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Impacts of loss of vegetation cover on biodiversity of Ikere-gorge, Oyo State Nigeria

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Abstract

Climate change is inevitable as it is caused by natural phenomenon but most often by human induced activities; the impacts of which can be devastating. Ikere-gorge is a freshwater ecosystem. The impact of climate change on Ikere-gorge is examined in this study. Remote sensing technique is employed and land use/cover classification was adopted. The processing of satellite data involved the manipulation and interpretation of images. The results showed that there was loss of vegetation cover around Ikere-groge. But, flow modification was governed by management decision, vegetation cover and climate change. The resultant effect of this was the observed dryness of some parts and changes in the shape of Ikere-gorge. The implication of this is that the biodiversity of Ikere-gorge is vulnerable to these changes. This led to change, modification and/or destruction of ecosystem. The ready-to-spawn fish lost their eggs and they were even becoming prey easily. The most affected fish were the newly spawned or recruited fish (billions of fish eggs, fry, fingerlings and juveniles) that could not swim swiftly to escape into the deeper parts of the gorge. Therefore, management of Ikere-gorge should be holistic incorporating all necessary stakeholders for the survival of the gorge and sustainability of the biodiversity it supports.

Keywords: Freshwater ecosystem; vegetation cover; flow modification; vulnerable; fingerlings

Impacts de la perte du couvert végétal sur la biodiversité de la gorge d'Ikere, état d'Oyo Nigeria

Résumé

Le changement climatique est inévitable car il est causé par des phénomènes naturels mais le plus souvent par des activités anthropiques; dont les effets peuvent être dévastateurs. Ikere-gorge est un écosystème d'eau douce. L'impact du changement climatique sur la gorge d'Ikere est examiné dans cette étude. Une technique de télédétection est employée et une classification de l'utilisation / couverture des terres a été adoptée. Le traitement des données satellitaires impliquait la manipulation et l'interprétation d'images. Les résultats ont montré qu'il y avait une perte de couverture végétale autour d'Ikere-groge. Mais la modification du débit était régie par la décision de gestion, la couverture végétale et le changement climatique. Cela a eu pour effet la sécheresse observée de certaines parties et des changements dans la forme de la gorge d'Ikere. L'implication de ceci est que la biodiversité d'Ikere-gorge est vulnérable à ces changements. Cela a conduit au changement, à la *modification et / ou à la destruction de l'écosystème. Les poissons prêts à frayer perdaient leurs œufs et devenaient même facilement des proies. Les poissons les plus touchés étaient les poissons nouvellement pondus ou recrutés (milliards d'œufs de poissons, alevins, alevins et juvéniles) qui ne pouvaient pas nager rapidement pour s'échapper dans les parties les plus profondes de la gorge. Par conséquent, la gestion d'Ikere-gorge doit être holistique et intégrer toutes les parties prenantes nécessaires à la survie de la gorge et à la durabilité de la biodiversité qu'elle soutient.*

Mots clés: écosystème d'eau douce; couverture végétale; modification du débit; vulnérable; alevins

Introduction

In freshwater ecosystems, there is diversity of aquatic habitats that determines the diversity of aquatic organisms. Therefore, the greater the diversity of aquatic habitats in a freshwater ecosystem, the greater the aquatic biodiversity they support. Meanwhile, the magnitude of biodiversity that each aquatic habitat supports is different with respect to its composition, human interference and other factors like weather variability. There is no aquatic habitat that is void of aquatic organisms. Each aquatic habitat accommodates variety of organisms that can adapt to its compositional structures and as such some organisms are named after their habitat. Nevertheless, freshwater habitats and aquatic organisms that inhabit them may be subjected to stress, complete displacement and destruction as a result of disturbances cause by anthropogenic activities and climate change. The disturbances caused as a result of human activities include overexploitation; increase in demand and consumption of water resources; changes in riparian and catchments vegetation; alteration of flow regimes; increase level of pollution; habitat loss and degradation; non-native species; change of land use – as many wetland have been converted to agricultural lands; *inter alia* (Darwall *et al*. 2018; Craig *et al*. 2017; Ramsar, 2017). These threats usually do not occur singly in freshwater ecosystems and their combine effects are described to be synergistic, antagonistic, additive and reversed. The resultant impacts of any of these combined effects of freshwater ecosystem threats with that of climate change make the aquatic organisms in freshwater habitats more vulnerable than terrestrial organisms. The disasters caused by climate change may be significantly higher than disasters caused by all other stressors. As a result of this, freshwater organisms are often displaced and may sometime loss from their native habitats. They have no ability or opportunity to escape life threatening conditions they are exposed to; making their conservation and restoration more difficult (Barange *et al*. 2018; Darwall *et al*. 2018; Craig *et al*. 2017). Temperature and rainfall are significant weather variables that have pronounced impacts on freshwater ecosystem. The increase in water temperature as a result of air temperature often forms the basis of impacts of climate change on freshwater ecosystem. Freshwater organisms are mostly ectotherms and their metabolism increases with water temperature; all their biological and chemical activities are influence by temperature. Water temperature and most other water quality parameters are climate dependent. The increase in water temperature can be more than 1.8 ºC contributing to high rate of species loss in freshwater ecosystems. Variability in rainfall can be linked to flow modification and change in water quality. Freshwater biodiversity is highly susceptible to climate change (Barange *et al*. 2018). Therefore, this study aims to investigate the impacts of climate change on flow modification and biodiversity of Ikere-gorge.

Materials and methods

Ikere-gorge is a 565 million cubic meters (mcm) multipurpose dam located at Ikere village, about 28km, North East of Iseyin in Oyo State. Ikere-gorge is located between longitude 8°10ˈ and 8° 20ˈN and latitude 3° 40ˈ and 3° 50ˈE (Figure 1). Ikere- gorge took its source from Sepeteri about 40 Km to Ikere through Asamu and Alagbon. Ikere-gorge has Ogun River as its major tributary and River Amaka, River Oowe and River Owu as its minor tributaries. Ikere gorge has twelve fishing villages, each village situated at a distance round the dam.

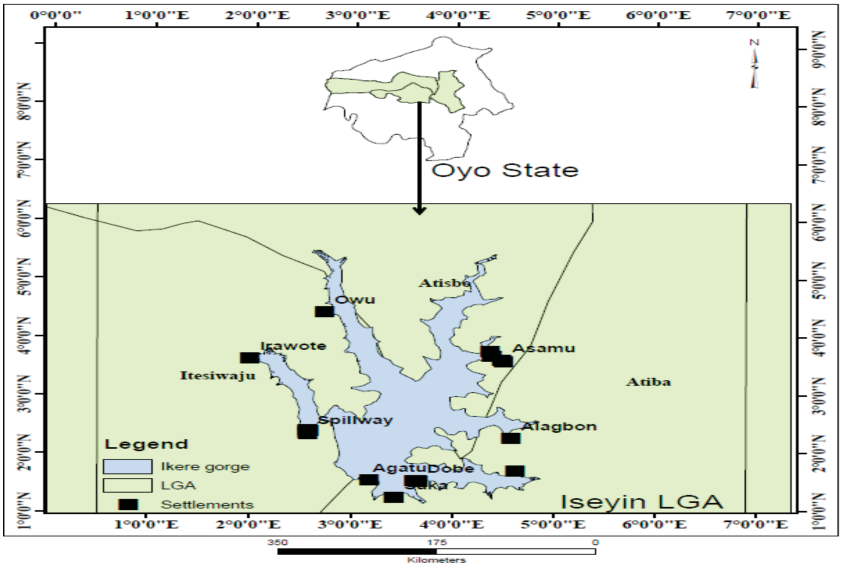

Figure 1: Map of Ikere-gorge dam (showing some fishing villages), Oyo State, Nigeria

Fish and aquatic plants sampling methods

Four sampling sites; Asamu, Agatu, Spillway and Irawote were randomly selected. The locations of the sampling sites and other fishing villages were documented using global positioning system. The selected sampling sites were sampled monthly for a period of twenty-four months (January 2017 to December 2018). Different fish species were sampled and examined from fishermen catch in each selected fishing village. The catches were sorted into taxonomic groups (species and families) using standard fish identification keys provided by Adesulu and Sydenham (2007); Olaosebikan and Raji (2013) keys. Aquatic plants were assessed by taking the inventory of floating; emergent and submerged plants of the dam. Adesina *et al.* (2011) sampling method was adopted and *identification was done using identification keys such as: Akobundu and Agyakwa (1998)* and web based manual.

Land cover development

Data set

Landsat satellite images of 2000 and 2019 were mined from the official website of US Geological Survey (USGS). The study area is located in the Landsat path 191 and row 54. The pixel sizes of the images are 30 x 30m. All the images were obtained in the same season (dry season). The obtained Landsat data (Level 1 Terrain Corrected (L1T) product have been pre-geo-referenced to UTM zone 31 North projection using WGS-84 datum. SRTM image was used to determine water depth. The other necessary corrections have been performed in this study. Table 1 presents the specifications of Landsat TM, ETM+ and OLI images.

Table 1: Research materials used

Satellite Sensor	Spatial resolution	Acquisition Years	Path	Row
Landsat 5, 8	30m x 30m	2009, and 2019	191	54
SRTM	30m interval	2018	-	-

Image classification

To classify the images, a modified version of the Anderson scheme of land use/cover classification was adopted and the categories include:

i. Vegetation area
ii. Bare surface area and
iii. Water body

The satellite data (Images) processing involves the manipulation and interpretation of images. The results form a new digital image was displayed in pictorial format. A digital cloud or satellite data (images) are typically composed of picture elements (pixels) located at the intersection of each row i and column j in each K bands of imagery. Associated with each pixel is a number known as Digital Number (DN) or Brightness Value (BV) that depicts the average radiance of a relatively small area within a scene. A smaller number indicates low average radiance from the area and the high number is an indicator of high radiant properties of the area. Digital Number (DN) of a 10 x 10 pixel are used in this study (Lillesand and Kiefer, 2008).

Results

Satellite imagery results presented the impacts of climate change on the biodiversity of Ikere-gorge over a period of 19 years between years 2000 and 2019. The result showed a distinct vegetation cover between Year 2000 and Year 2019 in Ikere-gorge are shown in Figures 2 and 3, respectively. The comparison of Figures 2 and 3 showed that there was deforestation over the period of investigation. There was increase in the percentage of bare soil in all parts of Ikere-gorge. This was more pronounced towards the southern parts of Ikere-gorge. The people of Ikere-gorge depend mainly on fuel wood as the source of all their domestic energy needs. They used fuel wood for fish processing that is, fish smoking. Wood was also used for the construction of fishing crafts like canoes and paddles. Wood is use for charcoal production, which is another lucrative enterprise in Ikere-gorge. All these activities are responsible for reduction in vegetation cover and corresponding increase in bare soil (deforestation). The only remaining sacred part and unaffected were the parts belonging to Old Oyo National Park located at the northern part of Ikere-gorge. These areas were guarded with securities and has minimal human imparts. The satellite imagery of water boundary of Ikere-gorge for the 2019 was superimposed on that of the 2000 (Figure 4). The result showed that Ikere-gorge has shrunk or reduced in size compared to her size in 2000. The dried part observed at Spillway fishing village in Ikere-gorge between May and July 2017 was inserted in Figure 4. The other dried or shrunk parts are shown as lighter blue colour in Figure 4. It was observed that the resultant effects of loss of vegetation covers, rose in temperature and unregulated water discharge led to the observed dryness or shrinking of outer parts in Ikere-gorge.

The flow modification and observed dryness had great impacts on fish population and other aquatic organisms of Ikere-gorge. This study sampled 41 fish species belonging to 13 families in Ikere-gorge. The most abundant families were Mormyridae (10), Cichlidae (8) and Cyprinidae (6). Bagridae family was represented by three species, while each of Channidae, Mochokidae, Clariidae, Alestidae, and Malapteruridae family had two species representation and likewise each of Arapaimidae, Hepsetidae, Centoropomidae, and Schilbeidae had one species representation in the fish composition of Ikere-gorge (Table 2). Likewise, 23 species of aquatic plants distributed among 13 families were identified; from which 13 were emergent, seven were floating and three were submerged (Table 3).

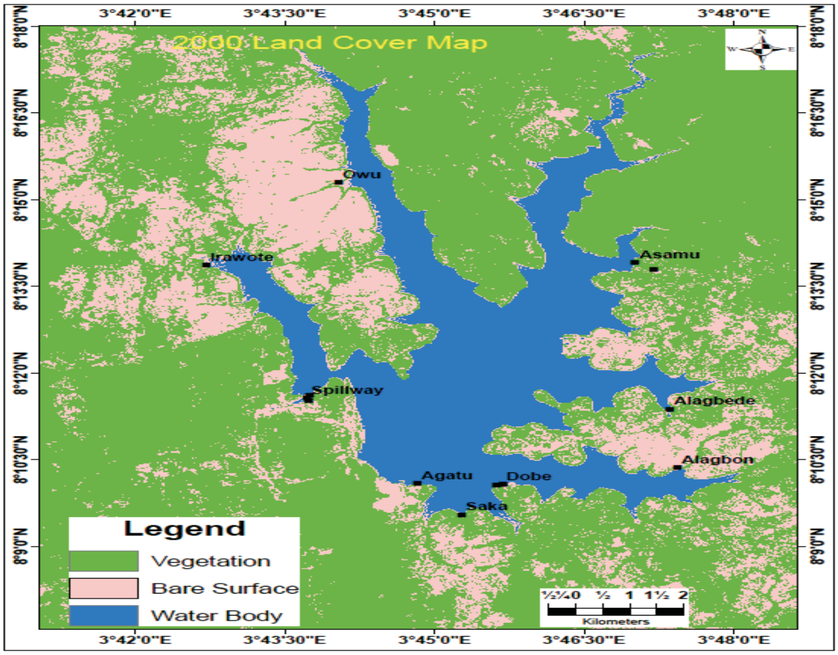

Figure 2: The vegetation cover map of Ikere-gorge, Iseyin, Oyo State, Nigeria for the Year 2000

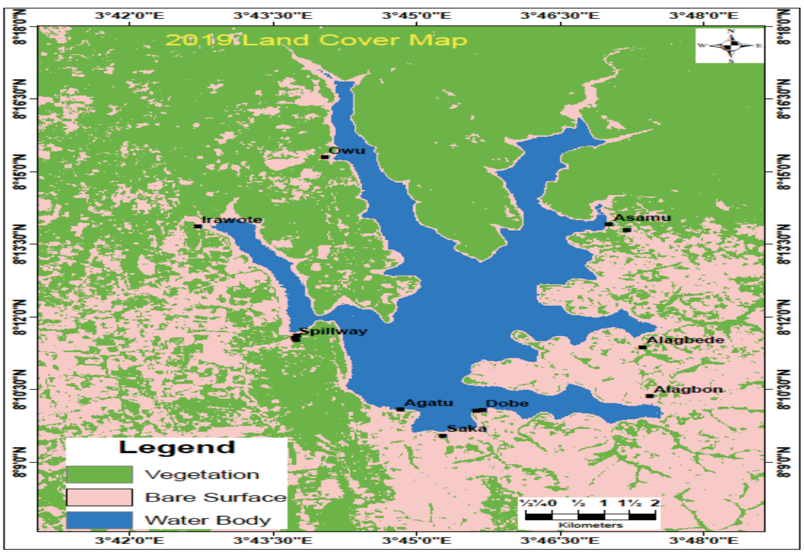

Figure 3: The vegetation cover map of Ikere-gorge, Iseyin, Oyo State, Nigeria for the Year 2019

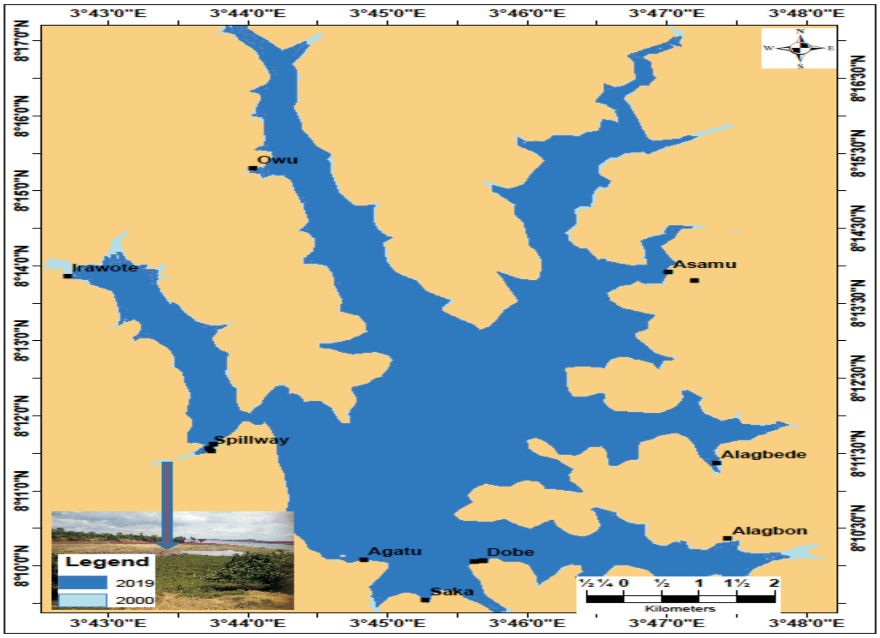

Figure 4: The satellite imagery superimposed 2019 imagery on 2000 imagery to show the dried parts of Ikere-gorge, Oyo State, Nigeria

The dryness altered the flow of water and destroys fish habitats in Ikere-gorge for that period of dryness. Aquatic plants provide suitable habitats for fish; such as spawning and nursery grounds. These aquatic plants were found at shallow parts of the gorge, where the current was minimal and suitable for fish recruitment. Therefore, another effect of dryness was the destruction of spawning grounds of most fishes in Ikere-gorge. The dried parts were exposed to direct solar radiation and become football pitch and playing sites for kids. This led to change, modification and/or destruction of ecosystem. The ready-to-spawn fish lost their eggs and they were even prey easily. The most affected fish were the newly spawned or recruited fish (billions of fish eggs, fry, fingerlings and juveniles) that could not swim swiftly to escape into the deeper parts of the gorge. The abundance of fish and other aquatic organisms lost as a result of dryness of Ikere-gorge could not be easily estimated. Another, observation was that, in the absence of flow of water at the dried parts of Ikere-gorge, weed and aquatic plants overgrown the stream path. This was also observed to increase when the water level was increase to cover the dried parts. This caused a change of ecosystem but, as the water level increases, the abundance of weeds were decreasing and the ecosystem was restored.

Discussion

Flow modification in Ikere-gorge is governed by the management decision, loss of vegetation and climate change. Management decision to discharge water is necessary to control flood in and around Ikere-gorge. This is in agreement with Mims and Olden (2013) report that flood control is one of the major reasons people have altered stream flow. But, the effects of loss of vegetation and climate change constitutes another factor for flow regime

Table 2: Fish species of Ikere gorge, Iseyin, Oyo State, Nigeria

Fish family	Finfish species
Bagridae	*Chrysichthys nigrodigitatus*
	Bagrus docmak
	Auchenoglanis occidentalis
Arapaimidae	*Heterotis niloticus*
Channidae	*Parachanna Africana*
	Parachanna obscura
Cichlidae	*Oreochromis niloticus*
	Sarotherodon galilaeus
	Tylochromis jentinki
	Pelmatolapia mariae
	Coptodon zillii
	Chromidotilapia guntheri
	Coptodon guineensis
	Hemichromis faciatus
Mormyridae	*Mormyrus rume*
	Hyperopisus bebe
	Petrocephalus bovei
	Mormyrops anguilloides
	Mormyrops oudoti
	Brienomyrus brachyistius
	Pollimyrus isidori
	Brienomyrus niger
	Marcusenius senegalensis
	Gnathonemus brucii
Mochokidae	*Synodontis batensoda*
	Synodontis nigrita
Clariidae	*Heterobranchus longifilis*
	Clarias gariepinus
Hepsetidae	*Hepsetus odoe*
Centoropomidae	*Lates niloticus*
Schilbeidae	*Schilbe mystus*
Alestidae	*Brycinus macrolepidotus*
	Brycinus longipinnis
Cyprinidae	*Labeo coubie*
	Labeo parvus
	Raiamas senegalensis
	Leptocypris niloticus
	Barbus chlorotaenia
	Barbus occidentalis
Malapteruridae	*Malapterurus beninensis*
	Malapterurus electricus

Table 3: Checklist of species composition of aquatic plants of Ikere-gorge, Iseyin

Family	Plant Species	Ecological status
Araceae	*Pistia stratiotes*	Floating
Ceratophyllaceae	*Ceratophyllum demersum*	Submerged
Convolvulaceae	*Ipomoea aquatic*	Emergent
	Ipomoea asarifolia	Emergent
Cyperaceae	*Carex autro-africana*	Emergent
	Cyperus dives	Emergent
	Rynchospora corymbosa	Emergent
	Scirpus articulates	Emergent
Fabaceae	*Neptunia oleracea*	Floating
Hydrocharitaceae	*Najas guadalupensis*	Submerged
Nymphaeaceae	*Nymphaea caerulea*	Floating
	Nymphaea lotus	Floating
	Nymphaea nouchalia	Floating
Onagraceae	*Ludwigia decurrens*	Emergent
	Ludwigia stolonifer	Floating
Salviniaceae	*Salvinia molesta*	Floating
Polygonaceae	*Persicaria senegalensis*	Emergent
	Polygonum senegalense	Emergent
Sphenocleaceae	*Sphenoclea zeylanica*	Emergent
Poaceae	*Echinochloa pyramidalis*	Emergent
Poaceae	*Phragmites australis*	Emergent
Poaceae	*Andropogon tectrum*	Emergent
Potamogetonaceae	*Potamogeton schweinfurthii*	Submerged

alteration and will interact with other anthropogenic flow modifications as seen in Ikere-gorge causing additional stress to freshwater ecosystems; leaving it particularly vulnerable (Mittal *et al*. 2015; Dyer *et al*. 2014; Schneider *et al*. 2013; Döll and Zhang, 2010). This is consistent with the report of Sun *et al*. (2017) that in a particular climate zone, vegetation cover change is one of the important contributing factors to streamflow variations. The effect of this is cut across broad taxonomic groups like aquatic plants, invertebrates and fish. The indication of this is that biota inhabit this parts of the gorge will be displaced, migrated or dead. Flow modification has been identified as one of the management tools that cause threat to biodiversity (Ramsar, 2017). Bunn and Arthington (2002) reported that the alteration of flow regimes is often claimed to be the most serious and continuing threat to ecological sustainability of rivers and their associated floodplain wetlands. Fish assemblage is also strongly related to habitat structure. Associations between fish and their habitat are influenced by flow variability at a range of spatial scales. The modification to flow regimes affects fish diversity and the functional organization of fish communities in regulated rivers. Poff and Zimmerman (2010) concluded that the biotic integrity of fish assemblages generally decreased with increased flow alteration.

The regulation of flow by opening and closing of Ikere-gorge which meant to be done in a sustainable way that will not cause damage to ecosystem and biodiversity they support; is particularly vulnerable as climate change is exacerbate the effects of regulation and placing many aquatic biological communities at risk. This is also extended to the observed changes in the shape and structure of Ikere-gorge as a result of flow modifications (Stagl and Hattermann, 2016; Dyer *et al*. 2014; Schneider *et al*. 2013). Fish abundance, demographic parameters, and diversity were found to consistently decline in response to both increases and decreases in flow magnitude. The most vulnerable among aquatic organisms affected by the flow modification are the fish eggs, newly recruited fish, fingerlings, juveniles, invertebrates, and etcetera depending on their sizes and stage of life.

Conclusion

Ikere-goorge as a freshwater ecosystem offered invaluable services to people living far and near the gorge. But, the ecosystem was threatening by flow modification especially caused by indiscriminate loss of vegetation cover and climate change. The effects of this are manifold but include loss of spawning and nursery grounds; dryness, alteration to shape and structure of the gorge. Therefore, management of Ikere-gorge should be holistic incorporating all necessary stakeholders such as scientists from hydrological, ecological and geomorphological field of studies to provide vital information for the survival of the gorge and sustainability of the biodiversity is supports. However, continuous monitoring and assessment of baseline conditions of Ikere-groge is highly recommended.

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