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Research Paper

The Dynamics Of Changing Landuse Pattern Resulting From The Upper OFU Stream Dam Project, Anyigba, Kogi State!

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Abstract
In this study, the dynamics of changing landuse pattern resulting from the upper Ofu stream dam project in Anyigba, Kogi state, was carried out with the aim of determining the extent to which the damming project caused a change in landuse pattern. In the assessment process, Geographic information Systems (GIS) and Remote Sensing Techniques were applied to analyze land change phenomena covering built-up area, vegetation, farmland, water body and bare-land. With this model, the satellite imageries covering2013 and 2019 were assessed for the analysis, using
Lansat ETM, and the GIS soft ware such as Erdas, Idrisi, Google Earth and ArcGIS 10.3. These softwares were employed to assess the prominent land uses in the study area and the impact relationships between the dissimilar variables were determined, while the following methods were applied: Survey Research Design (SRD) and Experimental Design (ED). A supervised classification revealed that in 2013, the total land covered by built-up area was 3.5973ha while in 2019, it increased to 7.7634, this is indicative of a positive change at the rate of 40.06%. This particular landuse created the highest impact on the environment more than the remaining four landuses with a change detection rate amounting to 4.17 ha. The percentage rate of change, as indicated in the analyses shows that agricultural land use, vegetation and water body changed negatively, thus provoking food insecurity in the study area. The positive change in built-up and bare surfaces is also a testimony to the growing rate of food insecurity in the study area. It was thus confirmed that variations in the extent of the landuses between these epochs were due to a number of influences caused by the dam project which culminated in a change on landuse patterns. The negative change in the area covered with vegetation from 5.2515ha to 3.2688ha in 2013 and 2019 respectively indicated much devegetation activities in the study area. The consequence of these rising phenomenon was demonstrated by the expansion in the size of farmlands, from 5.5773ha to 6.7401ha between 2013 and 2019 respectively. This phenomenon could be interpreted to mean that the damming of the Ofu stream caused significant loss of vegetation, particularly within the catchment area. Correspondingly, the rise in the water volume attested to these losses also as the catchment area became flooded. The impact would be more pronounced during subsequent rainy season and flood events. Morphometrically, the stream catchment basin is capable of reducing the risk of floods. In other to address the negative impacts of this project in the study area, it was concluded that the people should adopt farming techniques that can sustainably address the lingering food insecurity in the study area. Sustainable management plans should also be put in place early enough in order to cope with the potential floods that could occur as a result of high rainfall as it is common with downside flooding for decades. Relevant recommendations have been made to positively address these negative impacts.
Key words: *Water, dam construction, flood incidence, Geographic information system, Remote sensing.*

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I. INTRODUCTION

For decades, researches on Environmental Impact Study (EIS) on dams have been carried out in different parts of the world with significant results. A study of this nature cut across different disciplines with different approaches, with the aim of eliciting geospatial information required to make dams management sustainable in providing the needed hydrological resources for the people, with little difficulty. Essentially, information on the dynamics of dams is very important for the sustenance and management of dams/water

scheme project in Nigeria. Dam construction and operations have many benefits; nevertheless, they have also led to a number of negative social, health and human impacts, (Amidu and Lawrence, 2020). In the first place, the protection and conservation of forests in the watershed and mine spoil areas help in maintaining the water balance and soil erosion, (Shradha, Manisha and Ranjana, 2011). This development has to do with water and soil temperatures and their changing characteristics. --Therefore, the management of domestic waters is one of the challenges facing urban areas in most developing countries of the world. The resultant change of the original landscape through human intervention depends on and makes the environment more frazil, (Abdulkadir, 2007). Water has always played a vital role in human societies. Santra (2010) sees water as the most vital of all the resources of the earth. By composition, water is about 97.2% of the planet earth, it lies in the ocean as salt water, 2.15% in frozen ice and 0.65% as fresh water (water in streams, springs and rivers).The 2004 budget of the Federal Government of Nigeria identified the provision of water as one of its priority infrastructures to the people; others are health, agriculture, education, power and security, (Federal Ministry of Finance, 'FMF' 2004). Some 65% of the total capital budget was allocated to these sectors, in line with the objectives of NEEDS to grow the non-oil sector by unleashing the potential of the private sector. Availability of water in adequate quantity and quality is a necessary condition for Sustainable development. Water, is indispensable to sustain any form of life and virtually every human activity, (Akpan and Olarewaju, 2017) In order to manage the resource, a number of regions have built water reservoirs, including dams for sustainable development, growth and poverty reduction. In the first place, the protection and conservation of forests in the watershed and mine spoil areas help in maintaining the water balance and soil erosion, (Shradha, Manisha and Ranjana, 2011). The Upper Ofu Stream Dam Project (UOSDP), presently under construction by the Federal Ministry of Water Resources (FMWR) is a major economic undertaking in this sub-region by the federal government and one of the largest hydrologic ventures in the area in recent times. Preliminary study on the project reveals that the dam is to provide the much needed water for urban agricultural practices, improve fishing activities on the stream and provide enough water for domestic use in Anyigba urban area and its neighboring communities. The immediate neighbors of Anyigba are Agbenema, Oganeaji, Ojofu, Olofu,Ajagwumu, Ogbadu and Agala-Efimenye. The dam is expected to raise the level of the water of the stream so that adequate aquatic habitat can be achieved for fish and irrigation farming, provides enough volume of water for a number of socio-economic usages by the people. Water resources are many and the purpose for their development are also many. On a global scale, there are seven major sources of water: atmospheric water, surface water, ground water, oceanic water, refrigerated water, biological water and vegetation water, (Oyegun, 2007).

Because of the multidimensional focus of Geography and the interrelatedness of the discipline with other fields of study(e.g. Earth Sciences, Geodesy, Soil science, Hydrology and Geology), the contribution the discipline offers to an environmental study of this nature is never an option, but rather a path finder. For the sustainable management of the resource, a number of regions have built water reservoirs, including dams for sustainable development, growth and poverty reduction. Nevertheless, most of the mining or dam construction processes across the globe have side effects of an ecological nature. The various land uses that constitute this environment must be carried with obedience to the ethics of the environment with a view to reducing the negative environmental hazards that could be wrought on the environment. This situation is necessary in communities where water resource is inadequate for both domestic and industrial use. Therefore, a study of this nature is imperative, basically for the overall development of the environment. This covers both the bio-physical and socio-economic environments; the cultural, political and academic environments.

II. THE RESEARCH PROBLEM

An environmental study of dam projects of this nature on this particular segment of Ofu stream has not been carried out in the region before. However, mini damming operations have been carried out small weir/barrages across the Okura stream at Ochaja in the same LGA by the Anyigba Agricultural Development Project 'AADP' and the one at Egane in Olamaboro LGA, a natural dam. These weirs/barrages only have local relevance. It offers the people access to domestic supply of water for drinking, washing, fishing and local industrial processes. However, they have not been adequately put into use because of the local prevailing socio-economic, rural and geographical location of the region. In their recent study on the comparative analysis of water quality using physicochemical parameters in Ofu Mini-Earth dam, Oganeaji – Anyigba and Ofejiji dam, Dekina LGA, Musa, Simon and Ogidiolu (2019) affirmed that due to pressures exerted by human activities, settlement expansion and rural industrialization on the waters of the Dams, both the surface and the underground waters have degraded. The scarcity of water in the area was earlier investigated and reported by Ocholi, Ejoba and Abuh (2016), it attested to the fact that the resource must be managed to ensure its sustainable use. These authors proved that Nigerian waters suffer poor quality from infiltrated wastes. In most parts of the communities with large influx of people, high pressures are exerted on water resources, thus reducing the quality of water needed to sustain life. The damming of Ofu stream is therefore and essentially a welcome advantage to the people in this catchment area where the population of the people grows astronomically. Musa et al (2019)

further discovered that the beneficiaries of the Ofu stream have for several years been experiencing significant water discharge difficulties and associated hydrologic and geomorphologic and biogenic setbacks at varying degrees. The Ofu stream, the only natural water source after rains was beheaded by a mysterious lake called *Aabuja* Lake, in the early 1990s. The said lake consequently increased the volume and the drainage capacity of the Ofu stream to its present status, having beheaded it. On the negative side, the results of the negative survey shows that increase in volume of the stream generally altered the hydrologic terrain of the stream, caused its increased velocity, eroded and degraded the banks, flooded and silted with impurities the water channels, disrupted the ecosystem, produced water borne fluvial structures that damaged buildings along the stream, balkanized existing Anyigba-Ojofu road and destroyed farm lands. Sediment/siltation load also increased astronomically, due to the influx of runoffs from adjacent areas and stream banks. It also caused loss of useful agricultural lands, increased pest infestation, pollution of adjourning communities and many water related diseases (cholera, fever, dysentery and Diarrhea in children). In view of these, the hydrologic and morphometric characteristics of the stream changed negatively, (Shradha, et al 2011). Various researchers across the world have carried out morphometric analysis of various river basins in different continents of the world. Waikar and Nilawar (2014) carried out morphometric analysis for the drainage basin in Charthana, located in Parbhani district of Maharashtra state in India, extracting linear, areal and relief aspects of the basin characteristics. The parameters estimated include stream length, bifurcation ratio, drainage density, stream frequency, texture ratio, elongation ratio, circularity ratio and form factor ratio amongst others. Various researchers across the world have carried out morphometric analysis of various river basins in different continents of the world. Waikar and Nilawar (2014) carried out morphometric analysis for the drainage basin in Charthana, located in Parbhani district of Maharashtra state in India, extracting linear, areal and relief aspects of the basin characteristics. The parameters estimated include stream length, bifurcation ratio, drainage density, stream frequency, texture ratio, elongation ratio, circularity ratio and form factor ratio amongst others.

Communal classes and land disputes, resettlement hazards and numerous socio-economic problems were known to have ravaged the affected communities, as revealed during the reconnaissance survey. These problems are attenuated by the nonexistence or inadequate geodatabased infrastructure, reliable and up-to-date baseline information and maps, legal and administrative framework for mitigation measures. Because of their first experience as beneficiaries of dam projects in the area, the people of Anyigba and its environs are ignorant of the negative impact and implications of the impact of such a project, and therefore the need to inform them on the negative impact through this study is imperative. These measures are meant to save the people and government of the project area from environmental losses (ecosystem services), habitat disruption, land degradation, financial losses, and water related pollution and disease spread, among others. Worse of these related problems is the expected influence on the culture and tradition of the benefitting communities. Been the first of its kind in the region, the lack of essential geospatial data on health, culture, polity and education hinders the inability of the host communities as well as the stake holders to perceive the negative aspects of the Dam project.

III. AIM AND OBJECTIVES OF THE STUDY

Aim

The aim of this study is to examine the dynamics of changing landuse pattern resulting from upper Ofu water dam project on Anyigba and its neighbors with a view to suggesting mitigation measures to address the negative impacts in line with the Sustainable Development Goals, 'MDGs'.

Objectives

The study which is limited to Anyigba and its environs covers geospatial analyses of the dam project using Remote Sensing and Geographic Information "GIS' software to analyze and determine the changed character of landuses covering built-up areas, vegetation, farmland, water body and bare surfaces.

The objective one involves a detailed classification of the dam sites to determine the change detection of the landuses between 2013 and 2018 covering the outlined landuses.

The objective two involves an examination of the varied components of the biophysical variables affected by the dam project.

The objective three involves an examination of the varied components of the socio-economic variables affected by the dam project.

The objective four suggests mitigation measures aimed at addressing the negative effects of the dam on affected communities.

JUSTIFICATION FOR THE STUDY

Essentially, findings from this study will provide a breakthrough in people's general knowledge on dams as critical aquatic resources the people require ensuring in perpetuity the continued livability of the host communities. The result of an intensive local field survey shows that the upper Ofu stream dam is key to several facets of the economy of the study area: domestic, economic, social, geographical, cultural, political, etc. Given the geographic location of Anyigba and its environs, the need to embark on environmental baseline studies of this nature is important hence it offers support that are flexible and productive for a modeling process. It is well appreciated considering the fact that environmental resources are very diverse irrespective of the approach: from a tangible resource base to the intangible level, both at the synergy and systematically related, covering the following the historic and specific benefits.

1. Increased fish farming activities through an enhanced/ greater water volume and wider breading areas.
2. Introduction and provision of greater volume of water for Irrigation farming.
3. Greater opportunities for research opportunities and education on water, hydrologic and related aquatic studies.
4. Relieving the beneficiaries of environmental pressures caused by other sources of water for domestic and industrial use.
5. Tourism development and enhancing greater opportunities for recreational activities.
6. Contribution to the realization of the region's water security objectives
7. Attraction of new investments and expansion of existing ones (e.g. water packaging, supplies and sales).
8. Providing opportunities for local industrialization, especially water related projects, among others.

HYPOTHESES

1. Dam project in this area does not have any negative effects.
2. Dam project in this area does not have any positive effects.
3. Beneficiaries of the dam project differ significantly demographically and socio-economically.
4. Awareness of the effects of the dam project in the area is low among the communities.

IV. METHODOLOGY

The Study Area

Anyigba town is strategically situated between latitudes 07^0 15´ and 07^0 29´ N, and Longitudes 07^0 11´ and 07^0 32´ E. On the average, Anyigba is on the altitude of 420 meters above sea level. The total land area is about 62.5 km^2.

The climate of Anyigba, based on Koppen's climatic classification, falls within the tropical wet and dry (Aw) climatic region. With a mean temperature of about 25^0 C, rainfall in the area is high during the wet season, and ranges between 1600 - 2000mm, lasting for about seven months, (i.e. between April and October), Ocholi (2015). The area's hydrologic features are determined by the presence, and perhaps the source region of the biggest river in the local governments. The source/watershed of the mysterious lake (*Aabuja*) in the area is Ojofu, a sub-ub of Anyigba, about 1.5Km from the CBD. Boreholes are numerous in the area offering supplementary services to the inhabitants, particularly during the drought periods.

The dominant vegetation type in the area is the tropical savanna woodland; it houses mixtures of scattered tropical trees, shrubs, herbs and grasses.

The soils are mainly of sedimentary origin, (Yusuf, 2005). They are mainly lateritic and with some patches of hydromorphic and rich loamy types. The area is surrounded by low hills, escarpments and sloppy surfaces.

Anyigba is bordered by many communities: Ajiolo and Dekina towns to the north, Egume to the south East, Ologba and Iyale to the north East and Agbeji to the West. The town also has linkages with smaller communities such Etiukpolo, Agala Ate and Agala Ogane, Agbenema, Abadigba and Ojikpadala – Egume. Using the annual growth rate of 2.5, Anyigba has a projected population of about 95,400.00 persons, (after Ifatimehin, and Ufuah, 2006).

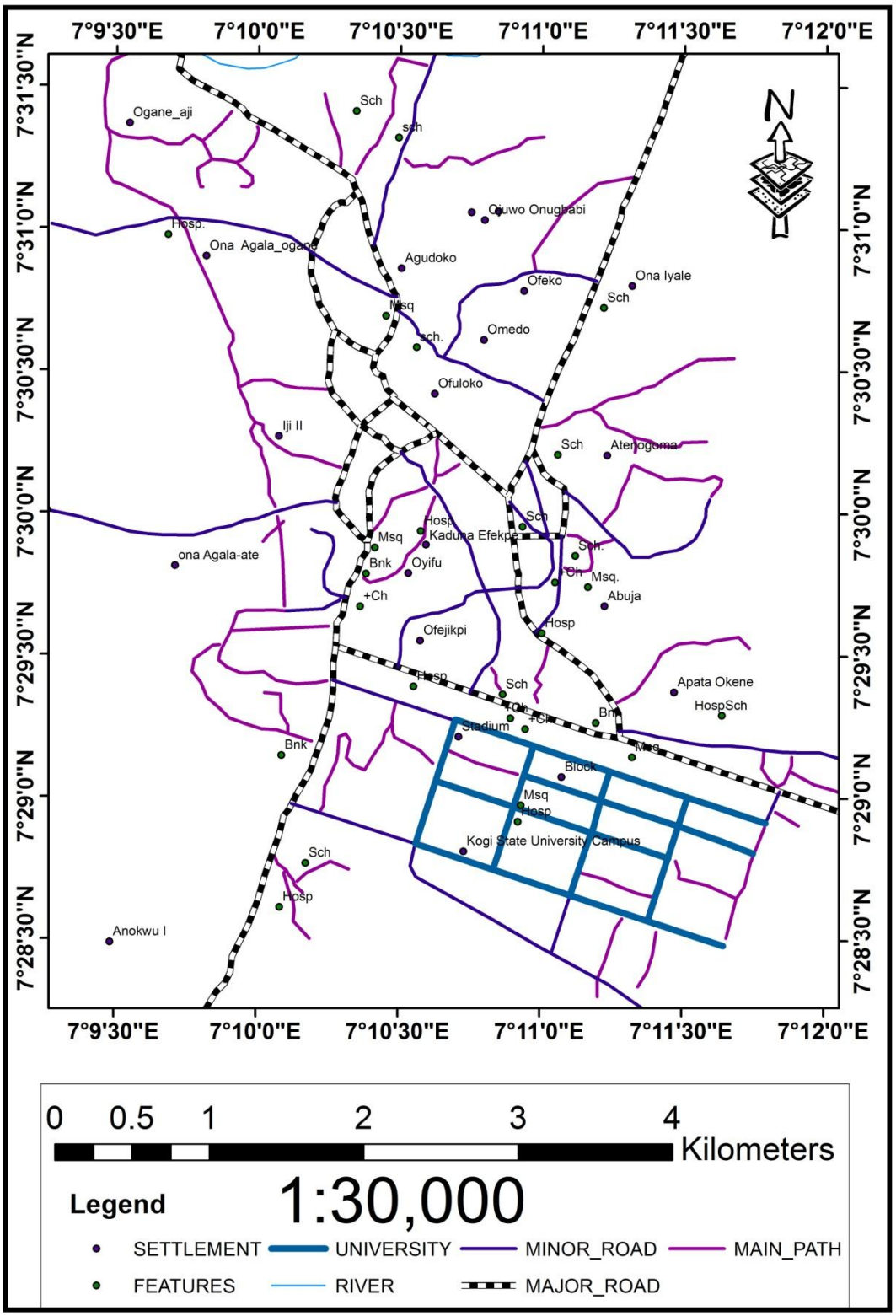

Figure 1: Anyigba and its Regional units**; Source:** GIS laboratory, KSU, Anyigba, (2017).

OFU STREAM CATCHMENT AREA GEOGRAPHY

Ofu stream sub-basin lies between latitudes 6^0 46' 48.38" N and 7^0 38' 31.2" N and longitudes 6^0 42' 3.56'' E and $7^0$20' 54.6" E covering parts of Dekina, Ofu, Igalamela/Odolu, Idah and Ibaji Local Government Areas in Kogi State and Uzo-Uwani Local Government Area in Enugu State, Nigeria within the humid tropical

rain forest of Nigeria. It falls within the Lower Benue River Basin Development Authority in North Central Nigeria.

Rainfall within the catchment area is concentrated in one season lasting from April/May to September/October. The main river within the sub-basin (Ofu) is perennial and parallel in pattern to Imabolo and Okura rivers which are close to the study area. It took its root from Ojofu, in Dekina Local Government area in Kogi State flowing in the north-west direction with a catchment area amounting to about 1,604 km^2 most of which is covered by derived or secondary forest, (Alfa, Ajibike, Adie and Mudiare, 2018). The authors delineated the Ofu river catchment and carried out its assessment using the Shuttle Radar Topographic Mission Digital Elevation Model (SRTM-DEM) version 3 and the drainage network extracted from the River map of Africa. The preprocessing was done using ArcHydro extension in ArcGIS 10.2.2 while the actual delineation was done using HEC GeoHMS extension in ArcGIS 10.2.2 with the DEM and drainage network as input *C.* Estimation of Morphometric Parameters *a*real characteristics such as basin area and perimeter of the catchment area were extracted from the attribute tables of the sub-basin and the main stream in ArcGIS while the other parameters were estimated using appropriate equations. Morphometric analysis of the stream complemented an assessment of the sub-basin morphologic and hydrological characteristics necessary to form a basis to appropriate flood hazards, vulnerability and risk within the catchment. This also provided a sound basis for the management of the watershed for optimum development of the resources within it.

Data generation Procedure and Analysis

The approach for this study covers comprehensive theoretical and empirical survey of the dam project in the study area, intended to generate a geodatabase needed for sustainable dam management. It intends to determine the resultant positive and negative effects of the project on affected regions, using landuse patterns as the baseline parameters. The resultant findings are essentially meant to explore strategies aimed at tackling the negative impacts of the projects on the host communities, the proponents and the local authorities within the catchment areas.

In the analysis of data, changes in land uses between 2013 & 2019 were determined with upto date and current remotely sensed images. The software adopted for this study included Idrisi Andes (land use modeler), ArcGIS 10.5, Erdas Imaging. The land use categories used in this work include built up areas, bare land, agricultural land, vegetation and water body.

The maximum likelihood classification algorithm was used to classify each of the two epochs of this study into the predetermined five classes adapted for this study based on their respective signature files. A classification accuracy of 70% was achieved.

The post classification comparison change detection method was used in this analysis. This was implemented with the Land use Change Modeler (LCM) of the Idrisi software environment to derive comprehensive land use to-fro transition maps for changes between 2001and 2016. A Markovian process was used to determine exactly how much land would be expected to transit from the later date to the predicted date based on a projection of the transition potentials into the future for which a transition probabilities file was created. This was achieved by developing a transition probability matrix of land use change from one time to another, which shows the nature of change while still serve as the basis for projecting to a later time period.

Reconnaissance Survey

Prior to the commencement of this study, a reconnaissance survey of the dam site was carried out to identify the ongoing dam project activities with a view to acquiring first hand information on the dam construction activities, and subsequently to avail us with the opportunity to assess the existing structures before the dam project started and the likelihood of the negative effects of the project. The reconnaissance survey involved visits to the site of construction, some staff of the Federal Ministry of Water resources on supervision, community leaders of the neighboring communities, including Ogane-Aji, Agbenema, Ogbadu, Ajagwumu, Agala-Efimenye, Ojofu and Olofu), individuals, the Ogohi-Onu Anyigba, selected farmers and some group Associations, particularly the Ogane-Aji Youth Club representative for pre-field briefing.

At the time of the preliminary investigation, information was gathered about the location of the dam project, the history of the host community (Anyigba) where the project is sited, the size and length of the dam, the geography and geomorphology of the dam site. These include the vegetation, soil, water and weather characteristics, and the landform features of the region within 5kilometer radius. Unfortunately, there was no archival record on the initial site conditions made available at the time of visit. Nevertheless, some critical information on both the positive and negative effects of the dam were generated. For instance, it was informed that the dam project could positively offer numerous opportunities to the benefiting communities in such as increased volume of water for domestic use, fishing, irrigation farming and the provision of commercial activities and employment generation to the inhabitants. Negatively, it was noted that the dam project could alter the existing geomorphic structure of the landscape of the affected communities, degrade the soil, change the

floral characteristics of the area, spread of disease vectors, and increase the current hazards of flood and erosion in the area, among others.

V. CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

Conceptual Framework

In this study, the concept of "Sustainable Development" has been considered relevant hence it offers the best conceptual understanding on environmental resources such as dams/water management and development generally.

Sustainable Development Concept

The Sustainable Development Concept describes the ability of a resource to be produced or sustained for an indefinite time without damaging the environment or depleting the resource, (Wiktionary, 2020). The Sustainable Development Goals (SDGs), also known as Global Goals, were adopted by all United Nations Member States in 2015 as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by the year 2030, (www.undp.org>undo>home>sus..., 2020). The seventeen development goals, it says include GOALs 1: no poverty, 2: zero hunger, 3: good health and wellbeing, 4: quality education, 5: gender equality, 6: clean water and sanitation, 7: affordable and clean energy, 8: decent work and economic growth and 9: industry, innovation and infrastructure. Others are 10: reduced inequality, 11: sustainable cities and communities, 12: responsible consumption and production, 13: climate action, 14: Life below water, 15: life on land, 16: peace and justice strong institution, and 17: partnership to achieve the goal, (United Nations Department of Economics and Social Affairs, 'UNDESA', 2020).

Sustainable Development must strike at a balance to meet the needs of the society, the economy and the environment. According to https://www.hq.nasa.gov, (2020), sustainable development indicators (SDI) include the various statistical values that collectively measure the capacity to meet present and future needs, while the SDI provides information crucial to decisions of national policy and to the general public. The five global scale environmental indicators include: biological diversity, food production, average global surface temperature and carbon dioxide concentrations in the atmosphere, human population, and resource depletion, (www.hq.nasa.gov >iwgsdi, 2020).

This concept has several meanings and interpretation across the globe. Although the term "sustainable development is not new, but today it has been used in a renewed way to reinvigorate global interest towards environmental resources management, with greater focus on *conservation* and *protection* of the quality of water, forests and soil. Nearly about two to three decades ago, the World Conservation Strategy was said to have promoted a *Sustainable Development* Concept in the eighties and nineties and so did **"**the Global 2000 Report to the President" Wikipedia Encyclopedia, (2007).

UNCED, (2000) defined Sustainable Development as a development that meets the needs of the present without compromising the ability of the future generation to meet their own needs. This position places the *Rio de Janeiro Earth Summit and the Rio declaration* among several others as platforms to achieve Sustainable Development, eradication of poverty and environment protection. One of the basic principles of this declaration was that the state shall develop national resources regarding liability and compensation for victims of environmental damage. Deforestation within the stream catchment areas and its consequent effects on the aquatic terrain was considered by Scruciu (2006) and Ocholi (2015) as an injury to a nation's economy. This can be explained in the numerous damages to nation's waters or rivers, soils, agricultural lands, the forest fauna and flora, and wildlife species. The continuous depletion of these resources of the land is indeed a matter of great concern. It is for this reason that attempts have been made globally to secure appropriate ways of utilizing these resources to avoid continues degradation. The process requires analyzation and knowledge of the alternatives than those traditional development processes. The process provides a contextual platform on which to improve overall sustainability when the road towards water resources development was unsustainable. In that regard, if there are two alternatives that satisfy the same need but one provides a better solution relative to sustainability, the more sustainable alternative is chosen. This line of thought was developed by Wikipedia Encyclopedia (2010) to provide a framework in which theoretical thinking on the environment and the natural resources therein could be appreciated. To analyze further, Khitoliya (2004) had remarked that, to be sustainable, development must possess both economic (economic consideration) and ecological (ecological consideration) sustainability. In his explanation, Khitohya informs that the concept of sustainable development has received much recognition after the Stockholm Declaration resulting from the United Nations Conference on Human Environment in 1972.

Conferences of this nature have since then been held in various parts of the world and with similar objectives. The 2030 agenda for sustainable development seeks to eradicate poverty which is considered a global challenge and also a requirement to achieve sustainable development for all by 2030. It advocates for conservation and mains to enhance global resource base, by gradually changing the ways in which we develop

and use technologies. One way to measure progress in this SDGs process is to on the '5 Ps': People, planet, prosperity, peace and partnerships, (www.researchgate.net>publication, 2020). According to Khitoliya (2004), sustainable development does not focus solely on environmental issues, rather and broadly too, on three general policy areas: *economic, environment and social*. It was in view of this goal that the 2005 World Summit Outcome Document refers to *"interdependent and mutually reinforcing pillars*" of sustainable development as *economic development, social development and environmental protection, water and river/stream protection* inclusive.

The merit in this discussion they said is the ability of the model to modify the previously "unqualified" development concept into a qualified one. In this perspective therefore, sustainable development would imply improving the quality of human life while living within the carrying capacity of supporting ecosystems. These proponents have given the necessary conditions for achieving sustainable development anywhere in the world thus: ecosystem security, economic efficiency and social equity. Sustainable Development, they said, requires that humans at a minimum should only use resources of nature such as the water/rivers/streams at a rate at which they can be replenished naturally. In order to illustrate these explanations, Wikipedia Encyclopedia (2007) provides the following model on resources usage and environmental sustainability in an open ecosystem.

Table 1: Renewable Resources and Environmental Interplay

Use of Renewable Resources	State of the Environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Not sustainable
Equal to nature's ability to replenish	Environmental equilibrium	Steady state sustainability
Less than nature's ability to replenish	Environmental renewal	Sustainable development

Source: ***After Wikipedia Encyclopedia, (2007).***

The above table is an illustration of the levels of sustainability attainable with reference to the state of the environment, and the extent of use. The more the environmental resources are put into use, the more they are degraded and the more they become unsustainable. Sustainability therefore can only be attained if the rate of consumption of the earth's resources, particularly water resources is less than what nature is able to replace.

Deductively, we presume that the idea put forward by this theory will open up new vistas of knowledge on how we can sustainably manage the rivers/waters of the land. It also affords us the opportunity to transfer the knowledge we've learnt from this concept to the people, particularly the vulnerable groups already highlighted. In order to attain full sustainability, the culture of pollution avoidance, siltation and all forms of degradation on the region's waters must be promoted and sustained. Many early thinkers such as William Kapp, Thomas Robert Malthus and Justus Von Lie Big equally shared their fate over the pessimistic prediction of Catastrophic consequences of continuing economic growth and rapid population growth, widespread ignorance, lack of imagination, complacency and inertia which hitherto did result in deplorable damage to vital environmental assets. These assets are slowly reparable where necessary; of particular example is the pollution and misuse of waters in the rivers/streams.

Sustainable Development is a multidimensional concept which explains a process rather than an end goal. It is multidimensional because of its interdisciplinary approach and multidisciplinary relevance. The choice of this concept therefore is premised on the philosophical explanation it offers to our knowledge of the phenomenon as well as the desire to seek for a comfortable way of living through understanding and adoption of the principles. This conceptualization of ideas across disciplines affords us the opportunity to explore this concept to protect and save the ecosystem particularly the rivers/streams from pollution for the benefit of future generation.

VI. LITERATURE REVIEW

A review of literatures in this proposal covers definition and types of dam, descriptive study and relevance of dam projects covering global, regional and local/Nigerian environments.

Definition, types and causes of dam

Definition: Dam, according to Google.com (2019), is a structure placed across a flowing body of water to stop the flow. A dam is a barrier that stops or restricts the flow of water or underground streams, https://en.m.wikipedia.org (2020). Iloeje (1980) had earlier described a dam as a barrier that is built across a river/stream in order to stop the water from flowing, used especially to construct a reservoir. A dam is a man made barrier, usually built across a river to hold back water and forming a lake, or reservoir, behind it, it can be constructed from concrete or natural materials like earth and rock, (The British Dam Society, 'BDS' 2019). The word dam can be traced back to Middle East, and before that, from Middle Dutch, as seen in the names of many old cities, (https://en.m.wikipedia.org, 2020). The first known appearance of dam was said to have occurred in 1165. The Wikipedia.org (2020) however maintained that there is one village called Obdam that is already mentioned in 1120, the word which seem related to Greek word taphos, meaning "grave" or "grave hill". It

further explained that early dam building took place in Mesopotamia and the Middle East. During this time, dams were used to control the water level. Reservoirs produced by dams, other than suppressing floods provide water for a number of socio-economic purposes such as water collection and storage and human consumption, industrial processing, irrigation, navigation purposes. Generally, dams serve the primary purpose of water retention and in some areas, they are used to manage and prevent the flow of water into areas. These types are common with *floodgates* (an adjustable gate used to control the flow of water via a sluice) and *levees/dykes or dike*.

The word dam, according to the last author, can be traced back to *Middle English*, and before that, from Middle Dutch, as seen in the names of many old cities. Dams are translated as Barrage (French), Damm (German), argine/diga (Italian), barrage/represa (Portuguese) and presa (Spanish).

Types and causes of Dams

The followings are the list of dams across the globe. The existence of dams is majorly the handwork of human agency. It can also be caused by natural forces and the intervention by wildlife species (e.g. the beavers). Man-made dams are typically classified according to their size (height), intended purpose or structure. In terms of structure and the materials involved in dam construction, they are classified as easily created without materials, arch – gravity dams, embankment/masonry dams, with several sub-types. Examples include the Arch dam in the United Kingdom (UK) and the Monar dam in Scotland. The earliest known dam is the Jawa dam in Jordan, dating to 3,000 BC; https://en.m.wikipedia.org (2020). Others are Arch dam/Arch gravity dam, such that are made from concrete; Barrage dam(the special kinds of Dams consisting of lines of large gates that can be opened and closed to control the amount of water running through the dam); Embankment dams (the types of dams that are made from compacted earth); Rock-fill dams **(** the kind of embankment or so called earth – rock dam, it is a water retaining barrier made up of three major parts), (www.thebalancesmb.com>uses, 2015). Others are Earth-fill dams (a kind of embankment (earth-rock dams), is a water retaining barrier composed of three major parts: fill of loose rock by dumping or roller compaction; impervious membrane made of masonry, concrete, asphaltic concrete, steel sheet piles, timber, or other materials; and transition layer, (link.sprinter.com>chapter, 2015); Fixed-crest dams (fixed-crest dam is a concrete barrier across rivers/streams. The Dashields Lock dam is an example of a fixed-crest dam on the Ohio river, located less than 15 miles downstream of Pittsburgh. On the dam, there are two locks, one for commercial barge traffic that's 600 ft long by 110 ft wide, and recreational auxiliary lock is 360 ft long by 56 feet wide, (https:en.m.wikipedia.org, 2020).: They include Low Head dam, Small dams, Non-jurisdictional dams, Saddle dam, Weir, Check dam, Dry dam, and Diversionary dam. Some dams are classified as follows: Underground dam, Tailings dams, Steel dams, Timber dams, Cofferdams, Natural dams and Beaver dams.

Uses and relevance of dams

A dam is an essential source of water to farmers of hilly countries. Adequate water is needed for drinking, personal hygiene, industrial purposes and a number of domestic functions. It is also needed for individual, public, commercial and agricultural purposes, (Oyegun, 2007). The demand for water for these purposes has consequently led to a close relationship between water availability and economic development of a region. To forestall the problem water can constitute in economic development of an area, requires proper planning and management of water resources. This is because, the challenge in most communities today is not only the problem of obtaining the minimum quantity of water needed to sustain life, but also that of the quality of water readily available for use, (Ezenwaji, 2010). According to author, the main reason for the poor health of the people has largely been attributed to the consumption of contaminated water from very doubtful supplementary sources. These sources often comprise rivers, streams, shallow wells and rain water.

Dams are established purposely to create room for the storage of water for irrigation or farming purposes and to produce electricity. In the generation of electricity or hydro-electrical power, water is collected or stored at a higher elevation and led downward through large pipes or tunnels (penstocks)to a lower elevation; the difference in these two elevations is known as the *head*, Encyclopedia Britannica,2001). In the course of its passage down the steep pipes, the falling water rotates the turbine, which eventually drives generators that convert the turbines' mechanical energy into electricity.

Other benefits of dams include: artificial lakes pondering behind dams provide great potentialities for fishing, irrigation, industrial and municipal water supply. The lake offers modifying influence on the weather /climate of the adjacent lands. Equally, the lake and dams as well as power stations in the catchment areas would be features of tourist interest.

The growth of towns and the neighboring communities benefiting from dams would be attributed to the influence of the dam.

By holding back some of the waters of the dam controls its flow and reduces flooding.

The project, when properly managed will generate several employments to benefiting areas.

On the negative side, the dam project will make some places/adjacent settlements flooded and submerged as the water is held back with a rise in its level. This may lead to the building of new settlements, with staggering costs.

Increases in the incidence of disease spread and outbreak of water borne diseases are common features of dam areas.

Large scale deforestation and land degradation are associated with dam construction.

At the international level, the usefulness of dams is considered in nations' economic viability. The Colorado river for example, is a major factor in the live and future of all the people in the great Southwest, (Encyclopedia Americana, 2006). In 1922, when the seven state Colorado river compact was drawn, modern efforts to control and use the river began, the first unit in the Colorado river project was the Hoover dam, between Nevada and Arizona. It was further revealed that, completed in 1936, its hydroelectric power plant supplied California with Industrial power. Similarly, the Mammoth Glen Canyon dam, just above Marble Gorge of Grand Canyon, was completed in 1964, the very year the Niger dam Project, Nigeria commenced.

In Nigeria, the Niger dam Project is a major dam project with outstanding socio-economic relevance. The major work on the project started in 1964 and the first phase was completed in 1968, formally opened up on 15th February, 1969. It has an overall length of 8km and a crest height of 145 meters, fitted with several spillways and lock gates. The principal aim of the Niger Dams Project is to provide the much needed power for the expanding Nigerian industries, (Iloeje, 1980). Work on it was divided into three phases. The first of it was scheduled for the 1962 – 68 plan period. It involved the construction of a dam across the river Niger at Kainji and the installation of a power station nearby with 4 generating plants. The second was the addition of 8 more generating plants in the same station and the building of a subsidiary dam at Jebba fitted with lock gates. The dam was meant to raise the level of the water below Kainji so that ships could sail on it with greater comfort. In the third and final phase, another dam was built across river Kaduna at the Shiroro Gorge, and a smaller power station erected there. According to the author, the Federal Government appointed the Niger dams Authority to plan and undertake this work. As at then, the sum of #72.4million and a loan of #103million from abroad were provided by the Federal Government and Foreign finance respectively, from which the first phase of the project was financed. The Kainji dams have an ultimate capacity of 960MW. In addition to the work at the main site itself, substations have been built at Jebba, Oshogbo, Lagos Benin, Kaduna and Asaba. These stations and the high voltage lines which connect them to kainji help to distribute the power to the western, north central and south eastern industrial zones in Nigeria.

Another good example of dam is the Oyan river dam in Abeokuta North local government area of Ogun state – Nigeria. The dam crosses the Oyan river, the tributary of Ogun river, used primarily to supply water to Lagos and Abeokuta. According to Wikipedia.org (2019), the dam has the potential for use in Irrigation and power generation. The said dam was commissioned on 29th March, 1983 by President Shehu Shagari and it is operated by the Ogun-Osun River Basin development Authority. Located in the Savanna region, the lake is surrounded by sparse trees and grasses and low fertile soil. It covers 4000 hectares and has a catchment area of 9000 square kilometers, a crest length of 1044m, height of 30.4m and gross storage capacity of 270 million m^3. The dam offered both negative and positive impact on the affected communities. During construction, 22 villages were submerged with the displaced people moved to three settlement camps, (Wikipedia.org, 2019). According the Wikipedia, some of the settlers fish the lake and farm vegetables along the fertile shoreline as the lake recedes in the dry season. Beneficiaries of the dam water were said to have been infected with water borne diseases due to the use of untreated water. An earlier study in 1990 – 1993 had indicated that the risk of the disease (urinary schistosomiasis), which is carried by snails could be greatly reduced if the reservoir were continuously discharged during the hot dry season.

In May 2009, after heavy rains, the dam operators were forced to release exceptional amounts of water from the dam for safety reasons, causing some flooding over an area of 2,800 hectares.

The cost implications were equally high. In 2010, the Federal Government budgeted N43 million for construction of the gravity irrigation scheme at the dam and N11 million for dam operations.

Data Presentation and Analysis

In the analysis of data, changes in land uses between 2013 & 2019 were determined with upto date and current remotely sensed images. The software adopted for this study included Idrisi Andes (land use modeler), ArcGIS 10.5, Erdas Imaging. The land use categories used in this work include built up areas, bare land, agricultural land, vegetation and water body.

The post classification comparison change detection method was used in this analysis. This was implemented with the Land use Change Modeler (LCM) of the Idrisi software environment to derive comprehensive land use to and fro transition maps for changes between 2013and 2019. A Markovian process was used to determine exactly how much land would be expected to transit from the later date to the predicted date based on a projection of the transition potentials into the future for which a transition probabilities file was

created. This was achieved by developing a transition probability matrix of land use change from one time to another, which shows the nature of change while still serving as the basis for projecting to a later time period. The images used in this analysis have been provided in figures 2 and 3 below.

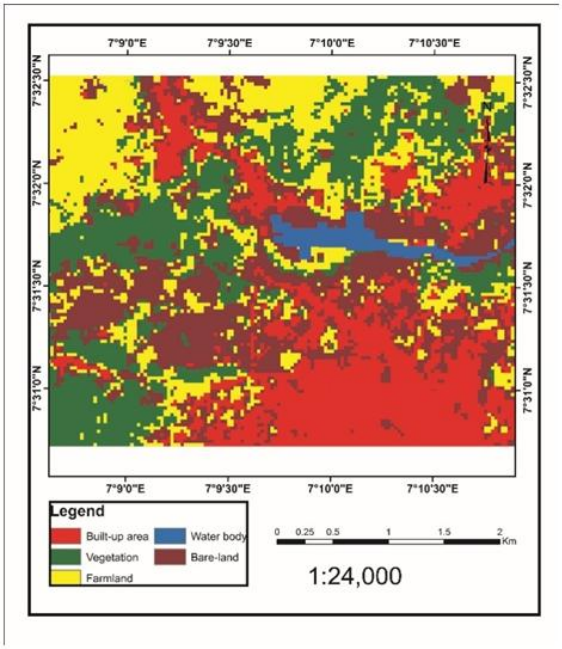

Figure 2: Land Use Classes of 2013

Source: Arise Geospatial Consults, Anyigba, (2019).

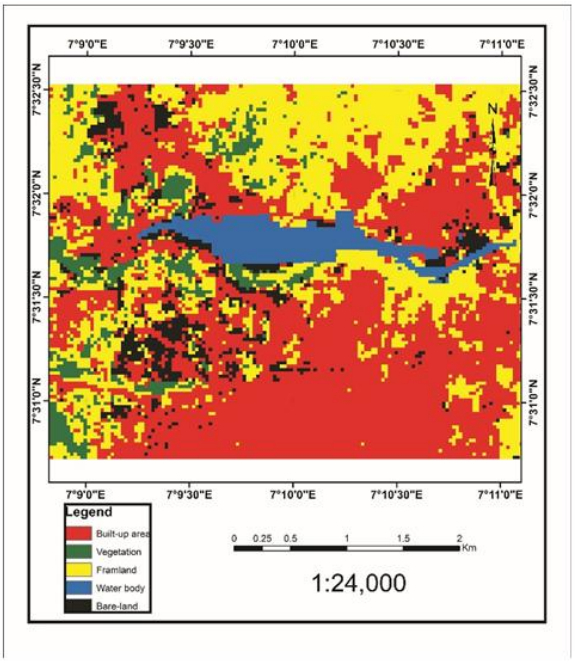

Figure 3: Land Use Classes of 2019

Source: Arise Geospatial Consults, Anyigba, (2019).

Table 1: Study area under different land uses, 2013 and 2019

	2013		2019		Change in Land uses between 2013 & 2019 (ha)
FEATURES	**AREA**	**PERCENT**	**AREA**	**PERCENT**	
Built-up area	3.5973	18.56	7.7634	40.06	4.17
Vegetation	5.2515	27.10	3.2688	16.87	-1.98
Farmland	5.5773	28.78	6.7401	34.78	1.16
Water body	0.1062	0.55	0.1818	0.94	0.08
Bare-land	4.8483	25.02	1.4265	7.36	-3.42
Grand Total	**19.3806**	**100**	**19.3806**	**100**	

Source: Arise Geospatial Consults, Anyigba, (2019).

VII. DISCUSSION OF RESULTS

In this analysis, five different categories of land use types were identified and analyzed. They include the built-up areas, vegetation covered areas, farm lands water bodies and bare surfaces. These landuses have been distributed in table 1, it show cased the classified landuse maps of the Ofu dam catchment area, measuring 19.3806 hectares, for the periods between 2013 and 2019. There are however variations in the extent of the landuses between 2013 and 2019 due to a number of influence which have both biophysical/environmental and socio-economic/human background. The result of this change detection shows that in 2013, the total land covered by built-up area was 3.5973ha while in 2019, it increased to 7.7634, this is indicative of a positive change at the rate of 40.06%. This particular landuse created the highest impact on the environment more than the remaining four landuses with a change detection rate amounting to 4.17 ha. The highest increase recorded by built-up area is evident in the number of buildings being developed in response to the rapid urbanization being experienced in the study area. However, the drastic decrease witnessed in vegetation and vacant land can be associated to the expansion of built-up area, water body (dam) and cultivated land uses. This finding corroborates the finding of Ifatimehin and Musa (2008) that the need for houses, open space and food are most responsible for the decrease in vegetal cover of a place.

The negative change in the area covered with vegetation from 5.2515ha to 3.2688ha in 2013 and 2019 respectively indicated much devegetation activities in the study area. Similarly a percentage difference of 16.87 was recorded for the area within the period of study. This phenomenon could be interpreted to mean that the damming of the Ofu stream in the area caused significant loss of vegetation, particularly within the catchment area. Correspondingly, the rise in the water volume attested to these losses also, as the catchment area became flooded. The impact would be more pronounced during subsequent rainy season and flood events, as revealed during onsite visit.

The consequence of these rising devegetation activities was demonstrated by the expansion in the size of farmlands, from 5.5773ha to 6.7401ha between 2013 and 2019 respectively. Two factors are inherently responsible for this expansion. These could be explained by the fact that the dam waters provided additional waters for farming purposes in the area; the recent policy of the present administration that encouraged more people to engage in farming activities and traditionally, the involvement of a larger proportion of the people in agricultural practices.

The proportion of the remaining bare lanscape is insignificant, compared with other landuses, for any reasonable socio-economic functions as such lands tend to be degraded and unproductive. Bare land accounts for 4.8483ha and 1.4265ha in 2013 and 2019 respectively at a percentage difference of -3.42.

Implicatively, this rate of change occupied an additional land area of about 4.17 ha. It means more damages are done on the ecosystem – the vegetation, water, soil, climate and numerous ecosystem services. Predictably, in the next two to three decades, a significant proportion of the landscape would be wrought with more influences, causing more damages to the environment. These damages range from displacement of existing natural and human features, ecosystem disruption, lost of useful plants and animal species (biodiversity loss) and pollution.

VIII. CONCLUSION

In this study, an intensive biophysical survey and analyses of the effects of the Ofu dam projects on the landscape was carried out with significant results. The study which spanned over a period of 6 to 8 months employed both survey and analytical methodologies to generate data. Data for the work were subjected to laboratory and statistical analyses in order to provide a suitable geo-database for reference purposes. Under careful management and preservation of soil, the accumulation of soil organic matter through soil restorative practices can help to improve soil productivity resulting in greater farm profitability. This is particularly important in soils that have been negatively altered by flooded waters from the dam project. It was thus proved that the stream basin is well capable of absorbing water into the surrounding soil and at the same time recharging groundwater while reducing the risk of floods. If such floods happen, they could be managed easily from this type of elongated catchments than from circular basins. The results of the areal morphologic study revealed that the Stream catchment is morphometrically capable of reducing the flood risk. Suggestively, sustainable management plans should be made in advance with a view to coping with the potential floods that can take place as a result of high precipitation as has been the case with downside flood plains for years. Similarly, while dams constructions are been agitated in the region, proactive steps should be taken to address the fallout from the projects in order to avert the negative consequences resulting from them.

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