Depletion Threat on Blue Space and Prospects of Blue Economy in Akure, Nigeria

CHIAMAKA LOVELYN OLISA[1], MICHAEL AJIDE OYINLOYE[2],
BABATOPE SUNDAY OLISA[3]
[1, 3]Department of Maritime Studies, Admiralty University of Nigeria, Ibusa, NIGERIA.
[2]Department of Urban and Regional Planning, Federal University of Technology, Akure, NIGERIA

Abstract: Blue space depletion remains a key concern to the sustainability of urban ecosystem, wellbeing and sustainable planning in the world today particularly Nigeria. This has led to serious degradation within urban environments and their possible economic gains. This study examined the condition of blue space depletion in Akure with a view to accentuate blue space economic gains. The specific objectives which include; identifying the existing blue space available in Akure; assessing the spatiotemporal pattern of the blue space between 1984 and 2022; examine the rate of depletion of blue space and examine blue space economic viability. The study used primary survey for observational and explorative study to identify existing blue spaces in the study area. It explored the use of Geospatial techniques in evaluating the depletion of blue space in Akure 1984 to 2022. River and stream network data of the study area was obtained from SRTM, while the quantification reflecting the depletion of blue space was done using classification method in ArcGIS. The study revealed significant disappearance of blue space networks, spatial distributions and levels of encroachment on the branches of blue spaces in the study area; which are attributed to human occupation, construction, and sand filling (burial). The connectivity of river/stream networks and pockets of blue spaces declined in the health and vigor. The study concludes that the rate of depletion of blue space is significant alongside its attendant related hazards of flooding problems and environmental degradation as observed within the study area. The study recommends that proper check and management of river and stream networks as well as other artificial drainage channels will offset the trajectory of blue space depletion.

Keywords: Blue Space, Economy, Drainage, Stream Network, Depletion, River, Management

Received: April 23, 2025. Revised: June 4, 2025. Accepted: August 6, 2025. Published: October 3, 2025.

1. Introduction

Depletion threats to blue space and the potential for a blue economy in Akure, Nigeria" are of the utmost concern. These hazards appear to represent significant dangers and obstacles to the long-term development of aquatic resources (blue spaces) and the expansion of ocean-related enterprises (blue economy) in Akure, a landlocked metropolis in southwestern Nigeria. Meanwhile, Akure is not directly adjacent to the shore of ocean; yet, there are ramifications and benefits for the larger region and its linkages to waterbodies and marine resources, particularly through surrounding rivers, lakes, and Nigeria's coastal areas. The term "blue space system" refers to space associated to hydrological functions, which includes ponds, vegetated waters, wetlands, streams, rains and urban storm water systems, as well as surface and groundwater aquifers [1]. Blue space has long been mentioned in urban planning as a means of providing resilient water supply and security. Such water areas can be natural, adapted, or man-made, and they serve functions such as slowing down, decentralizing and spreading, soaking into the earth, evaporating, and releasing water into the natural environment. However, the depletion of this resource has sparked a global discussion about its long-term viability in the urban ecosystem, well-being, and development. As a result of limited resource space, the urban blue space and its potential for a robust blue economy are shrinking. Human occupancy, construction, and sand filling (burial) have all contributed to the spatial distributions and levels of encroachment on blue space branches in developing countries like as Nigeria.

In the worldview, blue space could refer to water bodies such as oceans, seas, rivers, lakes, and other inland water systems. These areas are important for biodiversity, ecosystem services, and the blue economy, which refers to the sustainable use of ocean and water resources to drive economic growth, job creation, and ecosystem health. However, in the context of interior Akure, Nigeria, the word "blue space" may refer to rivers, lakes, and other water systems that feed into Nigeria's bigger coastal areas. This study aims to examine depletion of blue space in Akure with a view to conserve and preserve its water resources. The specific objectives are to identify the existing blue space available in Akure; assess the spatiotemporal pattern of blue space in the study area between 1984 and 2022; and examine the rate of depletion of blue space in the study area.

2. Study Area

Akure is the study area of this research work. Akure is a city situated in south-western Nigeria (Figure 1) [2] and is the largest city and capital of Ondo State with 9 political wards [3]. It is a city in Nigeria located on longitude 5.081 to 5.487 decimal degrees and latitude 7.078 to 7.436 decimal degrees, with a population of 360,268 persons in 2006 [4]. The spatiotemporal pattern of urban blue spaces in Akure metropolis covered 38 years (between 1984 and 2022) (Figure 2). Akure city is located in a gently undulating terrain surrounded by inselbergs and underlain by granites, charnockites, quartzites, granite gneisses, and migmatite gneisses [5].

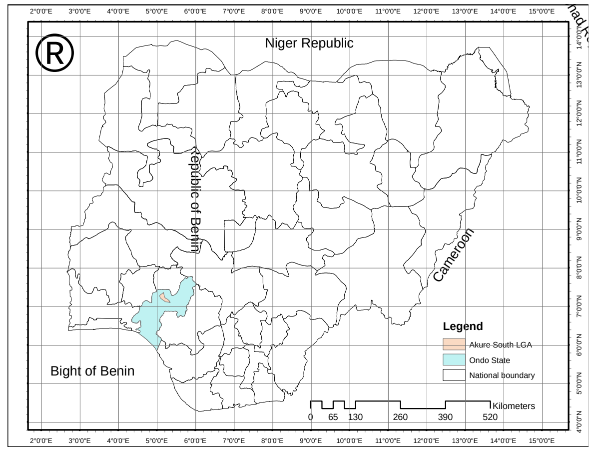


Figure 1: Map of Akure in its National Setting
Source: Survey Department of Ondo State Ministry of Works, 2024 [2]

Akure urban stream system is composed of two major rivers called Ala rivers, tributaries and distributaries among which are Osisi, Ete, Elegbin and Ogburugburu. Ala River took its source from the northwestern part of Akure town and flow towards the southeastern part of the town. Akure dominated upstream of River Ala while rural towns such as Ilado, Ehinala, Ajegunle, Owode Aiyetoro and Araromi are located in the downstream where the water is being used for drinking and other domestic purposes [6].

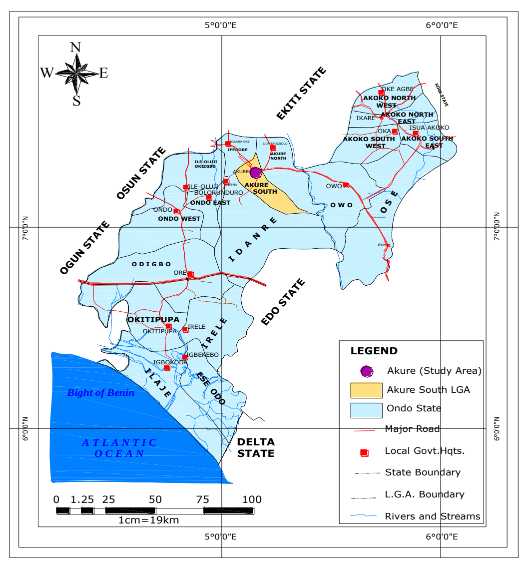


Figure 2: Map of Akure in its regional setting
Source: Ondo State Ministry of Physical Planning and Urban Development, 2024; source: [3]

Ala Rivers are tributaries to River Ogbese in the southwestern, Akure, Nigeria. The river has a total length of about 58 km, out of which about 14.8 km is within Akure township [6] contributing to the order of stream system and network of the urban blue space of Akure.

3. Related Studies

According to Chan (2019), green and blue places such as city parks, street trees, and ponds are typical techniques for bringing nature into urban areas [7]. As cities grow become denser, urban blue and green space become increasingly important for improving human health and well-being, and also for social interaction, economic benefits, and environmental quality [8]; [9]. The potential of urban blue space to support and promote health and well-being can be measured in terms of the environmental and human benefits it provides. These impacts can be utilized to assess the multifunctional advantages (and hazards) of these settings [10]. [11] stated that urban blue space, particularly its riparian zones, provides ecosystem services that help to mitigate global climate change-related concerns, such as moderating severe temperatures or floods and lowering air and noise pollution. Urban blue-and green spaces, such as vegetated buffers, structured swimming pools, water parks, streams, fish ponds, recreational areas, and so on, give health and well-being benefits such as recreation, social contact, and a connection to nature [11], [12], and [13].

[14] claimed that there are a huge variety of threats to the creation of a sustainable blue economy, including competition for space, rising pressure on coastal land driven by population growth, and changing political cycles. However, in cooperation with stakeholders, the InterAmerican Development Bank [15] has identified four major threats that are of the greatest concern: global market dynamics, climate change, the current relationship between economic development and environmental degradation, and pandemics like COVID-19.

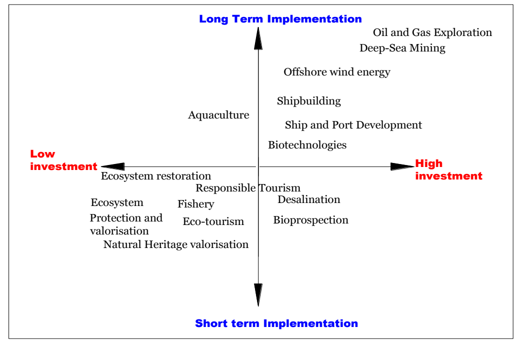


Figure 3: Characterization of blue space long and short-term investments
Source: Adapted from [14]

As evidenced by the present understanding of the value of ecosystems in developing nations, the indirect contribution of marine and coastal ecosystems is still underappreciated and ignored in ocean strategies. This is consistent with the work of [17], who emphasized that there is a chance to increase resilience to external shocks as the significance of developing countries' ecosystems to propel the blue economy's growth becomes clearer. it is of note that numerous blue economy sectors, including tourism and fishing, are supported by these ecosystems [18]. However, by definition, these ecosystems' indirect services—which are crucial to the nations' social and economic well-being—are difficult to measure and, as a result, are not adequately taken into account in both short- and long-term policy strategies (see Figure 4). This is true even though the necessity of protecting them is becoming more widely recognized. A thorough assessment of the economic and intrinsic value contributions made by marine and coastal habitats is desperately needed. Some of the world's best environments for sequestering carbon include kelp forests, seagrass beds, and mangroves. Reducing atmospheric carbon helps to mitigate the hazard of sea-level rise, which disproportionately impacts islands and coastal countries [19].

3.1.Blue economy in developed countries

In developed countries, the blue economy refers to sustainable ocean-related economic activities, aiming to balance growth with environmental protection and social equity. It includes sectors such as fisheries and aquaculture, tourism and recreation, shipping and ports, coastal protection and management, ocean research and technology, and marine and renewable energy. It is a concept that promotes better stewardship of ocean resources and recognizes economic benefits that extend beyond traditional markets, such as carbon storage and coastal protection [19].

The United Nations has noted that the blue economy will help achieve the UN Sustainable Development Goals, one of which is 'Life Below Water'. Several nations have recognized the ocean's potential to reduce poverty and improve overall economic performance. It is thought that existing strategies will contribute to better global ocean management, benefiting both people and the environment [20].

3.2.The Blue Economy in Nigeria

The blue economy has grown in popularity over the last decade, as people, governments, and economists have recognized the tremendous opportunities presented by the ocean and its resources. Nigeria, as a coastal nation, has vast marine resources, such as offshore oil and gas, fisheries, tourism, and coastal infrastructure, all of which contribute to the blue economy. Both coastal and inland areas, like Akure, an inland city in Nigeria, benefit from sustainable sectors including marine biotechnology, aquaculture, fisheries, renewable energy (wind and tidal power), and shipping, which are all included in the blue economy. Because of Nigeria's proximity to the Atlantic Ocean and the distribution of marine resources, Akure can profit from the larger blue economy. For instance, local ports might be used to handle and distribute agriculture and fisheries products, which could help Akure's blue-related industries and jobs.

Urbanization processes, land use conversion, sand-filling of wetlands, and water networks for various degrees of physical developments all contribute to the poor management, preservation, and/or preservation of the available water resources for sustainable uses. It is noteworthy that cities like Lagos, Ibadan, Enugu, Benin, and others exhibit a notable degree of urbanization. Akure city is not unique, though, as riparian zones around waterbodies are being encroached upon, water and stream networks are being covered with sand for construction projects, and numerous open spaces and blue spaces are being turned into physical constructions. Due to the decrease of available water resources, the likelihood of the blue economy developing is decreasing.

4. Methodology

The study explored the use of Geospatial techniques in evaluating the depletion of blue spaces within urban area of Akure for a period of 40 years (1984-2024). Blue network patterns of the study area were obtained from SRTM, while the quantification reflecting the depletion of blue space was done using ISO Clusters in Unsupervised Classification ArcGIS. Landsat images; TM 1984, TM 1991, ETM+ 2002, OLI 2022 were used for geospatial analysis. This study made use of these satellite imageries captured between 1984 and 2022 to assess and describe the network of urban blue space in Akure.

The main blue space components considered for study are vegetated water, ponds, swamps, streams and rivers. The study combined the use of Modified Normalized Difference Water Index (MNDWI) and Unsupervised Likelihood classification techniques to detect spatiotemporal details of the blue space including the drainage system/stream orders and other waterbodies. Below is the flow chart showing the pattern of approach used to carry out the study.

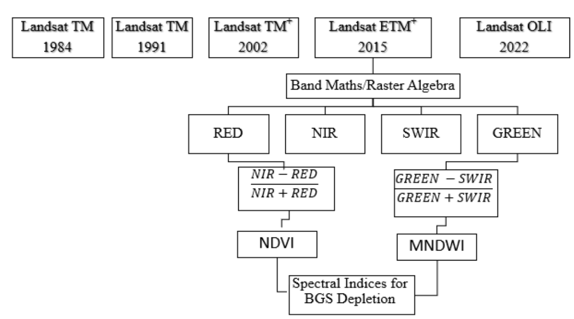
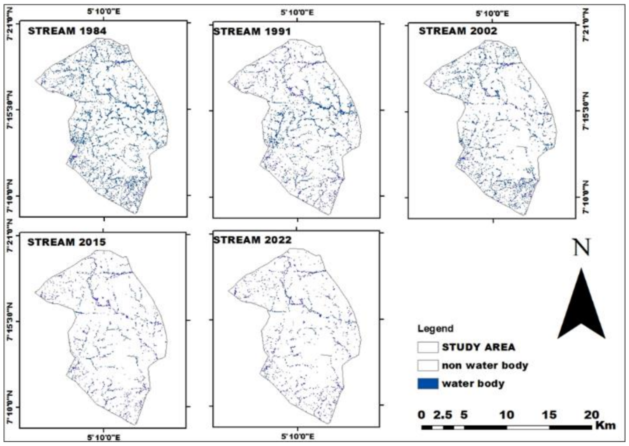


Figure 5: Modified Normalized Differential Water Index (MNDWI) Flowchart for the study

5. Results and Discussions



The proportion of blue space area coverage over Built-up areas was estimated as shown in Table 4.9. in 1984, the proportion of blue space was estimated as 19.7254 sq. km (11%) of total land coverage of the study area. Meanwhile, in 1991, the estimated space coverage of the blue space had a significant reduction to 14.2356 sq.km. (7.94%) with reference to 1984 record indicating an absolute change of -5.4898sqkm and a percentage decrease of -27.83. Findings revealed that this decrease continued in 2002, An estimate of -18.17 percentage change was detected resulting to an estimate of 11.649sqkm as the total area coverage remains of blue spaces. Also, in 2015, 8.0964 sq.km (4.51%) of the total area of the study area was estimated. The observed absolute change was -3.5526 sq. km, while percentage change was -30.50 indicating a decrease in the proportion of blue space network in the study area. In the year 2022, study revealed that substantial portions of blue spaces were lost. This resulted to estimated total blue space of 6.1392 sq.km (3.42%).

Table 1: Proportion of blue space area coverage over built-up areas in Akure

Year	Built-up area (sq.km)	Blue Spaces (sq.km)	Absolute Change	% change of Blue Spaces	Rate of Change
1984	12.5316 (6.99%)	19.7254 (11.00%)	-	-	-
1991	20.8719 (11.63%)	14.2356 (7.94%)	-5.490	-27.83	0.78
2002	40.3650 (22.50%)	11.649 (6.49%)	-2.587	-18.17	0.24
2015	57.4128 (32.00%)	8.0964 (4.51%)	-3.553	-30.50	0.27
2022	118.6749 (66.15%)	6.1392 (3.42%)	-1.957	-24.17	0.28

Source: Fieldwork 2024

Figure 6: Comparative analysis of spatial distributions of blue space network in Akure between 1984 and 2022; Source: Author, 2024

The study considered the blue space are natural and organized ponds, swamps, drainages, streams, and rivers and tributaries. The majority of blue space resources identified in the study area consist of ponds and streams, river, tributaries, and distributaries, such as the Ala River, Elegbin, and Ogburugburu drainage channels as shown figure 7. It is noteworthy that the study area is endowed with several blue networks cutting across its entire area. These blue space resources have been underutilized and mismanaged. Mismanagement practice of blue space as observed are the construction of buildings on blue spaces and the disposal of increased waste into stream channels, as evident along Ala and Elegbin river channels in Ade Super Area, Isinkan Market, and Danjuma Area, amongst others. This scenario reflects the study of [22] who asserted that poor waste disposal practices and management are hallmarks of many African cities, where about 80% of solid waste is disposed of indiscriminately in open space, storm water drains, streets, streams, and rivers.

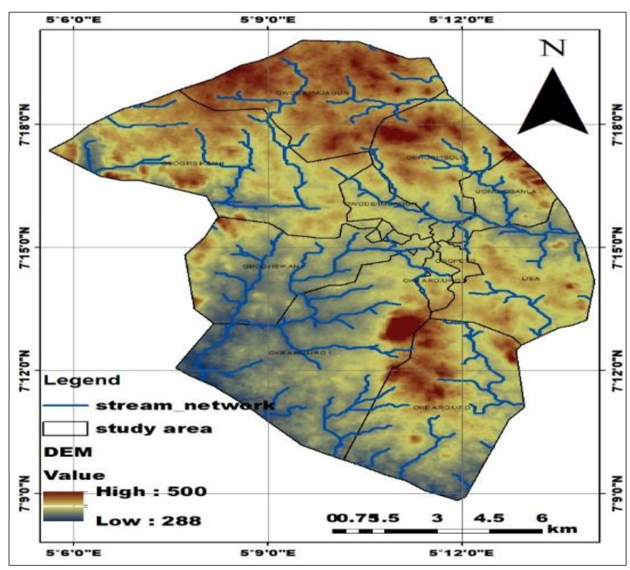


Figure 7: Digital elevation model (DEM) and stream network of Akure city 2022
Source: Author, 2024

5.1 Drainage Frequency

As indicate in Table 2, findings revealed significant disappearance of stream orders and natural drainage channels in Akure. In 1984, Stream order 1, 2, 3 and 4 were 276, 127, 65, and 8 respectively estimating a total number of stream order 1 as 476 stream edges. This reflected a well-known categorization based on the link between streams and tributaries of Strahler's stream ordering scheme [23]. A network of waterbodies that indicates the degree of branching in a stream system [24].

The stream order 1 and stream order 2 include Elegbin, Ete, Ogburugburu and tributaries of Ala River composed of small streams coming out of hillside, narrow riffled and shallow forested areas It is noteworthy that Akure has two major rivers and the two are known as Ala. One is located in the southern part and the other is located on the northern part of Akure; both have significant contribution to the Akure urban drainage system. Table 2 indicated that urban stream system significantly reduced in 1991 with estimated figures of 199, 112, 64 and 8 for Stream order 1, 2, 3 and 4 respectively. Seventy-seven (77) first-order tributaries, fifteen (15) second order tributaries and one (1) third order tributary had been buried, invaded or cut-off as a result of anthropogenic activities such as construction projects. It is of note that encroachment of the built-up areas into the stream channels and corridors worsened erosion processes.

Morphological alterations of the blue networks are observed as they reduced in width and depths due to building encroachments and silting/sedimentation processes from erosion, hence the incessant flooding in Akure. Changes in the length of natural drainage/stream systems overtime was observed in the spatiotemporal analysis of the blue space network in the study area. The water network and obliterated streams revealed the depleting status of blue space in Akure. As indicated in Table 2, the length of stream systems in Akure significantly changed as the number of stream orders continued to reduce in years 2002, 2015 and 2022 particularly stream order 1 and 2. The proportions of stream order 1 between 1984 and 2022 were 276 and 86 vertices respectively; while proportion of stream order 2 between 1984 and 2022 were 127 and 73 vertices respectively

Table 2: Classification of Stream Order and Number of Streams (Vertices) per stream order

	Vertex				
Stream Order	1984	1991	2002	2015	2022
Stream Order 1	276	199	163	113	86
Stream Order 2	127	112	104	99	73
Stream Order 3	65	64	64	58	58
Stream Order 4	8	8	8	8	8
Total	476	383	339	278	225

5.2 Stream Network Density

Conventional statistical indicators used to define the structure of the river/stream network include total length and density [25], water surface ratio [26], curvature degree [27], and branch ratio [28]. [29] stated that the water surface ratio and river network density are the most popular structural indices used to describe a region's river water storage capacity. Furthermore, the density of the river network serves as an indicator for determining the extent of regional drainage. This study used river network density analysis and water surface ratios to investigate and describe the geographical conditions and levels of regional drainage (urban blue resources) in the studied area. River network density is a feature of river distribution and can reflect the density of regional water flow pathways [30].

As shown in Table 3, stream density and the total lengths of stream (Li) in the years 1984 and 2022 were estimated as 1232.8km and 383.7 km, respectively, while the total area of the study remained 179.4015km^2. Based on the field study, the bank full widths of stream channels in Akure were measured, and the average bank full width was calculated as 54 feet (16.3m) as shown in Figures 8. This estimate revealed a substantial reduction in the length of available streams in the study area.

Figure 8: The bankfull width of Stream drainage channels in Akure city
Source: Author's Field work, 2024
Source: Author's fieldwork, 2024

Table 3. Trend of Stream Density network and Stream lenghts in Akure city between 1984 and 2022

Sn.	Year	Water Surface Area *(Fi)*, (Km2)	Total length of stream network *(L_i)* (km)	Total Area of the region (study area) *(A)*	Proportion of depletion in Stream Length	Stream Density *(D_r)*(km) $D_r = \frac{L_i}{A}$	Proportion of depletion in stream density	Percentage decrease in stream density
1	1984	19.7254	1232.8	179.4015	-	6.8719	-	
2	1991	14.2356	889.7	179.4015	-343.1125	4.9594	-1.9125	-27.8311
3	2002	11.649	728.1	179.4015	-161.6625	4.0583	-0.9011	-18.1699
4	2015	8.0964	506.0	179.4015	-222.0375	2.8206	-1.2377	-30.4970
5	2022	6.1392	383.7	179.4015	-122.325	2.1388	-0.6819	-24.1737

Source: Author, 2024

As indicated in Table 3, findings revealed a significant decrease in the stream density network of Akure city. In 1984, 1991, 2002, 2015 and 2022, the stream densities were estimated as 6.8719km, 4.9594km, 4.0583km, 2.8206km and 2.1388km respectively. An indication that substantial proportion of blue space have been lost to urban land use developments as at year 2022. The percentage decrease in the stream network ranges from 18% and 28% indicating a sharp decline in the health of blue space network in the study area. Xingyuan [30] supported this observation stating that 'health and longevity of a stream or river network is considerably more dependent on how well it is connected to one another, regardless of how abundant it is in a location'. However, connectivity of river network is a key factor affecting watershed ecosystems and an important criterion for evaluating the health of river.

The loss of the blue space network does not portend a sustainable future for it. Urban lives, comfort, and health might all greatly benefit from a paradigm change toward the conservation, maintenance, and sustainability of urban blue spaces. According to [31], people's physical and mental health improves when they spend time near water. Kelly [32] gathered information from 20,000 individuals in the UK, investigated the effects of blue space and inferred that coastal and marine environments are the happiest for humans.

5.3. Water surface Ratio

The ratio of water surface area (including rivers, lakes, marshes, and other bodies of water) to total drainage area (total area of watershed) and pervious surface proportion play critical roles in an urban drainage system [33]. These factors lessen the likelihood of waterlogging and flooding while also preventing an excessive increase in air temperature. It enhances the cooling benefits of green vegetation, particularly in quickly developed areas [34]; [33]. The higher a region's water ratio, the greater its part of water distribution and the more benefits it provides to the region.

Findings disclosed a substantial reduction in the proportions of surface water in Akure between 1984 and 2022. Table 4 indicated a continuous decrease in the water surface ratio in the study area (Akure City). As of 1984 and 1991, the proportions of water surface ratio were estimated as 0.109951km^2 and 0.079351km^2. In 2002, -0.0144 km^2 (18.17%) was lost to built-up areas, while 2015 record showed the largest estimate of 30.50 percent decrease in the water surface ratio. In the view of this, there was a significant change in the share of water distribution in the study area. This revealed 27.83 percent reduction in the surface water ratio of Akure between an interval of seven (7) years. This is also attributable to land use development and other anthropogenic activities that were triggered by urbanization.

Table 4: Trend of Stream Density network in Akure city between 1984 and 2022

Year	Water Surface Area (f_i), (Km^2)	Water Surface Ratio (W_p) $W_p = \frac{f_i}{A}$	Proportion of depletion	Percentage decrease
1984	19.7254	0.1099	-	-
1991	14.2356	0.0793	-0.0306	27.83
2002	11.6490	0.0649	-0.0144	18.17
2015	8.0964	0.0451	-0.0198	30.50
2022	6.1392	0.0342	-0.0109	24.15

Source: Authors, 2024

5.4 Drainage characteristics in the study area

Findings revealed that the capacity of the urban drainage system in the built-up areas of Akure is insufficient. It is characterized by narrow drainage channels that are not sufficient to collect a large volume of urban runoff (Figure 11). This is in agreement with Ogunmodede, who observed that significant parts of the built-up areas of Akure have no or very narrow gutters [35].

5.5. Effects on the Blue space depletion in Akure

The effects of blue space depletion often arise from urbanization, infrastructure development, and industrial expansion with resultant effects on both the quantity and quality of water bodies. Akure is inland, blue economy is affected by the depletion of blue space in the broader region, as it connects to economic activities associated with water resources. Depletion of blue space could harm blue economy prospects for Akure and its region in the following ways:

Flooding: With more Physical development, natural drainage systems are frequently interrupted, increasing the risk of flooding. Floodwater transports pollutants, debris, and garbage from building sites to surrounding rivers, lakes, and reservoirs, lowering water quality and harming aquatic ecosystems. *Reduced Access to Fishery Resources:* As marine and freshwater habitats are depleted, the availability of fish and other aquatic items decreases, affecting the food supply chain, local markets, and agriculture and aquaculture enterprises. This has had an indirect effect on the Akure inland economy.

Figure 9: Blue space for fishery at Danjuma, Akire
Source: Authors, 2024

Wetlands are crucial for maintaining water quality, regulating floods, and supporting biodiversity. Their loss reduces the land's ability to naturally filter and purify water, resulting in the degradation of water bodies. The loss of these natural areas due to construction can lead to a decline in biodiversity and disrupt the ecological balance of nearby water systems. Encroachment on the wetlands along Ala River is a good example. As the depletion of blue spaces has an impact on the local marine and fisheries industries, job losses or reduced income for persons who rely on water-based activities can cause economic challenges. While Akure is not directly dependent on coastal industries, the losses have far-reaching consequences. Environmental and social impact: The degradation of neighboring ecosystems resulted in increased flooding, soil erosion, and the loss of arable ground, affecting some agricultural and local residents. This, in turn, has social and economic ramifications for Akure's development.

6. Summary of Findings

The study revealed that the blue economy in Akure (an inland city) is faced with certain threats which have undermined its potential developments and economic gains. These threats include: Urbanization and Increased Runoff, Pollution, Overfishing, Climate change. The depletion of blue space in cities in Nigeria particularly in inland cities poses a significant challenge to the blue economy. This is a reference to the overuse and deterioration of water resources, especially in inland and coastal environments, which have detrimental impacts on the economy, biodiversity, and environment.

As Akure grows and more buildings, roads, and infrastructure are constructed, available blue spaces are land encroached, the increase in impervious surfaces (such as concrete, asphalt, and rooftops) leads to more surface runoff during rainfall with emerging narrow drainage systems.

7. Conclusion and Recommendations

A positive shift from an ocean economy to a coordinated inland blue economy is demonstrated by blue economic opportunities in the inland industries. Adopting sustainability and good governance concepts is therefore necessary. Implementing strong blue economy principles has the advantage of overcoming the threats previously mentioned. It is important to determine the financial ramifications and timeline of investments in industries that have potential for the growth of the blue economy. Possibilities for: sustainable resource extraction and production; cultivated economic development; and improved valuing of the ecosystems.

The study recommends that establishing partnerships with coastal communities, local governments, and international organizations could help address the depletion threats and protect the blue economy. The study emphasizes the vulnerability of blue space either coastal or inland and the risks posed to the prospects of the blue economy in Akure. However, the broader ecological and economic challenges related to the depletion of water bodies in Nigeria are should be serious concern to urban planners and other environment stakeholders. The depletion of blue space has affected its agricultural, industrial, and community livelihoods in Akure. It is highly expedient to addressing these challenges through sustainable management and innovation that can help mitigate these threats and open up new opportunities for economic growth in the region of Akure, Nigeria.

Reference

[1] Dreiseitl H., Wouters P., Wanschura B.,Wörlen M., Moldaschl M., Wescoat J., Noiva K., 2016, Blue-green infrastructures as tools for the management of urban development and the effects of climate change, Ramboll Environ, Madrid.

[2] Survey Department of Ondo State Ministry of Works, 2024

[3] Ondo State Ministry of Physical Planning and Urban Development, 2024

[4] National Population Commission, NPC, 2006

[5] Olarewaju, V. (1981). Geochemistry of the charnockitic and granitic rocks of the basement complex around Ado-Ekiti – Akure, S. W. Nigeria. University of London. pp. 17-28.: Unpublished Ph. D. thesis.

[6] Fagbayide, S., & Abulude, F. (2018). Effects of human activities on water quality assessment of Ala River in Akure, Ondo State, Nigeria. World Journal of Environmental Research, 8(1), 037–044.

[7] Chan, A. (2019, December 3). Environment Review. Creating community: The role of green and blue spaces in cities, pp. 1-3.

[8] Haahtela, T., Von Hertzen, L., Anto, J., Bai, C., Baigenzhin, A., Bateman, E., Chavannes, N. (2019). Helsinki by nature: The Nature Step to Respiratory Health. Clin. Transl. Allergy, 9, 57.

[9] Kabisch, N., Qureshi, S., & Haase, D. (2015). Human—Environment interactions in urban green spaces—A systematic review of contemporary issues and prospects for future research. Environ. Impact Assess. Rev., 50, 25–34.

[10] WHO/EURO. (2023, May 23). Assessing the value of urban green and blue spaces for health and well-being. (W. H. Europe, Ed.) p. 44.

[11] Zabelskyte, G., Nadja, K., & Zaneta, S. (2022, February 2). Patterns of Urban Green Space Use Applying Social Media Data: A Systematic Literature Review. (F. Katarzyna, Ł. Damian, & W. Ulrich, Eds.) MPDI Sustainability Foundation, Land 11, Volume 11(no. 2), 238.

[12] Peschardt, K., Schipperijn, J., & Stigsdotter, U. (2012). Use of Small Public Urban Green Spaces (SPUGS). Urban for Urban green, 11, 235–244.

[13] Song, X., Richards, D., & Tan, P. U.—E. (2020). Using social media user attributes to understand human—Environment interactions at urban parks. Scientific Reports, Nature Research; Green Version, 10, 1–11.

[14] Skewes T. D., Hunter C. M., Butler J. R. A., Lyne V. D., Suadnya W., Wise R. M. 2016: The Asset Drivers, Well-being Interaction Matrix (ADWIM): a participatory tool for estimating future impacts on ecosystem services and livelihoods. Climate Risk Management.12:69–82

[15] IDB, 2020a and the Caribbean Development Bank

[16] Nurse L.A., McLean R.F., Agard J., Briguglio L.P., Duvat-Magnan V., Pelesikoti N., Tompkins E., Webb A. 2014: Small islands Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 1613–1654.

[17] Patil P. G., Virdin J., Diez S. M., Roberts J., Singh A. 2016. Toward A Blue Economy: A Promise for Sustainable Growth in the Caribbean; An Overview. The World Bank, Washington D.C.

[18] Failler P., Pètre É., Binet T., Maréchal J. P. 2015. Valuation of marine and coastal ecosystem services as a tool for conservation: the case of Martinique in the Caribbean. Ecosystem services, 11:67–75.

[19] Trégarot E., Caillaud A., Cornet C. C., Taureau F., Catry T., Cragg S. M., Failler P. 2021. Mangrove ecological services at the forefront of coastal change in the French overseas territories. Science of the Total Environment,763:143004.

[20] Common Wealth, (2024). Addressing the challenges of ocean-related industries. Small island developing states. 29th, April, 2024

[21] McAlpine, A. (2023). Countries with Blue Economy Strategies, Borgen project. https: borgenproject.org/blue-economy/

[22] Adekola, P., Iyalomhe, F., Paczoski, A., Abebe, S., Pawłowska, B., Bąk, M., & Cirella, G. 2. (2021). Public perception and awareness of waste management from Benin City. SCI Rep, 11(1), 306.

[23] U.S. Environmental Protection Agency. (2023, October 13). Stream Corridor Structure - Stream Ordering. Watershed Management, p. 1. Retrieved from www.epa.gov/watershedacademy/ online-training-watershed-management.

[24] Koschitzki, T. (2004). GIS-basierte, automatische Erfassung natürlicher Fließgewässerhierarchien und ihre Abbildung in Datenbanken, beispielhaft dargestellt am Einzugsgebiet der Salza. Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Dissertation. Halle-Wittenberg: URN (NBN) urn: nbn:de: gbv:3-000007179 (Weblink, archive server DNB).

[25] Bogale, A. (2021). Morphometric analysis of a drainage basin using geographical information system in Gilgel Abay watershed, Lake Tana Basin, upper Blue Nile Basin, Ethiopia. Appl Water Sci - Springer, 11 (122).

[26] Rippin, D. M., Pomfret, A., & King, N. (2015). High resolution mapping of supra-glacial drainage pathways reveals link between micro-channel drainage density, surface roughness and surface reflectance.;. Earth Surf. Proc. Land, 40, 1279–1290. Doi: Doi: 10.1002/esp.3719.

[27] Deng, X. (2019). Correlations between water quality and the structure and connectivity of the river network in the southern jiangsu plain, eastern china. Sci. Total Environ., 664, 583–594. doi:doi: 10.1016/j.scitotenv.2019.02.048.

[28] Nanson, R. A. (2010). Flow fields in tightly curving meander bends of low width-depth ratio. Earth Surf. Proc. Land, 35, 119–135.

[29] Perron, J. T., Richardson, P. W., Ferrier, K. L., & Lapôtre, M. (2012). The root of branching river networks. Journal of Nature, 492, 100. doi:doi: 10.1038/nature11672.

[30] Xingyuan, Z., & Fawen, L. (2023, March 20). Study on the correlation between river network patterns and topography in the Haihe River basin. (N. I.-E. Linshan Yang, Ed.) Front. Earth Sci, Volume 11.

[31] Sanderson, C. (2023). Why Blue Space is better than Green Space. New Jersey: Wise and Well.

[32] Kelly, C. (2021). Blue Spaces: How and why water can make you feel better. United Kingdom: Trigger Publishing.

[33] Cheng, G., Jun, L., Han, C., & Zhuowen, W. (2014). Optimized water surface ratio and pervious surface proportion in urbanized riverside areas. Environmental Earth Science, 72, 569–576.

[34] Michael, O., Sandra, C., & Anne, J. (2010). Urbanization effects on watershed hydrology and in-stream processes in the southern. Water, 2, 605–648.

[35] Ogunbodede, E. F., & Sunmola, R. (2014, December). Flooding and Traffic Management in Akure (Nigeria) Metropolitan Environment. European Environmental Sciences and Ecology Journal, Vol.1 (No.2).