than half of the respondents were married (61.4%) while about half (48.8%) were of medium family size.

Table 1: Demographic characteristics of respondents

Variable	Measurement	Count	Percent (%)	Cumulative Percent (%)	Mean
Sex	Male	124	57.7	57.7	
	Female	91	42.3	100.0	
Age	18 - 20 Years	20	9.3	9.3	34
	21 - 30 Years	62	28.8	38.1	
	31 - 40 Years	78	36.3	74.4	
	41 - 50 Years	46	21.4	95.8	
	51 - 60 Years	9	4.2	100.0	
Marital Status	Single	75	34.9	34.9	
	Married	132	61.4	96.3	
	Divorced	8	3.7	100.0	
Family size	2-3 Family Members	50	23.3	23.3	
	4-6 Family Members	105	48.8	72.1	
	7-9 Family Members	30	14.0	86.0	
	10 Members and above	30	14.0	100.0	

Source: Fieldwork (2021)

Table 2: Socioeconomic characteristics of respondents

Variable	Measurement	Count	Percent (%)	Cumulative Percent (%)
Level of Education	Primary School Education	5	2.3	2.3
	Senior Sec. School Education	48	22.3	24.6
	Diploma/NCE	54	25.1	49.7
	Graduate	84	39.1	88.8
	Postgraduate	24	11.2	100.0
Occupational Status	Indoor	87	40.5	40.5
	Outdoor	128	59.5	100.0
Occupation	Construction Work	16	7.4	7.4
	Traffic Police	27	12.6	20.0
	Street Vendor	24	11.2	31.2
	Bus/Taxi/Automobile Driver	20	9.3	40.5
	Office Work	43	20.0	60.5
	Students	41	19.1	79.5
	Farming	13	6.0	85.6
	Artisan	31	14.4	100.0
Monthly Income	Less than 10,000	37	17.2	17.2
	11,000-25,000	43	20.0	37.2
	25,000-50,000	43	20.0	57.2
	51,000-100,000	61	28.4	85.6
	101,000-150,000	26	12.1	97.7
	151,000-200,000	5	2.3	100.0
Duration of stay in Ibadan	1 - 5 Years	17	7.9	7.9
	6 - 10 Years	57	26.5	34.4
	11 - 15 Years	72	33.5	67.9
	16 Years and above	69	32.1	100.0

Source: Fieldwork (2021)

Socioeconomic characteristics of respondents are presented on Table 2. It is remarkable to note that greater fraction of the respondents were first-degree holders (39.1%); one quarter had Nigeria Certificate in Education (25.1%); slightly above one-fifth had only Senior Secondary School Education (22.3%)

while the least educated respondents had no less than primary school education (2.3%). Forty percent of the respondents were engaged in indoor jobs whereas about sixty percent practised outdoor jobs.

Respondents were asked to specify their main occupations. 7.4% of the respondents were construction workers, 12.6% were traffic police; others were street vendors (11.2%), bus/taxi/automobile drivers(9.3%), 19.1% were student, farmers (6%), Artisan (14.4%) while one-fifth of the respondents were office workers (20%).

Physiological comfort and temperature variations in Ibadan.

The main objective of this study is to conduct a survey of physiological comfort in connection to temperature variations. To help determine the most acceptable result, questions that raises concerns about core temperature, rectal temperature, and thermal stress arising from temperature as felt by respondents are sorted for.

Table 3: Temperature changes in Ibadan and physiological comfort.

STATEMENTS	SA (%)	A (%)	N (%)	D (%)	SD (%)	Mean	Decision
Internal heat is produced when the temperature rises, hence body discomfort.	25	52	13	8	2	3.90	High Perception
When the temperature rises, I sweat profusely and cold when it drops below normal.	37	40	11	7	5	3.97	High Perception
The level of comfort is increased by sweat, particularly in the morning.	10	6	21	41	22	2.41	Low Perception
Most of the time, from midday to four o'clock, there is a rise in the amount of heat discomfort.	42	41	6	10	1	4.13	High Perception
A common occurrence during hot weather is an increase in heart rate.	27	38	14	17	4	3.67	High Perception
When temperatures are high, work performance improves.	7	11	15	44	23	2.35	low Perception
When exposed to heat for an extended period of time, weight loss is a regular occurrence.	19	26	20	31	4	3.25	Low Perception
Constant perspiration causes irritants including body itch, heat rashes, headaches, and more.	25	48	13	12	2	3.82	High Perception

Source: Fieldwork (2023)

Note: N=104, SA=Strongly Agree, A=Agree, NA=Neither Agree, D=Disagree and SD=Strongly Disagree. Decision – Weighted Average = 27.50/8 = 3.43.

Table 2 provides a thorough account of how the residents of Ibadan felt about their comfort as the temperature changed, especially when it went above normal. A high perception was reported of the statement that internal heat is produced when the temperature rises, hence body discomfort, and that when the temperature rises, residents sweat profusely and feel cold when it drops below normal.

Also, most of the time, from midday to four o'clock, there is a rise in the amount of heat discomfort, and a common occurrence during hot weather is an increase in heart rate and constant perspiration that causes irritants including body itch, heat rashes, headaches, and more. However, low perceptions were reported that the level of comfort is increased by sweat, particularly in the morning, and that when temperatures are high, work performance improves. Low perception was also noted when residents are exposed to heat for an extended period of time; weight loss is a regular occurrence.

Test of Hypothesis

H_0: *There is no significant relationship between Temperature Variation and Human Physiological Comfort in Ibadan.*

Table 4: Linear regression analysis of the relationship between temperature variation and human physiological comfort

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
	0.429[a]	0.184	0.180	1.860

Analysis of Variance

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	166.444	1	166.444	48.098	0.000[a]
Residual	737.091	213	3.461		
Total	903.535	214			

Source: Fieldwork (2023)

Table 4 presents the results of the hypothesis set (H_0) which unveils that there is a positive and significant relationship between Temperature Variation and Human Physiological Comfort in Ibadan ($F(1, 213) = 48.098$, $P<0.01$). Temperature Variation accounted for nearly twenty per cent (18.4%) of the total variance in the respondents' Physiological Comfort. The null hypothesis is therefore rejected.

Table 5 Correlation Coefficients of the Relationship between Temperature Variation and Human Physiological Comfort

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	T	Sig.
(Constant)	9.962	0.731		13.632	0.000
Temperature Variation	0.343	0.049	0.429	6.935	0.000

Dependent Variable: Human Physiological Comfort

The results in Table 4 also indicate that the predictor variable has a significantly positive slope ($B = 0.343$, $p<0.01$) and correlation with the Physiological Comfort of the respondent ($r = 0.429$). This establishes the fact that the change in Human Physiological Comfort is a function of the temperature variation that occurs over time.

Discussion

Temporal Variations in Daily Minimum and Maximum Temperature in Ibadan

Data was analysed using SPSS (Statistical Package for Social Sciences). The results of the Time Series Plot as shown in Figures 2 to 4 indicate statistically significant variations in the temperature series. Most variations tends towards increasing trend in air temperature especially at minimum temperature level with the coefficient of variability (CV) ranging between 13 and 21%.

The results of this study corroborate the findings of most studies carried out with respect to climate change, for example, Gurudeo and Mahbub (2010) found some changes over time in the 50 years data of rainfall and temperature in a research carried out in Australia. In another study conducted by Gillion (2005) in the Antarctic Peninsula for the period of 1950-2004, results show that there was a general increase in the mean surface temperature at the station.

In Adeshina and Odekunle (2011), study of climate change and adaptation in Nigeria; the results obtained for the minimum temperature generally indicated upward trends which can be ascribed to global warming. This is also in agreement with the assessment of the impact of climate change on water resource at Jebba hydropower reservoir using trend and reduction pattern methods by Salami (2011), statistical analysis here also revealed significant positive trends, which indicated that the parameters tend to increase.

However, the results of this study slightly deviate from the findings of Ogolo and Adeyemi (2009) who conducted a study of variations and trends of some meteorological parameters at Ibadan and found air temperature to be the least variable parameter having the coefficient of variability (CV) to range between 1-4% as against 22-97% of rainfall. With the ten (10) years data employed for the research, they observed an increasing trend in air temperature but not statistically significant. Therefore, it could be concluded that comparing the temperature data in Ibadan with the global

temperature trends, a warming drift was observed in the temperature series in the station.

Temperature Variations and Human Physiological Comfort

According to the results from Tables 3 and 4, it was discovered that there is a positive and significant relationship between temperature variation and human physiological comfort in Ibadan.

From a biological standpoint, the human body can be described as a constant-temperature apparatus. Heat is continuously produced by bodily processes and dissipated in an automatically regulated manner to maintain the body temperature at its correct level despite variations in ambient conditions. The findings of this study align with the explanation made by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc, about the thermal environmental conditions for human occupancy. It states in terms of physiology, that the experience of comfort is the achievement of thermal equilibrium with the minimum amount of body regulation. The human body normally rejects heat to the environment using evaporative cooling (sweating) and the heat transfer mechanisms of radiation, convection, and conduction.

The relationship between temperature fluctuation and human physiological comfort revealed by this study is also supported by the report of the study of spatial and seasonal patterns of physiologic comfort in Nigeria carried out by Ayoade (1978). He stated in his study that human health, energy, efficiency and physiologic comfort are affected more by climatic conditions than any other element of man's physical environment. He stressed further that the effects of climate on man particularly his physiologic comfort and physical and mental efficiency constitute a major theme of the science of bioclimatology.

Physiologic comfort, as defined by W.M.O. (1964) in a survey of Human Biometeorology, gives credence to the findings of this study. According to W.M.O's definition, Physiologic comfort is a feeling state in which a person has no wish to increase or decrease insolation or to adjust the ambient thermal environment. Nonetheless, it is imperative to state that the comfort of a given individual is affected by many variables. Health, age, activity, clothing, gender, food, and acclimatisation are all determining factors of the comfort conditions for any particular person. Since these factors will not be identical for all people, room conditions are expected to be available under which a majority of the expected occupants will feel comfortable.

CONCLUSION

The findings of this study offer remarkable insights into the temporal variation in the distribution of daily temperature in Ibadan for over thirty (30) years.

The study equally revealed that the average daily temperature has been increasing slowly over time with its attendant effects on human physiological comfort and physical wellbeing. This is because the minimum temperature trend was increasing faster than the decrease taking place in the maximum temperature trend. However if these temperatures continue in their respective trends, there is every possibility that Ibadan and many other cities in Nigeria as well as several other countries in the tropical regions will continue to experience global warming. The effect of it will be felt mostly in agriculture and many other sectors of the economy.

For Nigeria and the world at large to move out of the very challenging situation it has found itself, the government through its various intervention programmes must address some of these challenges. The citizens on their own should embrace eco-friendly activities and abstain from activities that are harmful to their immediate environment. This would help prevent environmental degradation and enhance healthy living.

The following are some recommendations that are derived from the findings of this study, which are considered important for the Nigerian government at all levels.

1. Most climatological research works suffer from a lack of adequate record of climatic elements. It is either that the records of such climatic elements are not being properly kept or there are no instruments to measure them. At times when instruments are available there is no manpower to monitor them. This study therefore recommends that adequate, regular and up-to-date records of climatic elements be properly compiled and well kept. More modern instruments e.g. automatic recording instruments should be installed in various meteorological stations to monitor the changes that occur in weather from time to time. All existing climatological stations should be served with at least an assistant to take the daily climate records.
2. Every effort must be made by the central office in Abuja to see that climatological stations send adequate records of their measurements promptly, and should ensure that such records are well kept. In this era of electronic computers, it is suggested here that climatic records be computerised for proper storage, easy retrieval, and quick extraction of data.

3. An illiterate populace is prone to misinterpreting good government policies that are intended to improve their lives, it also affects information dissemination among the people. Efforts of the government to encourage proper education in both rural and urban areas are a step in the right direction. If the people become literate it will create in them the awareness and consciousness of government policies.

4. The factors that engender habitability are very germane in the quality of life of the Nigerian masses. All communities in the country are worth living in, but some perennial problems prevail, and they aggravate the abysmally low level of living of the Nigerian citizens. If the Nigerian government, through the instrumentality of the Federal Environmental Protection Agency (FEPA), steps up actions in treating air pollution in the industrial areas and deforestation in the rural areas. If alternative ways of utilising the gases that are presently being flared are sought, the concentration of greenhouse gases (e.g. C02, CFCS etc) in the atmosphere would then reduce to the nearest minimum.

5. In order to guide against future atmospheric warming, the Nigerian government should discourage bush burning, gas flaring and non-conservative exercise and enjoin the citizens to participate actively in the tree planting programme as it is evident that vegetal cover exerts much influence on the surface air temperature condition of a place. This will help to mitigate the potential effects of global warming on agriculture, water resources, coastal zones and human settlement at a worldwide scale.

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Analysis of Socio-Demographic Characteristics of Slum Dwellers in Nigerian Cities

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ABSTRACT

Slum has taken unprecedented and uncontrollably increasing in Nigerian cities with its adverse effects on urban sustainability. The study sought to analyze the socio-demographic characteristics of slum dwellers' in Nigerian cities. 384 questionnaires through purposive sampling technique were administered among slum dwellers in Bosso LGA of Niger State, Nigeria. The results were analysed using frequency and percentage distribution. The study revealed that 56.2% of the respondents possessed tertiary education, followed by 23.2% possessed others, 16.3% possessed secondary education and 4.3% possessed primary education; 52.5% of the respondents were civil servants, followed by 17.2% were farmers, 16.2% engaged in other economic activities and 14.10% were traders; 60.30% earned more than N40,000 followed by 32.6% earned between N21,000-N40,000 while the remaining 7.1% earned N1000-N2000; 35.80% of the respondents have household size of 6-10 and 20.40% have household size of 11-15 followed by 17.20% have household size of 1-5 and 11.70% have household size of 16-20; 41% of the respondents utilized water vendor, popularly known as ''Mai Ruwa''and 29% used water from boreholes followed by 28.2% used well water and 13% used pipe borne water. 61.10% of the respondents used improved pit latrine followed by 21.70% used pit latrine, 17.20% of the respondents used water closet and 36% of the respondents disposed their waste through burning and 35% disposed their waste through drainage lines, while the remaining 28.2% of the respondents disposed their waste through open space. Effective recommendations such as slum upgrade, urban regeneration and low-cost affordable housing among others were made.

Keywords: *Urban Governance, Urban Poverty, Urban Regeneration, Sustainability Slums, and Informal Settlements*

INTRODUCTION

Slums are global urban challenges in both developed and developing countries, but they are more common in countries that are developing as a result of rural-urban migration and increased socio-economic activities, especially at the city centres. Slums are defined as regions in which residents do not live in durable housing, do not have access to safe water, do not have buildings that meet building regulations and standards, and do not have access to basic adequate amenities as a result of poverty as well as inadequate attention from government (UN-Habitat, 2003). A slum is a continuous settlement in which people are classified as having insufficient housing and essential services; it can also be referred to as informal settlements, squatters, shanty towns, or ghettos (Brijendra, 2016).

Africa and Asia together will account for 86 percent of all growth in the world's urban population over the next four decades, adding that this unprecedented increase will pose new challenges in terms of jobs, creating a breeding ground for slum. Africa's urban population will increase from 414 million to over 1.2 billion by 2050, while that of Asia will soar from 1.9 billion to 3.3 billion (UNPDDESA, 2011). The largest increase in urban population are expected in: India, China, Nigeria, USA and Indonesia, over the next four decades, India will add another 497 million, China – 341 million, Nigeria – 200 million, USA – 103 million, and Indonesia – 92 million to their urban population (UNPDDESA, 2011).

Currently, about 43% of Nigerians live in urban centres. Nigerian urban centres over time have experienced high rate of urban population growth resulting in proliferation of slums, high rate of unemployment among others (Aluko and Amidu, 2006). Residents of the slums constitute an indispensable part of the urban community and are key contributors to the informal sector of the economy (Wahab, 2017). This creates a breeding ground for poor accommodation, illegal and informal settlements, slums, high rate of unemployment among others. Uncontrolled urbanization as characterized by increased human population and rural-urban migration has resulted to demographic, economic and environmental challenge of the 21st century (UN and UNCHS, 2010).

Makinde (2012) revealed that urban centres have been challenged with inadequate basic services such as poor sanitation stemming from the lack of sufficient basic services results in compromised health conditions of the inhabitants as well as the

deprivation in social and economic opportunities for sustainable urban development. The study further found out that the urban areas currently account for about 3% of the Earth's surface, the ecological footprint associated with urbanization has important environmental consequences especially on wetland ecosystems. Urban centres are challenged with environmental deterioration, inadequate housing, traffic congestion, slums, crime, homelessness among others (Makinde, 2012). This is supported by various studies, which indicates that slum has it adverse effect on environmental pollution, traffic congestion, sanitation, commuter noise, inadequate parking space, and overcrowding of hawkers and food vendor (Adegbehingbe and Fadamiro, 2007).

Brian (2000) has associated urbanization and slum formation to be breeding ground for urban poverty, the rising crime rate, solid waste disposal, housing for the poor, environmental protection and pollutions. Ojigi (2012) observed that slums in Nigerian cities have serious aesthetic and functional effects on the landscape and sustainable development of a city. The study explained the effects of inadequate infrastructures in these areas often result into improper disposal of wastes, lack of good water supply and insecurity, among others. This increased influx of people into urban areas resulted in the formation of slums. Slums are densely populated areas that are characterized by poverty, poor physical development, socio-economic deprivations, insufficient urban infrastructure, and other inadequate support systems that can promote human comfort (Hossain, 2013).

The primary drivers of the rise of slums are linked with uncontrolled increased in movement of people from rural areas to urban centres. Due to high cost of accommodation at the urban centres, the poor urban dwellers are compelled to live in slums. These areas are characterized with slow pace of housing and environmental living conditions (UN-Habitat, 2003). The expansion of slums in cities are driven by the increasing window of economic opportunities at both formal and informal levels that are available at the city-centres due to rural-urban migration. The demonstrable effect of the metropolitan area's higher standard of living has drawn not only people from smaller settlements, but also rural migrants to the major urban centres. This creates a breeding ground for formation of slums at the metropolitan areas (Sufaira, 2013).

Other factors contributing to slum formation include a shortage of residential property, which become hard to get by the poor urban dwellers as a result of the costly nature of housing at within the cities and towns; an increasing number of individuals, rural drift to cities in "greener pastures" and insufficient access to basic services and infrastructure in urban areas. Slums are often the result of failed policies, adaptable markets for land, and a fundamental lack of political will (Gurumukhi, 2000). According to Zubair, Ojigi and Mbih (2015), the ripple effects of influence of urbanization, poor housing service delivery, unaffordable housing among poor urban residents led to slums and informal settlement in Nigerian cities.

Furthermore, slum development are linked to the prevailing socio-economic conditions in relation to slow pace of access to economic opportunities through trade and investment, spatial and social inequality in resources distribution among the urban rich and the urban poor, ineffective urban governance and planning tools among others in stimulating the economic, social and environment development in urban centres. Slum dwellers constitute a significant part of the urban community and contribute to urban economies, especially at informal level (Wahab, 2017). This creates a breeding ground for poor accommodation, illegal and informal settlements, slums, high rate of unemployment among others. Uncontrolled urbanization as characterized by increased human population and rural-urban migration has resulted to demographic, economic and environmental challenge of the 21st century (UN and UNCHS, 2010).

The formation of slums and informal settlements are driven by the interplay globalization and urbanization. Bosso Town over the years has experienced uncontrolled influx of migrant as a result of increasing rate of economic prospects such as jobs creation, provision of education needs especially at tertiary level such as Federal University of Technology among others increased the population of the area. This has attendant effects on the socio-economic activities within Bosso town and increased the proliferation of people into the area. Other factors are associated with uncontrolled physical development, inadequate drainage system, pollution, inadequate sanitary practices, and the inability of the poor urban dwellers to get accommodation at the city-centre increased the proliferation of slums and informal settlements within Bosso town. This pose significant threats poor accommodation, overcrowding in buildings, congestions, human habitation, livelihood of the residences in slum areas in Bosso.

Slum formation is more predominant in Nigerian peri-urban environment in general and Bosso in particular. This is owing to the obvious fact that there is appreciable increased in the urbanization processes in Bosso town as a result of employment opportunities, education and man desire

for better livelihood among other push and pull factors enhance the expansion of Bosso town, Niger State. Those that cannot afford expensive lifestyle at the city-centre thereby resort to stay the urban-fringes of Bosso, Niger State with a view to have access to employments, education facilities such as School of Science and Education Technology at the Federal University of Science and Technology, Minna, Niger State.

The population of the Bosso Local Government has increased dramatically in the previous decade, despite a lack of suitable housing and increased service supply (National Orientation Agency, Bosso L.G.A, 2017). The objectives of urban squatters, which include the possibility for a better living, work prospects, and other factors, alter throughout time as a result of the diverse circumstances in which they find themselves. However, one of the challenges they confront, and one that has persisted for a long time, is the lack of sufficient accommodation. However, with little financial and other resources, skills, or access to them, the dramatic alternative of unlawfully seizing unoccupied property to build a crude shelter appears to be the only choice accessible to urban squatters and the urban poor.

As a result, urban migrants have taken over some portions of Bosso, and enormous regions of expanding slums have developed owing to a lack of basic infrastructure. Anguwan Masa, El-waziri, Anguwan Biri, and Anguwan Bullet are examples of such locations. The lack of fundamental services and infrastructures that would allow for adequate living conditions in these places, as well as inferior housing units, a dirty and unorganized society, and high crime rates in the study area (Srinivas, 2004). This resulted to unregulated urban and physical planning, poor and shortage of accommodation, inadequate infrastructural facilities such as drainage system, sewage system, increasing pollution and development of slum and squatter settlements. This pose significant threats to human habitation, livelihood of the residences in slum areas in Bosso town, Bosso LGA, Niger State.

Growth and expansion of slums have both negative and positive impact on the national and regional economy. The negative aspect of slums relates to the fact that they are often burdened with high transaction costs including increase in transportation expenditures as a result of inadequate infrastructure and disease burden on urban dwellers due to the large number of people living in slums (Fox, 2008). Ambiguous property and tenancy rights can reduce the efficiency of urban land and housing markets which discourage investment or reduce participation in urban labor markets (Marx, Stoker and Suri 2013). This may potentially impact a country or a region's overall economic outlook in the global economy, making it less competitive in the worldwide arena (Gambo, Idowu and Anyakora 2012).

Less often mentioned in the literature is the economic good provided by slum dwellers. Slum dwellers provided cheap labour due to low level of educations (Brugmann, 2010). Furthermore, it has been argued that their low economic standing and general lack of education forces them to accept low paying jobs that may not be readily accepted by middle and upper class people (Pawar and Mane, 2013). Slum dwellers often find jobs in the informal sector, which is usually linked very closely to the needs of surrounding formal communities (Opeyemi et al., 2012). In some cases, this informal economy has positively impacted the country's gross domestic product (GDP) (Omole, 2010).

There is dearth in literature and paucity of data on the socio-demographic characteristics of slum dwellers in Bosso Town, Bosso LGA, Niger State, Nigeria. Alamgir *et al.* (2009) examined the living conditions of slum inhabitants in Dhaka. The findings of the study utilized social and economic variables as a means of assessing the livelihood of slum dwellers, however, the study did not measure the physical characteristics such as the house type, condition of the house, the layout, the roads and the general physical environment among others for assessment of slums in the study area. Ezeamaka, Daful and Oyetunji (2018) focused their study on profiling characteristics of squatter settlement in Jabi, FCT and its impact on settlers.

Ade and Afolabi (2012) assessed the changes in landmass or landuse/landcover and population increase in the Federal Capital Territory (FCT). The study revealed that the built-up area increased, decreased in rock-outcrop and vegetation as a result of urbanization. The study only focused on population increase and urban expansion. Zubair, Ojigi and Mbih (2015) in their studies revealed the influence of urbanization, poor housing service delivery, unaffordable housing among poor urban residents led to slums and informal settlement within the FCC. However, the study did not examine housing quality and the environmental living conditions in the study area. This is another gap in knowledge the study sought to fill.

The rise of many slum and squatter settlements of the world was due to urbanization. Bosso is not an exception due to the incoming of people in search of better life, education and job opportunities which result to an increase in population of Bosso town. The effect of urbanization in Bosso has led to the increase in population of

slum dwellers majorly at the suburb of the city due to the economic activities in Bosso town. This brings about disjointed development, overcrowding in buildings, congestions, absence of drainage line, pollution, inadequate sanitary practices, and slum and squatters settlements. This pose significant threats to human habitation, livelihood of the residences in slum areas in Bosso. To this end, most of the studies reviewed did not consider the physical variables such as the physical characteristics of the slum areas, the quality of housing and housing environment of slum areas which became a gap this study intends to fill. This is the gap in knowledge this paper seeks to fill. The paper analysed the socio-demographic characteristics of slum dwellers in Bosso Town, Bosso LGA, Niger State, Nigeria, determine the quality of housing and sanitary facilities in the study area which become a gap this study intends to fill.

MATERIALS AND METHODS

The Study Area

The study area is Unguwan Masa and El-wazir in Bosso town, Bosso Local Government Area of Niger State, Nigeria. It lies between latitude $9^0$3'7"N and latitude $9^0$4'0"Nand longitude $6^0$3'3"E and longitude $6^0$3'8"E. Its headquarters is in the town of Maikunkele. Bosso has an area of 1592km^2 and a population of 147,375 (2006 census). It is located in the southern part of Minna and environed by Tayi village, Bosso low cost, Bosso estate, Tudun Fulani, River basin, Rafin yashi and Maikunkele. It is located in the south eastern part of Niger State with elevation height between 243 and 300 meters above mean sea level. It is bordered by Shiroro LGA to the North, Muya to the North-East, Paikoro to the South-East, Katcha to the South and Wushishi to the West Respectively.

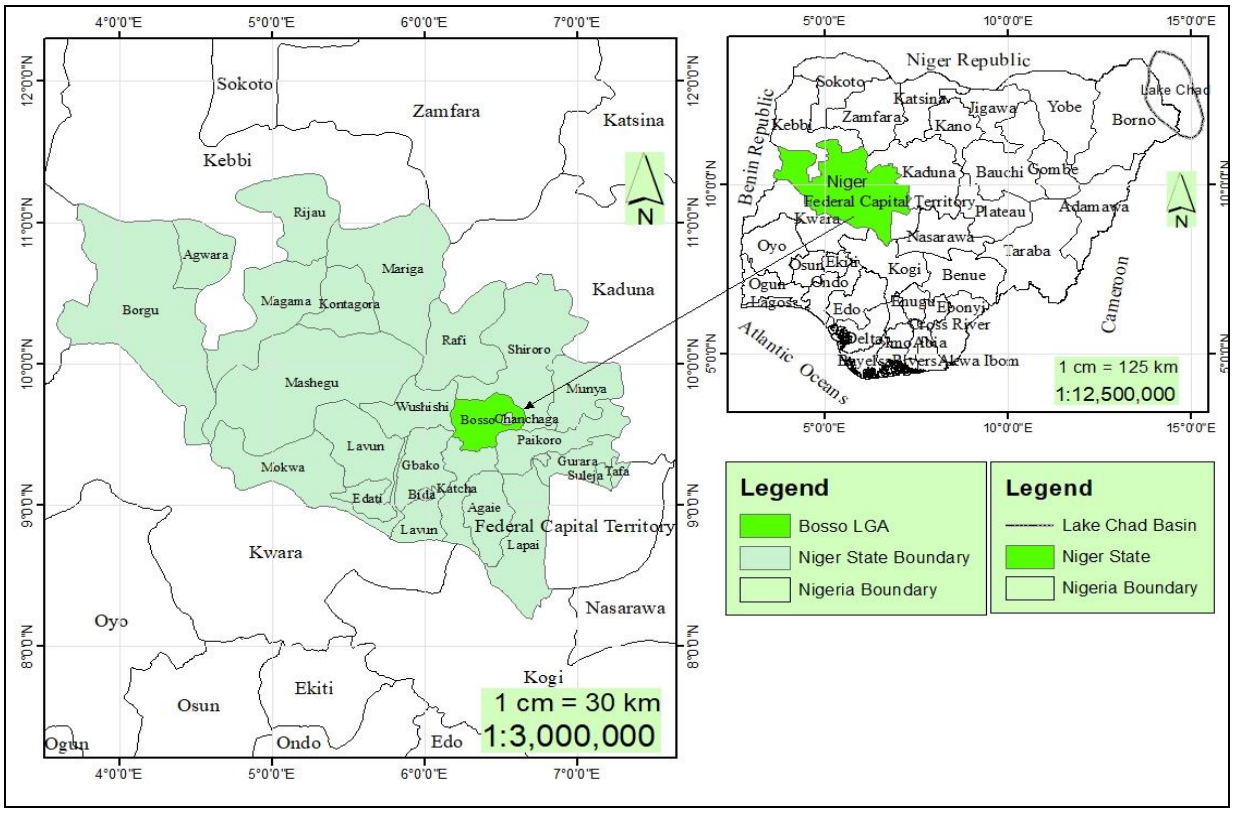


Figure 1 Bosso LGA, Niger Sate (Study Area)
Source: Niger State Ministry of Land, Minna

Bosso LGA like every other area in the north central area of Nigeria is divided into two seasons of wet and dry season within a year. The wet (rainy) season starts in April and ends in October, with a maximum rainfall occurring in august. Presently, Bosso LGA experiences a climate typical of the middle belt zone, Guinea savannah with distinct wet and dry season. It has a mean annual rainfall of about 1334mm (52 inches) with September recording the highest rains of about 300mm (11inches). The mean monthly temperature is highest in March at 39C and lowest in August at 23C. The mean monthly relative humidity is highest in August at 60% and lowest in February at 19% respectively (Musa and Aileku, 2017).

Mean annual rainfall ranges between 1,200mm and 1500mm. Rainfall in Bosso reflects the location on the wind ward side while the monthly rainfall distribution intensified during the month of July, August and September (Fatima, 2012). The summer has a good deal of rainfall. The rainfall lasts for eight months, from March to November. The average annual rainfall is about 1,400mm. The duration of the rainy season is approximately 180 days. The wet season usually begins in April/May and ends by October, while the dry season starts from November to March. The maximum temperature of 29 ^{o}C, average temperature of 22^{o}C and minimum temperature of 26^{o}C. The mean average temperature is around 32 ^{o}C. Dry season commences in October (Niger State Geographical Information System, 2020).

Bosso Local Government Area falls within the savannah zone vegetation of the West Africa sub-region. However, patches of rain forest occur in the plains that form one of surviving North-most occurrences of the natural forest vegetation in Nigeria. The vegetation of Bosso LGA is divided into three savannah types of park or grassy that occupies about 53 percent of the total area and where the vegetation is annually savannah wood land that occur mostly in the rugged and less accessible parts on the Robo and Rubochi plains and same ending hills, they cover 12.8 percent and the shrub savannah that occurs extensively in rough terrain close to hills ridges in all parts of Bosso and covers about 12.9 percent of the land area (Ehigiator and Jimoh, 2015).

Drainage systems are pathways created naturally or artificially to address the increasing problems of diffuse sewage and run-off over an area. The run-off whether deliberate or accidental can be a major cause of flooding and polluted stagnant water in urban environment Ojutiku *et al.* (2014). Two kinds of drainage Systems are available in the entire Bosso LGA, these are the artificial drainage system (constructed drainage system) and the natural drainage system (originated through occurrence of erosion or flooding).

There are inadequate artificial (man-made) drainages in most parts of Bosso Local Government Area and which are not enough to channel the water that flows on the earth surface for hours or even days after a heavy down pour. This surface flow is however what often leads to the occurrence of the natural drainages which on the other hand disorganizes and disintegrates the landscape of the area. River Chanchaga flows south-west in the southern area of the city. Its fundamental tributaries incorporate Wana Waterways, Shaho, Godina, and Dunalape, which are coming directly out of their highlands and isolated compounds for example; Gwam, Kpewi, Zuru, and TsauranNabi hills. The town also has other natural and manmade drainages that collect and drain off storm water (Ojutiku *et al.* 2014).

The population of Bosso LGA is 203,134 as projected in 2019 using the national population census Figure of 2006 with 2.5% annual growth rate. The people are predominantly engaged in local trade and businesses. The predominant ethnic groups in Bosso are Gbagyi, Nupe and Hausa while Yoruba, Igbo and other ethnic groups account for few of the population. The major language spoken in the town is Gbagyi. It is a predominantly Muslims society with few Christians.

The majority of the populace in Bosso LGA are farmers while the others are involved in vocations such as white collar jobs, business, craft and arts, markets, subsistence agriculture, and agricultural exports account for the majority of Bosso Local Government's revenue. With a low GDP and per capita income, Bosso LGA has repeatedly been rated near the bottom of the Human Development Index (Alfa, 2019). Subsistence agriculture and animal husbandry are the mainstays of the economy. The city's principal agricultural products include Maize, Rice, and Guinea corn (sorghum). Yam is also widely grown across the LGA to supplement revenue. Cattle trading, brewing, shea nut processing, and gold mining are all supported by the economy. Leather and metal working are two traditional Bosso businesses and crafts (Alfa, 2019).

Methodology

A reconnaissance survey was conducted in order to be acquainted with the physical characteristics, living conditions and other facilities such as drainage facilities, water supply, and housing condition, adequacy of existing infrastructural facilities such as health care centres, educational institutions, and other facilities for enhancing quality of life, conviviality and other environmental living conditions in the study area. The following data were used for the study:

i. Administrative map of the study area
ii. Socio-demographic characteristics of the study area such as age, sex, occupation, marital status, monthly income, and household size among others.
iii. Data on the housing conditions, sanitary facilities, electricity, water supply, schools, health care centers and waste management practices in the study area.

The data for the study were collected through field observation by the design and

administration of questionnaire and interviews. Other data were collected through review of literature from journals, conference proceeding and other both published and unpublished articles and administrative map from Niger State Ministry of Land, Minna, Niger State. The target populations are respondents that live in slums of Unguwan Masa and El-wazir Bosso LGA of Niger State. The 2006 population of Bosso LGA is projected to 2019 to 203,134. Due to lack of up to date data on the population of Unguwan Masa and El-wazir, Bosso LGA population was adopted to calculate the sample size. Yemane (1967) was adopted to calculate the sample size because, it provides a simplified formula to calculate sample size with 95% confidence and 5% sampling error assumption:

$$n = \frac{N}{1 + N(e)^2}$$

Where:
n= Sample Size
N=Population Size
e= Margin error of (0.05)

Using the above formula, a total of 384 questionnaires were administered among the respondents. Multi-stage sampling technique was used for the administration of questionnaire among the respondents that live in the study area. First stage involved the selection of identified locations where slums were found in the study area. The second stage was the selection of 10th household for the administration of questionnaire in the study area for valid generalization. Systematic random sampling technique was adopted for the administration of 384 questionnaires among household heads in the selected slums of Unguwan Masa and El-wazir Bosso LGA of Niger State

Both descriptive and inferential data analyses were conducted. In-depth interview with key informants were analysed through themes and content analysis. Data on the socio-demographic characteristics of beggars were analysed through frequency and percentage distribution. The results were presented in tables.

RESULTS AND DISCUSSION

Socio-Demographic Characteristics of Respondents

The socio-demographic characteristics of respondents is presented in Table 1.

The study shows that 56.2% of the respondents claimed to possessed tertiary education and were the most represented, followed by 23.2% possessed others, 16.3% possessed secondary education and 4.3% possessed primary education and were the least represented. This indicates that large number of respondents have basic education. It can be concluded that majority of the respondents possessed tertiary education and this can be attributed to their proximity to Federal University of Technology, Minna as majority took advantage of working in the University. The study is in line with Dauda (2020) revealed that 51.9% of respondents in Abuja Municipal Area Council (AMAC) were educated to university level.

Table 1 Socio-Demographic Characteristics of Respondents

Characteristics	Percentage
Educational Qualification	
Tertiary	56.2%
Others	25%
Secondary	12%
Primary	6.8%
Total	**100%**
Occupation	
Civil Servants	50.2%
Farmers	25%
Others	13.5%
Traders	11.2%
Total	**100%**
Monthly Income	
More than N40,000	60.30%
N21,000-N40,000	32.6%
N1000-N2000	7.1%
Total	**100%**
Household Size	
6-10	35.80%
11-15	20.40%
1-5	17.20%
16-20	11.70%
Total	**100%**

Source: Author's Field Survey, 2022

Based on the distribution of respondents by occupation, the study shows that 52.5% of the respondents were civil servants and were the most represented, followed by 17.2% were farmers, 16.2% engaged in other economic activities and 14.10% were traders and were the least represented. This indicates that majority of the respondents in the study area were civil servants. This could be attributed to the fact that the area is dominated by mostly educated elites that work at Federal University of Technology, Minna. There is a relationship between educational qualifications and occupations. This study disagrees with Ezeamaka, Daful and Oyetunji (2018) that revealed that majority of the respondents of informal settlements in Jabi district were traders.

The study shows that 60.30% of the respondents earned more than N40,000 and were the most represented, followed by 32.6% earned between N21,000-N40,000 and were fairly represented while the remaining 7.1% earned N1000-N2000 and were the least represented. This indicates that 92.9% of the respondents earned above N2,000 and more than N40,000 monthly. This suggests that majority of the respondents are middle income earners reflecting a favourable standard of living as many are able to meet their basic needs which make life bearable for them. It can be concluded that possession of tertiary educational qualification enhance chance of getting productive employments, especially white collar jobs and this increased their standard of living among others. The study slightly disagrees with Dauda (2020) showed that 49.1% of the respondents in Abuja were low and middle income earners and 50.9% were high income earners.

About 36% of the respondents have household size of 6-10 and 20.40% have household size of 11-15 and were jointly the most represented, followed by 17.20% have household size of 1-5 and 11.70% have household size of 16-20 and were the least represented. This indicates that 76.20% of the respondent have household size of 6-15 and were the most represented. It can be concluded that marital status, especially among people that are married influenced large household size. This shows that there is an average 4 persons per room as the occupancy ratio. This implies that the houses within the study area are bit overcrowded compared to UN standard of 3 persons per room as the occupancy ratio. This further suggests that the occupancy ratio is on the high side. The implication of this is reflected on the existing infrastructural facilities and daily life of the residents which is full of unpleasant and difficult situations.

Housing Conditions

The distribution of respondents by housing conditions is shown in Table 2. The study shows that 41% of the respondents utilized water vendor, popularly known as *''Mai Ruwa''and* 29% used water from boreholes and were jointly the most represented, followed by 28.2% used well water and 13% used pipe borne water and were the least represented. The reliance of water from water vendor may increase the vulnerability of the households to water borne-diseases such as cholera, typhoid fever, dysentery and hepatitis. According to World Bank (2007), poor access to water supply and sanitary facilities is a breeding ground for child mortality. The report further revealed that of about 1.7 million deaths that occur every year worldwide (90 per cent of which are children) are attributed to unsafe water, poor sanitation and hygiene, mainly through infectious diarrhoea.

This study is in line with Eja, Otu, Joy, and Edet (2011) who revealed that residents in Port Harcourt City mostly depend on public tap as a source of domestic water supply in the area. Ali (2018) which showed that majority of water subscribers within Jos area had connections with the public water supply source and multitudes of other alternate sources. Akoteyon (2019) showed that piped water connections and borehole are the major sources of water, representing 43.5% each in high-density areas.

The study shows that 87.70% of the respondent relied on Abuja Electric Power Distribution Company (AEDC) for sources of electric power supply and were the least represented, followed by 8.4% relied on generator and 3.9% relied on solar power and were the least represented. This indicates that majority of the respondents relied on AEDC for power supply which is more environmentally-friendly and cost effective unlike generator. It can be concluded that there is relatively stable power supply from AEDC in the study area.

Table 2 Housing conditions of respondents

Characteristics	Percentage
Housing Condition	
Bad Condition	44.6%
Fair Condition	36%
Good Condition	18.73%
Housing Types	
Detached	84%
Semi-Detached	9.2%
Flats	6.8%
Household Access to Water	
Water Vendor (*Mai Ruwa)*	41%
Boreholes	29%
Well Water	28.2%
Pipe-borne Water	13%
Sources of Electric Power Supply	
Abuja Electric Power Distribution Company (AEDC)	87.70%
Generator	8.4%
Solar Power	3.9%
Pipe-borne Water	13%
Access to Electric power Supply	
8 Hours	82%
6 Hours	22%
Sources of energy for cooking	
Firewood	46.20%
Charcoal	29%
Gas	21.10%
Kerosene	3.70%

Source: Author's Field Survey, 2022

Based on the hours respondents have access to electric power supply, the study reveals that 82% of the respondents have access to electric power supply for 8 hours and were the most represented, followed by 22% of the respondents claimed to have access to electric power supply for 6 hours. This shows that majority of the respondents have access to electric power supply, especially from AEDC for 8 hours. That is, four (4) hours in the day and four (4) at night while few others enjoyed power supply for six (6) in every twenty-four hours, that is, three (3) hours during the day and another three (3) hours during the night. This implication of this is that it will encourage people to switch to generator which may increase noise and air pollution in the study area.

The distribution of respondents by sources of energy for cooking reveals that 46.20% adopt firewood for cooking and 29% adopt charcoal for cooking and were jointly the most represented, followed by 21.10% adopts gas for cooking and 3.70% adopts kerosene for cooking and were the least represented. This indicates that majority of the respondents, 75% adopt firewood and charcoal for cooking in the study area.

Sanitary Facilities and Environmental Living Conditions

The distribution of respondents by the sanitary facilities and environmental living conditions is presented in Table 3. The study shows that 57.10% used shared kitchen and were the most represented, followed by 25.10% used self-contained/personal kitchen and 17.8% used open courtyard and were the least represented. This indicates that majority of the respondents used shared kitchen. The major conclusion that could be drawn is the lack of privacy, loss of cooking items in shared kitchen and leaving their food to be exposed to air may increase the household to air borne diseases as observed during the physical observation.

Based on the sanitary facilities, the study reveals that 61.10% of the respondents used improved pit latrine and were the most represented, followed by 21.70% used pit latrine and 17.20% of the respondents used water closet and were the least represented. This indicates that majority of the respondents utilized improved pit latrine. It can be concluded that high level of literacy among the respondents may increase the knowledge on the adoption of improved pit latrine for healthy lifestyles. In contrast, pit latrine increases the vulnerability of the households, especially females to infections, such as urinary tract infection among others. Based on the method of waste disposal, the study reveals that 36% of the respondents disposed their waste through burning and 35% disposed their waste through drainage lines and were jointly the most represented, while the remaining 28.2% of the respondents disposed their waste through open space and were the least represented. This indicates that majority of the respondents, 71% disposed their waste through burning and drainage lines.

Table 3 Distribution of Respondents by Sanitary Facilities and Environmental Living Conditions

Characterstics	Percentage
Cooking Place	
Shared kitchen	57.10%
Self-contained/personal kitchen	25.10%
Open Courtyard	17.8%
Kerosene	3.70%
Pattern of Cooking	
Shared kitchen	57.10%
Self-contained/personal kitchen	25.10%
Open Courtyard	17.8%
Kerosene	3.70%
Total	**100%**
Nature of Sanitary Facilities	
Improved pit latrine	61.10%
Pit Latrine	21.70%
Water Closet	17.20%
Total	**100%**
Method of Waste Disposal	
Burning	36%
Drainages	35%
Open Space	28.2%
Total	**100%**
Method of Waste Disposal	
Burning	36%
Drainages	35%
Open Space	28.2%
Total	**100%**
Level of provision of basic facilities	
Poor level of basic facilities	36%
Fair	27.70%
Good	11%
Very Good	3.9%
Total	**100%**

Source: Author's Field Survey, 2022

The implication of having drainage lines filled up with waste is the increasing chances of flooding; waste disposal in open space makes the environment unfit for human habitation and burning of refuse also causes unpleasant smell which affects the environment and in the long run affect the livelihood of the residents. This study agrees with Ezeamaka *et al.* (2018) profiled the characteristics of squatter settlements in Jabi District, Federal Capital City, Abuja revealed the dumping of waste in open

spaces, burning and also drainages within the study area.

Based on the level of provision of basic facilities, the study shows that 53.5% of the respondents claimed poor level of basic facilities and were the most represented, followed by 27.70% claimed fair, 11% claimed good and 3.9% claimed very good and excellent respectively and were the least represented. This shows majority of the respondents have poor access to basic facilities such as good electricity, quality water supply, and good roads in their neighbourhood among others.

CONCLUSION

The paper concludes that the presence of Federal University of Technology, Minna enhanced employment opportunities within the slum areas, especially for workers that may want to stay close their place of work, or unable to afford expensive accommodation at the city-centre or preference to have their own personal houses due to low cost of landed property within Bosso town increase the influx of people within the study area. Other factors are linked to the presence of the University increased investment in infrastructural facilities such as road networks, schools, health care centres among others increased the expansion of the area and consequently increased the socio-economic and other human activities, especially at informal level.

The low-level of infrastructural facilities such as drainage system, poor housing services and poor regulation of urban and physical planning are as a result of informality of the study area. This make allocation of lands and other landed property to be handled by the indigenes and other informal actors in land use planning and allocation. This has resulted in the growth of slums and other squatter settlements and pose significant threats to socio-economic development, urban aesthetic, livability, habitability, tranquillity and conviviality in the study area.

Based on the findings of the study, the following recommendations are made in finding lasting sustainable solutions to the menace of slums in the study. The recommendations are:

i. Slum Upgrading: The existing slums should be upgraded by the physical planning authority in Niger State with a view to address the illegality and its attendant problems in the study area. This would ensure compliance to planning standards and regulations.
ii. Urban planning and development control: the planning authority in the study area should put in place effective measures of urban planning such as infrastructural facilities such as road network, hospitals, drainage system, communication networks and schools for teeming population. Development control should also be put in place in identifying illegal and informal structure.
iii. There should be need for effective community-based waste management system for disposal of wastes generated by the households in the study area.
iv. Government should provide mass, low and affordable housing scheme, especially for the urban poor. This would reduce erection of structures in slums and squatter settlements.

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Trends in Recent Sexual Activity and HIV/AIDS Risk in the General Population of Plateau State, Nigeria

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ABSTRACT

This study explored recent sexual activity and the risk of HIV transmission in Plateau State, Nigeria. Explanatory Mixed methods approach was deployed in obtaining National Demographic and Health Survey data for 2003,2008, 2013,and 2018 and analysed using descriptive statistics, Chi-square test, and Multivariate logistics regression. Female dominated the study (>68.3%) and over half (51.0%-76.5%) were age group ≥ 25 years old. 60.0% of the respondents were married, with the majority resident in a rural setting (>60.2%). The proportion of those with high education increased from 7.3% in 2003 to 58.3% in 2013 and to 53.9% in 2018. The patterns of sexual behaviour across the survey years reveals that between 2003 and 2008 sexual activity increased from 40.2% to 45.8%; non-use of condom during the last most recent sex from 78.1% to 93.7%; and risky sex from 35.1% to 45.8%. Though the behaviours slightly declined in 2013, they significantly increased between 2003 and 2018. High-risky sexual behaviour was 2.5 times higher among male respondents than in females (AOR=2.5; 95% CI =1.70-5.78; p=0.000). Those aged 25 years and above were over 5 times at risk of engaging in recent sexual activity associated with HIV than those aged 15-24 years old (AOR=5.46; 95% CI =2.39-7.55; p=0.000). The likelihood of contracting HIV among those willing to buy vegetables from vendors living with HIV/AIDS was 3 times more likely (AOR=3.19; 95% CI =1.51-6.28; p=0.021) than those who were unwilling. Gender inequality in sexual relationship and shallow knowledge of HIV were the root causes of engaging in risky behaviour in Plateau State. Sustainable HIV prevention efforts involving a multilevel intervention programme is necessary to modify HIV risky sexual behaviours.

Keywords: *Recent Sexual Activity, HIV/AIDS, HIV Risk, and Plateau state*

INTRODUCTION

HIV/AIDS is a leading public health challenge that caused an incurable disease that led to deaths globally, with Africa the most hit in the last decades (WHO, 2020). Heterosexual intercourse in sub-Saharan Africa is responsible for over 90% of the risk of exposure to HIV infections (Lurie & Rosenthal, 2010; UNAIDS, 2012). The behaviour influences the possibility of contracting HIV and other Sexually Transmitted Infections (STIs) from people in sexual networks (Boily et al., 2009). HIV, being a disease with multiple modes of transmission, relies on sexual contact with an infected person and those at risk for it fast acquisition or transmission (Haggett, 2000; Sadikov et. al. 2011). Moreover, as the number of persons in sexual network is larger and increasing, so is the risk of HIV transmission within it (Potterat et al., 2005). The acquisition or transmission of the virus is also highly dependent on frequent sexual activity, particularly when prevention is not consistently used during intercourse with a partner who may have been exposed to infection (Kalam, 2010; Randal & Byers, 2003). Boily et al., (2009) reported that per sexual act with a risky person increases the chance of contraction or transmission, regardless of whether ejaculation occurs (Jin et al., 2010). The risk arises because the acute phase of the infection is immediately after the virus has been contracted, which replicates itself rapidly and repeatedly, resulting in a significant amount of HIV in the blood that subsequently weakens and attacks the blood cells that provide defence against intruders to the body (Brenner et al., 2007; Hollingsworth, 2008; Patel et al., 2014; Pilcher et al., 2004;).

The current prevalence of HIV among adults in Nigeria is relatively low compared with other countries in Southern Africa. However, the sheer size of its population means that it is one of the countries with the most people infected with HIV globally (UNAIDS, 2019). Within Nigeria, there are strong disparities in the rates of new infections within and between states that reflect changes in the spatial epidemiology of the virus (Granich et al., 2015). Plateau State was at the centre of Nigeria's HIV/AIDS epidemic, when it experienced the highest infection rates in the country, at 11% (Federal Ministry of Health - FMoH, 1996). Although the virus initially spread to surrounding states in the early 2000s, the infection started declining with encouraging reduction rates experienced among the children, women, and the

most-at-risk subgroups, such as sex workers (NACA 2015; Ogbe et al. 2014; Imade et al. 2014; Gomwalk et al., 2012). Lately, the experience indicates slow decrease, but remains above the national average (Bashorun et al., 2014; FMoH, 2019; Obidoa & Cromley, 2012). Hence, evidence-based outcome on sexual behaviour changes over time is important in the design of appropriate prevention strategies for sustainable sexual health.

Trend in sexual activity engaged in a shorter time or briefer intervals are easily recalled and accurately self-reported for tracking changes in understanding risky behaviour related to HIV infection than the longer interval (Carballo-Dieguez et al., 1999; Kerstin et al., 2003). Description of the sexual behaviour changes over time in Plateau state is noticeably rare than sex had in the last 12 months prior to the surveys at a time (Agaba et al., 2016; Envuladu et al. 2017ab; Egbodo et al.; 2022; John, et al., 2012; Slap et al., 2003;). Whereas, engaging in shorter time sexual intercourse, especially when a condom is not or inconsistent used or a partner is already infected, heighten the risk of HIV transmission (Ahmed, 2001; Boily et al., 2009). Yet, involvement in such sexual intercourse as an indicator of being sexually active has not been well researched (Aisha et al., 2017; Johnson et al., 2001, Ueffing et al., 2019). Though it is known fact that sex has a positive impact on human life (Allen, 2018), the manner in which the behaviour is expressed eith increases or reduces the chance of a person transmitting or acquiring HIV. The risk of infection increases with increased in age, as older people prefer sexual relationships without the use of a condom more often than those who are younger in age (Balkus et al., 2015) responsible for the spread of HIV in many sub-Saharan Africa settings (Halperin & Epstein, 2004). Moreover, fostering stigma and discrimination attitudes (Herek et al., 2002), low self-perceived risk of HIV from a healthy-looking person (Blankenship, 2018; 2017; Green & Witte, 2006; Muchini et al, 2011), and low awareness on HIV/AIDS leads to misconceptions (Tenkorang, 2013) that increased risky sexual behaviour.Studies reported that wives' who were in menopause and postpartum abstinence often turn down their husbands' sex advances, and having been engaging in short time sex, most husbands resorted to satisfying their sexual craves outside (Morrison-Beedy & Passmore, 2013; Zhou et al., 2014) and in most case, condom is not used (Beauclair et al., 2012). This may have been responsible to married women becoming infected with HIV by their husbands and are diagnosed only when seeking healthcare during pregnancy (Cohen & Reid, 1999).

Against the above milieu, information on the trend of short time interval sexual activity associated with risks of HIV in Plateau State are limited. Most studies on sexual behaviour on Plateau state are one-time cross-sectional surveys on long time interval sexual activity and focused largely on adolescents that used only quantitative desings (Agaba et al., 2016; Envuladu, et al., 2013, 2017ab, 2021; Dongurum, et al., 2009, 2010; John et al 2012; Slap, et al., 2003). None of the studies looks particular at the briefer interval sexual behaviour and the narratives on personal realities experienced for robust evidence to aid in the monitor of patterns and factors influencing risk behaviour and their implication for HIV/AIDS prevention policies. Also, the trend on the sexual behaviour and HIV risk provides a unique opportunity to understand the conditions in which changes in sexual behaviour occur in addressing related public health. It is in this context that this research is situated to thoroughly explore the changes in trends over the last decades and the perspectives individual held on the sexual behaviour essential to design appropriate sustainable public health policy (McCabe et al., 2013) in Plateau State. The study hopes to contribute new knowledge about the trend in the risk of recent sexual activity in Plateau State, with the aim of understanding the broader context within which to formulate policy, design, and implement appropriate prevention and interventions that address the root causes the sexual behaviour related to HIV risk.

MATERIALS AND METHODS

Study Area

The study deployed an explanatory sequential mixed method, a strategy that first obtained survey data, analysed, the outcomes then necessitated for qualitative interview with the study participants for their views, experience, and feelings on recent sexual behaviour and risk of HIV infection (McCabe et al., 2013; Raskind et al., 2019). The mixed method approach has reliable principles that guided the pragmatic and systematic ways in which data were collected, analysed, and entire process triangulated in the construction of evidence-based knowledge (Creswell, 2016; Creswell & Clark, 2018; Morgan, 2014) to contribute to current debates on sexual behaviour and HIV risk in Nigeria and Sub-Saharan African at large. The strengths of both quantitative and qualitative techniques were suitably integrated in the study to particularly understand the social phenomena under inquiry (Teddlie & Tashakkori, 2009). The quantitative source of data was from the last four National Demographic and Health Surveys (NDHSs) and the Individual

Interviews and Key Informants' as sources of qualitative data for rigour that ensured consistency.

Methods of Data Collection

As earlier highlighted; both quantitative and qualitative methods were used at different phases for the collection of data. The process undertaken during each of the phases are described in this section.

Quantitative data

The quantitative data for the study were from the 2003, 2008, 2013, 2018 National Demographic Health Surveys (NDHSs) obtained with permission from the United States Agency for International Development (USAID). The large data sets were accessed on the USAID databased web site, where the Microsoft Excel data files extracted and the variables relevant to the study were mined. The NDHS is a reliable and most used data source by researchers and policy makers around the world for its robustness and standardised indicators to produce statistics for monitoring and evaluating health impacts (Corsi et al., 2012; MEASURE DHS, 2013). The surveys datasets are the four recent series for obtaining demographic and health information relating to sexual behaviour, health, and HIV/AIDS in Nigeria. Though the next NDHS exercise is delayed, it is needfully expedient to utilise the available surveys for a retrospective analysis of trends in sexual behaviours to describe changing patterns of sexual behaviour, associating factors for the last over two decades, and the implications for public sustainable sexual health prevention policies.

The sampling approaches in the surveys used gave every man and woman in their reproductive age equal opportunity of being selected. The representativeness of the target population was based on a combined multistage, systematic, and stratified-random sampling that significantly validates the generalisability of the research results (Mertens, 2013; NPC & ICF 2014, 2018). Thus, 302, 1404, 1265, and 1090 cross sectional samples were apt and established from the four survey data sets. The data collected and variables were re-organised for harmony across the four surveys and new ones created by combining some of the originals in generating new ones that addressed the study purpose. Reponses on questions on whether a person engaged in sexual intercourse in the last four weeks, background information, attitudes/perceived HIV risk, and condom use during the last sexual intercourse across the four surveys were extracted. Sexual intercourse in the last four week, is contextually the being sexually active in short time interval than the longer interval (Erinosho et al., 2013; Schroder et al., 2003).

The qualitative research seeks to understand human behaviour and the dynamic surrounding real-life phenomenon and drawing meaning from a real-world setting, where the researcher does not attempt to manipulate the phenomenon of interest (Patton, 2002; Raskind et al., 219). The opinions and feelings experienced and flexibly expressed by a participant are useful evidence for insight in to the context in which a social phenomenon occurring in a setting (Strauss &Corbin , 2014; Silverman, 2015).This study utilised the qualitative method for its premise on interpretivist worldview that obtained accounts on prevailing social and sexual activities that made sense into understanding people's perceptions and experience on 'how' or 'why' the phenomenon occurred (Bell, 2014). Hence, Individual Interview and Key Informants Interviews are used for the collection of data that explain the outcomes of significant statistical models in the study.

Qualitative data

On qualitative sampling, HIV/AIDS prevalence characterisation in Plateau State informed the selection of study communities. Two Local Government Areas (LGAs), Jos North and Shendam were selected for their high HIV prevalence in the State. Two localities, one urban and one rural were further case selected. In Jos North LGA, Tudunwada and Angwan-Rimi were selected, while Shendam LGA has Shendam town and Kuka as study communities. Four interview participants were selected purposely in each study setting that total 48 sampled interviewees, using a snowball or chain strategy; having met the inclusion criteria. People in the general population, who were above the age of 18 years old; married or unmarried; have lived in the community for up to a year, and familiar with the social realities in their setting. Participants sampled referred the researcher to another person. The chain of referral was carefully handled to avoid dominance of same characteristics in the qualitative approach. The approach was helpful in the identification and selection of appropriate participant that were interviewed.

People living with HIV/AIDS and attending clinics also constituted the study population and were selected. The participants selected were conversant with sexual practices and HIV/AIDS situations in their communities and were willing to share their personal experiences in relation to the study context to assist construct knowledge. The Key informants selected involved Programme or Project, Monitoring and Evaluation Officers, Social and Community Leaders, who were actively or

previously involved in HIV/AIDS, sexual and reproductive health and related activities in the selected communities were each selected. In all the selected communities, the participants drawn volunteered relevant experience and opinions that aided in addressing the study objectives.

Prior to the interview, the participants were contacted and given details about the study and Research Information Sheets (in English and Hausa). For those who cannot read, the research documents were read and explained to their satisfaction. Participants' consents were sought, having accepted, they were each assured that any information that may lead to identifying them were anonymised. The commitment in protecting the rights of, and personal details of the study subjects represented best research practice of confidentiality and privacy in undertaking a sensitive study (Creswell & Creswell, 2018). The participants were confident and relaxed enough in their consent and freely shared their narratives relevant to the research purpose. The researcher used questions on recent sexual practices, use of condom, gender and sexual activity, HIV/AID awareness, belief, and practice, and HIV perceived risk for the interview.

Creswell and Creswell (2018) emphasised that this procedure is legitimate in data collection, as open-ended questions are used in engaging participants in fruitful talks. In such contexts, important verbal and non-verbal expressions were noted, as broader patterns of issues emerging from the discussions are observed and classified to account for the implications of an existing social phenomenon (Schwandt, 2014; Rallis & Rossman, 2012). The conversations were audio recorded, as interviewees expressed their social realities and opinions on the contextual sexual behaviour raised. This study is aware of the tensions associated with conducting interview in a sensitive study like this. As such, interviews were considered most appropriate, and ensured the rights and protect personal information of participants, who may not be free to share in the presence of a third party. Even married people who agreed to provide information were interviewed separately for tensionless atmosphere to freely express themselves.

Methods of Data Analysis

Microsoft Excel 2020 and Statistical Package for Social Sciences (SPSS) version 28 aided the survey data management. Earlier in the data analysis, variables relevant to the research were identified and extracted from the large database. This was edited, used for the construction of new variables and codes were assigned to each. The statistical process provided not only a detailed account of the background information on the recent sexual activity, but also association that compared variables relevant to the study. The descriptive, Chi-Square Test - the crude risk ratio (CRR), and Multivariate Binomial Logistics Regression Model were deemed the most appropriate statistical techniques used. The Chi-Square Test shows the CRR relationships between recent sexual activity and background characteristics. Categorical data whose variables are dichotomous, each takes the values 0, showing no risk occurred for the independent variables and 1 if sex in the last four week has risk of HIV transmission. The dependent variable shows a person is at 'high-risk' of HIV if he/she was sexually active in the last four weeks, did not used a condom at their last sexual encounter. In comparison, if a person ever had sex, used a condom at their last sexual encounter were described as 'low risk'. The multivariate analysis predicted the likelihood of engaging in HIV high-risk recent sexual activity. Moreover, each explanatory or independent variable has a reference category that serves as a standard variable for gauging sexual behaviour and the risk or factor of HIV transmission.

Evidence of a statistical relationship between the dependent (outcome) variable and the independent (explanatory or predictor) variables means that the predictor usually is non-linear (s-shaped). The logistic regression model estimates the likelihood. Thus, the result is an exponential function of the independent variables (Leavy, 2017). Survey data obtained and rigorously organised were built-in in the model equation as follows:

$$\text{Logit (p)} = \text{a}_{+} b_1 X_{1+} b_2 X_{2+} b_3 X_{3+} \dots\dots\dots\dots b_n X_n$$

Where:

Logit (p) = The log of the odds of the dependent variables (High-risk sexual behaviour in the last four weeks) coded 1,

a = the intercept

$b_1,\ b_2,\ b_3\ \dots\dots\dots\dots b_n$ = The regression coefficients, and

$X_1, X_2, X_3 \dots\dots\dots\dots X_n$ = Represents independent covariates (the significant background characteristics of the study population). The outcomes of the multivariate logistic regression modelling have been presented as an Odds Ratios (OR) at a 95% Confidence Interval (CI).

The multivariate analysis simultaneously uses more than one explanatory or independent variable to predict the effect of a dependent variable. The analysis concurrently used the socio-demographic characteristics and awareness on

HIV/AIDS to estimate the effect of the dependent variable to determine the probability that a person engaged in a sexual behaviour that exposed him/her to HIV infection in Plateau state. The multivariate analysis outcomes are interpreted in terms of the 'Adjusted Odd Ratio' (AOR) associated with the p values at 0.05 significance. The AOR accounts for the factors that influenced the chance of exposure to the risk of acquiring or transmitting HIV. The statistically significant outcomes of survey vigorous analysis model informed the need for interviews that explored the personal narratives that provided recent sexual experiences that filled the five years data since the 2018 survey; for insight into the root causes of behaviour that increase risk of HIV transmission .

After all the interviews were concluded, the audio recordings were listened to. The playback of the interviews helped to identify the emerging issues. Subsequently, interviews were grouped in separate folders and files based on the nature of participants and according to the communities from where they were obtained. This was followed by the transcription of the interviews obtained in English, Hausa, and Pidgin into English. The process involved listening repeatedly to each audio recording, typed into text or word document. The transcribed texts were inputted into a qualitative data analysis software, Nvivo 11. The tool facilitated the coding of words and phrases for each section of the interview guides. The sections in the guides consisted of: (i) participant profile, (ii) sexual behaviour (iii) HIV/AID awareness, beliefs, and practice, (iv) gender, sexuality, and marital experience. The coding was useful in the organisation of robust textual information that addressed the study objectives by identifying emerging themes that provides explanations on the significant predictors of sexual activity and HIV, which the survey data result requires narratives on personal experiences and inform of the exact quotes relevant to outcomes. The relevant illustrative quotes extracted based on identified themes were triangulated with significant statistical model results as evidence of existing social reality to understand the dimensions surrounding recent sexual activity and risk associated with acquiring or transmitting HIV in Plateau State.

RESULTS AND DISCUSSION

The quantitative outcome of the study is presented in Tables, followed by the themes that emerged from the qualitative phase. Table 1 shows that the females (>68.3%) and over half (51.0% -76.5%) in age group 25 years and above had sex four weeks before the surveys. 2003 and 2018 (Table 1).

Over three in five participants were married (>60.3%) among which majority (>60.2%) were resident in a rural setting. The proportion of those who practiced Christianity predominated (> 75.5%). Although the proportion of those who had higher education was initially low, there was an increase from 7.3% in 2003 to 58.3% in 2013 and slightly decreased to 53.9% in 2018. Between 2003 and 2018, the proportion of respondents from rich households reduced by 16.7%, poor household members increased doubled between 2008 and 2018. Ignorance of risk about a healthy person could have HIV steadily decreased from 21.5% in 2003 and remained low (14.4%) in 2018. The view that a married woman can request for condom during sex if her spouse has sexually transmitted disease remained high across the surveys. As the proportion of respondents who had discriminatory attitude toward people with HIV/AIDS substantially increased by 25.2% between 2003 and 2018.

Table 2 shows a fluctuating pattern of sexual behaviour in the survey years. The first bars, across the years account changes in sexual activity, followed by non-use of condom during the last sex, and risky sex involving sexual activity with no condom at the last encounters. Recent sexual activity increased between the first and the second survey years from 40.2% to 45.8% and slight declined to 42.8% in 2013. Whereas majority of those who engaged in sexual activity did not use condom during the last encounters. The proportion of non-use of condom rose from 78.1% in 2003 to 93.7% in 2008; as in sexual activity, it also declined to 84.6% in 2013 and increased to 95.5% in 2018 respectively. Also, those exposed to risk sexual behaviour that increase the chances of contracting HIV increased from 35.1% to 45.8% between 2003 and 2008, The behaviour substantially increased from 42.8% to 59.4% in the 2018 survey. Between 2003 and 2018, it stabilised to 39.0% in 2008 and 2013; then in 2018, increased to 57.9%. Generally, between 2003 and 2018 the proportion of people who engaged in the sexual activity increased from 40.1% to 59.4%; non-use of condom from 78.1% to 95.5%; and risky sex from 35.1% to 57.9% respectively.

Table 1: Background characteristics of the study population

Background Characteristics	2003 (N=302)	2008 (N=1404)	2013 (N=1265)	2018 (N=1090)
Gender				
Male	60/301 (19.9)	31.7 (445)	31.1 (393)	17.9 (195)
Female	241/301 (80.1)	68.3 (959)	68.9 (872)	82.1 (895)
Age group				
15-24	40.1 (121)	49.0 (688)	37.5 (475)	21.5 (230/1070)
25 +	59.9 (181)	51.0 (716)	62.5 (790)	78.5 (840/1070)
Married status				
Unmarried	39.7 (120)	36.3 (510)	32.9 (416)	18.4 (201)
Married	60.3 (182)	63.7 (894)	67.1 (849)	81.6 (889)
Place of Residence				
Rural	72.5 (175/241)	78.4 (1101)	77.6 (283)	60.2 (831)
Urban	27.4 (66/241)	21.6 (303)	22.4 (982)	23.8 (259)
Religion				
Islam	18.3 (55/301)	15.9 (220/1388)	25.6 (308/1204)	265/1080 (24.5)
Christianity	81.7 (246//301)	84.1 (1168/138)	74.4 (896/1204)	815/1080 (75.5)
Education level				
None	52.7 (129/245)	35.4 (497)	24.1 (304)	20.3 (221)
Primary	40.0 (98/245)	17.2 (242)	17.6 (223)	26.3 (287)
Secondary/Higher	7.3 (18/245)	47.4 (665)	58.3 (734)	53.4 (582)
Employment status				
Unemployed	28.6 (86/301)	46.8 (654/1396)	35.3 (442/1252)	18.1 (197)
Employed	71.4 (215/301)	52.2 (742/1396)	64.7 (810/1252)	81.9 (893)
Wealth Index				
Rich	37.4 (113)	17.7 (249)	28.8 (364)	20.7 (226)
Middle Class	18.5 (56)	59.8 (839)	48.2 (610)	19.6 (214)
Poor	44.1 (133)	22.5 (316)	23.0 (291)	59.6 (650)
A Healthy-Looking Person can have AIDS				
Yes	59.3 (179)	62.0 (870)	63.5 (803)	55.6 (606)
No	21.5 (65)	10.1 (142)	13.0 (165)	14.4 (157)
I Don't Know	19.2 (58)	27.9 (393)	23.5 (297)	30.0 (327)
Wife justified asking husband to use condom if he has STDs				
Yes	71.5 (216)	78.8 (1107)	65.7 (831)	76.0 (828)
No	15.2 (46)	11.4 (160)	20.4 (258)	22.9 (250)
I Don't Know	13.2 (40)	9.8 (137)	13.9 (176)	1.1 (12)
Would buy vegetables from vendor with AIDS				
Yes	28.1 (85)	45.8 (643)	53.7 (679)	53.3 (581)
No	68.9 (208)	39.9 (560)	27.3 (345)	32.8 (357)
I Don't Know	3.0 (9)	14.3 (201)	19.1 (241)	13.9 (152)

Table 2: Sexual behaviour between 2003 and 2018 in Plateau State

Sexual Behaviour	2003 (N=302)	2008 (N=1404)	2013 (N=1265)	2018 (N=1090)
Sexually active during the last four weeks				
Yes	40.3 (121/300)	45.8 (576/1258)	42.8 (542)	59.4 (647/1089)
No	59.7 (179/300)	54.2 (682/1258)	57.2 (732)	40.6 (442/1089)
Condom use during Last most Recent Sex				
Yes	21.9 (47/215)	6.3 (60/946)	15.4 (129/836)	4.5 (41/913)
No	78.1 (168/215)	93.7 (886/946)	84.6 (707/836)	95.5 (872/913)
Levels of Risky Sexual Behaviour				
Low	64.9 (190)	61.0 (856)	61.1 (773)	42.1 (458/1089)
High	35.1 (106)	39.0 (548)	38.9 (492)	57.9 (631/1089)

Table 3: Meta-analysis of Determinants of High Risk Sexually Active Behaviour in Plateau State Between 2003-2018

Background Characteristics	2003 (CRR 95%CI)	2008 (CRR 95% CI)	2013 (CRR 95% CI)	2018 (CRR 95% CI)	M.H Pooled (CRR 95% CI)
Gender					
Female	1.00	1.00	1.00	1.00	1.00
Male	0.77 (0.43-1.38)	0.71 (0.56-0.89)	0.92 (0.72-1.18)	0.30 (0.20-0.43)	0.88 (0.77-1.00)
Age group					
25+ years	1.00	1.00	1.00	1.00	1.00
15-24 years	3.34(1.96-15.71	0.98 (0.79-1.22)	92.32 (45.24-188.44)	2.55 (1.89-3.44)	3.37 2.93-3.87)
Married status					
Married	1.00	1.00	1.00	1.00	1.00
Unmarried	28.68(11.18-78.56)	28.68 (18.64-44.13)	6.00 (4.43-8.13)	18.64 (11.60-29.93)	14.84 (12.04-18.29)
Religion					
Christianity	1.00	1.00	1.00	1.00	1.00
Islam	0.77 (0.43-1.42)	0.73 (0.55-0.98)	0.75 (0.58-0.98)	0.81 (0.61-1.07)	0.74 (0.64-0.87)
Place of residence					
Rural	1.00	1.00	1.00	1.00	1.00
Urban	1.26 (0.69-2.32)	1.41 (1.09-1.82)	0.34 (0.25-0.47)	0.92 (0.69-1.23)	1.18 (1.04-1.34)
Education Level					
No education/Primary	1.00	1.00	1.00	1.00	1.00
Secondary/Higher	5.38 (2.25-12.31)	1.94 (1.56-2.42)	2.01 (1.60-2.53)	1.00 (0.78-1.27)	1.49 (1.32-1.69)
Employment Status					
Unemployed	1.00	1.00	1.00	1.00	1.00
Employed	2.02 (1.15-3.56)	1.63 (1.31-2.03)	2.55 (1.98-3.29)	1.93(1.41-2.83)	2.18 (1.90-2.50)
Wealth Index					
Poor/Middle Class	1.00	1.00	1.00	1.00	1.00
Rich	1.86 (1.12-3.20)	0.98 (0.74-1.30)	1.23 (0.96-1.58)	1.57 (1.17-2.11)	1.32 (1.14-1.53)
A healthy-looking person can have HIV/AIDS					
No	1.00	1.00	1.00	1.00	1.00
Yes	1.05 (0.65-1.70)	0.75 (0.60-0.93)	0.94 (0.74-1.18)	0.43 (0.26-0.68)	1.21 (1.07-1.37)
Wife justified asking husband to use condom if he has STD					
No	1.00	1.00	1.00	1.00	1.00
Yes	0.85 (-.50-1.45)	1.15 (0.89-1.50)	1.08 (0.85-1.37)	1.50 (1.12-2.00)	1.14 (0.99-1.31)
Would buy vegetables from vendor with HIV/AIDS					
No	1.00	1.00	1.00	1.00	1.00
Yes	1.54 (0.89-2.67)	1.08 (0.87-1.33)	0.71 (0.56-0.89)	0.87(0.68-1.11)	0.87(0.77-0.98)

Table 3 presents the pooled crude estimates of association between HIV risky sexual behaviour trend in Plateau state and respondents' selected background characteristics. The analysis indicated that unmarried respondents and those aged 25 years and above were also more likely than those married and those aged 15-24 to engage in high-risk sexual behaviour in the last four week. Others more at risk were those employed, and people with high education (secondary and tertiary). The risk of engaging in hig risk sexual behaviour significantly reduced with being a male, practicing Islam and also, those willing to buy vegetables from vendors living with HIV/AIDS.

Table 4 presents the pooled results of multivariate logistic regression modelling of recent sexual risk of HIV transmission between 2003 and 2018 in Plateau State.

Table 4: Adjusted odd ratio likelihood of HIV high sexual risk (P-value = 0.01** & 0.05*)

Background Characteristics	AOR (95% CI)	P-value
Survey Years		
2008	0.85 (0.60-1.24)	0.217
2013	0.81 (0.67-1.06)	0.030*
2018	0.61(0.49-0.77)	0.000**
Gender		
Female	1	
Male	2.51 (1.7-5.781)	0.000**
Age group		
25+ years	1	
15-24 years	5.46 (2.39-7.55)	0.000**
Married status		
Married	1	
Unmarried	0.09 0.07=0.11)	0.000**
Religion		
Christianity	1	
Islam	1.20 (1.10-1.43)	0.042*
Place of Residence		
Rural	1	
Urban	1.14 (0.98-1.32)	0.082
Education Level		
No education/Primary	1	
Secondary/Higher	1.16 (1.00-136)	0.054*
Employment Status		
Unemployed	1	
Employed	0.80 (0.68-0.95)	0.009**
Wealth Index		
Poor/Middle Class	1	
Rich	0.92 (0.76-1.11)	0.391
A healthy-looking person can have HIV/AIDS		
No	1	
Yes	0.91 (0.79-1.11)	0.227
Wife justified asking husband to use condom if he has STD		
No	1	
Yes	1.34 (1.16-154)	0.000**
Would buy vegetables from vendor with HIV		
No	1	
Yes	3.19 (1.51-6.28)	0.021*

The model controlled for the confounding effects of each of the selected variables and the adjusted relative risk ratios. The results reveal that the odds of engaging in high-risky sexual behaviour among male respondents was 2.5 time the odd ratio in females (AOR=2.5; 95% CI =1.70-5.78; p=0.000).

In addition, those age 25 years and above were about 5 times more likely than younger respondents aged 15-24 years old (AOR=5.46; 95% CI =2.39-7.55; p=0.000) to be at risk of high-risk sexual behaviour of transmitting or acquiring HIV through high-risk sexual behaviour. Furthermore, the likelihood of contracting HIV through high-risk sexually active behaviour was 3 times more likely (AOR=3.19; 95% CI =1.51-6.28; p=0.021) among those who were willing to buy vegetables from vendors living with HIV/AIDS and those who were unwilling. Whereas, in 2013 risk of HIV transmission through high-risk sexual behaviour reduced by 19% and by 39% in 2018. Unmarried respondents and people who were employed were less likely, in the last four weeks, to engage in high-risk sexual behaviour (Table 3).

PERSONAL REALITIES OF HIV RISKY BEHAVIOUR

A qualitative study explores the root causes of likelihood for people in Plateau state to engage in high-risk sexual activity that exposes one to contracting or transmitting HIV based on the statistically significant multivariate logistic regression analysis. As highlighted earlier, the men, older respondents aged ≥25 years and those who were unwilling to buy vegetable from vendors living with HIV/AIDS were reported at high risk of transmitting or acquiring HIV (see Table 3). These statistically significant outcomes necessitated in-depth discussions with the study participants for explanations on specific characteristics found to have predicted the likelihood of exposure to the risk of HIV transmission in Plateau state. Those in (or encounter with those) their older age group reveals that the adventure for new sexual experiences and unfulfilled sexual relationships with their spouses or partners of many years explains why they engaged in HIV high-risk sexual behaviour.

Male dominance in heterosexual decisions

Regardless of the status of a relationship, men were said to often assume, by default, to take the leading role or the dominant position in the relationship. Consequently, this feeds into how a relationship runs, as men often demand for sex to satisfy their sexual drive who often less considered the opinion of the female partner. Such dominance makes the men engaged in sex without the use of protection, A women share her view thus:

"*This is a man's world. He cannot accept no to a sex demand and so, a woman's view is less important even when it relates to her right to sexual and reproductive health. If she asks for a condom, he judges her for suspecting him on promiscuity… and so women trust the authority of their husband and would not question what he does with other women outside the union*" (Urban, married female 52 years old)

Quest for new sexual experience

Older adults remain sexually active as they grow in age. The desire differs, depending on a person's health status. Men and women maintain a strong sexual desire at an older age (Zhou *et al.*, 2014; Trompeter et al., 2012; Kelly et al., 2003). As such, they engage in sex with younger people or multiple partners as an adventure involving the seeking of new experiences and independence. Moreover, they often do not use condoms in their sexual encounters. A participant narrated a romantic relationship he had with an older woman, which indicates that some older women seek new sexual intimacy and independence to explore an experience they think is better than the societal norms that subjected them to their spouse.

"I have a sugar mama who was in her late fifties. She often comes for holiday and business trips here. On each arrival, she invites me over to her hotel room, where we live and made love until she completes her activities and would be returning… she appreciates how I treat her more than her spouse does".
(Unmarried male, 31 years old).

Another participant shared his experience on why he goes for a woman much younger than his wife, as sex with her was no longer exciting:

"*Sex with my wife is just like taking the same meal again and again all the time, which becomes boring. I go to blend it with a new and fresh one*". (Married male, 52 years old).

Masculinity and sex sensation seeking

The need for sexual sensation is a common trait among most men (Wade et al., 2013). This quest for a thrilling experience often blinds them to the risk of sexual and reproductive health consequences, thereby increasing risky sexual behaviour as using a condom or seeking to know the HIV status of a partner becomes less of a concern. Indeed, one participant was of the view that using a condom renders the experience unnatural:

"Eating chocolate in a wrapper does not give its sweet taste. Remove the cover; you enjoy the fat-bloom chocolate".
(Urban, unmarried male, 31 years old).

Men like Beautiful Flowers

Older people who are experienced and have resources represent an attraction to many younger people. As such, transactional sex between an older and younger person has become more prevalent. In a quest for modernity, most young women used their sexuality as a resource for economic gain:

"Men are easily attracted to a beautiful flower, (young lady) who usually come, or they see, and give them open check of promises to support in any way. Many of the girls of my age, now have cars and houses built for them, apart from regular financial support they receive from the men. I see this as a good prospect for having sugar daddies give what they like and get what I want for beautiful outlook".
(Urban, unmarried female, age 32 years old)

In his late 50s, a participant shares the view that he has worked hard and acquired wealth and it is now he needs to enjoy the fruit of his youthful investments with what gives him pleasure, which he described as:

"Many men in their later age in life have saved much money and are now wealthy because they control resources as politicians, managers or owners of businesses who travel a lot. They often do not travel with their wives and as they meet with colleagues and socialise, they go for girls who are much younger for pleasure they did not have while making investments here and there. When you have money, you get what you want... from beautiful girls willing to provide the services in return for financial benefits".
(Urban, married male, 58 years old).

The position of older people exploring new sexual encounters and independence in a sexual relationship is consistent with the findings that sex outside a primary relationship is driven by fun (Ranganathan, et al., 2018; Smith, 2007). These forms of sexual relationship often result in the lack of condom use (Beauclair et al., 2012) and studies have found that this pattern of behaviour is responsible for HIV spread in many sub-Saharan African countries (Halperin & Epstein, 2004). Moreover, because older people have accrued wealth over time, young people can be drawn into sexual relationships for their material benefit, without attention to the risk of HIV infection (Morrison-Beedy & Passmore, 2013). The findings further revealed men's displeasure over unmet sexual desires due to the ageing of their spouse. A similar experience in recent studies among the Yoruba men and women by Agunbiade and Gilbert, (2020, 2023) and Chinese men by Zhou *et al.*, (2014) reported the preponderance of unprotected sex with multiple partners.

Lack of Comprehensive HIV Awareness

The attitude and behaviour that unfairly attributes blame and judges people with certain health conditions displays a lack of social power to promote sustainable health. However, discriminatory attitude and claims of HIV risk awareness, and yet engaging in risky sexual behaviour also are indicators of low HIV risk perceptions, which are rooted in limited knowledge of HIV and AIDS. A participant with such attitude towards HIV infected people, reported to have never tested for HIV and inconsistently used a condom:

"Something must kill a man., whether HIV or accident. Many times, when such opportunity for sex comes, one hardly remembers the danger. Can

you see even healthy people are dying and the sick ones, even with HIV are looking healthy".
(Urban, married female, 39 years old).

Sewell and Blankenship (2018) and Lammers et al (2013) found that those who engaged in high-risk sexual behaviour perceived themselves to be at low risk of HIV and the reason why most people hide their status and avoid health services, which allows HIV to thrive (Arrey *et al.*, 2017; Marsicano *et al.*, 2014).

HIV/AIDS Denialism

Some people held the view that HIV does not exist at all. The AIDS denialists claim there is no proof that HIV causes AIDS, and they believe that HIV and AIDS do not exist. This attitude explains why HIV high-risk continues to thrive unabated in most African countries. A participant said he does not bother whether a person has HIV or no, because at the hospital, all diagnoses result always show one has HIV even if it were fever:

"There is nothing like HIV. The HIV thing is just an idea to discourage youths like me from having sex. If you have a high fever and go for a test, an HIV positive result will show. Go to another health centre for the same test; the result will be a high fever. I don't need such a place for a test of a virus that does not exist" (Urban, unmarried male, 36 years old)

Suspicions of HIV Prevention Services

Like the above view, some participants in the research expressed concern about the sincerity of the HIV services, indicating it is what you know that kills and not what a person do not know. This attitude prompted some people to suspect medical examinations, and discouraged them from attending services:

"I often do not use protection during sex, and I do not want to know my HIV status. My reason is 'a bin da ba kasani ba, bazai kashe kaba' (What you do not know, will not kill you). The problem with the test is once you go there and do it, the result will show positive ... so, what you know kills faster than what you do not know". (Urban, unmarried male, 31 years old).

Past studies showed that those who held this belief and attitude, such as doubting the existence and scientific validity of HIV and AIDS, were significantly less likely to be receiving antiretroviral therapy (Bohnert & Latkin, 2009; Kalichman et al., 2010;), and were discouraged from accessing HIV testing (Ford et al., 2013). Such beliefs ignore the importance of condom use. This situation has become more critical with the naming of non-scientific causes of HIV and AIDS to deceive people (Nattrass, 2012). This may have deterred people from seeking support at accredited hospitals and healthcare centres, and instead prompted their patronage of traditional healers and religious quacks who promise healing miracles. This represents a significant barrier to the global scientific efforts to halt HIV and AIDS by 2030.

Wife's Postpartum Abstinence

The male-man is traditionally impatient in terms of drive for sex. Culturally, when a wife gives birth, she stays away from having sex with her husband for some weeks after the child's delivery. The period in which the man allows his wife to recover after the delivery becomes an occasion to seek sexual satisfaction with partners other than his spouse:

"The time it takes women to stop having sex after she delivers a baby are always a serious tempting moment for most men with high libido. She is meant to stay away from sex for her body to recuperate from the labour experiences for her health and safety of the baby. I tell you, men do not hold their sex desires, but go to satisfy it with other women out there".
(Rural, married male, 66 years old)

"Each time my wife has a new baby, she stops having se with me. This has pushed me going outside because I find it difficult to stay without sex for long. So, I go to some girls in the period my wife is on sex-leave" (Urban, married male, 47 years old)

Major agents of HIV high-risk behaviour in Plateau State are the males, the adults in age group 25 years and above, and those with knowledge of HIV and prevention skills, who did not translate it into practice. Evidence from in-depth discussions reveal that the presence of the

exploration of new sex experiences among adults, and gender related encouraged respondents to engage in high-risk behaviour.

Discussion

This study found that people who were aged 25 years and above were engaged high risk sex that increased the chance of HIV transition. Increase in age comes with increased exposure to sexual relationships in or outside marriage (Macaluso et al., 2000). Older people engage in sexual relationships without the use of a condom more often than the young people (Bankole et al., 2007). As higher possibility of HIV infection has links with unprotected frequent sex (Anyanwu & Fulton; 2017; Boily et al., 2009), which is also responsible for the spread of HIV in in sub-Saharan Africa (Halperin & Epstein, 2004). In Malawi (Beauclair et al., 2016, 2018), South Africa (Maughan-Brown et al., 2016; Brouard & Crewe, 2012), and Zimbabwe (Schaefer et al., 2017) risky sexual activities often involve age differences, and this is associated with a risk of sexually transmitted infection. Older men are often more able to provide security to young women and girls than men of their own age. The same factor can operate in the case of some mature women who prefer younger men as sexual partners, contesting the heterosexual social norms and barriers that have deprived them of sexual freedom over time (Alarie, 2020; Kuate-Defo, 2004).

The study further found that the men engaged in high-risk sexual behaviour in the last four weeks. The dominant ideas around masculinity and men's sexual behaviours made some men think that they have a right to sex, eagerly seeking and practising it with multiple women). Gender inequality exacerbated by cultural norms and practices placed the man as superior, and as someone with the freedom to engage with multiple sexual partners. In Northern Nigeria, married men living with HIV often engage in a sexual relationship with their discordant spouse without the use of a condom increasing the risk of HIV transmission (Iliyasu et al., 2020). Zhou et al. (2014) in a qualitative study found that the wife's menopause and postpartum made them turn down husbands requests for sex. Hence, the financial freedom, peer influence and fun seeking-behaviour among men make them seek sexual relationships with young girls, which grows into a network that encourages multiple, concurrent partnerships (Morrison-Beedy and Passmore, 2013) in which a condom is often not used (Beauclair et al., 2012). Man requires appropriate HIV multilevel intervention programmes that focuses sexual partners, promoting gender equality and educate them on the long-term negative impact of their high-risk sexual behaviours to decrease HIV transmission in Plateau State.

The study also found that a person can be willing to relate with people living with HIV/AIDS and less likely to translate the experience into HIV preventive behaviour due. There are myths surrounding HIV/AIDS and have become significant barrier to curbing the spread of the pandemic (Tenkorang, 2013). These misconception and speculations such as, AIDS can be cured when an infected person has sex with a virgin (Smith, 2003); HIV/AIDS is an expression of God's wrath against sexual promiscuity (Olaore and Olaore, 2014). For example, Tenkorang et al. (2011) reported that 29% of men and 31% of women of reproductive age believed that HIV and AIDS are transmitted through witchcraft and superstitious practice. These myths and beliefs affect people's judgements about HIV/AIDS, causing the fatalistic belief that HIV/AIDs cannot be prevented or treated. Thereby reducing the positive impact of HIV/AIDS prevention services (Caldwell, 1999), antiretroviral treatments (Jolley and Dauglas, 2014); low level of knowledge of HIV (Hogg et al., 2017); negative attitudes towards the use of condoms, and inconsistent condom use (Ross et al., 2006). As such, knowledge about the transmission and prevention of HIV is on the increase, yet it has not been put into practice for change in high risky behaviour. There is the need for a comprehensive awareness about the reality of HIV/AIDs and understanding to reduce sexual risk that expose people to the HIV transmission.

CONCLUSION

This showed the trends and patterns of sexual activity in the last four weeks and the risk associated with HIV transmission in Plateau state. The men, those aged 25 years and above, and willingness to buy vegetable from a vendor living with HIV were particularly at high risk of HIV infection. The root cause of these risks was attributed to related gender inequality in sexual relationships and lack of translating HIV

awareness into practice. The gender appropriate interventions and comprehensive family and HIV education be explored in addressing HIV risky sexual behaviour in Plateau state.

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Land Acquisition for Crop Production in Barkin Ladi LGA, Plateau State, Nigeria: Implications of Farm Sizes on Food Security

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ABSTRACT

Land is a valuable resource for agricultural production which is key to the achievement of self-sufficiency in food. This study has investigated the modes of land acquisition for crop production, farmers' farm sizes under crop production and the trend in farm sizes for 2016 and 2018 in Barkin Ladi LGA and the implications of farm holdings on food security. Five village areas were selected from five districts through the use of stratified sampling, while 428 household heads were randomly selected for the study. Data were collected through the use of questionnaire administered to household heads. Data were transformed to frequency counts and percentages while results were presented by means of tables. Results reveal that the dominant modes of land acquisition for crop production are: land lease, inheritance and purchase which account for 40.0%, 20.1%, and 20.1% respectively. Of the 158.0 hectares of land cultivated by 428 farmers, Gwokim village (Fan) and Marit village (Ropp) cultivate 45.4% and 26.0% respectively. The trend in farm sizes of the farmers generally show an average decline of 27.1%, but was higher than the average in Gwokim(Fan) and Karat (Foron), whose percentage decline were 33.7% and 27.4% respectively. Peasantry in crop production was found to be a serious threat to food security, with multiplier effects. Sequel to these threats, the study recommended urgent interventions by tackling the activities of non-state actors, provisions of farm inputs and labour-saving technologies to farmers to mass-produce food and make every locality food secured.

Keywords: *Acquisition, farmland, food security, hectares, crop production*

INTRODUCTION

Land is a valuable resource that supports man's existence, as it provides most of his necessities of life. The importance of land as an essential resource can be deduced from the fact that no other economic activity has been able to alter the face of the earth as has agriculture, mainly because land is the basis of agricultural production (Enwelu, Morah & Ezeano, 2014). Land of any nation is the most valuable natural resource, as it supports all human activities, enabling the derivation of all other resources (Olusola, 2011; as cited in Ugwu & Okoye, 2019). Land acquisition is essentially a process for individuals, businesses and Government agencies to access for various purposes, including crop production. It has been estimated that 20% of the earth surface is ice-laden, about 20% made up of arid surface without much assurance of quick development, 10% is under cultivation, while 22% is under permanent pasture (Anyanwu, Anyanwu & Anyanwu, 1982).

Scholars have established that 30% of the lands cannot be cultivated because they are either too high, too rocky or the soil is too thin and under-developed to support the growth and development of crops. In a similar vein, McGraw (1987) lamented that the earth has a total of about 15 billion hectares of land and only 0.4 hectare is actually used for crop production per person and about 0.8 hectare per person is potentially usable for food crops, cash crops and pasture. This means therefore that as at 1980s, when the world population was about 5 billion people, each person potentially owned 1.6188 hectares of land, of which only 0.4047 hectare was under food crop production per person. This indicates that farmers are operating at small-scale which poses serious threats to food security and human well-being.

The earth remains an important natural capital for development and human welfare. However, land is a limited asset and the unprecedented growth in human population without increased in farm sizes is capable of plunging humanity into poverty, hunger and debilitation (PHD). Indeed, as impressive as land appears, agricultural production has failed to keep

pace with the world's demand for food and is in part, responsible for almost two-thirds of world's population suffering from hunger and malnutrition. It is an undeniable fact that the amount of land allotted to farming is not the same everywhere, it varies significantly from one country to another and between regions of any one country, varying from time to time.

Although, scholars have argued that suitability of physical environment (climate, relief, soil and diseases) is the major controlling factor to the use of land for crop production, it is obvious that socio-economic factors such as people's customs and traditions as well as demand, backed by monetary value of crop types have significant influence in the use of land for agriculture. There is therefore the need for better understanding of the methods of land acquisition, land sizes under crop cultivation and the temporal change in farm sizes of any given community, district, local Government, State and even the country.

Food is a basic necessity of life and is second only to water (Onyenze, 1999). It is the law of nature that as human population increases by a given proportion, food demand equally increases much more. It is unfortunate that over 70% of the population of Nigeria are farmers, but their output cannot feed the teeming population, despite the country's 71 million hectares of land under crop cultivation. Agricultural production is hampered by both environmental and socio-economic factors, which have to be overcome in order to achieve the Sustainable Development Goal 2 of zero hunger by 2030.

Barkin Ladi LGA is one of the agrarian areas of Plateau State endowed with good arable land that could boost agricultural production. Unfortunately, the area is facing low crop production because it has many derelict fields that have been ravaged by tin mining activities. Initially, mining of tin ore was on small-scale, involving the use of pick and shovel to extract the mineral from shallow deposits but with the introduction of heavy dragline excavators in the 1920s the land has been degraded. There are many long and deep-sided ridges of spoil heaps, with conical peaks up to 2 metres high. Deep mining paddocks, which have been abandoned after the cessation of tin mining are flooded and croplands are ruined.

Extraction of tin ore in Barkin Ladi LGA has adversely affected farm acquisition and sizes drastically. Reduction in farm sizes is also resulting in inability of farmers to mass-produce food to meet dietary needs of the populace (Olaoye & Adeagbo, 2004; Maton et al., 2020). Indeed, the relative harmony between the residents and the biophysical environment prior to commercial tin mining in Barkin Ladi has been disrupted, as the environment now suffers unprecedented degradation (Bot, 2009). A thought-provoking question that comes to mind is how the farm sizes impacft food security in the area.

MATERIALS AND METHODS

Study Area

Barkin Ladi is one of the 17 Local Government Areas (LGAs) of Plateau State, Nigeria which lies approximately between Latitudes 9°00'00"N and 9°45'00"N; and between Longitudes 8°32'00"E and 9°15'00"E (Bot, 2009) (see Figures 1 & 2). Its landmass is about 1,032km², with a population of 175,267 comprising 88,478 females and 86,789 based on the 2006 population census (NPC, 2006). Barkin Ladi enjoys a temperate climate of moderate temperature, average 22°C and rainfall amounts varying from 1,300- 1,500mm per annum, marked by wet and dry seasons. Wet season sets in from April to October, after which the dry season takes over and lasts for six months (November to March).The study area is made up of Pre-Cambrian Rock formations called Basement Complex Rocks (600million years to 1.5 billion years old), which underlain the Younger Granite Rocks of the Jurassic Periods (150-170 million years).

The area also has some volcanic activities especially around Heipang, but the hills have been levelled out by denudative processes. Denudative activities have also given rise to undulating landscapes, dotted here and there with hilly features, prominent of which is the Ropp Hills standing above 1,500m above mean sea evel. The area is drained by Rivers Rongot, Mundi and Bisichi. The heavily dissected hilly areas are sources of several swift- flowing Rivers that are common west of the LGA, forming Kurra Falls which descend in series of steps; and is being harnessed for generating electricity by the National Electricity Supply Company as early as 1929. Earth dams have been constructed to feed the Falls

especially in Gashish area and the reservoirs are also useful for dry season irrigation, industrial and domestic purposes. Considerable area of the LGA constitutes a fragile physiographic region that poses serious threats to the inhabitants because of the presents of many unreclaimed mined ponds, popularly known as "killer paddocks" (Bot, 2009; Maton et al., 2020). The soils of the study area are coarsed-grained, medium-sized and fined-grained.

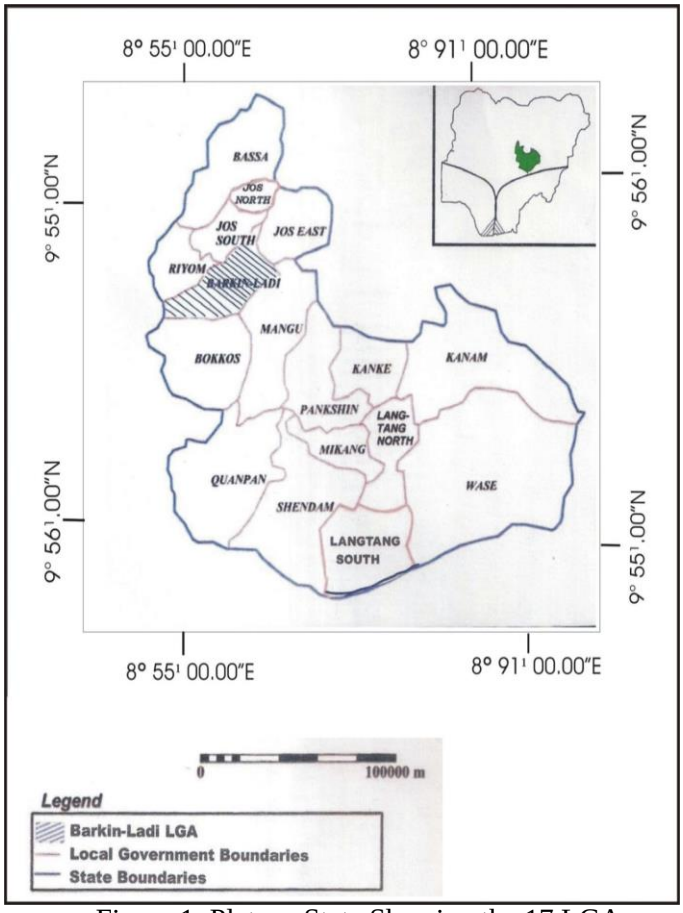


Figure 1: Plateau State Showing the 17 LGAs
Source: Plateau State Lands and Survey (2022)

The soils are characterized by low nitrogen, phosphorus deficiency, low calcium, exchangeable potassium, magnesium and micro- nutrients such as copper and zinc (Alleh, 2016). The soils found on basaltic and bio-granite rocks occurring along downslope are Entisols, Inceptisols and Alfisols which support both the Montane vegetation and food crop production. The vegetation is a kind of Guinea Savannah called Montane because it has been modified by elevation such that forest occur at foothills, with shrubs and grasses occurring towards the plateaux summits. Much of the original vegetation has been tempered with except those that occur along rugged escarpments that are neither cultivable nor dug for mineral deposits. Vegetation species are mostly shrubs and grasses interspersed with *Isoberlina Doga*, *Anderonia Digitata*, Mahogany, Raffia palm and exotic eucalyptus trees used for reclamation of the numerous spoil heaps of the mines of the mined fields of Jos Plateau (Morgan, 1983; Alleh, 2016).

The area is inhabited by Berom ethnic group, who are always coexisting with many other ethnic nationalities, most of whom migrated to the area during the tin boom of the 1905 to late 1980s. The dominant land use type is rain-fed agriculture and this is practiced by over 70% of the residents. Besides, there are considerable mined ponds, earth dams and streams that supply water for the production of mainly vegetables in the dry season.

In addition a substantial proportion of the inhabitants of Barkin Ladi engage in artisanal tin mining while the eroded lands are used for grazing cattle by Fulani Pastoralists, which often results in violent conflicts between them and crop farmers.

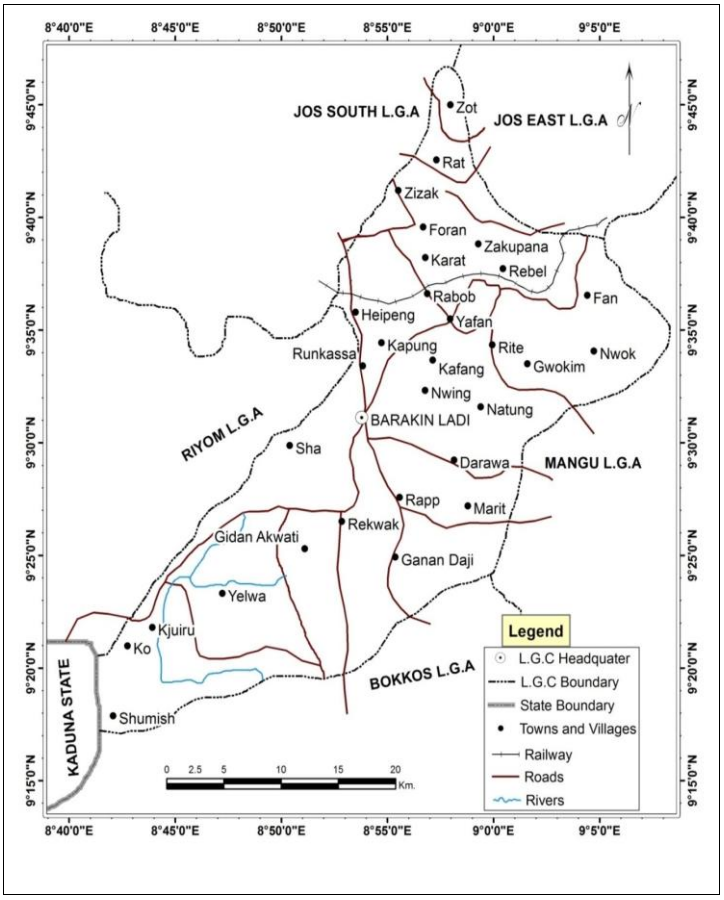


Figure 2: Barkin Ladi LGA, Plateau State
Source: Plateau State Lands and Survey (2022)

Procedures for Data Collection

Visits to agrarian communities of Gwokim, Karat, Kakuruk, Kapung and Marit were undertaken prior to data collection phase. The LGS was compartmentalized into five administrative districts. Stratified sampling was used to select a settlement each for the study which gives fair coverage of the local Government. A settlement was each selected by randomisation technique and an approximately 23% of the population was sampled for the study as displayed in Table 1. The sample size was then determined by the application of Krejcie and Morgan's (1970) formula:

$$n = \frac{X^2NP(1-P)}{d^2(N-1) + X^2P(1-P)}$$

Where, s= required sample size

X^2= 7the table value of Chi-Square for a 1° of freedom at the desired confidence level

N= population size

P= the population proportion (0.5), and

d= the degree of accuracy expressed as a proportion.

By applying the formula, 500 respondents were selected, representing a sample size of 23% of the total population of 11,374 farmers for the study. Sequel to that, a total of 500 household heads from the five settlements were randomly selected for questionnaire administration.

The main instrument of data collection consisted of semi-structured questionnaire, supplemented by personal observations. The

questionnaire was compartmented into sections A, B and C. **Section A** sought for information about farmer's demographic and socio-economic characteristics such as age, district, state of origin, nationality, place of birth, sex, marital status, number of wives, income, number of children, occupation, educational qualification and hectares of farm under crop production. **Section B** solicited for information about modes of acquiring land for crop production purpose, while **Section C** captured information on opinions about how to access agricultural land in Barkin-Ladi LGA. The instrument consists of series of questions with options, and respondents could then select the options that appeal to them by ticking or circling. They could also make comments if they so wish. Other information were about the implications of land holdings on food security, sourced from literature.

The questionnaire was given to two experts who validated it, followed by a pilot study with the aim of detecting any difficulties for amendment before the actual data gathering exercise could commence. Responses to questions from the questionnaire led to some amendments which increased the validity and reliability of the instrument. Thereafter, 500 copies were produced and 5 field assistants were recruited and helped in administering to household heads of each of the communities, under the supervision of the researchers. However, of the 500 copies of questionnaire distributed, only 428 were correctly filled and returned thus, representing about 86% recovery rate, while the remaining 72 copies were excluded because they were partially filled (see Table 1). The data were extracted from copies of the questionnaire and summarised, analysed using descriptive statistics of frequency counts and percentages, aided by the Statistics Package for Social Sciences (SPSS) version 22 software. Results are shown by means of tables for easy comparison of values.

Table 1: Distribution of sampled population from each district of Barkin Ladi LGA

S/N	District	Villages	Approximate Farmers	QuestionnaireA administered	Number Retrieved	Retrieved (%)
1	Fan	Gwakim	3,800	200	200	100.0
2	Foron	Karat	1,760	75	61	81.3
3	Gashish	Kakuruk	1,420	75	42	56.0
4	Heipang	kapung	2,430	75	54	72.0
5	Ropp	Marit	1,964	75	71	94.7
6	Total	5	11,374	500	428	85.6 (Mean)

RESULTS AND DISCUSSION

Data gathered was collated, organised, summarised and analysed using frequency counts and percentages, aided by SPSS-22 software. The results were then presented by means of tables to enhance understanding by comparing the numerical values. Highlights of major findings were made and compared with previous documented works in the literature.

Mode of Land Acquisition For Crop Production in Barkin Ladi LGA

Information about how farmers acquire land for crop cultivation were analysed and presented in Table 2. Results reveal that most (40%) of the respondents acquire land for farming through land lease, which involves payment of rental fee to landlord in exchange for the right to use the land for a specified period. The table further indicates that one-fifth (20.1%) of the farmers acquire land through inheritance and purchase, while free-land ownership accounts for one-tenth (10.0%). However, other modes of land acquisition, such as gift, pledge, share cropping and communal use of farmlands account for the least mode of land acquisition for crop production purpose in the study area.

Table 2: Mode of land acquisition for crop production in Barkin Ladi LGA

SN	Mode of Acquisition	Respondent	Percentage
1	Land lease	171	40.0
2	Inheritance	86	20.1
3	Purchase	86	20.1
4	Free ownership	43	10.0
5	Others (communal, pledge, share cropping)	42	9.8
	Total	**428**	**100**

Farm Sizes under Crop Production in Barkin Ladi By Village Area

In line with the objective two of the study, respondents were asked to quantify the hectarage of their farmlands under crop production and the processed results are presented in Table 3. The total croplands belonging to 428 farmers in Gwokim (Fan), Karat (Foron), Kakurut (Gashish), Kapung (Heipang) and Marit (Ropp) amount to 158 hectares as at 2018. When this figure is share equally among the 428 household heads equally, each of them will get just 0.37 hectare, which is inadequate to cater for the food needs of a typical six members of most households.

Table 3: Farm sizes under crop production in Barkin Ladi by village area

SN	District	Village	Respondent	Farm Hectare (2018)	Percentage
1	Fan	Gwokim	200	71.7	45.4
2	Foron	Karat	61	21.2	13.6
3	Gashish	Kakuruk	42	16.2	10.2
4	Heipang	Kapung	54	22.7	14.4
	Ropp	Marit	71	25.9	16.4
	Total		**428**	**158.0**	**100**

Trend in Farm Sizes of The Village Areas of Barkin Ladi LGA

Farmers' farm sizes under crop production in 2016 and 2018 were determined, thereafter, the difference between the years for each settlement were transformed to percentages (see Table 4). Results as contained in Table 4 reveal that the LGA is dominated by small-scale farmers whose hectarage are retrogressively shrinking in sizes with the passage of time. The average reduction in farm size between the years under consideration is about 27.1% and the shrinking rate is higher than the average in Gwokim (Fan) and Karat (Foron), whose farm sizes decreased by 33.7% and 27.4% respectively. The scenario is better for agrarian communities of Marit (Ropp), Kakuruk (Gashish) and Kapung (Heipang) whose decline rates were: 20.1%, 19.8% and 13.7% respectively. The reason for the continuous reduction in farm sizes belonging to the five agrarian communities is most likely associated with recurrent attacks and violent conflicts with marauding cattle rearers which sometimes lead to displacement of the inhabitants of such farming communities.

Table 4: Trend in farm sizes of the village areas of Barkin Ladi LGA

District	Village	Respondent	Hectare (2016)	%	Hectare (2018)	%	% Change
Fan	Gwokim	200	108.1	50.1	71.7	45.4	33.7
Foron	Karat	61	29.6	13.7	21.2	13.6	27.4
Gashish	Kakuruk	42	20.2	9.3	16.2	10.2	19.8
Heipang	Kapung	54	26.3	12.0	22.7	14.4	13.7
Ropp	Marit	71	32.4	15.0	25.9	16.4	20.1
Total		**428**	**216.6**	**100**	**158.0**	**100**	**27.1(mean)**

Discussion

The study has analysed the data collected on the modes of land acquisition for crop production, farmers' farm sizes under crop production and the trend in farm sizes for 2016 and 2018 in Barkin Ladi LGA. The study discovered that the prominent modes of land acquisition are lease holding, inheritance, purchase, free ownership as well as other forms listed as communal, grant, pledge, and share cropping, with land lease being the most common in the study area (see Table 2). The result on land acquisition mode agrees with the reported finding in Enugu State, where 41.7% of the 120 respondents that participated at the study acquired land through lease. The preponderance of acquiring farmland by land lease in Barkin Ladi for crop production has some considerable setbacks.

Leasing of land involves payment of rental fee to the landlords in exchange for the right to use the land for a specified period. The lease agreement in most cases, outlines the terms and conditions, including rental fee and the period permitted for the use of such farms. This method of land acquisition is fraught with many setbacks, including: high transaction cost, unavailability of land, crop failure, distance of land from home, fear of leasor family's abrupt interruption of the land lease, lack of security and poor land improvement (Ugwu & Okoye, 2019).

Personal observations by the researchers reveal that most tenancies are granted on yearly basis, which makes it difficult for the tenant farmers to use and tend such farmlands efficiently. If the farmlands are distant from homes, the farms may not receive dressings of farmyard manure. This explains in part why there are abysmally small farms holdings in the study area, which when measured gives an average of 0.37 hectare per household head (see Table 3).

The results contained in Table 4 indicate that farmers' farm sizes in the study area are retrogressively on the decline, from 216.7 hectares belonging to 428 farm holders to 158 hectares, in 2016 and 2018. This means there is general decline in farm sizes and crop production of about 27.1% between the years under review. This trend in farm sizes decline could be attributed to the high cost of land access and general insecuring precipitated by marauding cattle herders who often graze on croplands in the area. The people of Barkin Ladi, Bassa, Bokkos, Mangu and Ryom LGAs have been under violent clashes with marauding cattle herders for some years now leading to displacement of people. Zodoe (2018), reported that 233 farmers in Barkin Ladi were killed and Pwanagba (2018), reported the killing of 100 people in Daffo district of Bokkos LGA. All these attacks were accompanied with destruction of crops, destruction of properties and displacement of agrarian communities, with consequential abandonment of farmlands and reduction in overall crop production and leading to food insecurity.

IMPLICATIONS OF FARM HOLDINGS ON FOOD SECURITY

Food is a basic necessity of life, and second only to water (Onyenze, 1999). Nigeria is a country endowed with diverse agricultural resources, unfortunately, with its massive arable land of over 70.8 million hectares, it cannot guarantee food sufficiency to its teeming population of over 200 million. One of the reasons for the low performance is preponderance of small-scale farmers. Nearly 72% of Nigerian farmers are poor because many of them have small farms (Aliogo, 2022). According to the Global Food Security Index (GFSI) (cited in Aliogo, 2022), Nigeria ranked 94 out of 113 countries surveyed in 2019 with overall score of 48.4% in food security and 45.8% in food availability. Nigeria Country and Agriculture Delivery Compact (2023) also expressed fear that the high multidimensional poverty has already plunged 77.2 million Nigerian into poverty, and are facing food insecurity, while 57.4 million others are facing nutritional insecurity, with many people living on less than $1.90 per day or below the poverty line.

Food insecurity is a phenomenal event in Nigeria where in 2020, about 6.5% of children under 5 years were said to be underweight, accompanied by food-deficiency diseases that precipitate stunted growth in infants and children. This explains in part why domestic food crop production has not been keeping pace with population growth, resulting in rising food imports which is growing at unsustainable rate of 11% per annum, as well as obvious decline in national food self-sufficiency (Nigeria Country Food and Agriculture Delivery Compact, 2023). The gross domestic product (GDP) indicates a declining trend in food production, in which the percentages for

2005, 2006, 2007, 2008 and 2008 were 7.1%, 7.4%, 7.2%, 6.3% and 5.9% respectively. The Food and Agriculture Organization (FAO) of the United Nations (Ibirogba, 2022) laments that Nigeria's rice production which, though, rose from 3.7 million metric tons (MMT) in 2017 to 4.0 MMT in 2018, was far below its 7.0 MMT yearly demand. Nigeria's yearly rise in consumption of rice in 2018, 2019, 2020, 2021 and 2022 were 6.75 MMT, 6.80 MMT, 6.85 MMT, 6.90 MMT and 6.95 MMT, respectively (Ibirogba, 2022).

Under-production and under-supply of food are clearly being witnessed as inflation has already plunged over 7% Nigerians into avoidable poverty; with most households spending 56.0% of their hard-earned income on food, above the 6.4%, 8.2%, 9.1% and 9.8% being spent by the USA, UK, Canada and Australia, respectively (Allegheny, 2021). This phenomenon explains in part why on average 21.4% of Nigerians experienced hunger between 2018 and 2020, with about 25 million currently suffering from hunger, thereby making the country to rank first in Africa and second in the world's global chart of malnourished children (Allegheny 2021; Anigo, 2023; Maton et al. 2022). This issue needs to be addressed in order to achieve the Sustainable Development Goal-2, which is to: "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" by the year 2030.

CONCLUSION

The study has investigated the modes of land acquisition and found preponderance land lease, inheritance and purchase. These methods militate against individual initiating towards the development of land in terms of mechanization of the farm, erosion conservation measures and efficient application of backyard manure. The farm sizes were also noticed to have declined retrogressively to the detrimental of food security, which poses serious threats to the achievement of zero hunger for all of the United Nations Development Goal 1. This is evident from from mass importation of food into the country which is fast depleting the nation's already meagre foreign reserve and rising hunger, malnutrition the continuous riding cost of foodstuffs. Sequel to this, the following measures are recommended:

1. The three-tiers of Government should make more commitment to the agriculture sector by allocating substantial portion of finances to provide farmers with technical and input support in order to boost crop production.
2. Government should urgently tackle the recurrent security challenges in the study area.
3. The relevant authorities should provide extension services, sensitise, distribute farm inputs, fast growing seedlings and encourage farmers to use labour-saving technologies to enhance food production.

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Health Status of People Involved in Quarrying Activities in Jalingo Taraba State

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ABSTRACT

This work assessed the health status of respondents in quarry activities in Jalingo Local Government Area of Taraba State, Nigeria. The study adopted a single round survey. Using Krejcie and Morgan sample size determination table, 240 respondents were randomly selected from a population of 300 respondents involved in quarry activities in the study area. A total of 229 questionnaires were recovered. Questionnaire and interview were used for data collection. Descriptive statistics involving the use of frequency counts mean and standard deviation was used in analyzing the data. It was discovered that most (45%) of the quarry workers fell within the age group of 36-45 years and 48% were uneducated. Though only a seemingly small proportion of the respondents (20.1%) complained about frequent severe health challenges especially severe body aches, most others (79.9%) complained of mild pains such as headaches and mild body pains. The study however found that a significant difference existed between the number of persn who reported severe body pains and the number of those who reported mild body pains. A Chi-Squared test indicated a p-value of 0.0309. To determine the actual location of quarry activities that was significant, a posthoc test, an adjusted residual test, was conducted. Results showed that Shavon B, in Kona Ward of Jalingo, which had the least number of respondents, posted a significantly larger number of persons with severe body aches than expected, and a number of those reporting mild body less than expected as well. It was recommended that a better and more quality method of quarrying should be introduced so that respondents do not exert too much energy and effort and they should reduce the amount of hours spent on work daily. This will help maintain the health status of respondents and will subsequently increase productivity, especially now that the economy of the country, Nigeria, is becoming less sustainable than before.

Keywords: *Gender, Economic activities, Participation, Stone quarrying,*

INTRODUCTION

Women with children on their backs start and end their day extracting, lifting and crushing stones using simple handmade tools as source of their livelihood. Stone quarrying is a land use which involves extraction of non-fuel and non-metal minerals from rocks (Ukpong, 2012). It is usually done by open-cast method using rock drills, explosion of dynamite and other methods to break the rocks into smaller units that can then be manually quarried. According to Kitula (2006), quarrying has environmental and health effects. The operations in stone quarrying, whether small or large-scale, are inherently disruptive to the environment, producing enormous quantities of waste that can have harmful impacts for decades and that the environmental deterioration caused by stone quarrying occurs mainly as a result of inappropriate and wasteful working practices and rehabilitation measures (Sati, 2015). The degradation of the environment due to stone quarrying activities has put forth questions as to whether or not the mining activities should be discontinued (Nartey, Nanor & Klake, 2012; Sati, 2015). It has been revealed that very high concentration levels of particle matters such as nitrogen dioxide that cause acute respiratory problems emanate from quarrying activities (Okafor, Njoku & Akwuebu, 2023). The continuous increase in prices of things and unreliable climate variability is pushing farmers away from farming into other businesses such as quarrying. According to Wang (2012), over 500 million people in developing countries are engaged in occupations such as small-scale surface mining and quarrying for survival. This is also confirmed by Ibrahim and Asante (2012), Abass and Afriyie (2014), that since the formal sectors in developing

countries have very little potential in terms of job creation, the informal sector such as stone quarrying has become an attractive alternative for achieving livelihood.

Majority of women are generally perceived as poor due to cultural norms but they also possess inherent skills and knowledge. Quarrying is one of the economic activities in Jalingo where women are actively engaged in sourcing for means of livelihood. Many people in rural areas consider non-farming activity like quarrying as an alternative to farming to combat unemployment and poverty. It is for this reason that diversification of rural income has become common among those who wish to earn more income for better living conditions. Since non-agricultural activities in many instances yield as much or even more returns as subsistence farming one of the few options for those without access to productive farmlands is to subject themselves to stone extraction and small scale mining. Unfortunately, this activity comes at a heay cost for many participants, a large proportion of which are women.

The environmental consequences of quarrying activities are well-known and reported (Nartey et al., 2012; Sati, 2015; Opondo, Ajayi & Makindi, 2023). However, not much has been discussed on the personal costs that the women involved in quarrying activities bear. Nartey et al. (2012) and Opondo et al. (2023) have alluded to health implications of quarrying activities but at community or other levels, not at the disaggregated personal level of the persons involved especially those of the women. This study is designed to explore the health implications of quarrying activities on women who actively participate in it in Jalingo area, Taraba State, Nigeria. Despite the large numbers of women observed to be working in local quarry, there is insufficiency of data on this group people of persons in terms of health and related impacts, especially as their socioeconomic source of livelihood is the quarrying of stones in Jalingo Local Government Area.

MATERIALS AND METHODS

Study Area

Location Size and Position

Jalingo local Government area is situated between latitudes 8º 47‟ and 9º 01‟N and longitudes 11º 09‟ and 11º 30‟E. It is bounded to the North by Lau Local Government Area, to the East by Yorro Local Government Area, to the south and West by Ardo-Kola Local Government Area. It has a total land area of about 195km^2, according to Oruonye (2014).

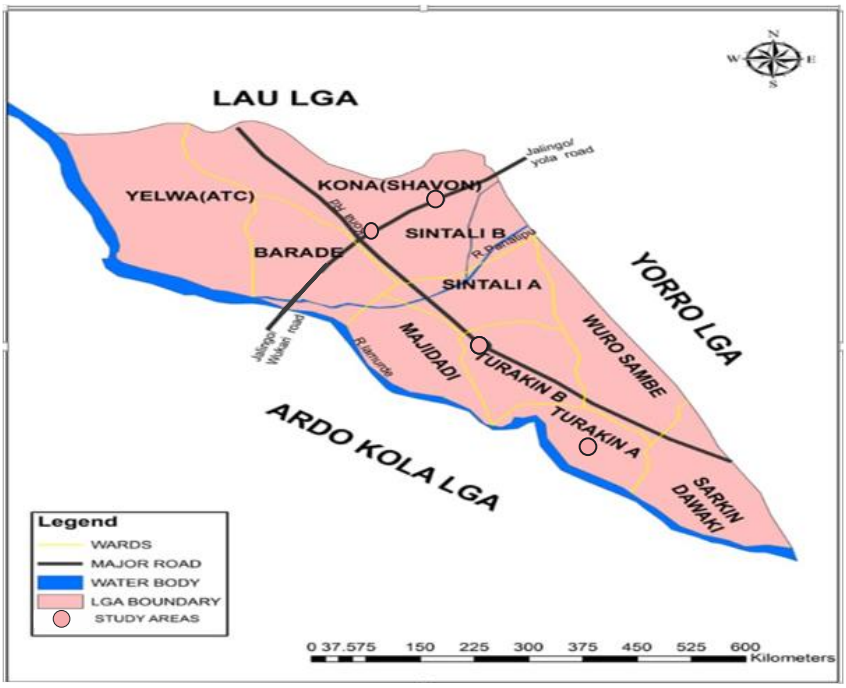


Figure 1 Jalingo Local Government showing the study area
Source: Bureau for Land and Survey, Jalingo

Based on the location of Taraba State with a lot of basement complex rocks, stone deposit is one of nature's gifts to the location serving as one of the main sources of economic activities apart from agriculture, fishing and others. The relief of Jalingo LGA consists of undulating plain interspersed with mountain ranges. This compact massif of rock outcrops (mountains) extends from Kona area through the border between Jalingo and Lau LGAs down to Yorro and Ardo Kola LGAs in a circular form to Gongon area, thus giving a periscopic semi-circle shape that is almost like a shield to Jalingo town, the state capital.

Jalingo LGA has tropical continental type of climate characterized by well-marked wet and dry season. The wet season usually begins around April and ends in October. The dry season begins in November and ends in March. The LGA has a mean annual rainfall of 1,200 mm^3 and annual mean temperature of 29°C. Relative humidity ranges between 60 and 70 per cent during the wet season to about 35 – 45 per cent in the dry season (Oruonye, 2014). Jalingo metropolis is drained by two major rivers Mayogwoi and Lamurde, which take their source from the mountain ranges in Yorro LGA and empty their content into the Benue river system at Tau village. The valley of River Lamurde is dotted with ox-bow lakes which are as a result of depositional activities (Oruonye, 2014).

Research Design

The study adopted a single-round survey design, which Fisher (1991) and Cleland (1990) found useful in descriptive and exploratory studies. The study aimed at assessing the health condition of women in quarrying activities in Jalingo.

Population of the Study

The study population consisted of all local quarry workers, although there was no registered figure from the State or Federal Government on the estimated number of quarry workers. Therefore, the study obtained the data of all quarry workers from the local mine quarry association, which is apparently very unstable.

Sample Size and Sampling Procedure

The research adopted two sampling techniques, and these are purposive and simple random sampling. Jalingo has ten (10) wards, out of which three (3) wards were purposively sampled because these wards are the wards where quarrying activities are concentrated. Based on the register provided to the researcher, there were about 300 people involved in quarrying in Jalingo out of which 240 respondents were randomly selected using Simple Random Sampling technique. Numbers from 1-300 was awarded to each person on the register the numbers was then written on papers and rolled for each one to pick, but only 240 numbers was written for pick. Two hundred and forty (240) copies of questionnaires were produced and administered. However, 229 were adequately filled and retrieved by the researcher. The administration and retrieval of the questionnaire was carried out within three months. The primary instrument that was used for data collection for this study was questionnaire and in-depth interview. The information obtained from the respondents included the demographic characteristic of respondents, participation in quarry activities and frequency at which the respondents worked the quarry in the study area. In order to fast-track the quick collection of data, the researcher engaged a research assistant, who was trained, and this facilitated the collection of data covering the various quarry sites. The period of study was July 2021 – September 2021. The data generated in this study were sorted and analyzed using Microsoft Excel and presented in tables of frequencies and percentages. A Chi-Squared test ws employed to test for any significant difference inn severity of illnesses reported. The Chi-Squared test is represented as:

$$\chi^2 = \Sigma \frac{(O - X)^2}{E}$$

Where: χ^2 = Chi Square
O = observed frequency
E = Expected frequency

A posthoc test, the adjusted residual test was then applied to identify the location of

significant differences in the study area. The adjusted residual test is represented as:

$$Adj\ Res = \frac{O_{ij} - E_{ij}}{\sqrt{E_{ij}(1 - \frac{m_i}{N})(1 - \frac{n_i}{N})}}$$

Where m = row total
n = column total
N = grand total

RESULTS AND DISCUSSION

Table 1 shows the demographic characteristics of the respondents for the study.

Table 1 Demographic characteristics of respondents

Response	Frequency	Percentage (%)
Age		
25 & Below	14	6
26 - 35 years	34	15
36 - 45 years	102	45
46 - 55 years	54	24
56 & Above	25	11
Total	**229**	**100**
Educational Qualification		
None	109	48
Primary	83	36
Secondary	33	14
Tertiary	14	6
Total	**229**	**100**
Religion		
Christianity	170	74
Islam	44	19
ATR	15	7
Total	**229**	**100**
Marital Status		
Single	16	7
Married	172	75
Divorced/Separated	9	4
Widowed	32	14
Total	**229**	**100**

Source: Field work, 2020

The result reveals that the majority of the respondents are within the age bracket of 36 and 45 (45%), followed by those in the age bracket of 46 – 55 (24%), 26 – 35 (15.6%), while those below the age of 25 years (6%) were the lowest.

This shows that the majority of the respondents involved in quarry activities are matured. On the respondents' educational qualification, the result shows very high number of respondents (48%) had no formal education, while on the other hand, 36%, had primary school as their highest level of education. Only a few respondents have secondary and tertiary education represented by 14% and 6%, respectively. Based on religious inclination, the result found that 74% were Christians, while 19% were Muslims, whereas 7% of the respondents are adherents of the African traditional religions. Based on the respondents' marital status, the result shows that the majority (75%) of the respondents were married. On the other end, 14% of the respondents are widowed, whereas 7% are single and separated, respectively.

The result, therefore, implies that the majority of the respondents did not have adequate education to be gainfully employed elsewhere, considering their age brackets and marital status; This is in line with the findings of Eshiwani (2014), in which it was found that educational background was generally poor with the majority of workers in the quarry having a secondary level of education. Quite a few had gone beyond postsecondary education. This implies that education is necessary for obtaining better job opportunity. Aboagye (as cited in Birbawa, 2006) associated informal activities with low levels of education.

Table 2 reveals the health status of respondents in the study area. In all the wards studied, women were dominantly affected by mild health challenges but there are no absence of very severe cases. About 80% of respondents complain of mild health issues, but about 20% of respondents have cases of regular health issues ranging from severe malaria fever, to typhoid and severe body aches. These are very much connected to the kind of job they engage in and this goes a long way in reducing their quality of life and subsequently their life expectancy if not checked.

Table 2 Respondent health status and quarry activities in Jalingo

Ward	Location	Malaria/ Typhoid/ Severe body aches	Percentage	Mild Body Aches	Percentage
Kona	Dinyavoh	12	5.2	80	34.9
	Shavon B	8	3.5	11	4.8
Turaki A	Rafin Sanyi	12	5.2	44	19.2
Turaki B	Nyamu Sala	14	6.1	48	21.0
Total		**46**	**20.1**	**183**	**79.9**

Opondo et al. (2023) also found that malaria was prevalent among those involved in quarrying activities in Nyando subcounty, Kisumu County, Kenya. They rightly pointed out that though malaria may not be directly linked to the actual quarrying, the people are exposed to mosquito bites from the open water collected in the trenches they have worked and atound which they still worked. This provides a plausible explanation of the incidences of malaria reported by women at the quarries. It is equally possible tha the long hours they spend at the quarries force them into eating cheap and unhealthy food that are vendored in such places thereby exposing them to typhoid infection as well.

It is equally important to state that mild body ache is only a state that describes level of severity and can easily lead to severe body ache if not checked. With increasing participation in quarrying activities this is expected to occur sooner than later. Severe body ache may also be symptomatic of arthritis, a leading cause of disability worldwide (Neogi, 2013). It is also known to cause stress and even depression. Severe body pain has been linked to significant levels of hospitalizations and loss of productivity (Yang & Peng, 2021). These (frequent hospitalization and loss of productivity) would easily defeat the purpose of adopting this activity as a means of livelihood.

It is important to note that the number of women who reported severe cases of body aches (alongside malaria and typhoid) appears to be much smaller than those who reported mild body aches. The study, in the light of the effects of severe body aches on hospitalization and loss of productivity explored if any differences existed between frequency of severe and mild body ache cases reported by women in the manual quarry industry in Jalingo.

Test of Hypothesis

Null: There is no significant difference in the frequency of severe body aches and mild body aches reported by women in manual quarry industry in Jalingo.

The Chi-Squared test was adopted as the data fitted all the conditions for its application, including the data being categorical, in frequency counts and no expected value cell had a frequency count value that was less than 5. The test was conducted at 0.05 level of significance. The test result is presented in Table 3.

The calculated Chi-Squared value was 8.8846, which is greater than the table Chi-Squared value of 7.8150 at 0.05 level of significance and df = 3 ((r-1)(c-1)). This means that the null hypothesis is rejected. This result is further tested using CHITEST for the observed and expected frequency counts and a CHIDIST test for the calculated Chi-Squaed value obtained, both in Microsoft Excel. The p-value returned by both tests was 0.0309, which was less than the level of significance at 0.05 and which confirmed that the null hypothesis should be rejected. The implication was that there was a significant difference in the number of severe and mild cases reported. This is not immediately apparent in the distribution. A posthoc test is needed to identify the locations with the significant differences in the study area. Table 4 presents the results of the adjusted residual tests conducted using Microsoft Excel.

Table 3 Test result for the Chi-Squared test

	Ward	Location	O	E	O - E	$(O-E)^2$	$(O-E)^2/E$
Severe	Kona	Dinyavoh	12	18.4803	-6.4803	41.9949	2.2724
		Shavon B	8	3.8166	4.1834	17.5009	4.5855
	Turaki A	Rafin Sanyi	12	11.2489	0.7511	0.5641	0.0502
	Turaki B	Nyamu Sala	14	12.4541	1.5459	2.3897	0.1919
Mild	Kona	Dinyavoh	80	73.5197	6.4803	41.9949	0.5712
		Shavon B	11	15.1834	-4.1834	17.5009	1.1526
	Turaki A	Rafin Sanyi	44	44.7511	-0.7511	0.5641	0.0126
	Turaki B	Nyamu Sala	48	49.5459	-1.5459	2.3897	0.0482
		Tota Observation	**229**			**Sum**	**8.8846**
						Table value	**7.8150**
						Sig	**0.0309**

Table 4 shows that the adusted residuals for Shavon B in Kona ward of Jalingo are significant. Interestingly, this is the location with the least number of respondents. The p-value was 0.01237, which was lower than the level of significance at 0.05.

Table 4 Adjusted residuals for Chi-Squared test conducted

Ward	Location		Mild	Severe	Row Total
KONA	Dinyavoh	Observed Count	80	12	92
		Expected Count	74.7	17.3	
		Column Total	183.0	46.0	
		Adjusted Residual	1.7603	-1.8356	
		Sig	0.07835	0.06642	
	Shavon B	Observed Count	11	8	19
		Expected Count	15.2	3.8165	
		Column Total	183.0	46.0	
		Adjusted Residual	-2.5015*	2.5015*	
		Sig	0.01237	0.01237	
TURAKI A	Rafin Sanyi	Observed Count	44	12	56
		Expected Count	45.5	10.5	
		Column Total	183.0	46.0	
		Adjusted Residual	-.56512	.58928	
		Sig	0.57199	0.55568	
TURAKI B	Nyamu Sala	Observed Count	48	14	62
		Expected Count	50.4	11.6	
		Column Total	183.0	46.0	
		Adjusted Residual	-.86820	.90531	
		Sig	0.38528	0.36530	
Total		**Grand Total**			**229**

The adjusted residuals therefore indicated that the number of reported severe cases of body aches in Shavon B was significantly higher than the expected (2.5015) number of cases, while the number of mild cases of body aches reported were significantly less than expected (-2.5015). According to Sharpe (2015) an adjusted residual value of 2 and higher or -2 and lower indicates significance. This means that the value

observed is significant in explaining any differences that may be found. The other locations posted adjusted residual values that were less than 2 or greater than -2, which therefore indicated that they were not significantly different. This was reflected in their p-values which all were larger than 0.05, therefore not significant.

Shavon B area is a place of intensive stone quarrying activities close to the urban area of Jalingo. Though the site is relatively small compared to some other locations of quarrying activities, its proximity to the urban centre is therefore a major attraction for patrons. It is relatively easy therefore for purchased stones quarried from the site to be transported at relatively cheap price to building construction sites in the city. The implication is that with large patronage, there is an expectation of higher productivity. Women, who bear the brunt of hard work producing the final product at the quarry sites, indulge themselves in long hours of hard labour to meet up with the demand. The stress and strain of the work prodce severe body pains that may have severe long-term implications for their health.

CONCLUSION

Most (45%) of the quarry workers fall within the age group of 36-45 years and about (48%) of them have not acquired any form of education, this work is mostly labor intensive and requires little or no education. Quarrying provides some level of employment and generates some income for the respondents of the selected areas in Jalingo, but this comes sometimes with a "cost" which include regular health decline. About 20% complain regularly of either severe malaria fever, typhoid or severe body aches. The majority of the people studied (80%) however, complain of mild body aches, mild fevers and headaches.

Based on the findings, the study recommends the following:

1. Better and more qualitative method of quarrying should be introduced such that will encourage people to engage in the business and increase the quality of life of respondents.
2. In order to control and increase quality of health, there should be sensitization on why respondents should patronize health facilities close to them on regular basis to for stall cases of severe health condition

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Academic Manpower Workload of Pedagogical Institutions in Jos South LGA: Rationale for Proper Manpower Planning In Nigeria

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ABSTRACT

This study investigated the academic manpower workload of pedagogical institutions in Jos South LGA of Plateau State, Nigeria. A total of 250 teaching staff were selected from 14 secondary schools using quota and simple random sampling techniques. The target population were drawn from public and private schools distributed across five districts of Jos South LGA. Data were collected through administration of structured questionnaire. The obtained data were analyzed using the SPSS-23, results were summarized in frequencies, mean and percentages and presented in tables and charts. Results revealed that about one-thirds (32.4%) of teaching manpower were within age group 35-39 years old and the teachers mean age was 40 years old. About three-fifth (58.4%) of study participants were professionally trained in education courses of various tertiary institutions. The mean Teacher- Student Ratio (TSR) was 1:13. Five schools (35.7%) have ratio above the mean, while nine schools (64.3%) have TSR lower than the mean. Over half (50.4 %) of teaching staff handled two subjects, with 34.0% of them taking between 15 and 19 lesson periods per week, with mean period being 15. However, 56.4% of teaching manpower have weekly workload exceeding 15 periods. Finally, seven-tenth (70.4%) of the teaching manpower were assigned at least 2 subjects to teach. The study therefore recommends a fair allocation of workload to staff based on their subject specialty in all secondary schools in the study area to guarantee quality assurance for sustainable and educational development in the study area.

Keywords: *Teaching, Jos South LGA, Manpower planning, Secondary School, Workload*

INTRODUCTION

Formal education is instrumental to improving people's socio-political status and poverty reduction, which is a "sine qua non" to the overall development of every nation. Teaching is a rewarding career however, with heavy workload, the teaching staff can easily fall prey to health risk. A well-managed academic workload in a school system is pre-requisite to the achievement of educational goal in every society. The imperative of secondary school education in the educational system cannot be over emphasized, as it provides a link between primary and tertiary education (Ige, 2013). Quality education is the most important tool for socio-economic development, poverty reduction, disease control, nutritional balance and technological advancement. Boit, Njoki and Chang'ach (2012) asserted that purpose of education is to adequately equip the citizens who in turn, will help reshape the society by eliminating inequality and bring about general development. This implies that secondary education is aimed at developing the child better than the primary level, in terms of literacy, articulacy, numeracy and graphicy (LANG), thereby ushering him into tertiary education levels and make him contribute to the overall development of the society in which he lives.

Realizing the importance of education to national development, the Nigerian government have over the years, promulgated many ordinances, bye-laws and edicts (OBE) to improve the quality of secondary education through establishment of teacher training colleges and faculties of education, regular payment of teachers' salaries, emoluments and entitlements, provisions of in-service teacher training, increasing employment of many teaching staff and student enrollment. According to Federal Government of Nigeria (2009), as cited in Ige (2013), there has been increase in the number of secondary schools: from 161 in 1955 to 275 in 1956, 297 in 1957, 303 in 1958, 305 in 1959 to 311 in 1960. After independence, the number of secondary education continued to increase from: 1,227 in 1960 to 1,654 in 1965, from 6,231 in

1985, 6,279,462 in 2004 to 6,398,343 in 2005 and 6,536,038 in 2006.

Enrollment of students witnessed remarkable increase from 168,309 in 1960 to 252,586 in 1965, 3,807,755 in 1985 and 6,536,038 in 2006 (Federal Government of Nigeria, FGN, 2009). According to United Nations Educational, Scientific and Cultural Organization (UNESCO), as cited in Ige (2013), there was 3,625,163 student enrollment in 2005/2006, while the number of academic manpower at junior school levels was 61,938 (one teacher to 59 students), out of whom 73.3% were qualified. The report further indicated that during the same period, the academic manpower at senior secondary school levels was 74, 641 (one teacher to 49 students), out of whom 73.0% were qualified.

Based on the aforementioned reports, it is now obvious that the increasing rate of student enrollment without a corresponding increase in teacher-employment is continually putting unnecessary pressure on the academic manpower. The academic manpower workload, which is the specific number of periods and other academic tasks a teaching staff is expected to cover weekly is becoming too burdensome to bear in many Nigerian secondary schools. The problem ensues when teacher's subject allocation and the number of periods significantly exceed the number that can comfortably handle. Many academic manpower saddled with excessive workload in their teaching carrier is known to derail classroom management methods, resulting in churning out students not fit for tertiary education (Mark, 2020). Corroborating the negative impact of teacher-workload, UNICEF (2007), stressed that poor working conditions for teachers in many countries of the world affect their abilities to provide quality education. This is because teachers' input is the principal factor in educational provision that can influence the quality of education in significant ways (Ankomah et al., 2005). This means that academic manpower plays crucial role in the attainment of educational goal because the teacher is ultimately responsible for translating policies into actions and principles based on interaction with students. Therefore, the inadequacy of academic manpower in schools, coupled with high workloads and wrong placements are issues that indicate gross deviation from quality and affects the attainment of educational goal and overall sustainable development in Nigeria.

Review of literature revealed that many scholarly studies have been carried out on various aspects of teaching- learning by many researchers (Adeyemi, 2008; Adeyemi, 2011; Nkweke & Dollah, 2011; Ige, 2013; Attah & Adebayo, 2018; Mark, 2020). The few works by Attah and Adebayo (2018) and Momoh et al. (2020) on manpower workload among teachers in Plateau State are limited in providing insight into the contextual reality about the teaching challenges. Moreover, none of the reviewed literature has investigated manpower workload of secondary schools in Jos South Local Government Area of Plateau State. It is against this backdrop that this study sets out to examine teachers' workload at the secondary school level in Jos South LGA, with particular interest in their age groups, professionalism, teacher-student ratio, teaching subjects' workload and weekly lesson periods allocation to the teaching staff. The outcome of the study will guide policy makers in education in the design and planning the the best pedagogical process to help achieve the desired educational goal for durable development in the study area and Nigerian in general.

MATERIALS AND METHODS

Study Area

Jos South LGA is located between Latitudes 9˚37'00' & 9˚54'00' North of the Equator; Longitudes 8˚41'00' & 8˚58'00" East of the Greenwich Meridian (see Figure 1). It covers the northern plains of the Jos Plateau, surrounded by Jos North to the North, Jos East to the Northeast, Bassa to the Northwest, Riyom LGA to the South and Barkin Ladi LGA to the East. Jos South has a total land mass of 768sq.km, with its Headquarters in Bukuru Town, about 15 km from Jos city, the Plateau State capital. Jos South has a population of 311,3922 (NPC, 2006). The LGA comprises five districts, namely Du, Gyel, Kuru and Zawan. It is a native land of the Berom ethnic group, who co-habit peacefully with other ethnic groups such as Afizere, Hausa, Igbo, Pan, Ron, Yoruba, among others. As part of the Jos Plateau, the climate of Jos South LGA is greatly influenced by the elevation of the land above the sea level which gives it a near temperate (Montane) climate with temperature ranging between 21˚C- 25˚C. Generally, Jos South LGA is located within the Koppen's Aw climate classification group, where

the wet season and the dry season alternate together but with modification due to elevation. The area enjoys an annual precipitation of about 1400mm-1800mm.

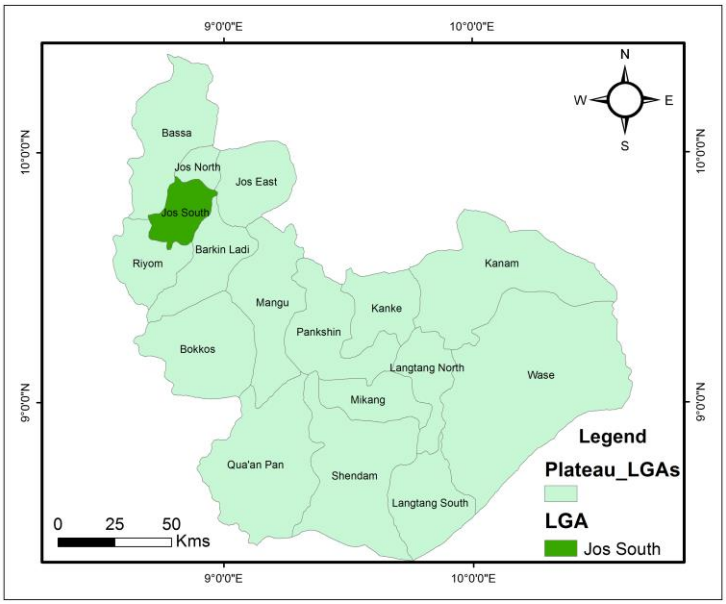


Figure 1 Plateau State showing Jos South LGA.
Source: GIS Lab, Department of Geography & Planning, University of Jos.

The study area forms part of the Jos Plateau, characterized by numerous, spectacular rock formation of all sorts, hills and valleys both natural and man-made. The land has an average elevation of 1,238 metres above mean sea level (AMSL), with Kuru Hill representing the highest peak of 1,300 metres AMSL. Generally, the topography of the land is rugged with rock outcrops of younger granitic rocks formed over 160 million years ago. The rocks which are mostly plutonic were formed during the Jurassic era but have been exposed by denudation. The elevated areas are the sources of many streams, which flow radially into bigger Rivers such as Kaduna and Benue Rivers. The study area is endowed with what Food and Agricultural Organization (FAO) classified in genetic terms as 'ferruginous soils', which dominantly form on crystalline acidic rocks, in tropical savannah regions. Soils are characterized by textual sub-surface horizon and when they are formed over biotite granite or gneiss, they are moderately depth but elsewhere, they tend to be shallow rocky soils. Naturally, the soils are well drained, intensively leached, have low- to-medium organic matter content and moderate to good water retention capacity and contain weathered reserve minerals of parent materials which support the bulk of crop and livestock production in the area.

Along flood plains of streams, there exists hydromorphic and alluvial soils, with high water retention capacity due to the presence of clay content with more cat-ion exchange capacity. These soil types, coupled with the near temperate climatic conditions support montane vegetation. However, the rapid rate of exploitation of the vegetation resources by man has destroyed most of the original vegetation in the area, leaving what is now referred to as ‘derived Savannah’.

Jos South LGA is well known for commercial tin mining that lasted for nearly 80 years (1904-1980s) which contributed significantly to the socio-economic development of the country. The dominant activity prevailing in most rural areas of Jos South is agriculture, where cereals, legumes and different temperate fruits and vegetables are produced and consumed locally in the country. Today, with the provision of infrastructure, many establishments and educational institutions have led to transformation of a substantial landmass into an urban area. The LGA is witnessing rural-urban drift especially of the able-bodied youth for want of paid sedentary

jobs and the general insecurity that characterizes some rural areas and the surrounding States in the country. The presence of social amenities, industries and institutions are also the pull factor to the migrants, leading to expansion of primary, secondary and tertiary institutions of learning as well as student enrollment.

Methodology

The study covered the five districts of Jos South LGA namely, Du, Gyel, Kuru, Vwang and Zawan. A quantitative research design, particularly cross-sectional survey was adopted for this study. Quota sampling technique was applied to ensure secondary schools from each of the five districts were represented. Schools in each of the five districts were categorised into public and private to ensure inclusion. On the basis of the varying number of schools in the five districts, two public and two private schools were each selected from Gyel and Vwang, while one public and one private schools were each chosen from Du, Kuru and Zawan districts for the study. Thereafter, Simple random sampling was used to select 50 teaching staff teaching in both public and private secondary schools in each of the five districts.

A structured questionnaire containing open and closed questions was designed to generate the requisite data from respondents. The questionnaire was divided into two sections. The first section elicited information about: school name, respondent's age, gender, highest educational qualification, marital status, household size, main occupation, work experience and monthly income. The second section sought for respondents' information about: number of subjects being allocated to teach, cumulative periods expected to be covered per week, class size, among other relevant details. Data obtained from each school management of each of each participating secondary schools include: school name, number of teaching manpower, subject and period allocation to each of the named staff, current student population per class and teaching staff.

A total of 14 secondary schools, comprising public and private were selected randomly from the identifed districts. After the questionnaire was validated, a pre-test conducted for reliability, 250 copies of the questionnaire were administered to teaching staff in the selected secondary schools through the help of three field assistants recruited and trained for the task by the researchers. All the 250 copies of the questionnaire were duly filled and returned. Subsequently, the data collected were screened, coded, entered and analyzed with the aid of Statistical Package for Social Science version 23. The data were summarized in frequencies, mean, percentages and presented in tables and charts for reporting.

RESULTS AND DISCUSSION

This section presents the analyzed data according to the set objectives. Descriptive statistics are employed and depicted by means of tables and charts. Highlights of what each result represent are given and compared with previous studies carried out elsewhere.

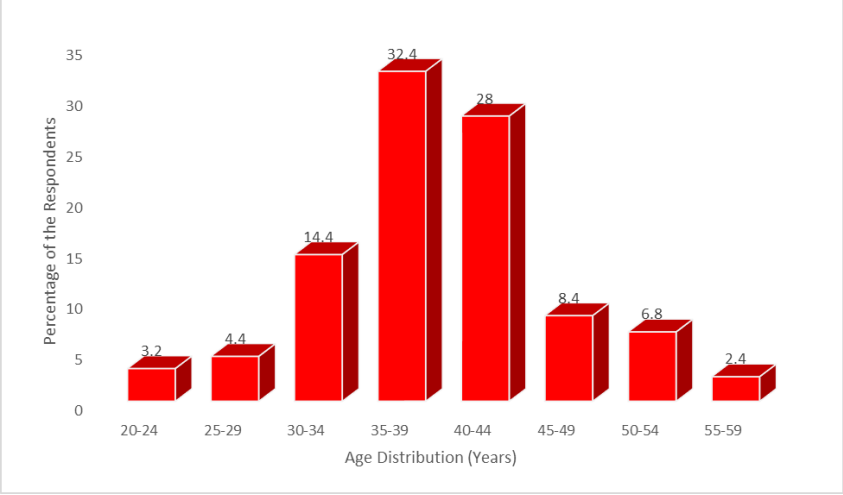


Figure 2: Age Distribution of Academic Manpower in Jos South

The result on age distribution of the respondents is presented in Figure 2. It shows that 32.4% of teaching staff were within the age group 35-39 years old, followed by 28.0% between the ages of 40-44 years old, and the least age groups were those between 55- 59 (2.4%) years and 20-24 years old respectively. This implies that the academic manpower in the study area were largely active population in their economically productive age engaged in teaching. Although, it is often argued that age is not always a barrier in teaching however, it is expected that teaching manpower who are advanced in age have gained more experience than the younger inexperienced active teacher. Nevertheless, Shah and Udgaonkar (2018) convincingly argue that young active teaching manpower can readily employ advanced technology in teaching-learning activities to enhance understanding than their older counterpart.

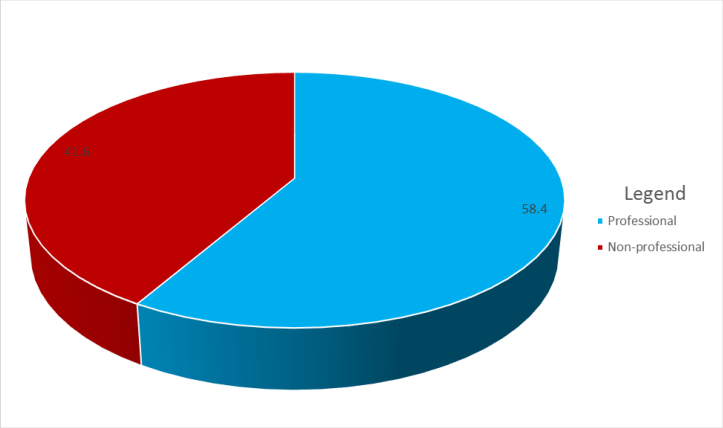


Figure 3: Distribution of Academic Manpower by Professionalism

Figure 3 shows the distribution of teaching staff according to whether they are professionally trained or not. The result has revealed that about 58.4% of the teaching staff possessed the minimum qualification to teach, having passed through the education courses in one of the recognized Nigerian tertiary institutions. Teaching staff without teaching qualification, otherwise known as non-professional teachers accounted for 41.6% of the manpower who participated in the study. This suggests that the problem associated with teaching qualification may not have been very serious issues in the study area.

Table 1: Distribution of Teacher- Student Ratio in Secondary Schools

Category	School	Student Population	Teaching staff	Ratio (Class size)
Public	GSS Anglo-Jos	511	32	1:16 (16)
	GSS Gyel	280	36	1:8 (08)
	GSS Hei-Rayfield	900	25	1:36 (36)
	GSSKanadap	280	29	1:10 (10)
	GSSS Kuru	874	42	1:21 (21)
	GSS Vwang	457	29	1:16 (16)
	GTC Bukuru	641	69	1:9 (09)
	Berom Community	272	27	1:10 (10)
	Zwan Community	216	31	1:7 (07)
Private	Adonai Vine School	202	32	1:6 (06)
	Bethel Christian Academy	351	33	1:11 (11)
	Diye Starlet	290	35	1:8 (08)
	Godiya Science	48	08	1:6 (06)
	Shiloh High	205	12	1:17 (17)
TOTAL		**5,527**	**440**	**1:13 (181= 1:13)**

Teacher- Student Ratio (TSR), vis-a-vis class size were estimated and presented in Table 3. The result shows that 35.7% had TSR above the mean (1:13), while the remaining 9 schools (64.3%) had TSR below the mean. Thus, it is safe to conclude that the Tteacher-Student Ratio is low enough to allow for convenient teacher-student lesson interaction that can enhance the achievement of educational goal of the schools.

On class size, results contained in Table 1 revealed that 5 schools (35.7%) have class sizes ranging from 16-36, while the remaining 9 schools accounting for 64.3%, have class sizes between 06 and 11 students per class. This suggests that though, secondary schools in the study area are not overcrowded during teacher-student interactions in class but unloaded periods can better enhance high academic performance and raise the level of productivity rather than the small class size.

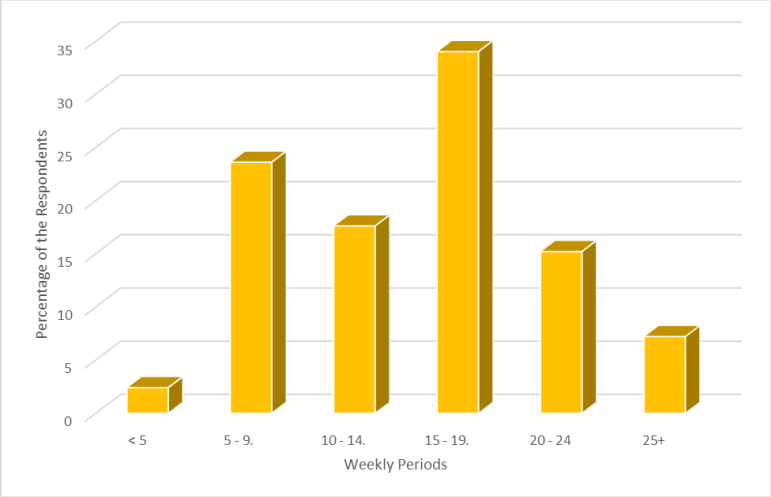


Figure 4: Distribution of Teaching Staff by Weekly Periods

Figure 4 reveals that majority (34.0%) of the teaching staff have between 15 and 19 periods per week, with the mean being 15. The result further indicates that 43.6% of the teaching staff have periods less than the mean (15 periods), while the remaining 56.4% of the teaching staff have periods exceeding the mean. Those schools with high number of teaching staff are likely to have periods lower than the mean and vice versa. This view is in agreement with Attah and Olubukola's (2018) report that teachers' workload have a significant influence on students' performance at secondary school level in Jos metropolis.

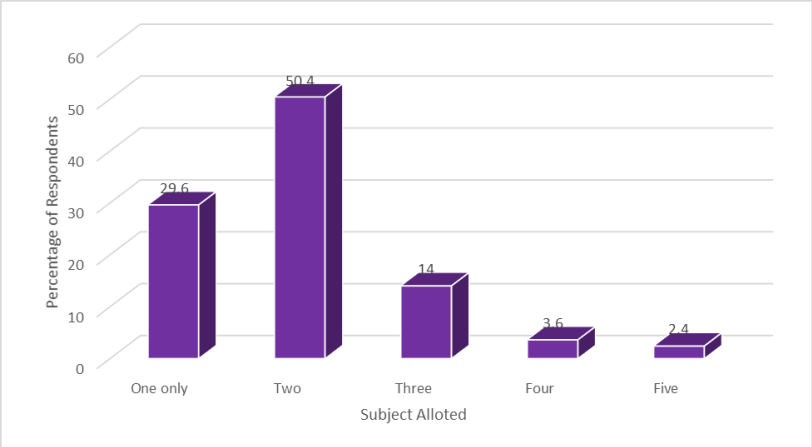


Figure 5: Distribution of the Number of Subjects Allocation to Teachers

Figure 5 shows that over half (50.4%) of the teachers were assigned two subjects to teach, followed by 29.6% assigned one subject, and those given five subjects to teach accounted for 2.4%. This suggests that a considerable number of teachers teach several subjects other than the one he/she specializes. This may compromise standards and mostly reduce innovative and productivity in pedagogical process. Assigning many subjects to a teacher likely indicates shortage of teaching manpower in some subject area that can negatively affect the quality and acquisition of knowledge in secondary education, which Gracia and Weiss (2019) argued, threatens students' learning ability and effectiveness of the teachers. On the other, allocation of appropriate subjects the teacher has good knowledge about helps in enhancing the best teaching and learning process (Rena, 2000; Akpan, Essien & Obot, 2022).

RESULTS AND DISCUSSION

The study investigated manpower workload of secondary schools in Jos South LGA. The result reveals that most teaching staff were in their active and productive age, with mean age of 40 years old (Figure 2). The result is in congruous with the average of 40 years old for teachers in Slovak Republic, 41 years old in New Zealand and 41 years old in Sweden as reported by the Organization Economic Cooperation and Development (OECD), (2022).

The evidence on quality of teaching manpower reveals that 58.4% of the secondary school teachers were professionally trained on teaching in tertiary institutions. The Nigerian Policy on Education (2004) recommended that the least qualification required for teaching in secondary schools is the National Certificate of Education (NCE) (NPE, 2004). This implies that there is deficiency in teaching manpower in the study area, as 41.6% of secondary school teaching staff were not trained to teach. It is safe to conclude that there is deficiency in the quality of teaching manpower at secondary school level in Jos South LGA. The NPE (2004) abhors qualifications such as National Diploma (ND) and Higher National Diploma (HND), among other non-educationally trained fields to teach in Nigerian secondary schools. Etiubon and Benson (2014) asserted that professionally qualified teachers contribute more to quality of education than the non-professional teachers. Similarly, Afangideh (2011) confirmed that teaching qualification has great influence on students' learning process, performance and effectiveness on the side of the teacher.

The study found that the Teacher- Student Ratio (TSR) was averagely 1:13 implying a low class size in the study area that can promote high productivity in close monitoring of learners by the teachers. The TSR obtained in this study substantially was lower than the average ratio of 1:44 for Sub-Saharan Africa and still lower than the 1:40 maximum recommended by NPE (2004). The ratio obtained in this study further suggests a lower ratio to the median ratio of 1:36 reported by Idowu and Oluwoye (2014) for Nigerian primary schools in 2010 and 1:46 in 2007. The lower TSR guarantees quality in education system as it allows for individualized instructions and effective pedagogical process.

The assigned weekly lesson periods in the study indicated that most teaching periods per teaching staff range from 15-29, which is a little less than the Federal Government's recommendation of 18 periods per week for some teachers in the study area. The result obtained in the current study in Jos South contrasts the with the 18- 24 workload per teaching staff for secondary schools in Ogba, Egbema and Ndoni settlements of Rivers State (Nweke & Dollah, 2011). Interestingly, 70.4% of teaching manpower in the study area were allotted at least between one and two different subjects to teach). This arrangement is likely to compromise the teacher's novel inputs and quality that may manifest in students' poor learning and low performance in school. A teacher assigned many subjects for which he/she was not trained to handle at secondary school level can compromise teacher's competence and mar the achievement of educational goal. Consequently, culminating in churning out half-baked students for the tertiary institutions.

Rationale for Manpower Planning in Nigeria

Education has been adjudged as one of the greatest veritable tools of national development, hence remains the surest way of self-actualization (Zwalchir, 2010). This means that reasonable

investment in education is not a waste of money, effort, energy and time (MEET), as education increases the stock of manpower supply, reduces illiteracy, enhances quality of life, above all, promotes nation building, integration and unity. Therefore, effective human resources are needed to plan, organize, direct, coordinate and control the use of other available non-human resources for the achievement of educational goals and objectives of Nigerian nation.

Akor (1995) observed that manpower planning depends to a large extent, on educational planning, which is not separate from general National Development Plan (NDP), that set out the Government's manpower planning to include: containing the incidence of youth unemployment by the provision of more training and employment opportunities; correcting the imbalances in educational system consistent with the changing requirements of the economy; meeting the manpower requirements for the successful implementation of the various Development Plans and the optimizing development of the economy. Since formal education produces the bureaucratic, managerial, technical and professional manpower needed for modernization in both public and private sectors, therefore, careful manpower planning, with adequate allocation of national resources becomes imperative.

According to the 1999 UNICEF report, as quoted in Zwalchir (2010), about 4 million Nigerian children have no access to basic education, those who were lucky to get enrolled, are given substandard education because of ubiquitous corruption, inadequate funding, acute shortage of qualified- trained pedagogists, and the 'annual culture' of teachers of all levels going on strike due to non-implementation of agreements pertaining to improved welfare and educational infrastructure. Of recent, members of the Academic Staff Union of the Nigerian Universities (ASUU) have gone on strike not less than 30 months since the entrenchment of democratic rule (1999- 2022) to press for better treatment. It is obvious that no standard of education can be realized under the prevailing non-motivational heavy workload of the pedagogists. Proper management of pedagogical institutions require human, physical and financial resources to meet different competing costs such as equipping laboratory, recruitment and payrolls of staff, training programmes for both academic and non-teaching staff, physical facilities, students' needs and other important administrative costs. For proper efficiency of operations, management needs effective planning, otherwise the quality assurers, the pedagogists or the essential manpower will not be able deliver and maintain quality educational standards of such an institution. Therefore, proper manpower planning is a *sine qua non* for the achievement of pedagogical goal in every pedagogical institution.

Building a sophisticated society of literates hinges much on the number and quality of academic manpower, code-named pedagogists and the management techniques (https:/wpschoolpress.com; accessed March 8, 2023). There is the need for the management board at the Federal, State and Local levels to develop a productive school culture through effective management of staff to ensure that they teach using appropriate instructional materials, evaluate and discipline students in order to achieve the overall goal of establishing the pedagogical institution. It behooves that for proper manpower planning, management should regularly oversee to meet the welfare needs of their pedagogists as well as ensure that such employees improve their pedagogical skills, attend seminars and conferences, keep up with studies in pedagogy and acquire additional qualifications to build up their careers. Under-qualified teachers should not be sacked, but can be allowed to contribute to creating a conducive environment for academic activities and should be motivated to acquire pedagogical skills through in-service training programme. In other words, for management to be efficient in manpower planning, a deliberate programme of retraining is required for specialized subject areas rather than allocating such subject(s) to a non-professional to teach. Furthermore, management should keep track of daily teachers' attendance, allocate tasks with moderate workload in specific subject of specialization, and monitor evaluation process and schedule regular meetings of staff to improve performance and effective communication.

CONCLUSION

The study found that most of the teaching manpower were largely in their productive age, professionally trained, and allocated moderate

workload by their respective school management. Achieving secondary educational goal requires moderate workload for the teaching manpower. Where the staff is heavily loaded with academic tasks, the tendency for breakdown health-wise is high. However, seven-tenth (70.4%) of the teaching manpower were allotted, at least two subjects to teach, irrespective of subjects of specialties. The problem with assigning this kind of task is that, where an academic staff is not competent in the subject area he was trained for, quality in lesson delivery may be compromised. Sequel to these findings, the paper hereby gives the following recommendations:

1. There is the need for fair allocation of academic workload across all the teaching manpower by each school management to curb disequilibrium.
2. Efforts should be intensified by the Ministry of Education in the State, through the Inspectorate Office to give opportunities to teaching manpower to undertake studies in education in any faculty of the Nigerian tertiary institutions to improve their teaching qualification.
3. There is need for regular supervision of secondary schools by of Inspectorate Division of the Ministry of Education sited in the locality to enforce government policies, such as the right subject allocation and appropriate number of lessons to cover per week per teaching manpower.
4. Secondary schools with low teacher-student ratio should either be merged together or effort should be intensified to increase students' enrollment in order to avoid under- utilization of academic manpower in the study area.
5. Managers of educational institutions should motivate their academic staff adequately to guarantee quality assurance for the achievement of educational goal.

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PhD THESIS SYNOPSIS

An Assessment of Communication Approaches of Abuja Environmental Protection Board (AEPB) on Drainage Sanitation in Selected Satellite Towns of Abuja, FCT, Nigeria

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INTRODUCTION

Drainage sanitation plays a crucial role in the conversation on sanitation and hygiene in Nigeria due to the high morbidity and mortality rate blamed on poor sanitation and hygiene. The prevalence of stagnant drainages has been attributed to various factors, such as the lack of waste management facilities, poor evacuation services, inadequate enforcement, and poor public attitude. In the Federal Capital Territory, the Abuja Environmental Protection Board (AEPB), the body responsible for addressing these problems, has been unable to effectively clear stagnant wastewater and trash from storm drains and peri-domestic drainages, especially in the satellite towns and slum areas. An assessment of the communication approaches applied by this agency indicates that they were disseminative and non-participatory, as they relied more on mainstream media, which, as other studies have revealed, does not lead to behavior change. The novelty in this study relates to passing the baton from the agency to the communities to manage their water and waste disposal and prevent illnesses associated with poorly kept peri-domestic drainages.

Research context

Several studies have suggested that the prevalence of unclean drainages, also known as poor drainage sanitation, is primarily a result of poor public attitudes. Behavior change communication can help to bring about a significant shift in this regard. The study focused on two areas in the FCT, namely Nyanya and Dakwa, to identify gaps in the communication strategies used by the Board and to develop a communication plan to achieve the desired paradigm shift.

Research Questions

1. What are the sanitary practices of the residents of Nyanya and Dakwa regarding drainage sanitation?
2. What are the communication approaches of the AEPB regarding drainage sanitation in the study locations?
3. How have the communication approaches of AEPB influenced the behaviour of the residents in Nyanya and Dakwa on drainage sanitation?
4. What participatory communication strategy can this study propose to address poor drainage sanitation effectively?

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Theoretical Framework

This study is based on two theories - the Transtheoretical Model (TTM), which identifies the stages at which individuals are open to behavior change and provides guidelines to adopt, and the Health Belief Model (HBM), which posits that personal vulnerability to a health threat is essential in determining interest in behavior change. Both theories were used to develop a communication strategy for drainage sanitation.

Research Methodology

The descriptive and cross-sectional study applied quantitative and qualitative instruments to generate a pool of data from the two communities and the AEPB. For the quantitative approach, the study deployed stratified and systematic sampling techniques for selecting households in these settlements. According to data from the National Population Commission, the average household population in the FCT is 4.2. Dakwa has a population of 171,672, and Nyanya has a population of 186,399, which means that both areas have a sample frame of 40,874 and 44,380, respectively. Using the Yamane (1967) formula, each study area had a sample size of 380, which was later increased to 500 by adding a 30% margin of error. Therefore, the total sample size for the study was 1000.

Key findings

1. The study findings revealed that the communication approaches applied by AEPB, mainly radio and television, did not lead to behavior change because of their limited scope.
2. The study also revealed that the messages deployed through these media did not significantly affect public behaviour on drainage sanitation.
3. Respondents' wide range of media choices indicated the need for a mix of conventional, traditional, interpersonal, and new media methods.

Conclusion

The study concludes that agencies of government should apply the appropriate combination of communication channels and messages if they are to succeed in changing harmful practices and behaviour of citizens; those communication channels must be participatory and horizontal in their application, and not just disseminative and vertical.

Author's Information

Suleiman Haruna received his Ph.D. in Development Communication from the Department of Theatre and Performing Arts, Faulty of Arts, Ahmadu Bello University Zaria, in July 2023. His supervisors were Prof. Jegede Emmanuel, Prof. Oga Steve Abah, and Dr. Emmanuel Gana, all from Ahmadu Bello University, Zaria. His External Examiner was Prof. Emmanuel Dandaura of Nasarawa State University, Keffi.

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Published article:

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