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AN ASSESSMENT OF WATER QUALITY AND IRRIGATION FARMING PRACTICES IN GADA-BIYU, KWALI AREA COUNCIL, FCT ABUJA, NIGERIA

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Abstract

This Paper assessed the Water Quality used for Irrigation farming in Gada-biyu, Kwali Area Council. It also examined the famers' perception of the soil fertility of the irrigation farming, and their associated problems. The study made use of both primary and secondary data. The Primary data include water samples collected and the questionnaire administered, while the secondary data are the documented

Keywords
Water quality, Irrigation, Perception, Soil fertility and Gada-biyu

INTRODUCTION

Surface water and groundwater have long been considered separate entities, and have been investigated individually. Chemical, biological and physical properties of surface water and groundwater are indeed different. In the transition zone a variety of processes occur, leading to transport, degradation, transformation, precipitation, or sorption of substances. Water exchange between groundwater and surface water may have a significant impact on the water quality of either of these hydrological zones.

Farmers are vulnerable to water pollution, particularly in the developing nations where rapid

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materials obtained from journals and FAO. Water samples were collected using thoroughly washed and rinsed plastics containers with the water to be sampled from. Three well water samples in the farms and three surface water samples at their pumping source in the river were collected, a total of six water samples were collected and analyzed at AEPB laboratory for pH, EC, Na, Ca, NO_3, SO_4, K, CO_3 and HCO_3. The farmers who are practicing the irrigation farming were about 46 persons on the average and all of them were considered and been served with the questionnaire. The statistical methods used was descriptive analysis (tables, charts) and inferential statistics such as Analysis of Variance and Student t-test were used with the aid of the Statistical Package for Social Sciences (SPSS). Results show that there is low variation in the occurrences of all parameters except EC and NO_3 that are moderate and high respectively. Results show that all except TDS are higher in ground water. All the parameters fall below the FAO permissible limit. Majority of the farmers constitutes an active age, out of which 51.5% have no formal education, while 20% attended primary school and 9% have Junior School certificate. Tomatoes and Maize are the major crops produced in the area and 50% of them earned above N40, 000. About 50% indicated that there is decrease on their yield and 30.1% attributed it to low soil fertility, followed by pest and diseases and poor seeds. Statistics shows that there is no significant variation in the distribution of the analysed parameters, but there is significant difference between the surface and ground water, and the FAO standard. The soil generally is of low soil fertility with very low values of N and P, and in some cases K. However continuous use of the water especially the sub-surface, in dry season may lead to sodicification of the soil. It is therefore recommended that use of inorganic and organic fertilizers might help to increase its productivity. Above all, extension workers are needed to in order to educate the farmers on the modern irrigation practices.

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Industrialization is taking place. Traditionally, farmers rely on surface water irrigation due to its availability and cost effectiveness, which is likely to be deteriorated from industrial discharge and result in declining crop production and increased food insecurity.

The quality of irrigation water directly influences the quality of the soil and the crops grown on this soil. Poor irrigation water quality has negative effect on crop productivity, crop product quality, and public health of consumers and the farmers who come in direct contact with the irrigation water (Qadir *et al*., 2007; Listkas *et al*., 2010; Muthana, 2011). Problems originating from irrigation water quality can be categorized into four groups: (1) salinity hazards, (2) infiltration and permeability problems, (3) specific ion toxicity, and (4) miscellaneous problems (Simsek and Gunduz, 2007).

Water quality concerns have often been neglected because good quality water supplies have been plentiful and readily available (Shamsad and Islam, 2005). This situation is now changing in many areas. Intensive use of nearly all good quality supplies means that new irrigation projects, and old projects seeking new or supplemental supplies, must rely on lower quality and less desirable sources (Islam and Shamsad, 2009), and the face of irrigated agriculture is changing with respect to the quantity and quality of water.

Irrigation water quality is related to its effects on soils and crops and its management requirements. High quality crops can be produced only by using high quality irrigation water keeping other inputs optimal. There may be great differences in the quality of water available on a local level depending on whether the source is from surface water bodies (rivers and ponds) or from groundwater aquifers with varying geology and whether the water has been chemically treated or not. The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering availability of nutrients (Ayers and Westcot, 1985). Drainage water produced the highest soil salinity levels compared to soil irrigated with canal water. The influence of soils on water quality is very complex and can be ascribed to the processes controlling the exchange of chemicals between the soil and water (Asante *et al*., 2007). Apart from natural factors influencing water quality, human activities such

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as domestic and agricultural practices impact negatively on river water quality. It is, therefore, important to carry out water quality assessments for sustainable management of water bodies. A better measure of the sodium (Na) hazard for irrigation is the Sodium Absorption Ratio (SAR) which is used to express the suitability of water for irrigation purposes (Alfred *et al.,* 2011). Poor quality irrigation water becomes of more concern as the climate changes from humid to arid conditions. Salts are originated from dissolution or weathering of rocks and soil and are carried with the water to wherever it is used (Nata *et al.,* 2008). Quality of water may vary from place to place, stratum to stratum and season to season. The determination of suitability of water would, therefore, involve a description of the occurrence of the various constituents and their relation to the use to which water would be put. To determine the quality of irrigation water, we need to identify the characteristics that are important for plant growth, and their acceptable levels of concentrations. Having the water tested by a reputable laboratory is the first step in this process. The water quality data also provides information about geologic history of rocks and quality of the water and its suitability to agriculture.

Several authors have reported concerning water quality and its suitability for irrigation from different parts of the world and the effect of saline water on crop production and soil salinity (Heluf, 1985; Mekuria, 2003; Causapé *et al*., 2004; Islam et al., 2004; Rao and Devadas, 2005; Vishwanath and Anantha, 2005; Raju, 2006; Singh, 2008; Dhirendra et al., 2009; Megersa *et. al*., 2009). Water quality is one of such factors affected by land use change and which is sensitive to changes in landscape patterns in a watershed (Xia et al., 2011), and it is generally linked to land use/land cover in catchments (Ahearn et al., 2005). Water quality parameters in various aquatic systems have been closely linked to the proportions or types of land use within a watershed and have been influenced by different landscape types (Fulazzaky, 2010).

However, very little information and baseline data are available regarding irrigation, irrigation water quality and its environmental implications of the study area. The effects of water logging are manifested in loss of stand, reduced soil aeration, reduced rates of plant growth, reduced yields, and in severe cases, total crop failure. Gada-biyu sugarcane, tomatoes and

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vegetables productions are majorly dependent on irrigation. Agricultural activities in Gada-biyu are highly supported by irrigation water that is supplied by the two rivers. However, sustainable utilization of water as a source of water for irrigation requires quality and quantity fitness of the water for this purpose. It is against this background that this study attempts to address the gap, by determining the quality and suitability of both surface and ground water use for irrigation purpose.

METHODOLOGY

Gada-biyu (meaning two river bridges) is located in Kwali Area Council, Gada-biyu wetland is a floodplain (Fadama) of about 5000 hectares, lying at the foot of a hill, and drained across Kaduna-Lokoja road. It is located within Latitude 8°30'N and 8° 54'N and longitude $06^{0}25''$E and 07^{o} 34'E, (Figure 1). The wetland is predominantly for agricultural (Irrigation) activities serves as the major source of livelihood support to the surrounding communities. It has a scanty vegetation of indigenous tree species of economic and medicinal value which are depleted as a result of several years of deforestation for cultural activities, charcoal production and firewood (Balogun, 2001).

Figure 1: Federal Capital Territory showing the study area.

Source: Office of the Surveyor General of the Federation, (OSGOF) Abuja, 2018.

The area has distinct wet (March-October) and dry (November-February) seasons with average annual rainfall of 1358.7mm and mean temperature range of between 20.7^{0}C-30.8^{0}C. Rainfall play a vital role with respect to agricultural activities within the study area and most firming activities highly depend on rainfall

(Balogun, 2001). About 60% of the annual rains fall during the months of July to September. Relative humidity (RH) is lowest in the drier months of November to March, with about 10% being recorded in February. The study area has a long term mean temperature in the study area ranges from 30^0C-37^0C yearly and means total annual rainfall of approximately 1,650mm per annum.

The soils in Kwali are generally shallow and sandy in nature, especially on the major plains such as Iku-Gurara. The high sand content makes the soils to be highly erodible. The shallow depths is a reflection of the presence of stony lower horizons, which shows a high level of variability comprising mainly of sand, silt, clay and gravel. Alluvial soils cover very small part of Kwali and the water table around the places where this type of soil is usually very high. These soils are products of down-wash from the hills and are generally the local soil developed on the foot plains located within the Iku-Gurara plains, (Balogun, 2001).

The vegetation type of Kwali is that of shrub savannah and the vegetation type also covers other areas which include Iku-Gurara plains, Usuma valley, and Chibiri. Gwako and also between Gwagwalada and Tunga Agunre (Balogun, 2001). The dominant indigenous groups are the Gwari which consist 61.7% and other groups includes Bassa 17.4%, Koro 6.1%, Gade 4.8%, Hausa 3.0%, Gwandara 2.7%, Ebira 1.3% and others 3.0%, (Balogun, 2001).

Types and Sources of Data

The data for this research work was obtained from two sources, which are primary and secondary sources. The primary data are information obtained from the field which includes the water samples and the questionnaire, while the secondary data are the information from past study and those from WHO, FAO ADP among others.

Sample size and Sampling Procedure

The farmers were contacted through their chairman, where the population of the farmers practicing irrigation farming was obtained. Though their population is not fixed but it was disclosed that they are about 46 persons on the average and all of them were considered for the study.

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Water sampling procedure

The water samples were collected from ground and surface water used by the farmers in the study area during the dry season. Six Water samples were collected using thoroughly washed and rinsed plastics containers with the water to be sampled from in order to avoid any contamination. Three well water samples in the farms and three surface water samples at their pumping source in the river which is used to irrigate their crops. The collected water samples were analyzed in AEPB laboratory for pH, EC, Na, Ca, NO_3, SO_4, K, CO_3 and HCO_3. The instruments used for the analysis are summarized in Table 1.

Table 1: Parameters and their laboratory equipment used for the analyses.

Parameters (Units In mg/l Except Stated).	Equipment used for the corresponding parameter
pH	pH Reagent/pH Disc
Conductivity (µs/Cm)	Conductivity Meter (Hach Co 150)
Salinity (%)	Conductivity Meter (Hach Co 150)
Sulphate	Hach Sulphate Colorimetric Test Kit
Nitrate	Hach Nitrate Colorimetric Test Kit
Magnesium	Hach Magnesium Colorimetric Test Kit
Potassium	Ion Meter K Electrode
Sulphide	Ion Meter S^-Electrode

Source: Field survey, 2019

Questionnaire Design and Administration

The instrument used for collecting the data from people was the questionnaire, haven passed validity test. The opened and closed-ended questionnaire was used in collecting the information from the farmers. The statistical methods used were descriptive analysis (tables, charts) and inferential statistics such as Analysis of variance was used to find out the variation within and between the sample points. Student t-test was used to find out the mean difference between the seasons and the mean difference between the heavy metals concentration and FAO standards, with the aids of the Statistical Package for Social Sciences (SPSS).

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RESULTS AND DISCUSSIONS

Laboratory Analysis of Gada-biyu Irrigation Water

The water samples collected for this study was analysed and presented below.

Table 2: Results of Surface water analysis

Parameters(mg/l)	No. of samples	Min	Max	Mean	Std	COV
pH	3	6.57	6.81	6.71	0.13	1.9
EC	3	0.10	0.13	0.11	0.02	18.2
TDS	3	53.0	57.0	55.0	2.0	3.6
Na	3	3.58	3.81	3.68	0.12	3.3
Ca	3	3.21	3.64	3.39	0.22	6.5
NO_3	3	0.01	0.04	0.02	0.01	50
Mg	3	0.53	0.71	0.64	0.09	14.1
K	3	2.36	2.65	2.49	0.15	6.0
SO_4	3	0.37	0.37	0.37	0.00	0
HCO_3	3	3.02	3.14	3.07	0.06	2.0

Source: Field survey, 2019

Table 2 presents the results of surface water analysis of Gada-biyu Irrigation Water. The mean, standard deviation and coefficient of variation of the parameters show that the following parameters shows low variation in their occurrences pH, EC, Na, Ca, SO_4, K, and HCO_3 except EC and NO_3 the varied moderately and high. This result implied that the occurrence of the elements along the surface water in Gada-biyu is fairly distributed.

Table 3: Results of Underground water analysis

Parameters(mg/l)	No. of samples	Min	Max	Mean	Std	COV
pH	3	6.78	7.01	6.87	0.13	1.9
EC	3	0.11	2.16	0.81	1.17	18.2
TDS	3	44.0	46.0	45.0	1.0	3.6
Na	3	4.39	6.32	5.44	0.98	3.3
Ca	3	4.23	6.51	5.35	1.14	6.5
NO_3	3	0.02	0.09	0.06	0.04	50
Mg	3	0.72	3.18	1.56	1.40	14.1

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K	3	2.31	3.46	2.96	0.59	6.0
SO_4	3	9.36	10.3	10.0	0.55	0
HCO_3	3	3.14	9.14	6.77	3.19	2.0

Source: Field survey, 2019

Table 3 presents the results of underground water analysis around Gada-biyu irrigation farms.

The mean, standard deviation and coefficient of variation of the parameters show that the following parameters shows low variation in the occurrences of pH, EC, Na, Ca, SO_4, K, and HCO_3 except EC and NO_3 the varied moderately and high respectively. This result implied that both surface and ground water occurrences have similar trend in Gada-biyu and was fairly distributed.

Comparison Analysis of Surface and Underground Water

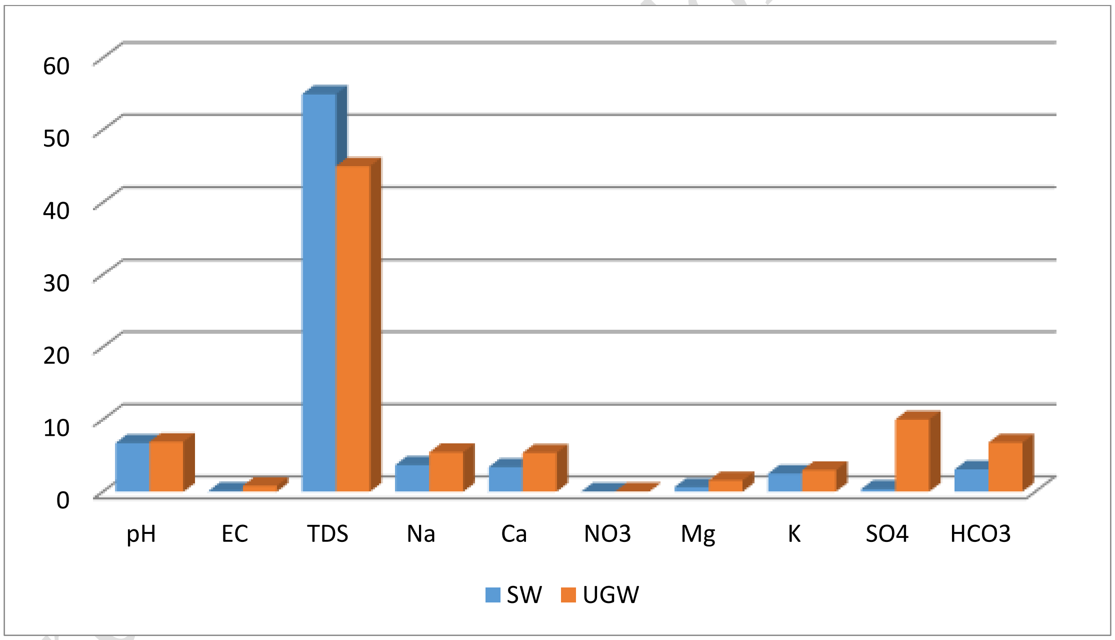

Figure 2: Mean concentrate surface and underground water

Source: Field survey, 2019

Figure 2 presents the mean concentration of both surface and ground water used in Gada-biyu irrigation farms. Results show that EC, Na, Ca, NO_3, Mg, K, SO_4 and HCO_3 are higher in ground water, while TDS is higher in surface water.

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Comparison of Surface, Ground Water and FAO standard

The mean concentration of the analysed parameters of both surface and ground water were compared with the FAO standard for irrigation water quality as shown in Table 4.

Table 4: Comparison Surface water, Underground Water and FAO standard

Parameters(mg/l)	SW	UGW	FAO (2009)	Recommendation
pH	6.71	6.87	6.5-6.7	Within the limit
EC	0.11	0.81	1.00 -3.00	Below the limit
Na	3.68	5.44	10.00	Below the limit
Ca	3.39	5.35	10.00	Below the limit
NO_3	0.02	0.06	5.00	Below the limit
Mg	0.64	1.56	5.00	Below the limit
K	2.49	2.96	5.00	Below the limit
SO_4	0.37	10	10.00	Below the limit
HCO_3	3.07	6.77	10.00	Below the limit

Source: Field survey, 2019

The pH of the surface water was found to be 6.71 which are within the permissible limit set by FAO. The remaining parameters all fall below the FAO permissible limit. This probably means that the water sources are still within the required quality.

QUESTIONNAIRE ANALYSES

This session presents the Questionnaire analyses of irrigation farming in Gada-biyu, the farmers' demographic characteristics, their sources of water, farm size, level of yield, income soil fertility and related problems.

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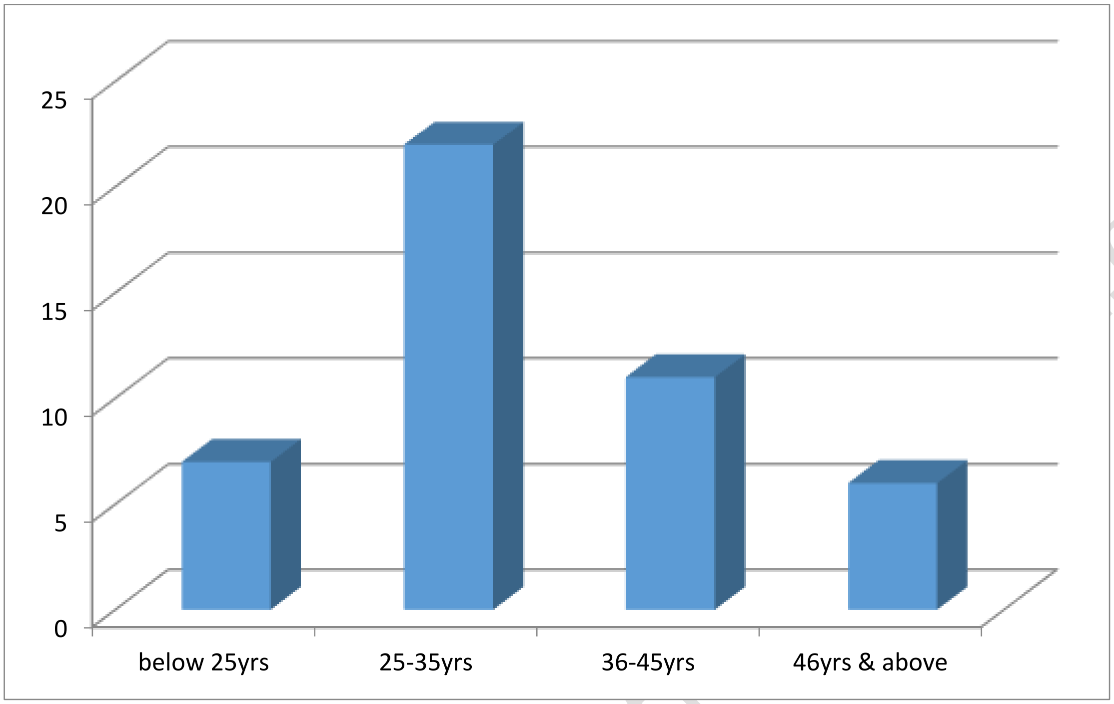

Figure 2: Age distribution of the respondents
Source: Field survey, 2019.

The composition of the respondents shows that all the respondents are males. This is probably due to the fact that most of them are immigrants from the northern part of the country. From the survey results, age distribution of the respondents revealed that the ages of respondents below 25years of age is 15%,those within the age bracket (25-35) years is 48% while those within the age bracket (36-45) years is 24% and 46 years and above is 13%. This distribution implies that majority of the farmers constitutes an active age. This result confirms the findings of Ebenezer, (2014) who reports that job is not for the aged who are considered to be weak and fragile. Irrigation farming is therefore, a profession that requires young and energetic people who can work round the length and breadth of the farm. Mustapha, (2011) gave reasons such as the strenuous activities which the work entails and the environmental conditions involved this could also attribute to possible reason for the absence of female scavengers in the study area and the much energy required to effectively participate and enjoy the job. Socially, the job cannot fit women, as they have to take care of the children, cook for the family and carryout some domestic works in their homes.

Educational level of the respondents

Occupational choice is influenced by many factors, including life context, personal aptitudes and educational attainment (Ferry 2006). Figure 4.3 presents the distribution of the respondents' base on their educational status.

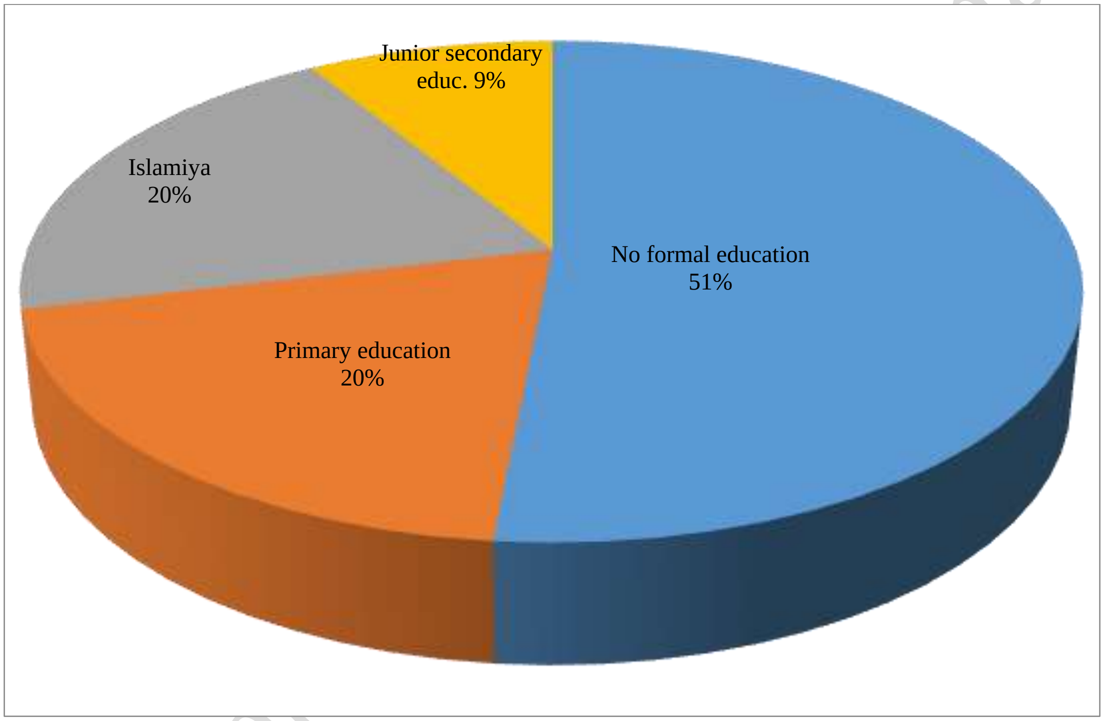

Figure 3: Educational status of the respondents
Source: Field Survey, 2019

Figure 3 revealed that 51.5% of the respondents had no formal education, 20% attended Islamic education, while 19.7% had Primary education and 8% attended Junior Secondary school. This shows that, a greater percentage of the respondents where school dropouts, but yet a few of them attended one form of education or the other. This facilitated the respondents' ability to response to the issues being investigated. Survey results revealed that all the respondents interviewed were Hausas from the northern parts of the country.

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Family size of the respondents

The sizes of the families determine the degree of ones responsibilities and sometimes the number of helping hands that might be involved. The larger the family size the greater the responsibilities.

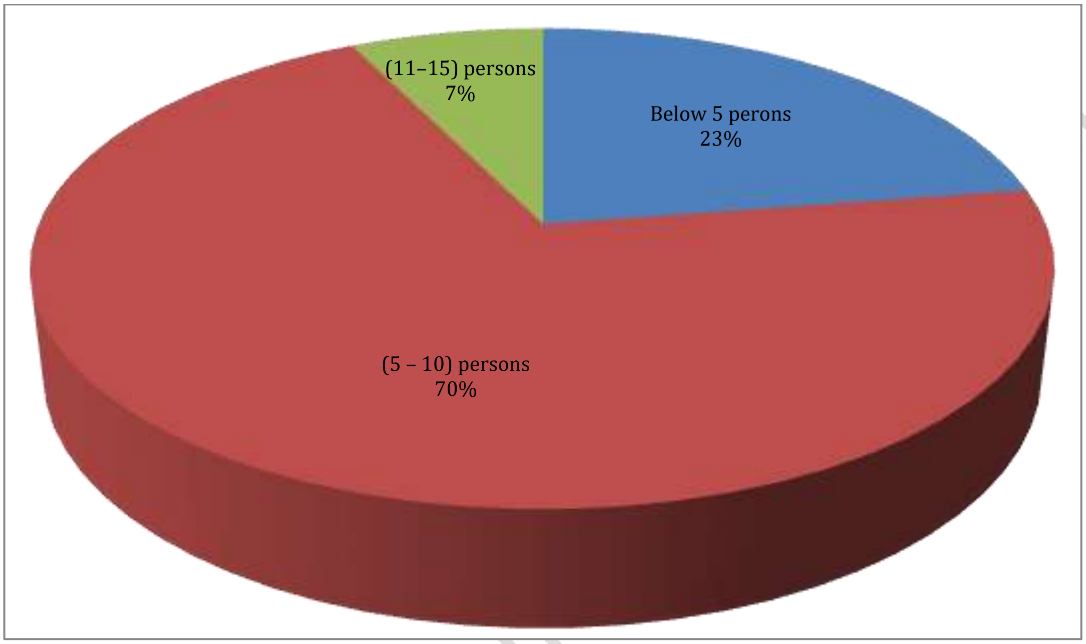

Figure 4: Family size of the respondents
Source: Field Survey, 2019

Figure 4 presents the distribution of the respondents according to their family size. Analysis shows that 22.6% of the respondents have less than 5 persons in the family while 70.1% have family size of (5-10) persons and 7.3% have 11 persons and above. This analysis also implies that the famers have lots of responsibilities to carter for, as polygamous family is part of their culture which in turn increases the family size.

Monthly Income of the respondents

Individuals earning have a trickle-down effect on his/her economic strength which in turn affects general lifestyle such as clothing, housing, eating etc. most waste scavengers work at open dump sites and live adjacent to these dump sites where they operate in poor housing, sanitation and water supply; lacking basic infrastructure.

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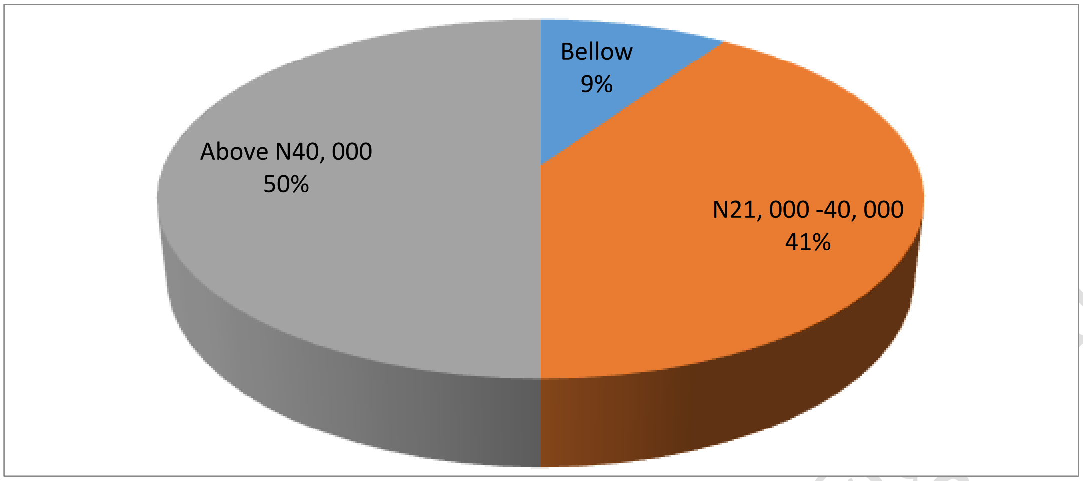

Figure 5: Income of the respondents
Source: Field Survey, 2019

Investigation shows that 50% of farmers earned about N50, 000 monthly, 41% of them earned between N21, 000-N40, 000monthly which is above the daily minimum wage $1.67 (July 2017 exchange rate). Total monthly income during the dry season ranges from less than N 20, 000 (2.2%), N 20,000 – N 40,000 (90.5%) while N 41,000 and above (7.3%).

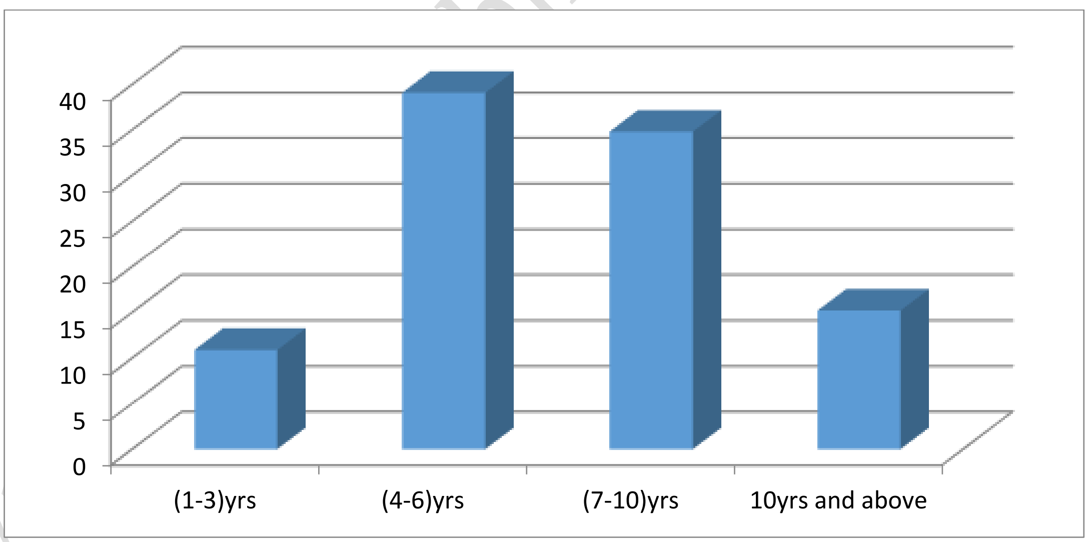

Figure 6: Duration for being in the profession
Source: Field Survey, 2019

Figure 6 shows that 39.1% of the respondents have been in the profession for (4-6) yrs. 34.8% have been on it for (7-10) yrs.. 15.2% for about ten years and above, only 10.9% are (1-3) yrs. in the profession. This distribution will is good enough to supply information that will be helpful to this study.

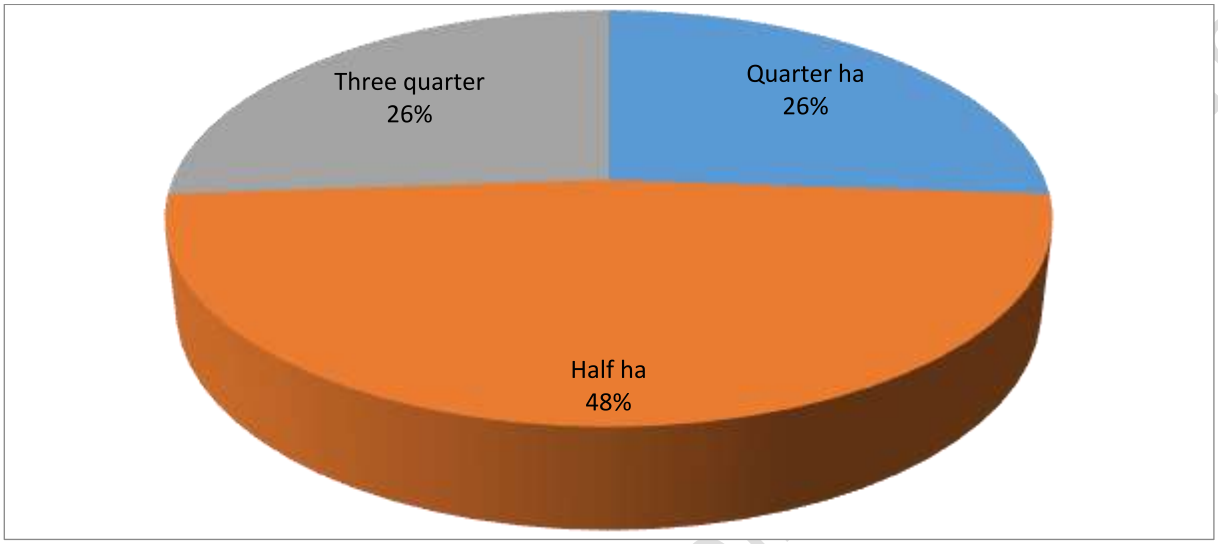

Figure 7: How many acres of land do you cultivate?

Source: Field Survey, 2019

Figure 7 present information on the size of the farms they cultivate. Analysis shows that 48% of the farmers cultivate about half an acres of land, while 26% cultivate three quarter and a quarter acres of land each respectively.

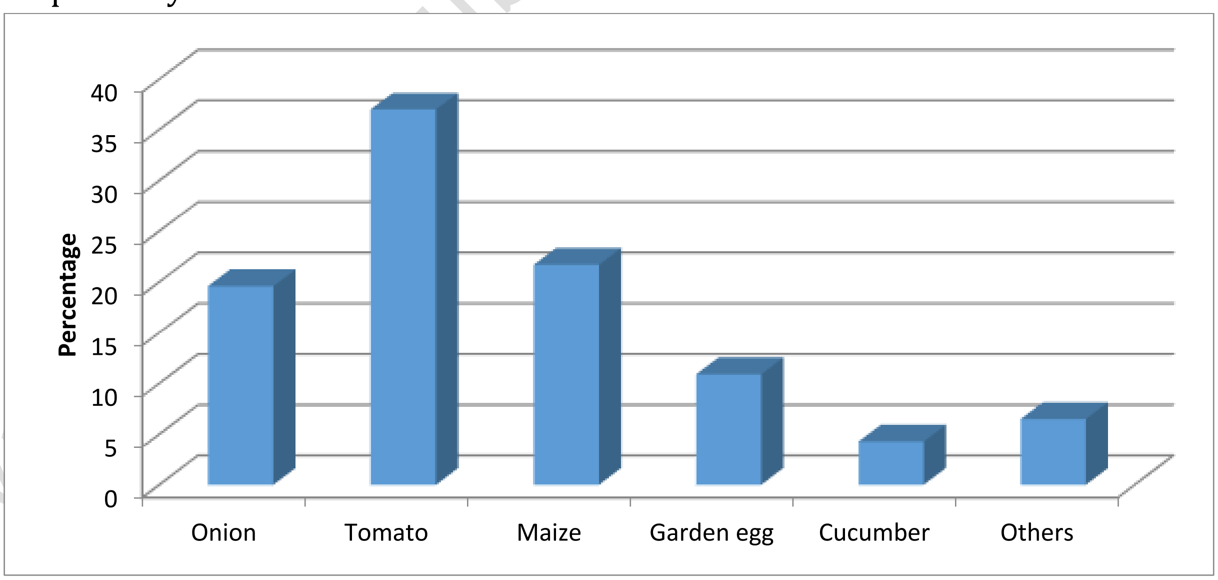

Figure 8: Types of crops cultivate in Gada-biyu.

Source: Field Survey, 2019

Analysis shows that Tomatoes is the major crop cultivated in that area having 37%, followed by Maize with 21.7%, Onions 19.6%, Garden egg 10.9%, Cucumber 4.3% and others 6.5%.

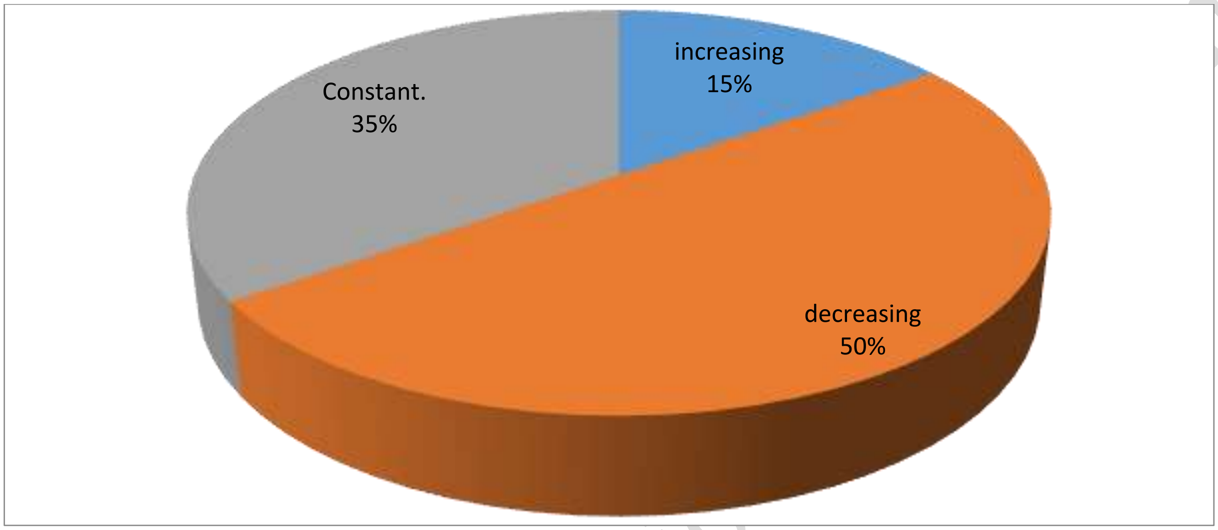

Figure 9: Their yield status

Source: Field Survey, 2019

Figure 9 present information on the level of crops yield. Results of the analysis show that 50%, of the farmers indicated that their yields are decreasing, 35% said is the output is constant while only 15% said that theirs are increasing. A follow up of what could be the reasons of their low yield is presented in Figure 10

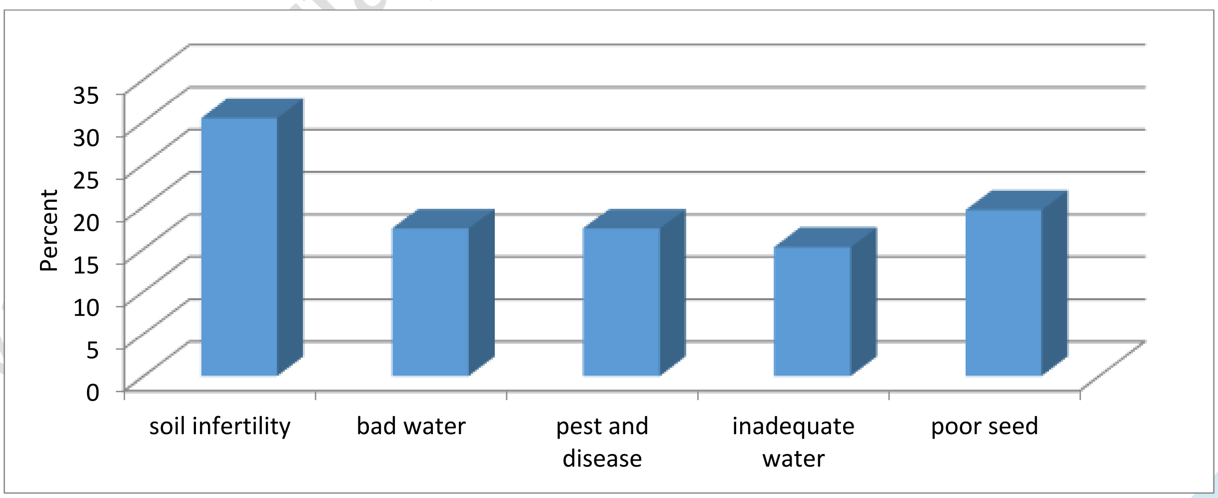

Figure 10: The Problems of irrigation farming

Source: Field Survey, 2019

The analysis in figure 10 shows that 30.4% of the farmers attributed the causes of their low yield to soil infertility. 19.6% to poor seeds 17.4% to bad water, pest and disease. 15.2% said that the low yield is as a result of inadequate water supply.

Table 5: sources of farm input

What are the sources of water used for your irrigation						
	Surface water		Groundwater		Both Surface & ground water	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
	13	27.1	0	0	33	68.8
Have you ever received any training concerning irrigation farming						
	Yes		No			
	Frequency	Percent	Frequency	Percent		
	39	84.8	7	15.2		
Organizers of the training						
	Government		NGOs		From my family	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
	0	0	3	6.5	43	93.5
Have you ever received any grand from any agencies such as GOs, NGOs or both?						
	Yes		No			
	0	0	46	100		

Source: Field Survey, 2019

Table 5 shows that 68% of the respondent use both surface and ground water sources, while 27.1% use surface water only, probably they cannot bore any well for irrigation purpose. None of them use ground water only as ground water is only been used to complement the surface water in cases of water scarcity. The farmers were asked of receiving any training concerning irrigation farming, results shows that 84% of the farmers have been trained while 15.2% of them never receive any training before joining the profession. They were further asked of the organizers of the training, the response shows that 93.5% learned the profession from their families and relations, while 6.5% from NGOs, none of them was trained by government agency. They were further asked if they have ever received any grand from any agencies such as GOs, NGOs or both and their

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responses shows that they have never receive any grand from any agency. The type of fertilizer do affects the properties of the soil, the farmers were asked of the type of fertilizers they used, and their responses were presented in Figure 11.

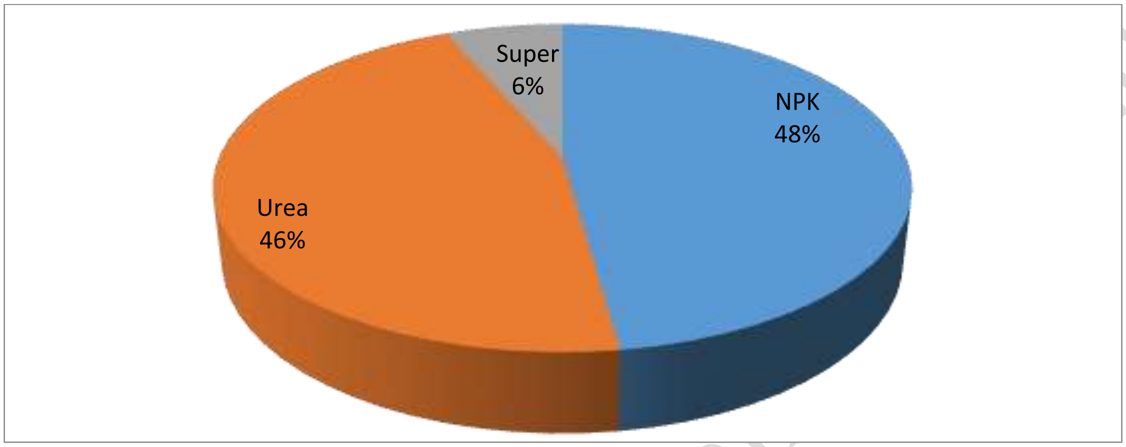

Figure 11: The type of fertilizer used in the irrigation farms
Source: Field Survey, 2019

The results of the analysis show that 48% of the respondents used NPK, while 46% of them use Urea and only 6% use Super fertilizer.

The data were subjected to statistical analyses to verify the hypotheses

Ho_1: There is no significance variation in the concentration of the elements between and within both the surface and underground waters**.**

Table 6: Results of spatial analysis of both surface and underground water.

Surface Water	Source of Variance	Sum of Variance	df	Mean Square	F	P-value	F-critical	Remark
	BSS	24.2	2	12.12	0.058	0.9441	3.3541	
	WSS	5678.7	27	210.32				Accept
	TSS	5703.0	29					
Underground Water	BSS	1.255	2	0.628	0.004	0.996	3.3541	Accept
	WSS	4739.3	27	175.5				
	TSS	4740.6	29					

The statistical analysis reveals that the calculated F-ratio is less than the p-value in both surface and underground water. That means that the null hypotheses are accepted. It is then concluded that there is no significance

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difference in the concentration of the analysed elements of both surface and underground water from different sampling points.
Ho_2: There is no significance variation between the concentration of both surface and underground waters samples.

Table 7: Results of t-test analysis comparing the results of both surface and underground water with FAO standard

Variables	Mean	Std. dev.	t	df	Sig. (2-tailed)	Decision
UGW-SW	0.9340	4.78687	0.617	9	0.553	Rejected
UGW-FAO	2.1889	3.02884	2.128	8	0.66	Rejected
SW-FAO	2.5867	2.04	3.788	8	0.005	Rejected

The statistical analysis reveals that the concentration of bases elements between the surface and underground water. Results revealed that the calculated t-test for surface and underground water is greater than the significance value of 0.553. This implies that the difference between the surface and underground water is significance. The underground water, surface water and FAO have significant difference since t-calculated is greater than t-critical value. This is probably due to increase in the level of pollution in the surface water.

Conclusion and Recommendations

Base on the forego discussions, it was revealed that all the parameters investigated did not exceed the maximum limit; rather they appear to be very low. That is the soil generally is of low soil fertility with very low values of N and P, and in some cases K. However continuous use of this water especially that from sub-surface, in dry season may lead to sodicification of the soil. Perception of farmers in crops production was found to be very low both in terms of inputs usage, knowledge in farming and poorly facilitated in terms of funding and extension service.

It is therefore recommended that extension workers should train the farmers on sustainable management practices such as a pre-planting irrigation, use of salt tolerant crop varieties, use of acidifying agents such as Ammonium sulphate and use of crop residues as an agronomic input. There should be regular monitoring of water used for irrigation in order to

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monitor its salt contents. Use of inorganic and organic fertilizers to this very poor soil is mandatory in order to increase its productivity. The Government and as well as NGOs to come up with programmes that will educate the farmers on modern farming methods through extension services.

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