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RESEARCH ARTICLE

Effect of Harnessing Water Resources in Geographical and Ecological Diversity in Enugu State, Nigeria

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ABSTRACT

This study examined the means of harnessing water resources in the midst of geographical and ecological diversity. The variable adopted by the study is the effect of the dry season and rainy season on ecological diversity in southeast Nigeria. The study adopts an in-depth review of existing literature that relates to the theme under consideration. The result revealed that the dry season has a significant negative effect on ecological diversity, it shows dry seasons always produce high levels of water scarcity in ecological diversity while the rainy season has a significant positive effect on ecological diversity, it shows that the rainy season always produces enough water for the ecological diversity. We concluded that there is always a high level of water scarcity during the dry season, which results in water harassment while there is always enough water during the rainy season. We recommend that a provision should be made during the rainy season for the preservation of water against the dry season.

***Keywords**: Ecological Diversity; Water Resources; Enugu State*

Introduction

The occurrence of the water cycle is a means of aiding the ecosystem in the provision of resources like food and fuel, regulating and supporting the environment and its biological diversity, and providing cultural services and fundamental ecological processes. Therefore, sustainable management of water resources is dire for both ecosystem health and food production. The challenges linked to increasing water scarcity highlight the need to achieve a very high degree of possible water use efficiency (Lloyd et al., 2013). Water is a fundamental need with vast implications for sanitation and hygiene, agriculture and food production, industrialization, and development. Goal six of the Sustainable Development Goals (SDG) aims to fulfill all water needs by 2030. Water drives economic growth and supports healthy ecosystems, agriculture, energy production, sanitation, and sustainable waste management. The significance of water to economic growth, healthy living, and the prevention of the spread of infectious diseases, manufacturing, and industrialization cannot be overstated (Onuh and Bassey, 2021).

Water resource systems have benefited both people and their economies for many centuries. The services provided by such systems are multiple. Yet in many regions of the world, they are not able to meet even basic drinking water and sanitation needs nor can many of this water resource systems support and maintain resilient biodiversity/ecosystems (Loucks and Beek, 2017). Almost half of the world's population faces water scarcity. Water use has grown at more than twice the rate of population growth in the past century. Although there is not a global water shortage, about 2.8 billion people representing more than 40% of the world's population, live in river basins with some form of water scarcity. More than 1.2 billion of them live under conditions of physical water scarcity, which occurs when more than 75% of river flows are withdrawn (WHO and UNICEF JMP, 2010).

Accessibility of water resources for human consumption and ecosystems largely depends on the spatiotemporal distribution of both precipitation and evaporation. As a result, changes in characteristics of precipitation and evaporation due to human-caused climate change in the 21st century may result in changes in water availability

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(WA) that have implications for both humans and the biosphere (Konapala, Mishra, Wada, and Mann, 2020). Nigeria is endowed with enormous water resources as is evident in the volume of rainfall, and surface and underground water deposits, and yet, the gap between water needs and water supply appears to be widening. Water resource development in Nigeria is threatened by both natural factors such as outcomes of climate change, and hydrological extremes and anthropogenic factors such as pollution of water bodies with industrial wastes, oil spillages, and salinity of surface and ground waters through irrigation and fertilizers. These natural and anthropogenic threats to water sources trigger variations in the physiochemical and biological characteristics of the water, ultimately impairing the quality of the water (Onuh and Bassey, 2021).

Although Nigeria has abundant freshwater resources in some regions, the per capita national average of about 2260m^3 puts Nigeria in the category of water-scarce countries (FAO, 2005). Even in regions where water is physically abundant, this has not translated to access for the population, due to poor liquid resources and infrastructure development (Uguru and Meldrum, 2019). Also, the fact that human activities always involve landscape modifications is now being increasingly realized and causing a shift in thinking among ecologists. While it is being increasingly understood that humanity will have to live with change, sustainable development is about sustaining the potential and capacity for prosperous social and economic development. It relies on ecosystem services and support and will continue to do so in the foreseeable future. Current approaches are getting more process-oriented with stress on the biophysical interactions between water (the bloodstream of the biosphere) and ecosystems (Falkenmark, 2003).

Statement of the problem

Owing to harsh environmental conditions the weather is hotter and drier and the effect of desert encroachment is so adverse in some regions compared to other parts of the country. The underlying causes of water scarcity in Nigeria are largely due to institutional failures, poor water governance, and water pollution are widespread. In addition, the sub-continent of Sub-Saharan Africa where Nigeria is located is particularly dry. Many rural communities in Nigeria are exposed to the variability of water supplies as a result of seasonal variations in rainfall affecting river flow; especially in the dryer region of the country. It is important to note that although there is more physical availability of water in the rainy season due to higher precipitation, the lack of protection of water sources from pollution often leads to widespread contamination from stormwater, compounded by poor sanitary conditions. These lead to water scarcity due to the lack of quality of the water resources that are available.

Aim of the study

The aim of this research is to investigate the means of harnessing water resources in the midst of geographical and ecological diversity in Enugu state, Nigeria.

The objective of the study

The specific objectives include:

i. To examine the effect of the dry season on ecological diversity in Enugu state, Nigeria.
ii. To examine the effect of the rainy season on ecological diversity in Enugu state, Nigeria.

Hypotheses of study

i. The dry season has no significant effect on ecological diversity in Enugu state, Nigeria.
ii. The rainy season has no significant effect on ecological diversity in Enugu state, Nigeria.

Review of Related Literature

Water Resources

Water resources and ecological biodiversity are intimately interrelated and interdependent. Both provide a wide range of functions and have intrinsic value as well as provide for the sustenance of human populations. Degradation of water quality, depletion of water resources, and loss of aquatic biodiversity are prominent features of the environmental/geographical landscape diversity requiring urgent attention at global and national scales (Alkins-Koo et al., 2004). The groundwater and surface water quality is a function of natural influences and human activities either severally or collectively. Without human influences, water quality would be influenced only by natural processes such as weathering of bedrock minerals, atmospheric processes involving evapotranspiration, deposition of dust and salt by the wind, natural leaching of organic matter and nutrients from the soil, hydrological factors leading to runoff and biological processes in the aquatic environment that may bring about changes in the physical and chemical composition of water. Thus, water in the natural environment may contain dissolved substances as well as non-dissolved particulate matter. Minerals and dissolved salts are necessary components of good quality water as they help maintain the health and vitality of organisms that rely on this ecosystem service (Khatri and Tyagi, 2014).

The quality of both surface water and groundwater is affected by natural and anthropogenic factors. The natural factors that affect water quality in rural and urban areas are similar. The composition of surface water and groundwater is dependent on e.g., geological, topographical, meteorological, hydrological, and biological factors. It varies with seasonal differences in weather conditions, runoff volumes, and water levels (Khatri and Tyagi, 2014). For instance, the impact of seasonal dynamics on the bacteria community was analyzed in that study. Changes in seasons have an impact on bacteria population and composition as a result of multiple environmental pressures and this has been proven by various studies exploring the impact of seasonal changes on bacteria communities in diverse ecosystems (Wang et al., 2019).

Ecological and Geographical Diversity

The term ecosystem refers to a set of interacting organisms and the solar-driven system that they compose, comprising both primary producers, consumers, and decomposers. In combination, they mediate the flow of energy, the cycling of elements (including water), and spatial and temporal patterns of vegetation. An ecosystem may be of any scale from global all the way down to local. At the upper end of the scale, the life support system of our planet is an ecosystem energized by solar energy and kept together by the circulating water that functions as the bloodstream. At the lower end of the scale, the local biotic systems are spoken of as ecosystems: grassland, a forest, a lake, a stream, and so on. This is the kind of ecosystem that supports local societies with crops, fodder, fuel, wood, timber, fish, meat, and so on, and that local inhabitants strongly care about (Falkenmark, 2003).

The diversity of the ecosystem is a complex, spatially explicit aspect of biodiversity, which is affected by bioclimatic, geographic, and anthropogenic variables. The distribution of habitat types is a key component for understanding broad-scale biodiversity and for developing conservation strategies (Cervellini et al., 2021). Ecosystem diversity deals with the variations in ecosystems within a geographical location and its overall impact on human existence and the environment. Ecosystem diversity addresses the combined characteristics of biotic properties (biodiversity) and abiotic properties (geo-diversity). It is the variation in the ecosystems found in a region or the variation in ecosystems over the whole planet. Ecological diversity includes the variation in both terrestrial and aquatic ecosystems. Ecological diversity can also take into account the variation in the complexity of a biological community, including the number of different niches, and the number of other ecological processes. An example of ecological diversity on a global scale would be the variation in ecosystems, such as deserts, forests, grasslands, wetlands, and oceans (Alkins-Koo et al., 2004).

Geological factors are due to the contribution of the geosphere to groundwater composition, mainly through the effect of chemical water–rock interactions in aquifers. The main factors affecting water quality in wells drilled into bedrock seem to be the rock type and the mode of weathering of the particulate minerals. The composition of the bedrock influences not only the chemical composition of the groundwater in the fissures and fractures but also that of the groundwater in Quaternary deposits (Stark et al., 2000). Geographic diversity is described as diversity in the locations where people, by choice or necessity, live and work (Angus, Atalay, Newton, and Ubilava, 2020).

When there are no human influences, changes in water quality occur due to factors such as weathering of bedrock, evapotranspiration, and the deposition of dust and salt by the wind. Furthermore, natural processes such as the leaching of organic matter and nutrients from the soil, hydrological factors leading to runoff, and biological processes within the aquatic environment bring about changes in the physical and chemical composition of water. Thus, due to these natural processes, water in the natural environment may contain dissolved as well as undissolved solids. Although some dissolved salts and minerals are necessary components of good quality water as they help maintain the health and vitality of organisms that rely on this ecosystem service (Stark et al. 2000). All these factors affecting water sources have prompted research in the area of water resource management.

Effects of Seasonal variations on Ecological Diversity

Most ecosystems work in a cause-effect relationship. When one resource is lost or added, it affects the entire ecosystem. A good example is the food chain, an integral part of an ecosystem. If the lowest life form in the food chain disappears, then larger animals may begin to die off. When seasons change, the biological and chemical functions of an entire ecosystem are altered. When one resource is lost or added, it affects the entire ecosystem. Climate change is expected to negatively impact ecosystems. Hence, ecosystems adapt to the cycles of the seasons, but climate change radically shifts the cycle, harming all parts of the ecosystem (Fitzpatrick, 2010). The seasonal variability of water input and atmospheric conditions generates differences in hydrological partitioning and can lead to divergent patterns of ecosystem water use and productivity. Larger rainfall events combined with higher radiation and atmospheric water, during rainy season demand typically lead to higher water losses through evapotranspiration (ET) and from runoff occurring through various channels. While the lower intensity precipitation during the winter, when radiation and atmospheric water demands are much lower, typically favors the downward percolation of water through deeper soil layers, with minimal ET and runoff production, but may still support ecosystem productivity and water use within that season (Perez-Ruiz, Vivoni and Sala, 2022).

The inter-annual variability of water and carbon dynamics revealed that net ecosystem productivity during the wet season was unaffected by its proportion of annual rainfall. This was attributed to the inability of the shrubland to fully utilize available soil water within the wet season, and to the hydrological processes leading to runoff production and channel transmission losses. Higher proportional rainfall during the wet season benefits the hydrological partitioning of water into subsurface storage, which then serves to increase dry season Net Ecosystem Production (NEP). The soil moisture carryover is considered a legacy effect mediated by landscape properties in the watershed. This mechanism allowed for water to be reserved for ecosystem use during the dry season, when gross primary productivity (GPP) can be sustained at higher levels than total rainfall, thus enhancing annual NEP and the strength of the mixed shrubland (Perez-Ruiz, Vivoni, and Sala, 2022).

Water Resource Management

Water resources management refers to a whole range of different activities: monitoring, modeling, exploration, assessment, design of measures and strategies, implementation of policy, operation, and maintenance, and evaluation of water resources. It also covers supportive activities such as institutional reform. Water resources management includes local, national, and international activities, directed at either the short or the long term. As such, water resources management is rather a diffuse field. It includes the whole set of scientific, technical, institutional, managerial, legal, and operational activities required to plan, develop, operate, and manage water resources (Savenije and Hoekstra, 2002).

Water resources management includes management at two distinct levels. Management at the first level refers to the actual tasks and central objectives of the water manager. This includes all activities directly aimed at the sustainable use of water, the provision of clean drinking water to all, the allocation of water to different sectors of society, the provision of safety against flooding, etc. Management at the second level refers to the management of the management organization and process itself. It is supportive of the actual tasks of the water manager. Management at the first level is also called external management, while management at the second level is referred to as internal management (Savenije and Hoekstra, 2002).

Integrated Water Resources Management (IWRM) may be defined as a process that promotes the coordinated development and management of water, land, and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. IWRM aims to strike a balance between the use of water resources for livelihoods and the conservation of the resources to sustain their functions for future generations. The definition of IWRM promotes economic efficiency, environmental sustainability, and societal equity. Water resources have to be used to increase economic and social welfare without compromising the sustainability of vital ecosystems (Falkenmark, 2003).

The dearth of water management and supply system in Nigeria has led to many citizens resorting to self-help and exploiting the underground water resources in an unstructured and uncoordinated, and unsustainable manner. As noted by Omole (2013) in Onuh and Bassey (2021), over 60% of Nigerians with access to drinking water now get it from underground sources. According to the author, sustainable groundwater use in Nigeria is challenged by funding, weak institutions, poor data management system, and poor implementation of groundwater exploitation regulation, in addition to hydrological factors. Many private business ventures have emerged from the decadence of water management and supply in Nigeria. The uncoordinated exploitation of groundwater may have other consequences, considering that geological and anthropogenic conditions may affect the quality of the water.

Some private individuals and business concerns usually do not have the capacity to treat the water before making it available for human consumption. This is the case in most urban areas in Nigeria, where groundwater quality is affected by the geochemistry of the environment, rate of urbanization, industrialization, landfill and dumpsite leachates, and heavy metals (Onuh and Bassey, 2021). Other fundamental challenges to water resources in Nigeria include wetland degradation and climate change among others. All these have caused the need to look into the proper management of water resources amidst geographical and ecological diversity. Hence, this study is to assess how to harness water resources in ecological and geographical diversities.

Materials and Method

Materials were drawn mainly from an in-depth review of existing literature that relates to the theme under consideration. They include maps,

Study Area

The study area is within the Anambra Basin in the Lower Benue Trough, Southeast Nigeria. The formation of the Benue Trough sedimentary basin followed the break-up and separation of the South American and African continents in the Early Cretaceous. Three major tectonic cycles can be identified in southeastern Nigeria. The first major tectonic phase (Aptian–Early Santonian) is related to the initial rifting and the opening of the Benue Trough. The second phase (Santonian–Early Campanian) was characterized by compression tectonics resulting in the folding and uplift of the Abakaliki Anticlinorium, the subsequent formation of the Anambra Basin, and the complimentary Afikpo Syncline. The third phase (Late Campanian–Eocene) involved rapid subsidence and uplift in alternation with subsequent progradation of a delta and deposition of the Anambra Basin sedimentary fill. The Anambra Basin is a Cretaceous depocentre that received Campanian–Tertiary sediments (Obiadi, Obiadi, Akudinobi, Maduewesi, & Ezim, 2016).

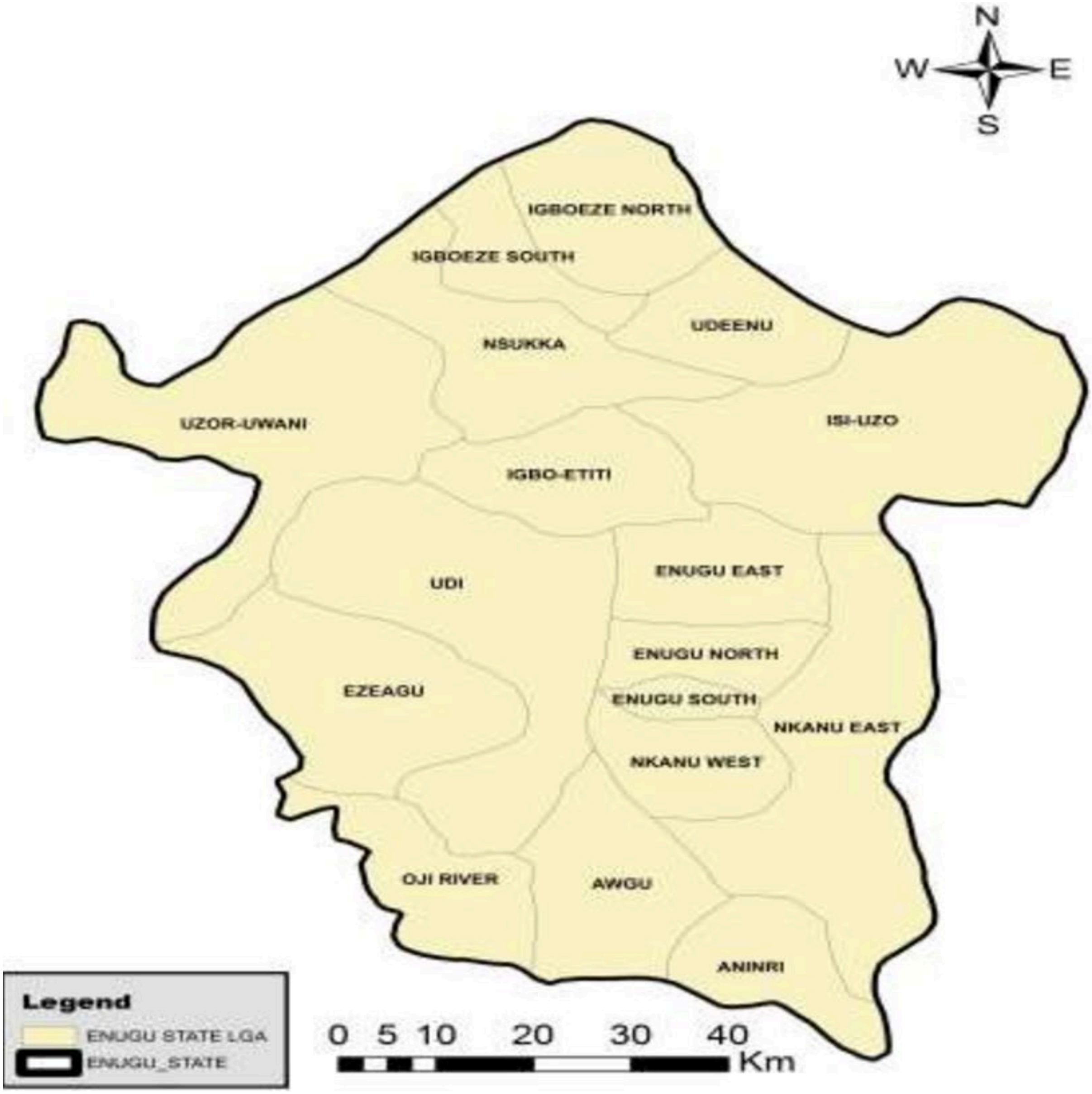

Figure 1. Study Area: Enugu State

Enugu State is in the South East geo-political Zone of Nigeria. It is located at 6°30' North of the Equator, and 7°30' East of Latitude. Enugu, a town, capital of Enugu state, southeastern Nigeria, is located at the foot of the Udi Plateau. Enugu is on the railroad from Port Harcourt, 150 miles (240 km) south-southwest, and at the intersection of roads from Aba, Onitsha, and Abakaliki. The town owes its existence to the discovery of coal on the plateau in 1909, which led to the building of Port Harcourt. With the completion of the railway from the port in 1916, Enugu developed rapidly. Its name comes from the traditional Igbo (Igbo) word "menu Ugwu", meaning "at the top of the hill." It covers an area of 7,161 km2 (2,765sq m) and ranks 29th out of the 36 States of Nigeria in terms of land area. Enugu State has good climatic condition all year round. The hottest month is February with about 87.16°F (30.64°C), while the lowest temperature is recorded in November/December, reaching about 60.54°F (15.86°C). The lowest rainfall of about 0.16 cubic centimeters (0.0098 cu in) is recorded in February, while the highest rainfall is recorded in July at about 35.7 cubic centimeters (2.18 cu in) (Britannica).

Results and Discussion

Plate 1: Effect of the dry season on ecological diversity

The plate above showed the effect of the dry season on ecological diversity. A dry climate is a region of the world where there is little precipitation and the air is very dry, according to Maps of the World. Dry climate is divided by climatologists into the subclassifications of dry arid and dry semiarid.

Plate 2: The Effect of the rainy season on ecological diversity.

The plate above shows the effect of the rainy season on ecological diversity. The **temperatures** also vary in a remarkable way depending on the climatic zones. In the north, **winter** is warm and dry; it can get uncomfortably hot during the day, up to 40 °C (104 °F), but it is usually cool at night, and it can even get cold in the northern hilly areas, where cold records are around freezing (0 °C or 32 °F). By February, the **heat** increases in all the inland areas, and it becomes scorching in the center-north from March to May, when temperatures can easily reach 40 °C (104 °F). On the contrary, in the south, the increase in temperature is limited, both because of the proximity to the ocean and because the rain showers begin earlier. The **rains** increase in intensity and frequency and gradually move to the north until they affect all of the countries in June. In the area where the wet front advances, clashing with the existing hot and dry air mass, small tornadoes may form. **From June to September**, the air is humid and the sky is usually cloudy throughout the country; temperatures are uniform, and are everywhere around 28/30 °C (82/86 °F); the daytime temperatures are lower than in winter, but relative humidity is higher.

Conclusion

Based on the study, the dry season has a significant negative impact on ecological diversity because there is always a high level of water scarcity during this time of year, and the ecosystem suffers from having to heavily rely on water resources in the middle of a geographically challenging area. In contrast, the rainy season shows that it has a significant positive impact because the temperatures are always very favorable for both plants and animals in the ecosystem. Ecological diversity always has a lot of water available to it.

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