Proposed Gbugudu Dam Construction: An Environmental Impact Assessment on the Inhabitants

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Abstract

Gbugudu is located around Latitude N080° 39' 38.5", Longitude E040° 46' 28.6' 'in Moro area of Kwara state. Impounding Oshin River of about 185 km length will be harnessed for the dam water source. Its axis traverses various communities like Oshin-gada, Oke-oyi, Beri, Ilaga, Onikoko, Gbugudu and many more. The impact the proposed dam will have on its inhabitants and their socio-economic activities was evaluated. Design adopted for the study entailed a detailed analysis of water, soil, and air quality samples in the area. More importantly, questionnaires were designed and administered to assess the salient features in the area that will address the negative impacts of the proposed project. Major findings of this study have revealed the proposed area for the construction of a dam will be feasible to impound water for storage that will be treated for the inhabitants to serve them with good potable water. Catchment area of 38 km^2 is envisaged, annual runoff has been estimated to be about 52,988,620 m^3 Freeboard is expected to be 2 meters. Crest length and elevation are 106.9m and 45m asl. (above sea level) respectively. Spillway type and discharge rate are evaluated to be broad crested and 377 $m^3 s^{-1}$ respectively. Positive impact prediction on socio-economic, food production and public health are high and good across investigated areas, but adverse impacts will be recorded and include among others sedimentation i.e. silting of the dam, risk of eutrophication/growth of non-native and/or invasive species, growth of aquatic macrophytes in the littoral and sub-littoral zone of the reservoir, creation of favourable habitats for the growth and proliferation of disease vectors, loss of land, noise/air pollution, risk of introduction of new diseases like schistosomiasis, bilharzias. With more positive impacts than the adverse effects the study concluded that the project is feasible and will contribute to economic prosperity of the areas.

Keywords: *Macrophytes, Crest length, Silting, Spillway and Schistosomiasis.*

INTRODUCTION

A dam is an engineering structure constructed on a river or stream to divert, or store water for the purpose of water supply, energy generation, agricultural purpose, flood control, ground water recharge, conservation storage and recreation among others (Umoren et al., 2016).

Gbugudu in Moro area of Kwara state was investigated for the Environmental impact of a proposed dam in the area for the purpose of

increasing food security in the country. Oshin River (Figure 1) and its tributaries will be diverted and impounded for the purpose of constructing the highly anticipated dam. It is worthy of note that the inhabitants are majorly farmers that depend so much on rain-fed agricultural practice due to non-availability of storage dam water that can be used for their farmlands during the dry season. At the time of this investigation, the streams were moderately flowing forming trellis and dendritic drainage patterns. The study area lies within the undifferentiated basement complex of Nigeria. The Gbugudu study area is underlain by Precambrian basement rock which consist mainly of medium to coarse-grained granite-gneiss (with foliation), some aplitic, fine to medium-grained granite and quartz mineral content (Ibrahim, 2020). The basement complex rocks are inherently characterized by low porosity and near negligible permeability except where there is more fracture network.

Location

The proposed dam axis/site is located across Oshin River (Figures 1and 3) in Gbugudu, 1-3 km to Oke-oyi constructed dam (Figure 2), Kwara State for irrigation purposes. The proposed dam axis is geographically located around the coordinates of latitude N080° 39' 38.5', Longitude E040° 46' 28.6" and Latitude N080° 39' 26.9", Longitude E04° 46' 33.3". Crystalline igneous rocks are highly visible at the river bed at some portions of the downstream and upstream of the dam axis, (Ibrahim, 2020).

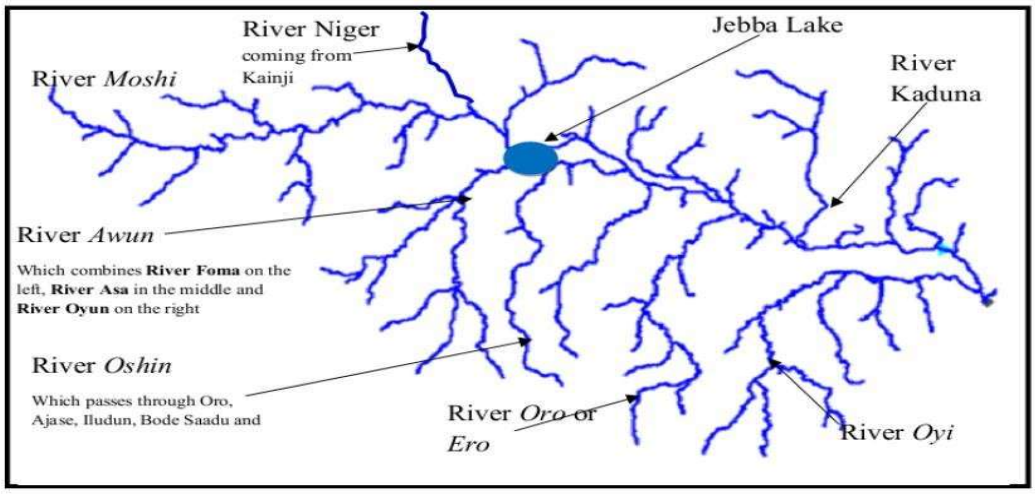

Figure 1: Sketch of Jebba lake showing the Oshin River at Gbugudu area.

Geomorphology

Generally, the vegetation of the site is guinea savannah with medium–small girth trees and grasses growing within the vicinity of the dam site. The proposed dam site is covered with tall grasses, shrubs, and medium/small girth trees along the river channel and beyond. There were noticeable farming activities at close proximity to the river bank. The terrain of the site is rolling with steep slopes at both approaches to the river valley. The river is perennial, ridges of outcrops is

well noticed alone the river bed. The aerial view of the area has revealed the dam axis to be a homogenous earth fill, with a catchment area of about 39km^2, surface area, including the irrigable area to be about 68 hectares. More importantly, total volume of earth fill is expected to be about 48,330m^3 as an earth fill of 43,675m^3 was recorded at the Oke-oyi dam constructed few years back (Figure 2). All available data for the proposed dam revealed its feasibility.

Figure 2: Constructed Oke-oyi dam which is about 1-3 kilometre to study area.

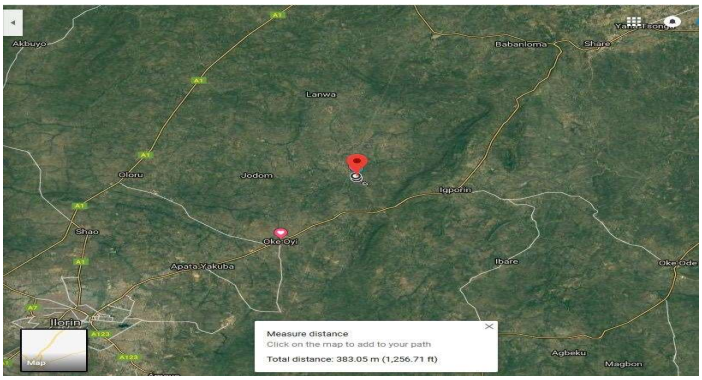

Figure 3: Aerial view of the Gbugudu current study area

MATERIALS AND METHODS

The environmental impact assessment consists of ten steps with each step equally important in determining the overall performance of the project study (Figure 4). These ten steps of the impact assessment are: project proposal, Screening; Scoping; baseline data collection, Impact prediction; impact assessment Mitigation; Reporting; EIA statement (Ibrahim et al., 2019), Review of EIA; EIA follow-up (Figure 4). For the Engineering designs in the determination of soil stratification, bedrock location and location of possible fracture zones which are important in the design of the proposed dam construction, trial pits were dug to get samples for laboratory analyses. More importantly, Oshin River water and soil samples

were collected for laboratory determination of salient features to evaluate the environmental impacts on the inhabitants. Structured questionnaires were also administered to respondents in the study area. Site photographs were also taken.

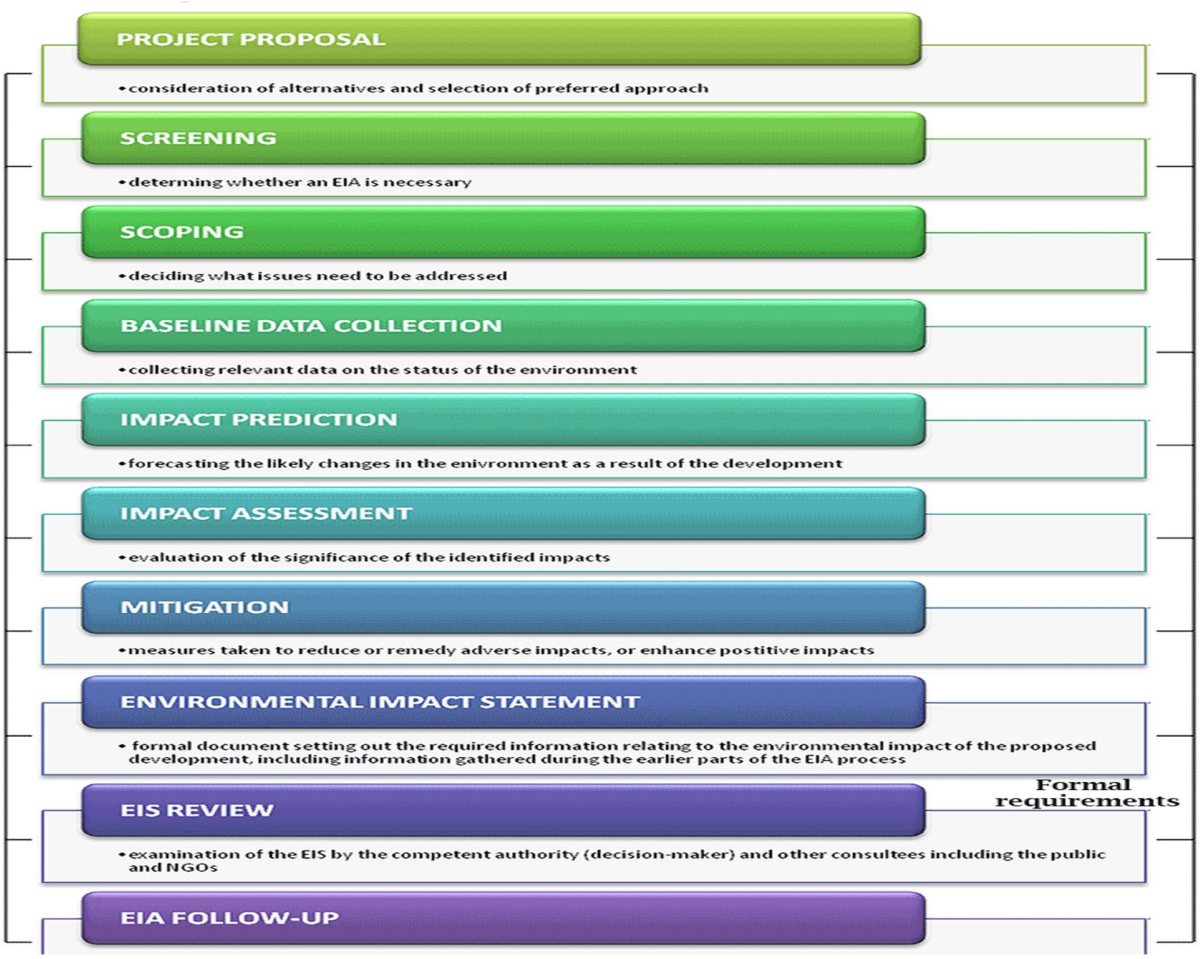

Figure 4: Methodological flow chart adopted for the study.

FINDINGS OF STUDY

Major findings of this study have revealed that the proposed area for the construction of a dam will be feasible. Catchment area of 42 km^2 is envisaged, annual runoff has been predicted to be about 32,988,620m^3, total volume of earth fill will be about 27,926.0m^3 - 36, 222m^3. More importantly, maximum base width and maximum height are expected to be 28.91m and 11m respectively. Freeboard is expected to be 2m. Crest length and elevation are 86.9m and 37m asl. (above sea level) respectively. Spillway type and discharge rate are expected to be broad crested and 265 $m^3 s^{-1}$ respectively.

Proposed project study and screening

Major finding of this study has revealed during screening that the proposed project study area which is located about 14 kilometres to Ilorin metropolis is the most suitable due to the fresh basement emplacement in the area. This condition is expected to support the reduction of leakages of the reservoir water to be impounded and diverted for the purpose of storage till the peak of dry season farming exercise. Precipitation trend in the area revealed average rainfall of 877mm (Figure 5), this is expected to contribute greatly to the runoff that will be collected for storage in the dam. The district's yearly temperature is 28.29ºC and it is -0.19% lower than Nigeria's averages. Gbugudu typically receives about 877 mm of precipitation and has 128.83 rainy days (36.23% of the time) annually. Gbugudu area has a relative humidity of 61.02% and ranges from 29.12% in January to 61.02% in December every year. All these factors point towards a favourable climatic condition that will be important for the rainfall impoundment and storage in the proposed dam.

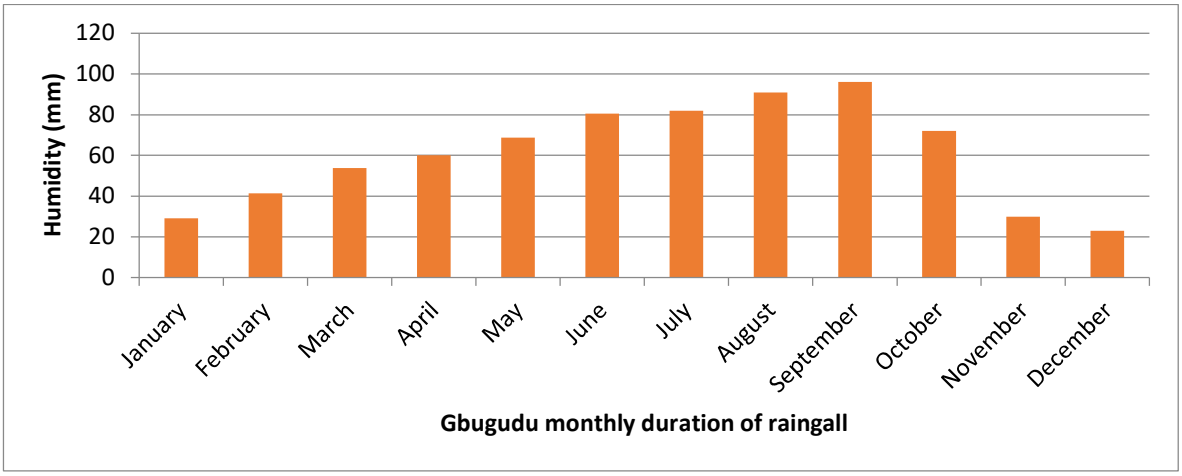

Figure 5: Monthly rainfall pattern in the study area of Gbugudu

Furthermore, the screening exercise was done with population density, gender, and most irrigable areas. Population density study revealed Oke-oyi inhabitants having the highest population of male and female gender (Figure 6), while Gbugudu which is along the same traverse of untarred road is having the lowest male and female population in the area. Irrigable area study conducted revealed Gbugudu is second to Beri with the largest irrigable land of 20% in irrigable land that can be used for cultivation of crops. Its worthy of note that other inhabitants along the area included Beri, Ilaga, Onikoko and Osin-gada. Osin-gada is having the lowest irrigable land of 14% in the area. All these settlements are just 1-3 kilometres apart. In essence, the screening of the investigated areas favoured Gbugudu for the precise location of the proposed dam with active participation of other inhabitants from other areas (Figure 6).

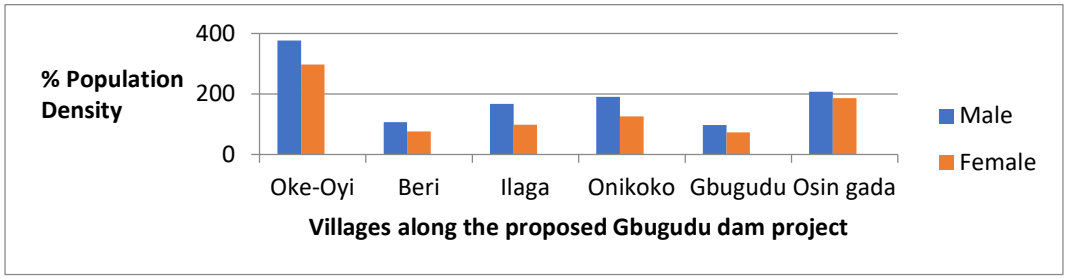

Figure 6: Graph of population density across the investigated area of proposed dam location

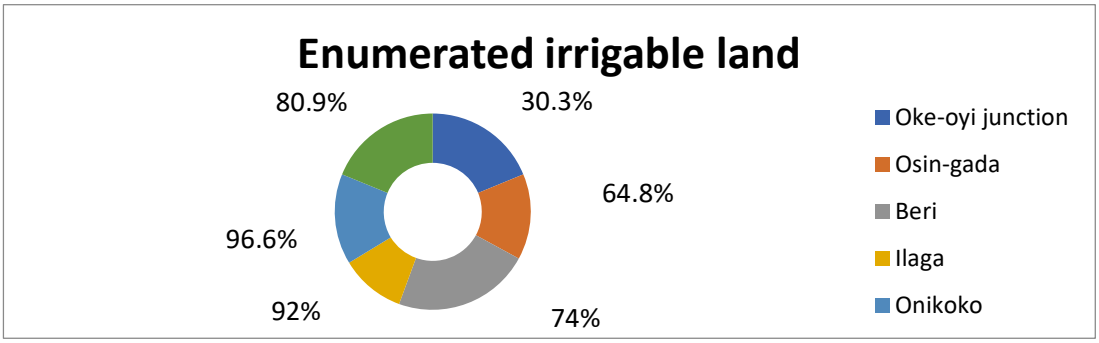

Figure 7: Available irrigable land across the investigated areas.

Scoping and baseline data of the study area

The scoping of the project activities indicated that clearing of vegetation, dredging, transportation of materials to site during construction phase, diversion of Oshin River water during operational phase poses a threat to the biotic and abiotic components. Most of the adverse effect will come from construction phase involving noise and air pollution and its attendant effect on public health of the inhabitants. The air impacts (Table 1) on the environment are hereby tabulated.

Air Quality and Noise pollution

Noise pollution, Total Suspended Particulates (TSP), Suspended Particulate Matter (SPM), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Ammonia (NH_3), Volatile Organic Compounds (VOC/HCs), Methane (CH_4), Hydrogen Sulphide (H_2S) were monitored in the study area. To have a detailed assessment of the noise pollution in Gbugudu area before the intervention i.e., the construction of the proposed dam, a detailed evaluation exercise was done by selection of 10 data collection points in the area which has revealed the following noise pollution information of the study area (Table 2).

Table 1: Air quality measurement of Gbugudu study area

S/N	PARAMETER	Gbugudu dry sea-son	Gbugudu wet sea-son	FMENV
1	SPM [ug/m3]	14.9	1.07	250
2	TSP [ug/m3]	24.9	1.76	
3	SO_2 [ppm]	0.7	0.56	0.1
4	NO_2) [ppm]	0.06	0.06	0.04-0.06
5	CO [ppm]	2.09	8.76	0.08
6	H_2S [ppm]	0.02	0.02	26
7	CH_4 ppm	1.12	3.99	-
8	VOC ppm	12.9	4.64	-
10	NH_3 [ppm]	0.38	0.01	-
11	Noise [dBA]	55.98	55.03	-

Table 2: Noise pollution measurement across Gbugudu study area

S/N	SAM-PLING POINTS	NOISE LEVEL 1 (dBA)	NOISE LEVEL 2 (dBA)	MEAN (dBA)
1	GB1	39	37	38
2	GB2	20	21	20.5
3	GB3	32	31	31.5
4	GB3	29	28	28.5
5	GB4	27	27	27
6	GB5	22	22	22
7	GB6	21	21	21
8	GB7	24	24	24
9	GB8	25	25	25
10	GB9	21	22	21.5
11	GB10	19	18	18.5

Impacts from operational phase which are expected to be long term impact were not evaluated. The social components are expected to have beneficial impacts like the recruitment of labour forces that will improve on the socio-economic activities of the area.

Underground water condition of the area

The existing baseline indicators of the area has revealed that water table for underground water production is at shallow aquifer of about 17-24 meters depth and cannot support irrigation of farmland but domestic use. Only one hand-pump and one motorized pumps scheme were available and cannot even support the growing population for their domestic use. Pumping test exercise conducted in the area also revealed 0.41- 0.56 litres of pumping per second. Moreso, the possibility of opening the network of fractures that will support the economic production of underground water in the area is very low due to the high cost of drilling such boreholes. The only hand-pump scheme

available at Oke-oyi junction is commonly populated by inhabitants for domestic utilization, and as such shall be difficult to use for irrigation purpose.

More importantly, the shallow wells in all the evaluated areas have revealed water depths of 16 meters for Gbugudu during the rainy season and 27 meters during the peak of dry season when water table must have gone down drastically. At Ilaga and Beri areas, their shallow wells during the peak of rainy season gave 14 meters water depth, but during peak of dry season 26.8 meters water depth was recorded and not sustainable for the population in the areas. Onikoko area gave a water depth in their shallow wells to be about 19 meters at the peak of rainy season, while 27 meters was recorded at the peak of dry season. Osin-gada and Oke-oyi gave a water level of 25 meters and 19 meters during the peak of dry and rainy seasons respectively.

Table 3: Physico-chemical analysis of Gbugudu river water sample

S/N	Parameters	Analytical result	Permissible level (NIS)	FMEnv.
	PHYSICAL PARAMETERS			
1	Temperature (°C)	27.2	Ambient	30
2	Colour (TCU)	2.87	3	
3	Turbidity (NTU)	5.36	5	1
4	Odour	No odour	Unobjectionable	
5	pH	7.2	6.5-8.5	6.5-9.2/ 6.5-8.5*
6	Electrical conductivity (µS/cm)	175	1000	
	CHEMICAL PARAMETERS			
7	Chloride (mg/L)	3.71	100	
8	Total Dissolved Solids (mg/L)	140	500	1500/ 500
9	Total Hardness (mg/L)	22.75	100	
10	Calcium (mg/L)	2.25	-	200
11	Magnesium (mg/L)	20.5	2	150
12	Total Alkalinity (mg/L)	0.35	-	-
13	Total Acidity (mg/L)	0	-	-
14	Lead (mg/L)	Nil	0.01	0.05
15	Nitrate (mg/L)	24.74	10	0.05
16	Sodium (mg/L)	103.08	100	
17	Residual Chlorine (mg/L)	2.02	0.2	600
18	Potassium (mg/L)	Nil	-	-
19	Manganese (mg/L)	Nil	0.1	-
20	Total Iron (mg/L)	66.12	0.3	1
21	Cadmium (mg/L)	Nil	0.003	0.01
22	Arsenic (mg/L)	Nil	0.01	-
23	Zinc (mg/L)	0.06	5	15

Impact prediction and assessment

It has been forecasted that the socio-economic activities of the area will increase tremendously with the construction of a dam in the area. This is because the inhabitants are majorly farmers and the source of water for dry season farming is a daunting challenge that has militated against such development. Estimation has shown Oke-Oyi will be more impacted.

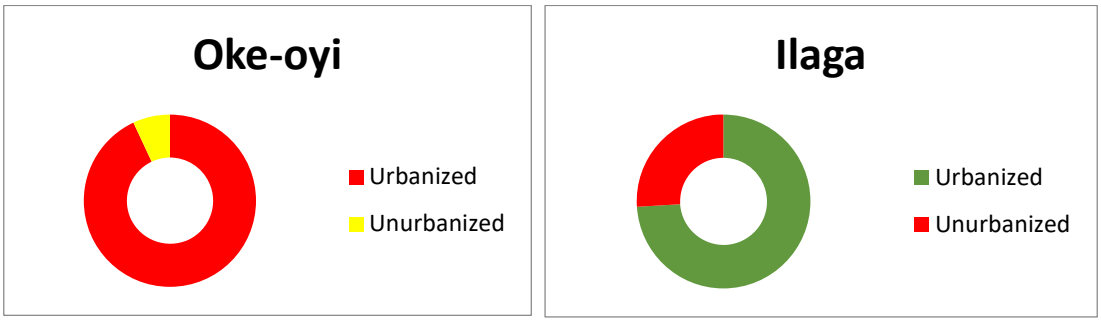

Figure 8: Urbanization rate evaluation of Oke-oyi and Ilaga study areas

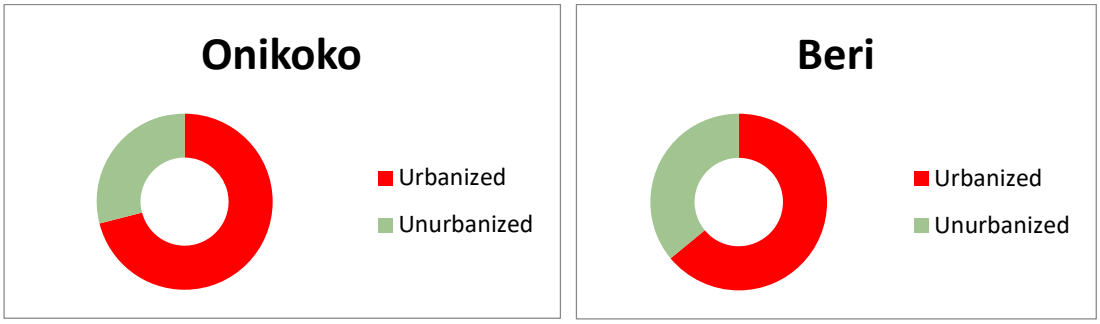

Figure 9: Urbanization rate evaluation of Onikoko and Beri study areas

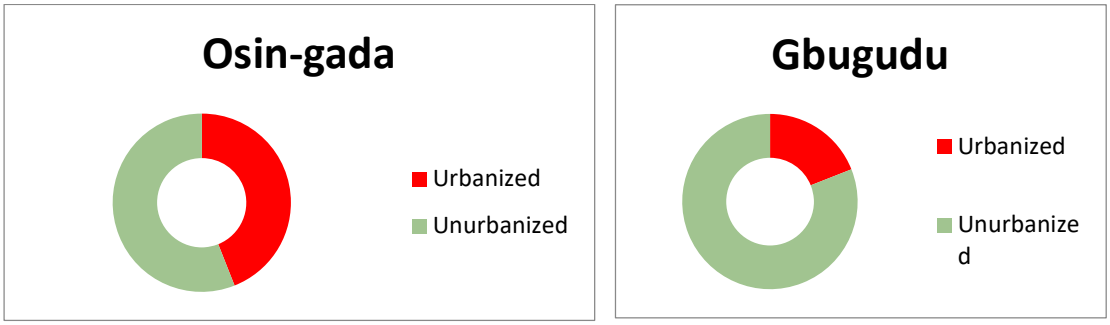

Figure 10: Urbanization rate evaluation of Osin-gada and Gbugudu areas.

Findings have shown that 93% and 7% urbanized and unurbanized exist in Oke-oyi area respectively. 74% and26% urbanized and unurbanized exist in Ilaga area respectively, while around Onikoko 71% and 29% urbanized and unurbanized exist respectively. It is worthy of note that at Beri 64% and 36% urbanized and unurbanized land exist in the area respectively. At Osin-gada 44% and 56% urbanized and

unurbanized land exist respectively. Lastly, the precise location of the proposed project Gbugudu recorded 19% and 81% urbanized and unurbanized area respectively.

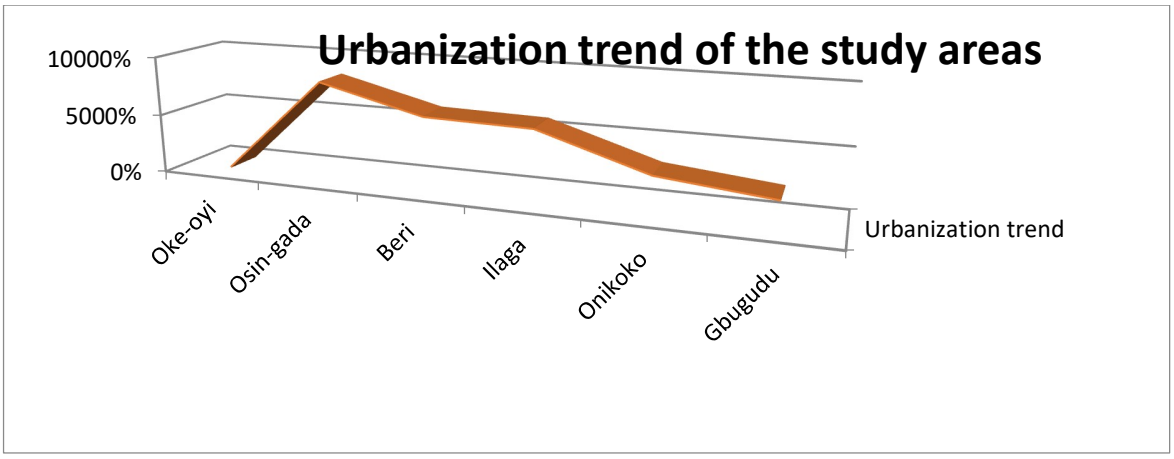

Figure 11: Urbanization trend across investigated area of the proposed dam-site

In essence, the higher the urbanization rate of the settlements, the lesser the availability of irrigable land for agricultural and irrigation activities and the more prevalent the environmental health challenges that may spring up due to the closeness of inhabitants to the dam and reservoir areas. The study has also allowed assessment of the most critical pollutants in relationship to the health effects such may have on the environmental condition of these areas (Table 4).

The significance of this development is that more inhabitants and outsiders will quickly key into the agricultural revolution, armed robbery will significantly reduce and more importantly a new source of livelihood is obviously created with better income to be generated from the activity. This array of significance will ultimately contribute to the Gross Domestic Product (GDP) of the state and Nigeria as a whole.

Mitigation and environmental impact statement

Adverse effects are expected from this laudable intervention and ranges from increase in back-pain, due to unmechanized farming activities, notable health challenges, increase in pests on farm, assess to fertilizer, flooding, and challenges of collecting water rates for maintenance of the dam facilities. Studies from the communities have shown that flooding is going to be a major issue the proposed project will help curtail for effective agricultural output. In essence, the following adverse impacts and mitigation measures were evaluated during the study.

Table 4: Major environmental pollutants and attendant health effects in the area

S/N	POLLUTANTS	POSSIBLE EFFECTS	WHO BENCHMARK
1	Sulphur dioxide (SO_2)	❖ affects the respiratory system, particularly lung function, and can irritate the eyes. ❖ It irritates the respiratory tract and increases the risk of tract infections. ❖ Coughing, mucus secretion, asthma, and chronic bronchitis	40-50 µg/m3 (annual mean). 100-150 µg/m3 (Daily average)
2	Suspended Particulate Matter (SPM)	❖ Causes increased mortality, morbidity, and deficits in pulmonary function. ❖ Decrements in lung function among children	Black: 40-60 µg/m3 (Annual mean). 100-150 µg/m3 (Daily average) Total SPM: 60-150 µg/m3 (Annual mean). 150-230 µg/m3 (Daily average)
3	Nitrogen dioxide (NO_2)	❖ Can cause chronic lung disease. ❖ Reducing a person's ability to smell an odour. ❖ Harmful to vegetation—damaging foliage, decreasing growth, or reducing crop yields	150 µg/m3for 24 hr mean; 400 µg/m3: Not to be exceeded
4	Carbon Monoxide (CO)	❖ Can cause carboxyhaemoglobin.	10 µg/m3 (for 8 hr); not to be exceeded.

Ecological impacts and mitigation efforts of proposed Gbugudu dam

Its worthy of note that sedimentation i.e., silting of the dam is expected after few years of operation of the dam. These negative impacts can be controlled by regular desilting exercise. Other notable adverse impacts and their proposed mitigation efforts of the proposed dam project are contained in Tables 5,6 and 7.

Table 5: Major ecological impacts and mitigation efforts

ECOLOGICAL EFFECTS AND MITIGATION MEASURES OF THE PROPOSED DAM		
	Ecological Impacts	**Mitigation measures**
1	Sedimentation in the reservoir	• Ensure regular penstock releases • Increase frequency of releases when sediment load of inflowing water increases. • Ensure catchment protection and watershed management
2	Release / accumulation of bye-products of anaerobic decomposition	• Ensure regular penstock releases • Monitor water quality, including penstock releases
3	Changes in downstream ecology	• Ensure minimum ecological releases, • Monitor seepage /penstock release volumes
5	Release / accumulation of bye-products of anaerobic decomposition	• Ensure regular penstock releases • Monitor water quality, including penstock releases
6	Impacts due to air emissions/noise, and dust generated during earthwork / construction	• Ensure that emission levels of machinery are within permissible limits. • Ensure that there is no night work
7	Loss of terrestrial habitats due to impoundment	• Catchment protection and watershed management plan

Socio-economic impacts and mitigation efforts of Gbugudu dam

The following represent the researched socio-economic impacts and associated mitigation efforts.

Table 6: Adverse socio-economic impacts and mitigation efforts

ADVERSE SOCIO-ECONOMIC IMPACTS AND MITIGATION MEASURES		
1	**Socio-economic Impacts**	**Mitigation measures**
	Compensation due to loss of land, farmland, fishponds etc	• Gender equity in compensation • ensure payment is to affected women. • Use verifiable documents to compensate all claims, irrespective of gender, class, ethnic or religion inclination
2	Skilled workforce from outside the Gbugudu area	• Ensure all unskilled workforce comes from the immediate community. • Ensure food vendors are from the immediate localities of the area
3	Conflicts commonly arise between the communities, cultural heritage, tradition, and customs.	• Encourage community meetings • Accessibility to the facility should be the same across tribes and tradition, irrespective of the precise location. • Sensitization on any destruction of heritage site.
4	Unwillingness of farmers to pay the token water rates	• Collection of water rates through community meetings
5	Risk of accidental drowning. Injuries during dam construction and/or due to vehicular traffic	• Keep unauthorised persons away from dangerous zones • Put warning signs (written in English and local languages) at strategic sites • Ensure regular monitoring of embankment, penstock, and spillway.

Public health impacts and mitigation efforts

The impact of a dam in the area will strengthen the health of the inhabitants but few diseases may break on communities closer to the reservoir area (Table 7).

Table 7: Major public health impacts with mitigation efforts

	ADVERSE PUBLIC HEALTH IMPACTS AND MITIGATION MEASURES	
1	**Public health Impacts**	**Mitigation measures**
	Opportunistic growth of aquatic macrophytes in the littoral and sub-littoral zone of the reservoir could hinder public health	• Monitor for any unusual floral species • Remove such species when seen.
2	Creation of favourable habitats for the growth and proliferation of disease vectors	• Monitor the presence of disease vectors • Contribute to strengthening of local health facilities through public enlightenment • Contribute public health programmes to eradicate / protect against malaria, schistosomiasis, etc • Continuous flow of spillway, hence the likelihood of creation of habitats for bilharziasis
3	Conflicts commonly arise between the communities, cultural heritage, tradition, and customs.	• Encourage community meetings • Accessibility to the facility should be the same across tribes and tradition, irrespective of the precise location. • Sensitization on any destruction of heritage site.
4	Unwillingness of farmers to pay the token water rates	• Collection of water rates through community meetings
5.	Relocation of large population of about 200 meters radius to the dam area.	• This can be mitigated by giving compensation to the rightful owners

Environmental impact statement review and follow-up

Both international and Nigeria's environmental guidelines and standard safety will need to be enacted and proper enlightenment carried out to all the inhabitants at 200 meters radius especially downstream in the event of the need to release excess water during rainfall. This is very crucial to prevent flooding around the downstream of the area. Monitoring shall involve sampling and analysis of environmental components like soils, vegetation, water, air, and biota, as well as emissions, effluents, or systems at regular intervals. At the end of the design life of the Gbugudu dam it shall be decommissioned and a comprehensive plan shall be prepared for the area restoration and subsequent

protection of the environment with series of enumerated follow-up activities.

CONCLUSIONS

With average rainfall of 877mm and humidity of 61.02%, construction of Gbugudu dam is thus feasible. Catchment area of 42km^2 is envisaged, annual runoff has been estimated to be about 32,988,620m^3, total volume of earth fill will be about 27,926.0m^3 - 36, 222m^3. More importantly, maximum base width and maximum height are expected to be 28.91m and 11m respectively. Freeboard is expected to be 2m. Crest length and elevation are 86.9m and 37m asl. (above sea level). respectively. Spillway type and discharge rate are expected to be broad crested and 265m^{3}s^{-1} respectively. Mean noise pollution ranges from 18.5-38dBA. These all point to a feasible dam in the area. Moreover, environmental impact assessment has shown 93% and 7% urbanized and unurbanized areas exist in Oke-oyi area respectively and it's the area among others that is expected to be more impacted. The higher the urbanization rate of the settlements, the lesser the availability of irrigable land for agricultural and irrigation activities and the more prevalent the environmental health challenges that may spring up due to the closeness of inhabitants to the dam and reservoir areas except they are properly relocated. On the other hand, Gbugudu is the least urbanized at just 19% urbanization and 81% unurbanized. Adverse effects are expected from this laudable intervention and ranges from increase in back-pain, due to unmechanized farming activities, notable health challenges, increase in pests on farm, assess to fertilizer, flooding, and challenges of collecting water rates for maintenance of the dam facilities with various mitigation efforts suggested for the project to commence quickly.

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