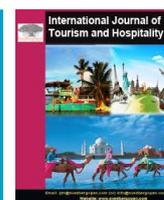




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Research Paper

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Hydrometeorological Systems of Major River Basins for optimizing Agricultural and Tourism Potential in Ekiti State, Nigeria

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Abstract

This study explores the hydrometeorological systems of major river basins in Ekiti State, Nigeria, to enhance agricultural and tourism potential. The state's river catchment basins, including Ero, Oye, Ogbese, and Little Osse, offer valuable resources for both the environment and humans. With a mean annual rainfall of 1400mm to 1800mm, the area's hydrologic characteristics were analyzed to identify opportunities for development. The study reveals varying hydrologic ratios, rainfall seasonality indices, and specific water consumption values across the river basins. Ero environment shows a high hydrologic ratio of 0.75 to 0.85, indicating its viability for agricultural and tourism activities. In contrast, Ogbese basin's hydrologic ratio of 0.6 to 0.5 suggests inadequate soil moisture in certain areas. The findings of this study can inform decision-making for farmers, sustainable tourism practices, water resources management, and policy-making, ultimately contributing to the diversification of the economic base of the study area. By understanding the hydrometeorological systems of Ekiti State's river basins, stakeholders can unlock opportunities for sustainable development and economic growth.

Keywords: *Hydrometeorological, Major river, Catchment basins, Tourism, Agriculture, Agritourism, Hydrotourism, Landform-Landuse*

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1. Introduction

Tourism is a significant economic driver that can bring numerous benefits to developing countries. By expanding services and commercializing indigenous products, tourism generates economic effects and adds value to local societies (Fernandes *et al.*, 2020; UNWTO, 2023). As one of the world's largest economic sectors, tourism fosters job creation, drives exports, and promotes prosperity globally (UNWTO, 2024). The importance of tourism is underscored by the 2024 World Tourism Day theme, "Tourism and Peace," highlighting its potential to contribute to global harmony and development. Moreover, tourism can help achieve the Sustainable Development Goals (SDGs) in disadvantaged regions, making it a vital tool for promoting economic growth and social progress (Omonijo *et al.*, 2025).

The relationship between agriculture and tourism highlights the importance of environmental and social responsibility in rural areas (Bowen *et al.*, 1991; Gálvez *et al.*, 2023). Agriculture not only supplies the tourism industry with food

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resources but also contributes to the economic development of rural areas in developing countries (Telfer and Wall, 1996; Wang *et al.*, 2024). Agritourism, a form of tourism that involves leisure, recreational, or educational activities related to agriculture, offers a unique opportunity for tourists to engage with rural communities and experience local culture (Ammirato *et al.*, 2020; Roman and Grudzień, 2021; UNWTO, 2012). By promoting agritourism, rural areas can diversify their economy, preserve traditional practices, and showcase their natural beauty.

The global water landscape is facing significant challenges, with water use increasing substantially since the end of the last millennium (Gössling *et al.*, 2012; CDP, 2010). Climate change is projected to exacerbate water scarcity, affecting approximately 3.2 billion people by 2100 under a 4°C global warming scenario (Parry *et al.*, 2009a; Rosenzweig, 2021; Heitman *et al.*, 2023). The drivers of increased global water use include population growth, economic expansion, technological advancements, international trade, and agricultural demands (Özsayin, 2024). Agriculture is expected to be the primary factor in future water consumption, highlighting the need for sustainable water management practices (UN-Water, 2009).

In the face of climate change, supplementing rainfed agriculture with additional water supply is crucial in many regions. This is due to declining groundwater and glacial ice, water pollution, and changes in precipitation patterns, leading to increased frequency of droughts and evaporation (IPCC, 2024; Parry *et al.*, 2009a; Heitman *et al.*, 2023). A recent study by Ray and Majumder (2024) highlights the significant role of irrigation in agriculture, accounting for nearly 70% of total water withdrawals and over 90% of consumptive water use. Effective water management strategies are essential to ensure sustainable agricultural practices and mitigate the impacts of water scarcity. Water is a vital component of tourism infrastructure and recreational activities, such as swimming, sailing, and fishing, which are enjoyed by many tourists (Auernheimer and González, 2002; Ikpi and Offem, 2012; Digun-Aweto and Oladele, 2018). Various types of tourism, including agritourism and wildlife tourism, also indirectly depend on water (Carpio *et al.*, 2008; Goharipour and Hajiluie, 2006; Olaniyi *et al.*, 2016).

The tourism industry's water use is expected to increase due to factors such as growing tourist numbers, higher hotel standards, and more water-intensive tourism activities (UNWTO-UNEP-WMO, 2008). Recent studies confirm this trend, citing increased water demands from spas, wellness areas, and swimming pools, as well as higher water consumption for food and fuel (Omonijo, 2024). In Nigeria, various hydrological modeling studies have been conducted to better understand the country's water resources (Adefolalu, 1996; Adejuwon, 1994; Omonijo, 2000; Omonijo and Ojomo, 2005; Omonijo *et al.*, 2003; Ndulue *et al.*, 2018; Oseke *et al.*, 2021; Adeogun *et al.*, 2014; Ukpai, 2024). This study aims to promote Ekiti State, Nigeria as a prominent tourism destination, leverage on agritourism and hydrotourism to generate foreign exchange and fight poverty.

1.1. Water-Based Tourism (Hydrotourism)

Water-based tourism, or hydrotourism, is a vital component of the global tourism industry, attracting millions of tourists worldwide (Gössling *et al.*, 2012; Hall and Stoffels, 2006; Auernheimer and González, 2002; Ikpi and Offem, 2012; Digun-Aweto and Oladele, 2018). According to the World Tourism Organization, international tourism has experienced a remarkable rebound, with 1.4 billion international arrivals and \$1.9 tn spent on tourism in 2024, marking a near-complete recovery from pre-pandemic levels (UNWTO, 2025). The tourism industry has experienced a strong rebound from recent crises, supporting economic growth and well-being (OECD, 2024). However, the recovery is uneven, and new challenges such as geopolitical tensions, cost-of-living pressures, and climate-related events require robust policies to build a more resilient, sustainable, and inclusive future for the tourism sector.

The tourism sector is expected to continue growing, with widening impacts on socio-economic development in both mature and emerging destinations (WEF, 2024; OECD, 2024; UNWTO, 2025). As the number of tourists increases, it is essential to keep pace with their needs while addressing the challenges posed by climate change and economic uncertainty. Water-based tourism can play a significant role in promoting sustainable development and economic growth, while also providing opportunities for people to enjoy and appreciate natural resources.

Water-based tourism is a significant aspect of the industry, with various studies addressing its importance (Campón-Cerro *et al.*, 2020; Rahmat *et al.*, 2023; Wirakusuma, 2017; Folgado-Fernández *et al.*, 2018). Many researchers have highlighted the importance of water in tourism, including its role in supporting various indoor and outdoor settings (Alonso-Almeida, 2012; Borboudaki *et al.*, 2005; Sánchez and Sellers-Rubio, 2020; Yfantidou *et al.*, 2024; Pàsková *et al.*, 2024). These studies highlight the need for a better understanding of the value of water, enhancing the quality of life for everyone, and safeguarding ecosystems.

The significance of water in tourism is further underscored by the fact that water stress affects a large and growing share of humanity, with an estimated 450 million people already living under severe water stress in 1995 (Vörösmarty

et al., 2000). Climate change is expected to exacerbate water scarcity, affecting up to 3.2 billion people by 2100 under a 4°C global warming scenario (Parry *et al.*, 2009a; Parry *et al.*, 2009b). As the tourism industry continues to grow, it is crucial to manage water resources sustainably to ensure the long-term viability of water-based tourism activities.

1.2. Agriculture and Tourism (Agritourism)

Agritourism is a growing sector that combines agriculture and tourism, offering a range of benefits for local economies and communities. Studies have shown that agritourism can generate additional income, diversify the farming economy, and form a symbiotic relationship between agriculture and tourism (Pavić *et al.*, 2018). It can also have economic incentives, including increased income and marketing possibilities, as well as improving farmers' livelihoods (LaPan and Barbieri, 2014; McGehee and Kim, 2004; Schilling *et al.*, 2012). However, agritourism attractions may face seasonal challenges, with fluctuations in visitor numbers and income throughout the year (DeLay *et al.*, 2019).

Research has also highlighted the potential for agritourism to contribute to farm incomes, with tourists' farm overnight stays accounting for around 10% of total farm incomes in some cases (Fischer, 2019). Additionally, agritourism can create opportunities for the supply of commercial agricultural products to the tourism industry, as seen in the case of Bale Mountains National Park in Ethiopia (Welteji and Zerihun, 2018).

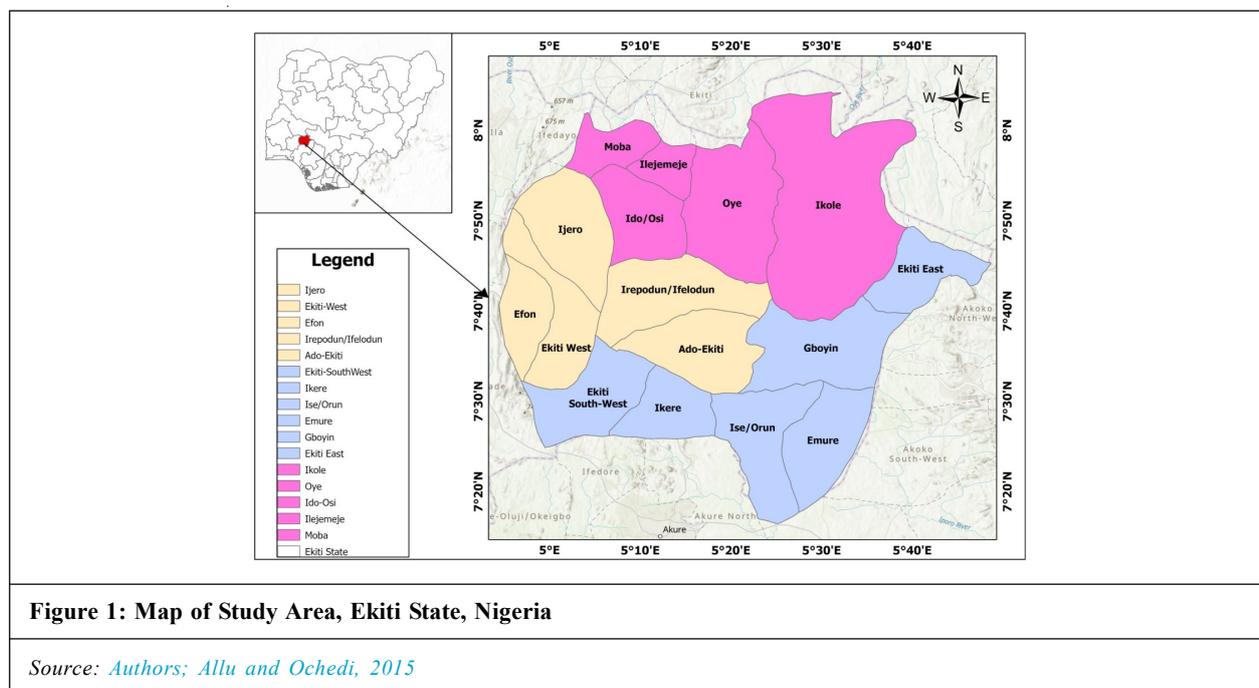
The global agriculture industry is significant, with countries like Brazil, India, and Thailand being major producers of crops such as sugarcane (Msomba *et al.*, 2024). Agritourism can provide opportunities for farmers and local communities to benefit from tourism, while also promoting sustainable agriculture practices and preserving natural resources.

2. Materials and Methods

2.1. Study Area

Ekiti State, Nigeria, is located between longitudes 4.82° E and 5.60° E and latitudes 7.84° N and 8.27° N, in Figure 1 (Allu and Ochedi, 2015) and reproduced by ArcGIS Pro 2.0 (ESRI, 2017), is a beautiful region with diverse natural features, including rocks, mountains, cloud formations, and warm springs. The state's unique attractions have prompted the government to establish the Bureau of Tourism Development, aiming to leverage tourism for economic growth.

This study focuses on four major rivers in Ekiti State: *Ero*, *Oye*, *Ogbese*, and *Little Osse*. These rivers were selected due to their economic potential in agriculture and tourism, particularly in agritourism, which can contribute to the state's economic development. The study area's natural resources and tourism potential make it an ideal location for exploring the intersection of agriculture and tourism.



2.2. Identification, Description, Hydrological Data Collection and Analysis

The instruments used for this study were extensive field survey and hydrological data/information and analysis, such as, rainfall and soil moisture relationship; gradient values for assessing soil erodibility and water logging/flood problems;

and Landform-Landuse features for 30 years (1995-2024) period obtained from the Benin Owena River Basin Development Authority (BORBDA), an organization saddled with the responsibilities of collation and documentation of hydrological information among others within the catchment Basins by the Federal Government of Nigeria. The Global Positioning System (GPS) Meter, ([Garmin GPS etrex 10, 2011](#)) was used for the locations of rivers for this study. Hydro-eco zones of major river catchment basins of the study area were mapped for easy identification and location for tourists.

These methods enabled the collection of accurate and reliable data, which were analyzed to have knowledge of the hydrological characteristics of the study area and inform the development of agritourism and hydrotourism initiatives potential.

2.2.1. Rainfall and Soil Moisture Relationship

Rainfall is a crucial element of climate that determines water availability in river basins. The relationship between rainfall and soil moisture is vital in understanding the hydrological characteristics of an area. The hydrologic ratio (λ) is a useful parameter that measures precipitation effectiveness, indicating the degree of wetness or dryness of a place.

The hydrologic ratio is calculated based on annual rainfall and potential evapotranspiration (PE), providing insights into soil moisture surplus or deficit ([Thornthwaite and Mather, 1955](#); [Dourado-Neto et al., 2010](#)).

That is;

$$\lambda = \frac{\bar{P}}{PE}$$

where \bar{P} is the annual rainfall; PE is the potential evapotranspiration.

The above relationship is essential in understanding the water balance in river basins and informing decisions on agriculture, tourism, and water resource management.

2.2.2. Rainfall Seasonality Index

The Rainfall Seasonality Index (SI) measures the distribution of rainfall throughout the year, providing insights into the variability of precipitation patterns. It is calculated as the absolute deviations of mean monthly rainfall from the overall long-term monthly mean, weighted by mean annual rainfall ([Walsh and Lawler, 1981](#); [Sadiq, 2020](#)).

$$SI(SA) = \bar{R}(SA)^{-1} \left[\left| \bar{r}(i, SA) - \bar{r}(SA) \right| \right]$$

where $\bar{R}(SA)$: Long-term mean annual rainfall

$\bar{r}(i, SA)$: Mean monthly rainfall at the study area

$\bar{r}(SA)$: Overall (long-term) monthly rainfall

The SI is a useful tool for understanding the seasonality of rainfall in a given area, allowing researchers to identify patterns and trends in precipitation. By analyzing the SI , it is possible to gain a better understanding of the hydrological characteristics of a region and inform decisions related to agriculture, water resource management, and tourism development.

2.2.3. Specific Water Consumption

Specific Water Consumption (W) measures the amount of water used or required in a particular area, taking into account factors such as rainfall, evaporation, and seasonal variations. It is calculated using a formula that considers the length of wet and dry seasons, rates of evaporation, and average daily rainfall during these periods ([Broering et al., 2024](#)).

The water consumption (W) for a particular area (A) is defined as:

$$\frac{W}{F} = [Dr(Qr - Pr) + Dd(Qd - Pd)]$$

where: W : Water (equivalent of rainfall) to avert drought

F : Constant (which is derived from area A)

Dr : Length of wet season in days

Dd : Length of dry season in days

Qr : Rate of evaporation during wet period

Qd : Rate of evaporation during dry period

Pr : Average daily rainfall during wet period

Pd : Average daily rainfall during dry period

Determination of Specific Water Consumption by researchers can lead into the water requirements of a given area, informing decisions related to water resource management, agriculture, and tourism development. This information can help identify areas where water conservation measures may be necessary and optimize water use for various purposes.

3. Results

The study reveals the findings of an extensive field survey, hydrological analysis, and environmental assessment of the hydro-eco zones of major river catchment basins in the study area. The results include the identification and location of rivers *Ero*, *Oye*, *Ogbese*, and *Little Osse* within the study area, as illustrated in Figure 2. These findings provide valuable insights into the hydrological characteristics and environmental factors of the study area, laying the groundwork for further analysis and recommendations.

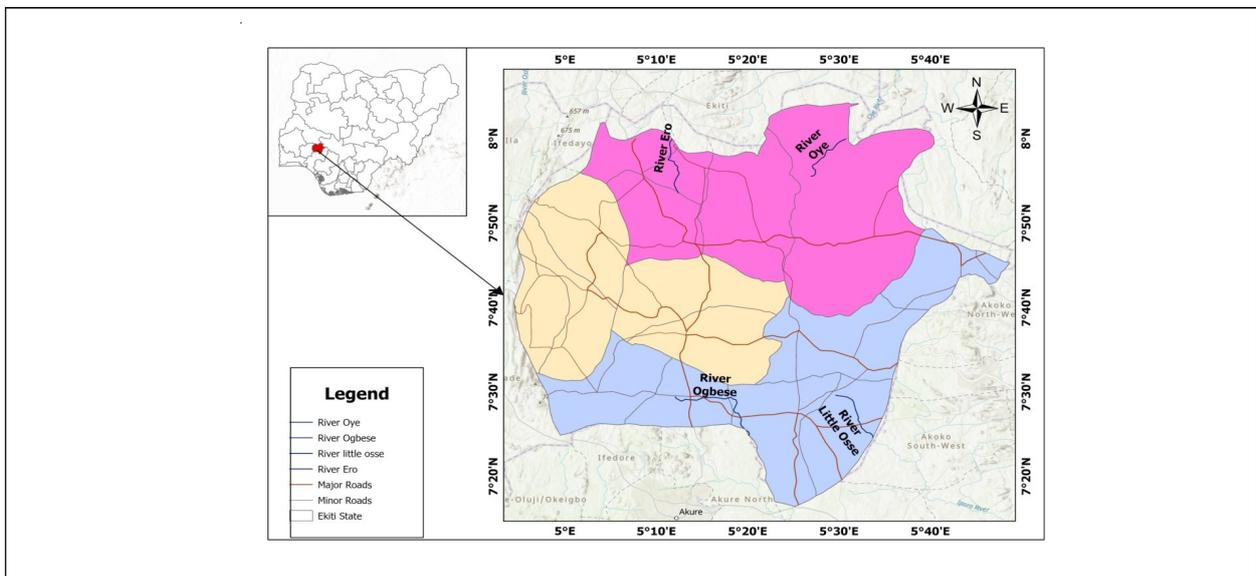


Figure 2: Map of Study Area, Ekiti State Showing Rivers *Ero*, *Oye*, *Ogbese* and *Little Osse*

Source: Authors

Ero–Oye Basin: The *Ero-Oye* basin is located in the northern part of Ekiti State, comprises Rivers *Ero* and *Oye*, as well as River *Ele*. The basin covers several local government areas, including Moba, Oye, Ido-Osi, Ikole, and Ekiti East. River *Ero* is dammed at Ikun-Ekiti, providing pipe-borne water to numerous towns and villages. The water in the dam is usually overflowed at the peak of rainy season between July and September (Figures 3 and 4).

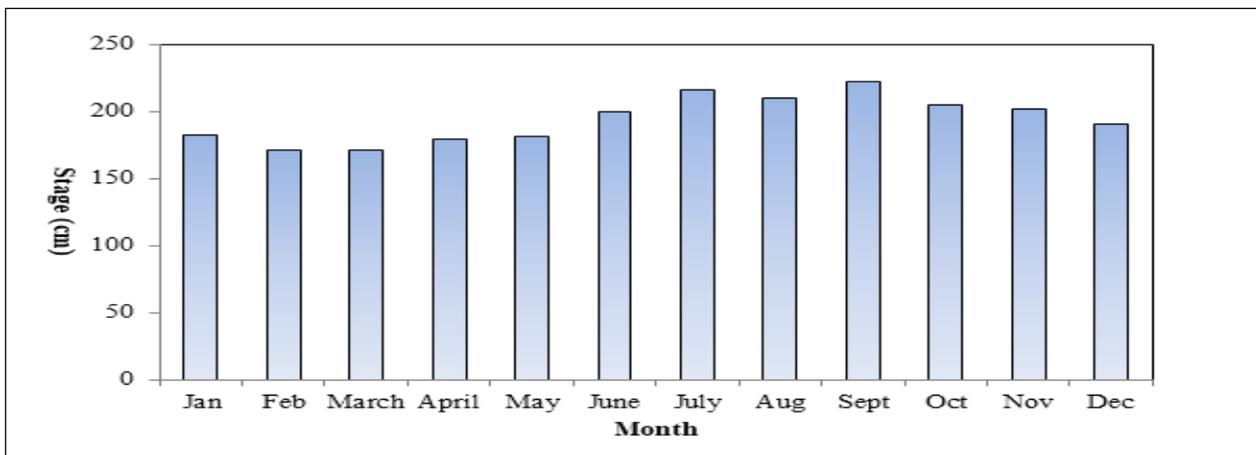


Figure 3: Mean Monthly Values of Water-Stages of River *Ero* at Ikun-Ekiti (Moba LGA), Ekiti State, Nigeria (1995-2024)

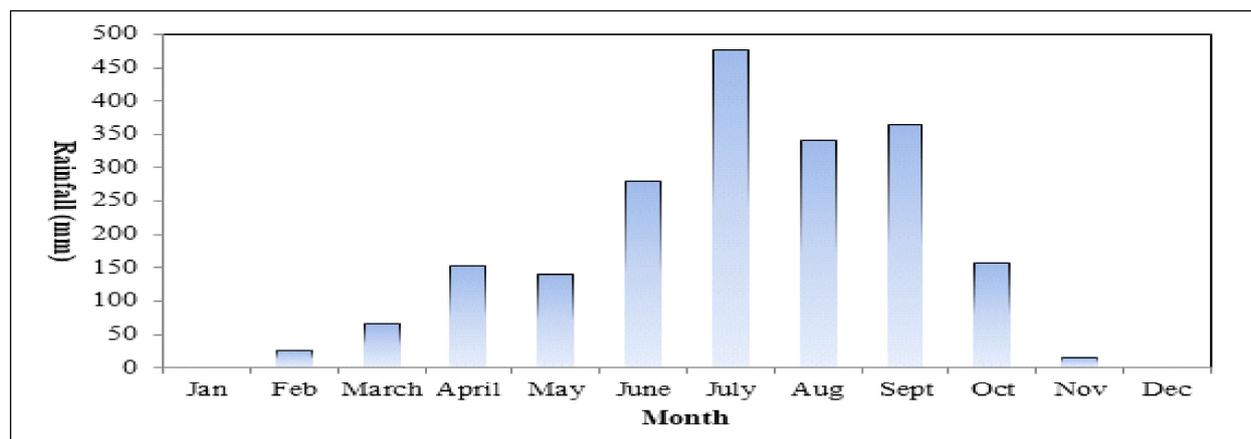


Figure 4: Mean Monthly Rainfall at Weather Station, Otun-Ekiti (Moba LGA Secretariat), Ekiti State, Nigeria (1995-2024)

The southeastern part of the study area receives a mean annual rainfall of approximately 1800mm, gradually decreasing westward to over 1400 mm in the central region, with a secondary peak observed in the extreme western sector. Notably, River *Oye* flows southward through an area with rainfall ranging from 1400 mm to 1600 mm, allowing it to accumulate water from numerous tributaries along its course toward Ire-Ekiti. The rainfall distribution pattern aligns with the degree of wetness or dryness, as represented by the Hydrologic ratio (\bar{Z}). The high Hydrologic ratio values (0.75 to 0.85) near the *Ero* dam suggest reduced water loss to evapotranspiration, indicating a more stable environment conducive to improved crop management and yield enhancement.

The Rainfall Seasonality Index varies between the *Oye* catchment basin (0.4) and the *Ero* catchment basin (0.8), indicating a more pronounced seasonality in the *Ero* basin. Both basins experience a gradual decline in rainfall steadiness. Due to lower rainfall in the *Ero* basin, Specific Water Consumption values range from 200mm to 300mm, whereas the *Oye* basin exhibits lower water needs, ranging from 0 to 200mm. Analysis reveals that the *Oye* channel falls within a near hydroneutral zone, characterized by values between 0 and -100mm. The *Ero* basin's gradient is relatively gentle, ranging from 0 to 25, and the *Ero* dam's water extends approximately 2km upstream. The *Oye* environment's rugged hill ranges support well-organized streamlets, contributing twice the water to the *Oye* catchment basin compared to those feeding the *Ero* downstream.

The most pressing concern regarding landform modification is the expansive *Ero* dam, which poses a significant threat to the town housing it due to its gross underutilization and consistently high water levels. This issue demands immediate attention, as satellite imagery reveals that the dam now occupies a larger land area than the town itself. The *Ero* basin is surrounded by degraded landforms with poor soil moisture retention, leading to uncoordinated land use, particularly in the Fadama areas. According to the field survey results, only about 20% of arable land remains viable in the *Ero* basin, compared to approximately 60% in the *Oye* basin, which features undulating high plains and sparse settlements. Diversifying the use of the *Ero* dam for sustainable agricultural activities could revitalize the degraded areas within the basin.

Ogbese Basin: The *Ogbese* Basin is home to the longest and most perennial river in the study area, River *Ogbese*. Originating from the upland areas around Ijesa-Isu Ekiti, the river flows southwest through Igbemo and Aduloju's village in Ado Local Government Area, eventually reaching the boundary between Ikere and Ise/Orun local governments. The river experiences annual flooding between July and September, with the floodwaters typically lasting two to three months (Figures 5 and 6). By October and November, the river often breaks into pools, and its tributaries in this section are seasonal, flowing only during certain times of the year.

The *Ogbese* basin receives moderately high rainfall, ranging from 1100mm to 1600mm annually. The lowest rainfall values are typically recorded in the extreme northwest, northeast, and southeast areas. The hydrologic ratio in the basin varies, with high values of 0.8 corresponding to maximum annual rainfall in certain sectors, while values of 0.6 to 0.5 in the northwest, middle belt, and southeast indicate inadequate soil moisture. The rainfall seasonality index ranges from 0.4 to 0.5, suggesting moderate to high steadiness of seasonal rainfall, except in the extreme northwest where values exceed 0.6. Water consumption estimates range from -100mm to +400mm, indicating low to moderate water availability to mitigate drought annually. The *Ogbese* channel has a generally low gradient, with the worst vicinity at Osun-Ikere-Ekiti, which experiences flooding from July to September. The basin features large Fadama areas, with minimal degraded land. Existing forest reserves and plantations, particularly in Ikere-Ekiti, Ise-Ekiti, and Ode-Ekiti, limit further exploitation.

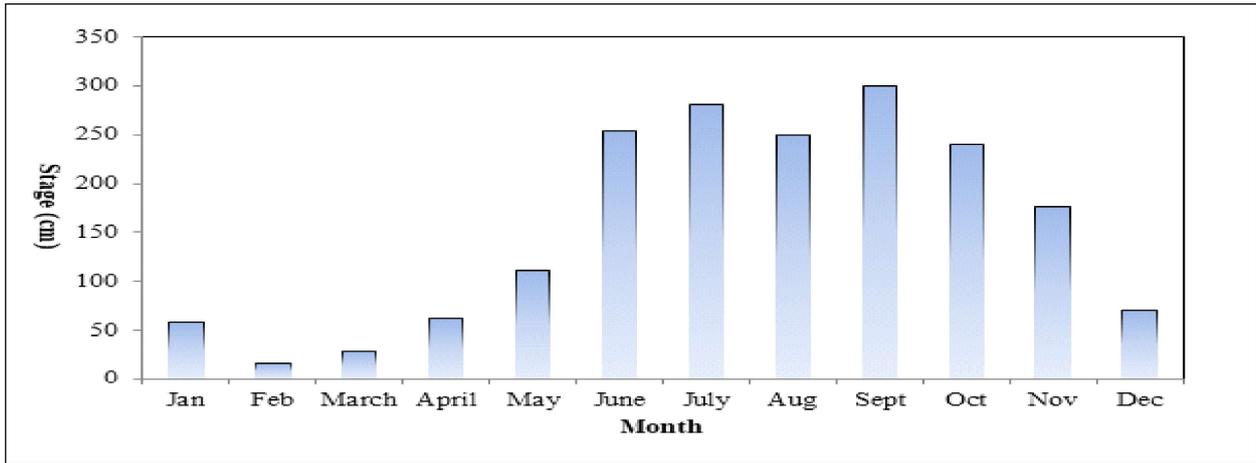


Figure 5: Mean Monthly Values of Water-Stages of River Ogbese at Aduloju village (Ado LGA), Ekiti State, Nigeria (1995-2024)

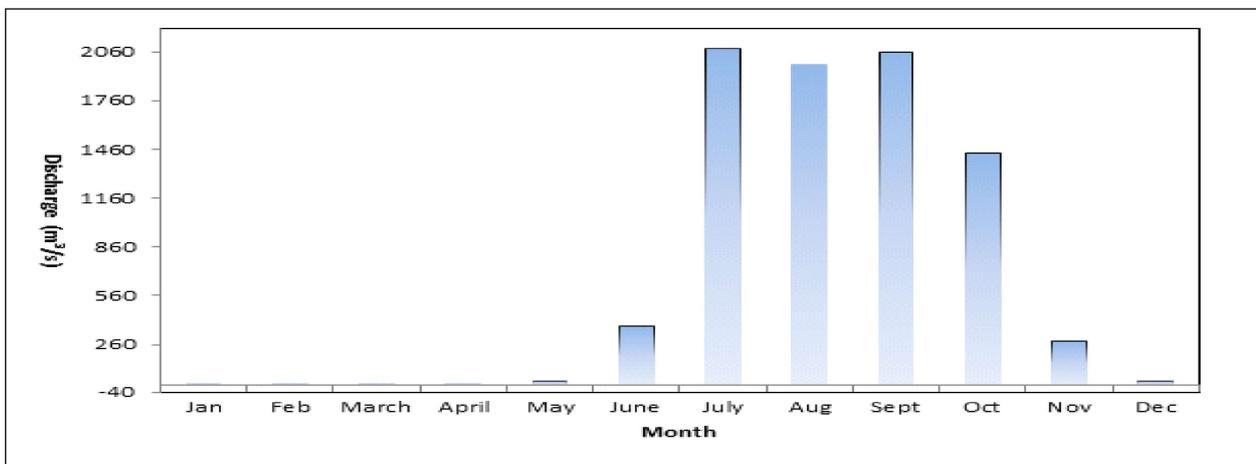


Figure 6: Mean Monthly Discharge of River Ogbese at Aduloju village (Ado LGA), Ekiti State, Nigeria (1995-2024)

Little Osse River: The *Little Osse* River originates from Ode and Isinbode areas of Ekiti State, flowing through Egbe and Imesi before being dammed at Egbe-Ekiti for domestic water supply. The river’s environment experiences a wide range of rainfall, with maximum values reaching 1800mm and minimum values between 1100mm and 1200mm. Notably, the southern areas exhibit anomalous rainfall patterns, corresponding to higher hydrologic ratio values of 0.7 to 0.9, whereas the northern parts of the basin have lower hydrologic ratio values of 0.60 to 0.55. These values suggest that the river and its tributaries maintain high soil moisture levels in the south, despite lower annual rainfall, and contribute to fewer perennial rivers in the north.

The river is located in an area characterized by moderate to low rainfall steadiness. The specific water consumption pattern reveals that the extreme northern periphery of the river falls within a hydronutral zone, whereas the immediate vicinity of the *Little Osse* channel experiences high water demand, requiring up to +300mm annually. The excess surface flow is consistent with the low gradient values in the sector, which facilitate rapid runoff and result in low water retention capacity.

The river catchment basins land and coordinates in the study area (Table 1) has total of 316,600 hectares.

River	Land Along the Basin (Hectares)	Location (Coordinates) Latitude	Longitude
Ero	21,000	7.583°	5.5160°
Oye	27,400	7.9932°	5.5240°
Ogbese	173,700	7.750°	5.5000°
Little Osse	94,500	7.492°	5.5608°

4. Discussion

The study area boasts significant potential for agriculture and tourism, based on its abundant natural resources. With its natural resources as a foundation, the study area is well-positioned to capitalize on opportunities in agriculture and tourism, driving progress and prosperity. Agritourism and hydrotourism have the potential to drive growth, create new opportunities, and improve the overall well-being of the local community. By embracing agritourism and hydrotourism, the study area can capitalize on its unique resources and strengths, ultimately achieving sustainable development and economic prosperity which aligned with the study of Canovi and Lyon (2020) that regarded agritourism initiatives as an important diversification strategy for agricultural entrepreneurs which has the potential to contribute to the development of the rural economy.

The effects of climate change which have resulted in heavy decline in agricultural outputs and tourism activities justified the need for this study as stated in the study of Fischer (2019). The Hydro-Eco zone of major rivers catchment basins in the study are discussed in relation to agriculture and tourism in the study area. Some of the specific constraints in the study area are the nature of the rivers that are seasonal which reduces the discharge at the time of maximum need during the dry season and sedimentary nature of soil formation which is characterized by unconsolidated porous medium to coarse sand that resulted to high permeability.

The steep gradient in *Ero-Oye*, *Ogbese*, and *Little Osse* rivers encouraged high slope-wash which accelerating land degradation that could lead to extinction. More degraded landform that surrounds the *Ero* river whose high soil moisture retention capacity encouraged an uncoordinated landuse (e.g. Fadamas). The diversification of the *Ero* dam to sustainable agricultural activities, these degraded areas can be revitalized again. The *Oye* river which has about 60% of Fadamas are still viable. The undulating high plains of the place make direct access of the area less compelling that resulted to few numbers of settlements along the river basin of the place. The above statement has already been established in the literature. For example, United Nations (2018) reported that rural areas are very essential to the development of society because they provide living spaces and natural resources for people even though the larger percentage of the world's population lives in urban areas. In other to promote peace and the world's population not to suffer hunger, the conservation and development of the rural areas should be a concern of everybody.

It is obvious that the *Ogbese* river basin with more networks of rivers and tributaries in the northern half of its catchment is more stable in terms of soil moisture surplus than the central and southeast parts where there is lower soil moisture. Part of *Ogbese* river basin that is characterized by large Fadamas with very small area constituting degraded portions. The above result from this study confirm the results from the studies of Lamie et al. (2021); Welteji and Zerihun (2018) that worked on the concept of agriculture and tourism.

The existing forest reserves and plantations constitute limitations to further exploitation in Ikere-Ekiti, Ise-Ekiti and Ode-Ekiti. There is *Egbe* forest at the bank of *Little Osse* at *Egbe-Ekiti* and *Eporo* forest reserve at Emure-Ekiti. The *Little Osse* is recharged by other rivers and streams within the catchment area. The total approximate area of land along catchment basins in the study area is 316,600 hectares. The land along catchment basins in the study area has prospects of Fadama development as follows: *Ero-Oye*-48,400 hectares; *Ogbese*-173,700 hectares and *Little Osse* – 94,500 hectares. The previous studies of (Gössling et al., 2011; 2012; Auernheimer and González, 2002; Msomba et al., 2024), agreed that the study area has potential that can be developed as Fadama sites which can be easily harnessed for development of sugarcane, rice and maize plantations. The study area can be ranked among the top producers of sugarcane in the world.

The calculation of water consumption in the catchment area of the rivers of the study indicating that all-year-round cropping is possible with minor irrigation at the peak of the dry season with proper planning. There is danger of excessive surface flow in the northeast where the specific water consumption shows surplus surface water of -200mm or more. Water (rainfall) is essential for tourism infrastructure as stated by many researchers (Verdegem and Bosma, 2009; Pigram, 2001; Eagles et al., 2002). Gössling et al. (2012) stated that tourism accounts for less 1% of water use while agriculture accounts for about 2% (Pavić, 2019). The combined study of agriculture and tourism with respect to river catchment basins of the study area will bring improvement to the economy of the study area by attracting many visitors that would participates in an agricultural process for recreation or leisure purposes of the study area in agreement with the study of Telfer and Wall (1996).

The outcome of this study conformed to the work of DeLay et al. (2019) on the premises that certain periods of the year attract more visitors than others. It is abundantly cleared that running a successful agritourism and hydrotourism operation requires various combination of farming techniques and business skills, such as marketing, customer service, and event management. This approach has the potential to unlock the study area's full potential, fostering innovation, entrepreneurship, and community development.

5. Conclusion and Recommendations

5.1. Conclusion

The study identified the location of *Ero*, *Oye*, *Ogbese* and *Little Osse* rivers and also revealed the role of environmental management in the productive sector of the agricultural and tourism economy. Findings from this study show that maximum and minimum annual rainfall in *Ero-Oye* basin is 1800mm and 1400mm. The annual rainfall in *Ogbese* basin and its environs ranged from 1100mm to 1600mm. The study also observed that the highest and lowest annual rainfall values are 1800mm and 1100mm in *Little Osse* basin.

Another important finding of this study is the Rainfall Seasonality Index, which is 0.4 and 0.8 in *Oye* catchment and *Ero* catchment basins respectively. The value of rainfall seasonality index that ranged from 0.4 to 0.5 revealed moderate to high steadiness of seasonal rainfall in *Ogbese* basin while the values of hydrologic ratio keep the soil moisture high in the southern part of *Little Osse* basin despite its low annual rainfall and less perennial rivers in the north.

The study also discovered that specific water consumption values ranged between 200 to 300 mm while *Oye* basin ranged between 0 to 200 mm. In *Ogbese* basin, the estimate of values of water consumption between -100 mm and +400 mm suggests that water equivalent to avert drought is low to moderate annually. The findings of specific water consumption in *Little Osse* channel show that the extreme northern periphery of the river belongs to the hydronutral zone while the immediate vicinity is in the high water demand sector of up to +300 mm annually.

Agritourism and hydrotourism can effectively promote and market the study area's goods and services to tourists and visitors, contributing to the local economy's growth and development. By showcasing the area's unique agricultural and water-based attractions; the study area can capitalize on its natural resources and cultural heritage, ultimately benefiting the local community and economy.

5.2. Recommendations

To mitigate the risks associated with climate change, promote sustainable agricultural and tourism development, the following recommendations are made:

- i. Diversify the use of *Ero* dam in the *Ero-Oye* basin to include agritourism, reducing the threat to lives and properties.
- ii. For sustainable *Fadama* development in *Ogbese* and *Little Osse* basins, consider sourcing water from underground aquifers during the dry season where dams are not feasible.
- iii. Implement aggressive tree planting campaigns, rehabilitate depleted forest reserves, and develop tropical pines to mitigate slope degradation due to high gradients in the river catchment basins.
- iv. Leverage the study area's potential to attract international tourists and visitors, and develop the area's economic frontiers. This can be achieved by promoting agritourism and hydrotourism, showcasing the area's unique attractions, and capitalizing on its natural resources and cultural heritage.

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Conflicts of Interest

The authors declare no conflict of interest.

Authors' Contributions

AGO is the lead author of this paper. He conceptualized the research work and conducted the analysis. He edited the manuscript's draft and did overall compilation of the manuscript.

SAO is the second author of this paper. He involved actively in the fieldwork of the study and drafted the manuscript of the paper.

POI is the third author of this paper. He involved actively in the fieldwork of the study and also participated in the writing of the manuscript.

SOY is the fourth author of this paper. He involved actively in the fieldwork of the study. He collected data and arrangement of those data for analysis. He used GIS to produced those maps in the study.

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