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ASSESSMENT OF THE CHANCHAGA DAM FOR SUSTAINABLE AGRICULTURAL PRODUCTION

by

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Abstract
Sustainable water resource systems are those designed and managed to fully contribute to the objectives of society now and in the future while maintaining their ecological, environmental and hydrological integrity. This study has investigated the Chanchaga dam for sustainable agricultural production**.** Socio-economic status of the stakeholders in the study area was assessed using questionnaires and checklists based on Rapid Rural Appraisal technique. The data obtained were subjected to descriptive and inferential statistics. The descriptive statistics used were mean and standard deviation while the inferential statistic used was Pearson Product Moment Correlation coefficient. The nature of ecological impact facet had the highest mean (M = 3.14) while the socio-economic impact had the lowest mean (M = 2.95). Two diseases considered most serious in the study area in 2020 and 2021 were malaria and typhoid with 1,600 and 254 cases respectively. Surface and groundwater sampling operations were conducted and water samples were taken to laboratory for analysis. For the three water samples, the average value of electrical conductivity, total dissolved solid, sodium adsorption ratio, chloride, boron and sodium were 2.24 ds/m, 206.67 mg/l, 3.17 mg/l, 1.72 mg/l, 1.63 mg/l and 11.07 mg/l respectively. The study concluded that the water in this dam is suitable for sustainable agricultural production in terms of the levels of physico-chemical properties without compromising the sustainability of the vital ecosystems.

Keywords: Assessment, Chanchaga Dam & Sustainable Agricultural production.

Introduction

The growing human needs together with economic activities which exert increasing pressure on the earth's resources have led to the awareness of environmental problems generated by lifestyles that are incompatible with the regeneration process of the environment (UNEP, 2002). Although agriculture continues to be the engine of development in the 21st century, it faces new challenges such as the degradation of natural resources, climate change, free trade and the development of new technologies (FAO, 2019).

The assessment of the Chanchaga dam for its sustainability for agricultural production is a critical evaluation of the socio-economic benefits and impacts of the water resources development, the water management challenges communities around the study area face and the solutions people have developed. The assessment places water resources management in agriculture in a social, ecological and political context and assesses the dominant drivers of change.

In order for agriculture to be sustainable, it must be sufficiently productive, economically viable, culturally and socially acceptable and ecologically adequate. That is, it needs to conserve natural resources and preserve the integrity of the environment such as the ecological diversity and the capacity of the agro-ecosystem to self-maintain. Sustainable agriculture preserves diversity, improves soil resources, protects waterways, provides healthy food, reduces the producer's dependence on external sources and grants a reliable source of income for farmers.

In the study area, particularly at the upstream of the dam where irrigation is being practiced on regular basis, farmers apply fertilizers to help crop yields while herbicides were applied to control weed development. Not all of the fertilizers applied are used by plants as treatment rates surpass crop requirements and inappropriate application methods are utilized. Some of the excess chemicals are washed into the dam during irrigation or rainfall while some remain in the soil, penetrate and contaminate the groundwater.

According to WHO (1998), the presence of nitrate from fertilizers in drinking water at concentrations greater than 50 mg l^{-1} could cause methaemoglobinaemia in babies aged less than 6 months. In addition, nitrate in the alimentary canals of humans may react with amines to form carcinogenic nitrosamines which could contribute to the development of gastric cancer. An over abundance of nutrients, primarily nitrogen and phosphorus had started a process called eutrophication in the dam. Eutrophication is the enrichment of water bodies by nutrients especially compounds of nitrogen (N) and phosphorus (P) causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms and the quality of the water concerned (Andinet*et al.*, 2015). Runoff and sediment are the main carriers of nutrients. Retention and regulation of runoff and sediment by dams cause slow water flow, declining runoff and the accumulation of nutrients which subsequently trigger the development of water eutrophication (Tang *et al.*, 2018).

According to WHO (1993), about 80% of all diseases in human beings are caused by water; therefore a regular monitoring of the water in the irrigation dam is very essential for physicochemical and microbiological analysis to know the suitability of water under use not only to check the outbreak of diseases and occurrence of hazards but also to prevent the water from further deterioration. Due to the steepness nature of topography in the study area, soil erosion resulting from catchment anthropogenic activities is a major contributor to reservoir sedimentation. The quantity and type of sediment depend on the topographic character, geology, vegetation type, climate and land use within the catchment (Schleiss, 2013).

Therefore, the assessment of Chanchaga dam in Minna, Niger State,Nigeria outlines the effective water management strategy intended to provide consistent direction while at the same time allowing for enough flexibility to address different situations. The assessment supports sustainable resource and environmental management and recognizes both short- and long-term needs and values for water.

Description of the Study Area

The study area is situated in Chanchaga, with geographic coordinates of latitude 9°32′6″N and longitude 6°34′55″E. The region experiences an average annual temperature of 35°C and receives an average annual precipitation of 1209.7 mm. It is located within the southern guinea savanna zone of Nigeria. The major rivers in Minna include Bosoo River, Chachanga River and Tagwai River. These rivers are connected to outlets and channels that are utilized for irrigating agricultural farms during the dry season. However, this water may be contaminated with pollutants, as both domestic and industrial waste water are discharged into these water bodies (Wogu and Okaka, 2011).

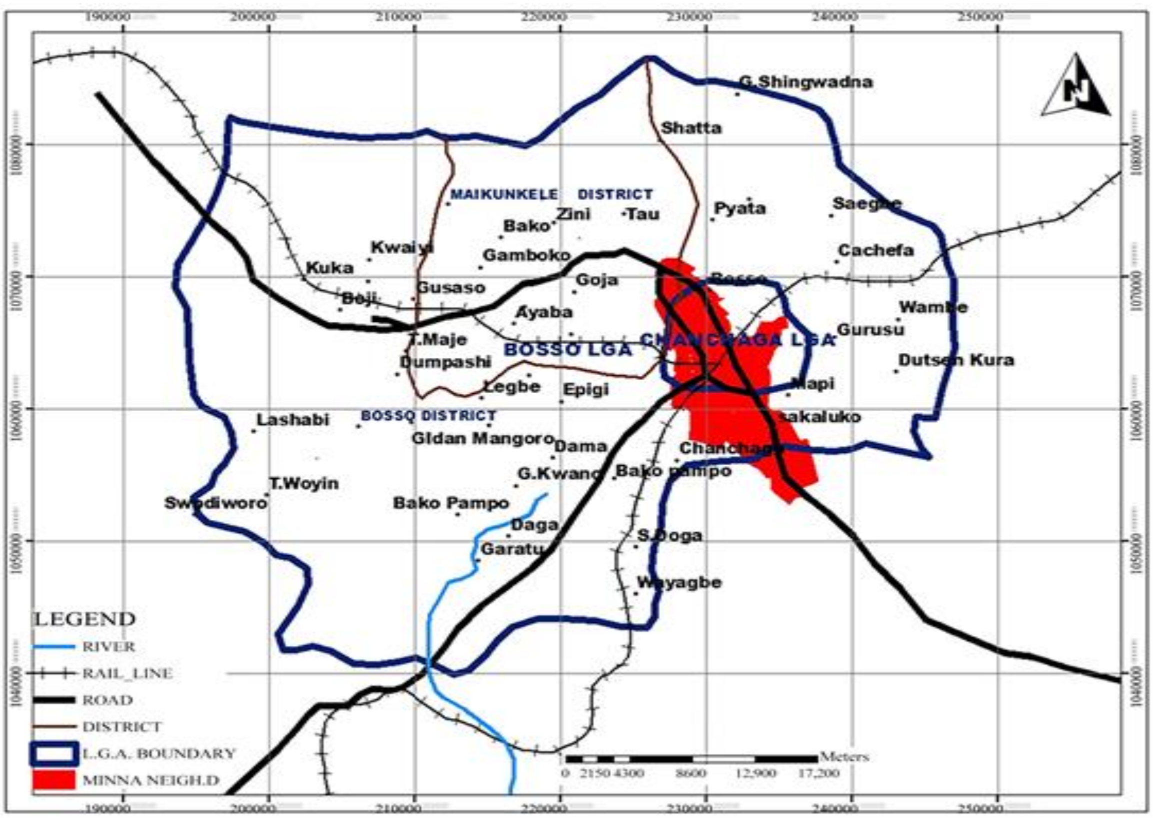

Figure 1: Map of Minna showing the study area.
Source: **Idowu *et al.,* 2020**

Socio-Economic, Ecological and Health Status

The term household economy refers to the total pattern of productive household maintenance and reproductive activities of a group of people who eat from a common pot and share a common stake in perpetuating and improving their socio-economic position from one generation to the next (FAO, 1992). In the assessment of the socio-economic, cultural, gender and health issue in the study area, a combination of primary and secondary sources was used. The observation and measurement of the physical and human environment of the study area were undertaken to generate primary data. This involves series of field trips to the study area spread over a period of three months. It entailed actual observation of social and environmental features within the study area, the administration of questionnaires, taking photographs and conducting structured and unstructured interviews on individuals and groups.

These activities involve the use of checklists that were designed to elicit information and data, based on the Rapid Rural Appraisal (RRA) techniques. RRA involves meeting the people and their leaders, making enquires and getting responses on the spot. Sample of checklists created are 'Irrigation Checklist' and 'Health Checklist' to gather data on the irrigation activities and health status of the people in the study area, and their demographic characteristics.

The essence of the health assessment component of this study was to find the epidemiological evidence of water related diseases and the vectors with particular emphasis on schistosomiasis, onchocerciasis, elephantiasis, malaria, sleeping sickness and guinea worm. Secondly, to evaluate the productivity of irrigation farmers due to infections and preventive measures required to be taken to reduce disease vectors and to assess the availability of health facilities in the study area. Finally, to suggest necessary plans, actions to prevent or mitigate the present health problems identified.

Research Hypothesis

The following research hypotheses were generated for the purpose of the study:

(1) General Hypothesis

There is no significant relationship between Chanchaga dam and potential impacts on the local environment.

(2) Operational Hypotheses

(i) Hypothesis I (Ho_1)

There is no significant relationship between Chanchaga dam and potential impacts on the ecological status in the study area.

(ii) Hypothesis II (Ho_2)

There is no significant relationship between Chanchaga dam and potential impacts on socio-economic of the people in the study area.

Population and Sample

The population for the study consisted of the users/beneficiaries of the Chanchaga dam in the study area. The population sample of the study area is about 65 from which some were not readily available according to the head of the community during the interview. Using pure random procedures, the research selected 20 respondents as a sample from male and female. The respondents include; head of each ward, traders, households and neighboring farmers and others were given questionnaires.

Instrumentation and Administration of Questionnaires

A questionnaire was created titled 'Socio-Economic Impact Questionnaire' (SEIQ). This consisted of sections A and B. Section A dealt with personal information of the respondents i.e. their dependent, sex, level of income, marital status, employment and rank. In section B, the respondents were to put a tick (√) in one of the six columns that correspond to their opinion. Another questionnaire was created titled 'Ecological Impact Questionnaire' (EIQ) which includes the types of ecological features that the users of the dam utilized and the sex of the users. Characteristics addressed by the questionnaire were; age, gender, marital status, ethnicity, years of living in the area, years of use of the irrigation facilities, tenure status and number of children. Twenty (20) copies of Socio-economic Impact Questionnaire (SEIQ) and Twenty (20) copies of Ecological Impact Questionnaire (EIQ) were administered to the respondents. The population sample of the study area is about 65 people from which some were not readily available according to the head of the community during the interview. The SEIQ and EIQ were distributed with a covering letter. The covering letter explained the purpose of the study and included a description of procedures used to facilitate the tracking of feedback. In accordance with procedures recommended by Dillman (2000), questionnaires were numerically coded to limit follow-up notifications. Survey responses were kept confidential. Three weeks after initial distribution, members of the sample population who had received instruments were sent text message requesting completion and return of survey instrument.

Of the 20 copies of Socio-Economic Questionnaires (SEIQ) distributed, 18 copies were completed and returned (91%) and out of 20 copies of Ecology Impact Questionnaires (EIQ) distributed, 19 copies were completely returned (95%). The majority of respondents were male (75%) between the age of 35 to 65 years. A quarter of respondents were female between the ages of 30 to 50 years. The most common ethnicity of respondents was Hausa. Regarding employment, most of female respondents were traders, followed by subsistence farmers. Respondents reported that the average amount of time they devoted to farming was 60%, to domestic work was 30% and to other activities was the remaining 10%.

The study utilizes a six-point Likert-type scale with 1 representing disagrees, 2 for strongly disagree, 3 for disagree, 4 for agree, 5 for strongly agree and 6 representing agree very much. These scores were multiplied by average values of the structured questions in the questionnaires. Data from completed questionnaires were scored accordingly within four facets: ecology, social, economic and health status. Four items that were computed to provide a score for each facet represent each facet, and an overall measure of potential impacts of Chanchaga dam on the local environment was obtained by calculating the total from all 4 items. Thus, scores for each facet is 25%, representing the lowest degree of impacts, and scores for the overall measure of potential impacts is 100%, representing the highest degree of overall impacts on the environment. Stepwise multiple regressions were used to determine variables that predicted differences in the potential impacts and the amount of difference they predicted. Both descriptive and inferential statistical analysis methods were used on data collected. The descriptive statistics used were mean and standard deviation while the inferential statistic used was Pearson Product Moment Correlation coefficient.

Evaluation of Surface Water Quality

For the purpose of investigation of surface water quality, water samples were collected from Chanchaga dam which is the main source of water for irrigation in the study area at two different specific locations, randomly using sampling bottles. The collection is done in clean rinsed bottles which were refrigerated for more than a few hours and taken to the laboratory for analysis. Testing procedures and parameters evaluated are grouped into physical and chemical categories for the purpose of this study. Colour analysis is done by visual comparison to a set of platinum-cobalt standards in Nessler tubes. Total Nitrogen was determined by modified micro Kjedahl method, pH by using glass electrode pH meter in soil-water and soil-KCL filtrates, Turbidity was measured by nephelometric turbidity units (NTU) and exchangeable cations by flame analyzer after extraction with neutral ammonium acetate. The analyses were compared with the guideline and standard recommended by Food and Agriculture Organisation (FAO) of the United Nations for the interpretation of water quality for irrigation.

Evaluation of Groundwater Quality

A total of three groundwater samples were collected in the study from a groundwater sources and mixed together to represent one groundwater sample. Water sampling techniques were followed as outlined by Hunt and Wilson (1986) and APHA (1995). The collected groundwater samples were taken to laboratory for analyses to characterize the physico-chemical and biological parameters in the samples. Testing procedures and parameters are grouped into physical, chemical and bacteriological categories for the purpose of this study. The conventional testing method used for *E. coli* (or alternatively, thermotolerant coliform bacteria) provides an appropriate indicator for the enteropathogenic serotypes in water sample. The results of analyses were compared with the recommended World Health Organization (WHO) standard.

Result of Socio-Economic, Ecological and Health Status

The output data was then analyzed using descriptive statistics; Mean and Standard deviation and the results are shown in Tables 1 and 2, respectively.

Table 1: Correlation co-efficient of Chanchaga Dam and Potential Impacts on Ecological Status

Variables	No.	Mean	Standard deviation	Calculated (r-value)	Critical (r-value)	Decision
Ecological Impacts	20	3.135	12.55	0.995	0.025	Hypothesis I (Ho_1) Rejected
Chanchaga dam	20	0.884	3.76			

P >0.05 (Significant)

Table 2: Correlation co-efficient of Chanchaga Dam and Potential Impacts on Socio-Economic

Variables	No.	Mean	Standard deviation	Calculated (r-value)	Critical (r-value)	Decision
Socio-Economic	20	2.954	13.32	0.9985	0.025	Hypothesis II(Ho_2) Rejected
Chanchaga dam	20	0.775	3.290			

P >0.05 (Significant)

The nature of ecological impact facet had the highest mean (M = 3.135) indicating that respondents were least satisfied with the type of environment they need. The lowest mean (M = 2.954) was obtained for socio-economic impact which signified that respondents were satisfied with the social and economic needs. Two null hypotheses were tested using Pearson Product Moment Correlation Co-efficient formula. The Pearson correlation coefficient often referred to as the Pearson R test is a statistical formula that measures the strength between variables and relationships. The result of the calculated r-value is shown in Table 1 for hypothesis I and in Table 2 for hypothesis II. Based on Pearson Product Moment Correlation Co-efficient, the hypothesis is rejected if the calculated r-value is greater than the critical r-value but if otherwise, the hypothesis is accepted. The P value, the probability of observing a sample statistic as extreme as the text statistic has resulted to be P = 0.00502. Therefore, the P value is below the 5% and 1% significance level (P > 0.05 > 0.01). From the analysis in Table 1, the calculated r-value of 0.995 is greater than the critical r-value of 0.025. As a result of this, the null hypothesis which states that there is no significant relationship between Chanchaga dam and potential impacts on ecological status is rejected. From the analysis in Table 2, the calculated r-value is 0.9985 while the critical r-value is 0.025. Since the calculated r-value is greater than the critical r-value, the hypothesis is rejected; i.e. there is a significant relationship between Chanchaga dam and potential impacts on socio-economic of the people.

Health Status Analysis

The health problems associated with Chanchaga dam are water-related in one form or another. The diseases are water-borne, water-washed, water-based or insect-vector-borne. These include; typhoid, Cholera, malaria, bacillary dysentery, amoebic dysentery, diarrhea, ascariasis, schistomiasis, yellow fever, etc. Health checklist was administered to Senior Medical Officer at Medical Centre which falls within the study area. The data and information obtained were analyzed. The two diseases considered most serious in the study area from 2015 to 2017 are malaria and yellow fever with 1,600 cases and 254 cases respectively, in which Mosquito is the vector. This may be due to water logged condition as a result of irrigation activity in the study area that allows breading of the Mosquito. Therefore, based on the number prevailed malaria and yellow fever from 2015 to 2017, further study will be required to investigate the impact of irrigation practice on the health status of the people in the study area.

Table 3 shows the diseases and their corresponding hosts in the study area. The curative measures usually employed on these diseases(s) by the people are the use of clinic or dispensary.

Table 3: Diseases and their Corresponding Host in the Study Area

S/N	Name of Disease	Name of Vector
1	Malaria and yellow fever	Mosquito
2	Sleeping sickness	Tsetse fly
3	Cholera	Water
4	Salmonella	Food
5	Amoebic dysentery	House fly

Results of Surface Water Quality

Water quality-related problems in irrigated agriculture include salinity, infiltration rate, toxicity, sodicity and available nutrients (FAO, 1994). Parameters analyzed were used to evaluate the common irrigation water quality problems in the water samples. Table 4 shows the results of surface water analysis.

Table 4: Results of Water Quality Analysis of Surface Water

S/N	Parameter	Symbol	Unit	Sample 1	Sample 2
1	**SALT CONTENT**				
	Electrical Conductivity	EC_W	ds/m	0.30	0.20
	Total Dissolved Salt	TDS	mg/l	120.0	330.0
2	**CATION / ANION**				
	Calcium	Ca^{++}	me/l	14.0	24.0
	Magnesium	Mg^{++}	me/l	5.00	12.0
	Sodium	Na^{+}	me/l	11.7	9.12
	Carbonate	$C0_3^-$	me/l	0.0	0.20
	Bicarbonate	$HC0_3^-$	me/l	4.50	2.30
	Chloride	Cl^-	me/l	1.95	1.50
	Sulphate	$S0_4^-$	me/l	6.98	10.0
3	**NUTRIENTS**				
	Nitrate - Nitrogen	$N0_3$-N	mg/l	0.60	0.20
	Phosphate -Phosphorous	$P0_4$-N	mg/l	1.57	0.50
	Ammonium -Nitrogen	NH_4-N	mg/l	0.0	0.30
	Potassium	K^+	mg/l	1.50	0.70
	Boron	B	mg/l	1.50	1.80
4	**MISCELLANOUS**				
	Acidity/Basicity	P^H	-	7.20	6.90
	Sodium Adsorption Ratio	SAR	me/l	0.50	0.23

Salinity

Electrical Conductivity (EC_W) and Total Dissolved Solid (TDS) in irrigation water are direct measure of its salinity. The electrical conductivity for water samples are 3.00 and 0.20ds/m, respectively while the total dissolved solid are 120.0 and 330 mg/l respectively. Comparing these with FAO irrigation water quality guideline, it shows that the electrical conductivity of the water sample 1 fall under no restriction on use and water sample 2 fall at low to moderate salinity. Total dissolved solid of the water sample 1 and 2 of Chanchaga dam fall under no restriction on use in the FAO standard limit and therefore, the water is suitable for irrigation practices.

Infiltration

Infiltration problem can be evaluated using EC_w and Sodium Adsorption Ratio (SAR) (FAO, 1994). Parameters used for the calculation of SAR are Sodium, Magnesium and Calcium. The results of calculated SAR for water sample 1 and 2 are 3.8 and 2.2 respectively. Using EC_w and Sodium Adsorption Ration (SAR) values to compare with FAO standard limit, it was found that the two samples fall within the acceptable limit category. Therefore, there is no restriction on use and suitable for irrigation practices.

Toxicity

Toxicity problem can occur in any crop if present in sufficient quantity depending on the crop sensitivity and duration. However, perennial crops are mostly affected. The toxic ions of primary concern in irrigated agriculture are Chloride (CL-), Sodium (Na+) and Boron (B). From the results of the analysis, Chloride levels for the water sample 1 and 2 are 1.95 mg/l and 1.50 mg/l, respectively and boron level are 1.50 mg/l and 1.80 mg/l respectively. These are within the FAO standard limit and thus pose no problem to irrigation practice. However, sodium levels of sample 1 and 2 are 11.3 and 9.12 mg/l respectively which is not within the FAO guide limit indicating high sodicity and it is not suitable for irrigation practices. From the response of irrigation checklist administered, the difference in sodium levels of sample 1 and 2 may be due to washing of cloths which might introduce sodium element at downstream of Chanchaga dam.

Nutrients

These include Nitrate, Ammonium, Phosphorous and Potassium level in irrigation water. Nitrogen level in irrigation water can be reported in terms of Nitrate ($N0_3$-N) and Ammonium (NH_4-N) and of equivalent electrical nitrogen available in the irrigation water. Phosphate ($P0_4$-P) can be reported in terms of equivalent elemental phosphorous. Results revealed that the nutritional compositions of all the water sources are within the FAO guide limit and suitable forirrigation practices. Therefore, there is no need for soil nutrients monitoring in the study area.

Results of Ground Water Quality Analysis

The physical, chemical and bacteriological results of laboratory analysis of groundwater sample is presented in Table 5 and was compared with World Health Organization standard (WHO) for the interpretation of water quality for drinking purpose.

Table 5: Result of Ground Water Sample in the Study Area

S/N	Parameters/Unit	WHO Standards	Groundwater Sample
1	Colour (Appearance) (TCU)	15	Clear
2	Turbidity (NTU)	5	18.1
3	Total Dissolved Solid (mg/l)	1500	225
4	Nitrate (NO_3) (mg/l)	10	1.90
5	Iron (Fe) (mg/l)	0.3	0.02
6	Copper (Cu^{2+}) (mg/l)	1	0.03
7	Calcium (Ca^{2+}) (mg/l)	200	40.1
8	Magnesium (Mg^{2+}) (mg/l)	150	18.5
9	Manganese (Mn) (mg/l)	0.1	0.04
10	pH	9.2	7.18
11	Total Hardness ($CaCO_3$)(mg/l)	500	176
12	Sulphate (SO_4^{2-}) (mg/l)	400	5.0
13	Chlorides (Cl) (mg/l)	250	19.0
14	Sodium (Na) (mg/l)	200	12.4
15	Alkalinity (mg/l)	500	38.0
16	Coliform/100ml	0	0
17	E-Coli/100ml	0	0

The result of the colour for the ground water sample in the study area is less than 15 TCU indicating clear appearance and fall within the acceptable limit of WHO standard. Changes in the appearance may be the first evidence of a problem. Colour in water may be caused by the presence of minerals such as iron and manganese or by substances of vegetable origin such as algae and weeds. Parameters values obtained for groundwater sample are less when compared with WHO standard limit except turbidity value which is 18.1 NUT and greatly over the WHO limit of 5 NUT. Turbidity in some ground water sources is a consequence of inert clay or chalk particles or the precipitation of non-soluble reduced iron and other oxides when water is pumped from anaerobic waters (WHO, 2011). Therefore, high level of turbidity in water sample can have a negative impact on consumer acceptability of water because of visible cloudiness. Hence, borehole in the study area is suitable for drinking purpose.

Conclusions

This study has investigated Chanchaga dam and found that the water in dam is suitable for sustainable agricultural production in terms of levels of physical, chemical and biological properties. The nature of ecological impact facet had the highest mean indicating that respondents were least satisfied with the type of environment they need while the lowest mean was obtained for socio-economic impact signifying that respondents were satisfied with the social and economic needs under the dam.

However, two diseases considered most serious in the study area in 2020 to 2021 are malaria and typhoid, with 1,600 and 254 cases, respectively.Water in the dam was analyzed considering the parameters suggested by FAO to evaluate common irrigation water quality problems such as salinity, infiltration, toxicity and nutrients. Compared with FAO standards, all the parameters are within acceptable limit with no restriction on use and no need for soil nutrients monitoring except toxicity with only Na^{+} values indicating high sodicity due to washing of clothes and bathing with detergents around the dam. Parameters values obtained for groundwater samples are less compared with WHO standard, except turbidity value which is greatly over the WHO limit of 5 NUT. Hence, the groundwater sources in the study area are suitable for drinking purpose**.**

Recommendations

It is recommended that further study should be conducted to evaluate the productivity of irrigation farmers due to infections and preventive measures required to be taken to reduce disease vectors particularly, malaria and yellow fever that are found most serious in the study area.

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