Water Bodies (Riparian Boundaries) Delineation in Rivers State, Nigeria using Globalland 30

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Abstract:

Water bodies are of utmost importance to both humans and other living organisms, fulfilling various crucial roles. They not only contribute significantly to determining water availability but also serve as indicators for areas at risk of flooding and environmental changes. Satellite sensors have played a significant role in categorizing land use and identifying water bodies over the years. This study aim delineating water bodies in Rivers state, Nigeria. The Globalland cover dataset for Globalland 30 was downloaded from the National Geomatics Center of China (NGCC) and then mosaicked and masked to the study area in Rivers State using ArcGIS software. Water bodies were vectorized and delineated, and their size was estimated using QGIS software through the computation of area using unique value query QGIS tools. The analysis revealed that inland waters spanned an extensive area of 476,049,600 square meters, while Major Rivers covered a vast region of 558,684,000 square meters. It is advisable to use remote sensing land cover data, such as Globalland 30 data, for regular spatial-temporal mapping of water bodies. This will facilitate the delineation and monitoring of shoreline alterations and erosion within the inland water boundaries of Rivers State and Nigeria as a whole.

Keywords: Land Cover, Globaland 30, Riparian Boundaries, Rivers State, Remote Sensing

1.0 Introduction

The occurrence of global sea level fluctuations, the influence of El Niño on oceans and the atmosphere are collectively termed as global change phenomena. Previously confined to research endeavours, recent environmental agreements now necessitate the establishment of monitoring mechanisms to ensure compliance with ratified conventions. One such example is the Kyoto Protocol, enabling emission trading between developed and developing nations. Decision makers require comprehensive understanding of the scientific factors underlying these concerns in order to make informed choices.

According to the USGS (1984), approximately 71% of the Earth's surface is covered with water, with the oceans containing around 96.5% of all the water on our planet. Additionally, water exists in various forms such as water vapor in the air, in rivers and lakes, as well as in icecaps, glaciers, and soil moisture. Indeed, water plays a crucial role in ecosystems, serving as an essential component for the sustainability of life on Earth. It effectively regulates ecosystems, ensuring a balance and facilitating climate variations, carbon cycling, and related processes (Verpoorter et al., 2012).

Water bodies play a crucial role not only for humans but also for other forms of life. Their presence contributes to the growth of forests and grasslands, and vice versa. Conversely, their excess or absence can lead to disasters and drastic changes in land utilization. Therefore, the identification of water bodies is an indispensable process in scientific and engineering research. This identification process serves various purposes, including estimating water areas, delineating flooded regions, conducting wetland inventories, detecting changes over time, and more (Verpoorter et al., 2012). Additionally, being able to identify water bodies is valuable for estimating irrigation requirements for agricultural land, enhancing productivity, harnessing hydropower energy, and numerous other applications.

Inland water bodies hold significant importance in the global biogeochemical cycles, particularly lakes and reservoirs serve as crucial sinks for reactive nitrogen (Harrison et al. 2009). The amount of carbon dioxide emitted annually by inland water bodies into the atmosphere is comparable to the carbon dioxide uptake by oceans. Additionally, the burial of organic carbon in sediments of inland waters surpasses organic carbon retention on the ocean floor (Cole et al. 2007; Battin et al. 2009; Tranvik et al. 2009). To comprehensively understand the spatial and temporal patterns of inland waters worldwide, the utilization of satellite remote sensing remains the most practical approach (Alsdorf et al. 2003; Seekell and Pace 2011). According to Verpoorter et al. (2012), given the dominance of small lakes in the global size distribution of lakes and the uncertainties related to measurement approaches, the use of high spatial resolution imagery becomes crucial.

Satellite imagery has become increasingly crucial in the recent past for mapping natural resources like water bodies (Mishra and Prasad, 2015). It is essential to monitor both forest and water resources regularly, as they are vulnerable to intensive exploitation. This enables sustainable management practices. By analyzing and assessing the extent and rate of degradation and disappearance of water bodies in the spatiotemporal domain, we can understand their impact on the global carbon cycle and climate variations (Mishra and Prasad, 2015). Geospatial tools are proving to be highly beneficial in assessing these impacts and implementing effective conservation strategies (Mishra and Prasad, 2015).

Diverse satellite data with different spatial, spectral, and temporal characteristics have been utilized by researchers worldwide to produce thematic maps of land use land cover or maps with a specific focus on water bodies (Mishra and Prasad, 2015). Simultaneously, various techniques have been employed to extract these features from satellite imagery, each possessing its own advantages and disadvantages. Although visual interpretation of satellite data offers the most accurate identification of water bodies of various sizes, it is a time-consuming process, particularly when dealing with high-resolution data (Mishra and Prasad, 2015). According to Mishra and Prasad (2015), a commonly used approach for unsupervised classification, which involves an interactive self-organizing data analysis technique, tends to yield results with significantly low accuracy when there is spectral overlap between water bodies and other classes. On the other hand, Olmanson et al. (2008), Kloiber et al. (2002a), and

Reis and Yilmaz (2008) have established that unsupervised classification techniques such as "isodata" (Iterative Self-Organizing Data Analysis Technique) or "k-mean" clustering can be employed effectively to generate spectral signatures for each class.

There are various methods for extracting water bodies, but not all of them can be automated or applied to large regions. Additionally, some approaches become complex due to the nature of the data involved. However, the combination of Remote sensing and Geographic Information System (GIS) methods provides an automated and extensive solution.
In this study, The Globalland cover dataset 30 was sourced from the National Geomatics Center of China (NGCC) and subsequently acquired through download. The information was further refined by merging and masking it to align with the research focus on Rivers State using ArcGIS software. Following this, the process of vectorisation and delineation of Water Bodies was undertaken, and the size of the water bodies was estimated utilizing QGIS software. This entailed the precise calculation of each water body's area through the application of QGIS unique value query tools.

2. Materials and Methods

2.1 Study Area

Rivers State was established on 27 May 1967 during the tenure of General Gowon. Its administrative headquarters, Port Harcourt, oversees a total of twenty-three (23) Local Government Areas. The geographical coordinates of the state's boundaries range between 210590.00m and 344490.00m in the northings direction, while the eastings span from 477432.00m to 634925.00m, all with reference to UTM Zone 32N origin (refer to Figure 1 and 2). To the south, Rivers State is bordered by the Atlantic Ocean, and to the north, it shares boundaries with Imo, Abia, and Anambra States. Akwa Ibom State lies to the east, and to the west, it is bounded by Bayelsa and Delta states. The state is home to a vibrant and diverse population, encompassing various ethnic groups such as Abua, Andoni, Ekpeye, Engenni, Etche, Ibali, IKwerre, and Kalabari.

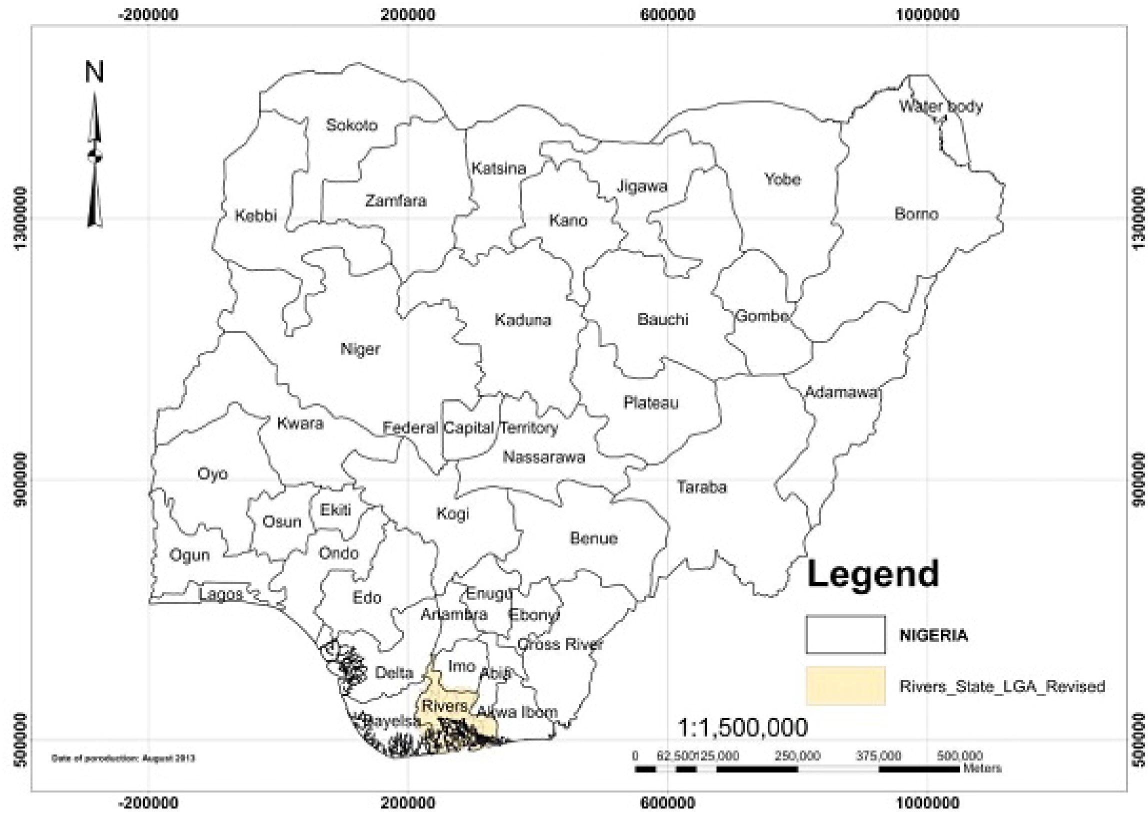

Fig 1. Map of Nigeria and location of Rivers State.
Source: Office of Surveyor General, Rivers State

According to Eludoyin et al (2011), the drainage in the aforementioned low-lying area is subjected to a substantial amount of surface water and high precipitation, ranging from 3,420 mm to 7,300 mm. This region is primarily influenced by two main river systems, namely freshwater systems and tidal systems. The freshwater systems originate from the River Niger, while the tidal systems are primarily derived from the Bonny New Calabar River, both of which are predominantly found in the southern half of the state.

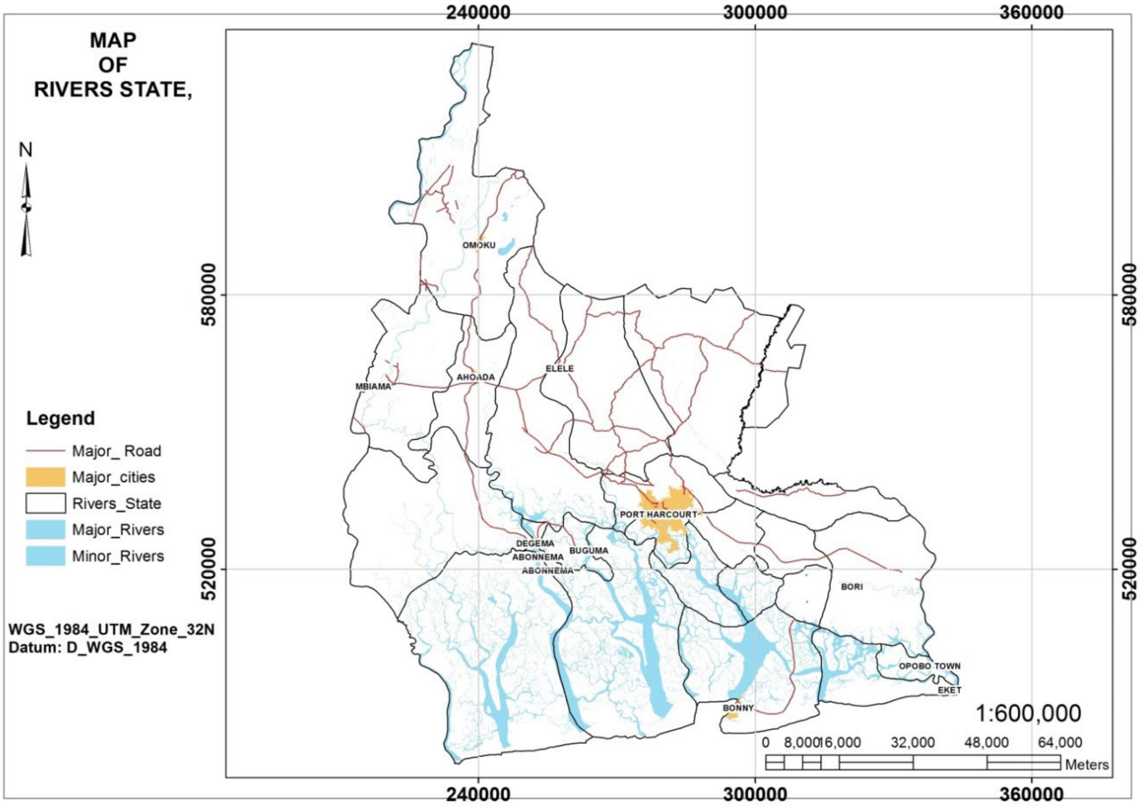

Fig 1 Map of Rivers State. Source: Office of Surveyor General, Rivers State

These systems demonstrate a notable increase in width and speed downstream, particularly in the freshwater zones located in the northern region. The riverbanks are distinctively marked by levees, while the slopes on the sides of the valley possess a remarkably gentle gradient. These slopes undergo significant processes of erosion and sediment accumulation. Ultimately, all rivers converge into the expansive estuaries of the Bonny River, serving as pathways to the sea. These rivers are abundant sources of diverse marine life, offering valuable seafood such as crabs, oysters, shrimps, and fish. Moreover, they provide habitats for various species of mammals and birds.

2.2 Data used

The National Geomatics Center of China (NGCC) has provided the Globalland 30 dataset, a global post processing land cover data. This dataset comprises 10 classes and offers a resolution of 30 m for the year 2020. The Global Land Cover (GLC) information included in this dataset is highly valuable for conducting research on environmental change, managing land resources, promoting sustainable development, and benefiting various aspects of society. Spanning the entire Earth, the dataset encompasses over 10,000 Landsat-like satellite images, each with a

resolution of 30 m. To achieve classification, automated methods were employed, which involved integrating pixel- and object-based approaches with knowledge. This resultant approach, known as the POK-based approach, was developed by Jun et al. in 2015.
The administrative map of Nigeria and Rivers State, along with settlement and road data, was acquired from the esteemed Office of the Surveyor-General of River State. This dataset was primarily utilized to cover and merge with the study area, enabling the production of an accurate map depicting the study area.

2.3 Methods

The primary approach employed in this study involves the utilization of both remote sensing-based land cover mapping technique and geographic information systems (GIS) analysis technique.

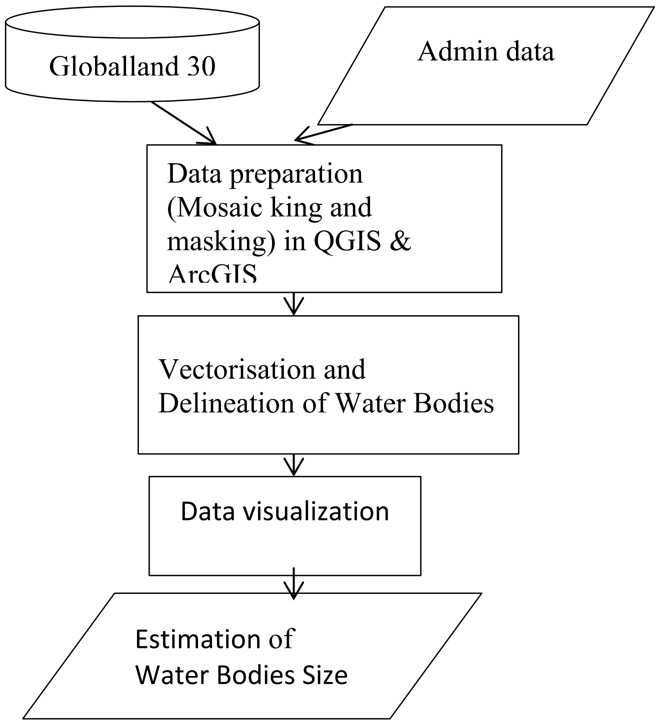

Fig 3: Methodology flowchart

In the initial step, the original dataset stored as raster geotiff format underwent conversion into a vector format utilizing the efficient vectorisation tool available in QGIS. Subsequently, a query based on selection by attribute was performed to identify the water bodies within the dataset. The determination of the total size of these water bodies, measured in square meters, was accomplished through a unique value query. For the current study, the Globalland 30 dataset of 2020, an esteemed Remote Sensing dataset, was acquired from the National Geomatics Center of China (NGCC). The acquired dataset was further modified by mosaic and masking techniques to suit the study area requirements.

3. Results and Discussion

The land cover digital maps showcase the geospatial data on land cover for 2020 in Rivers state. These maps are presented in UTM Zone 32N Projection and WGS 84 Datum, with units in meters. Figure 4 below provides a visual representation of this information.

The study area was analysed and categorized into nine different land use/cover change classes: Cultivated Land, Forest, Grassland, Shrub Land, Wetland, Water bodies, Artificial Surfaces, Bare Land, and Major Rivers, each identified by their digital number (DN) ranging from 10 to 90. The findings of the land use assessment are summarized in Table 1. This table provides insights into the sizes of Water bodies (inland waters) spanning 476049600 m^2 and Major Rivers covering an area of 558684000 m^2.

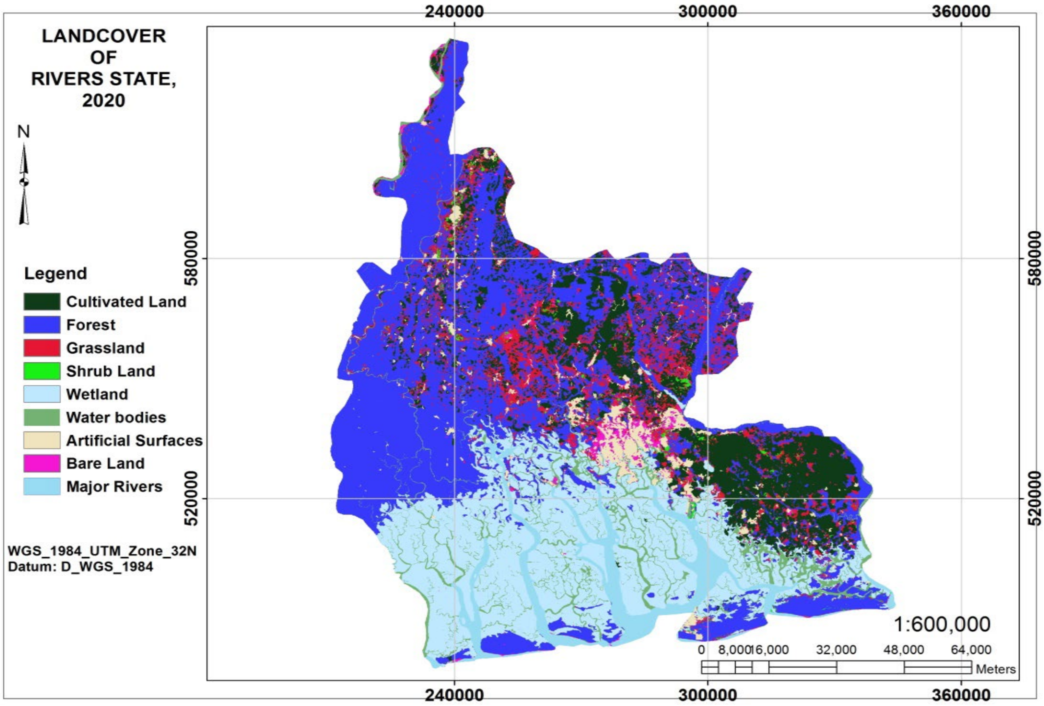

Fig 4: Land cover distributions in Rivers state for 2020 \

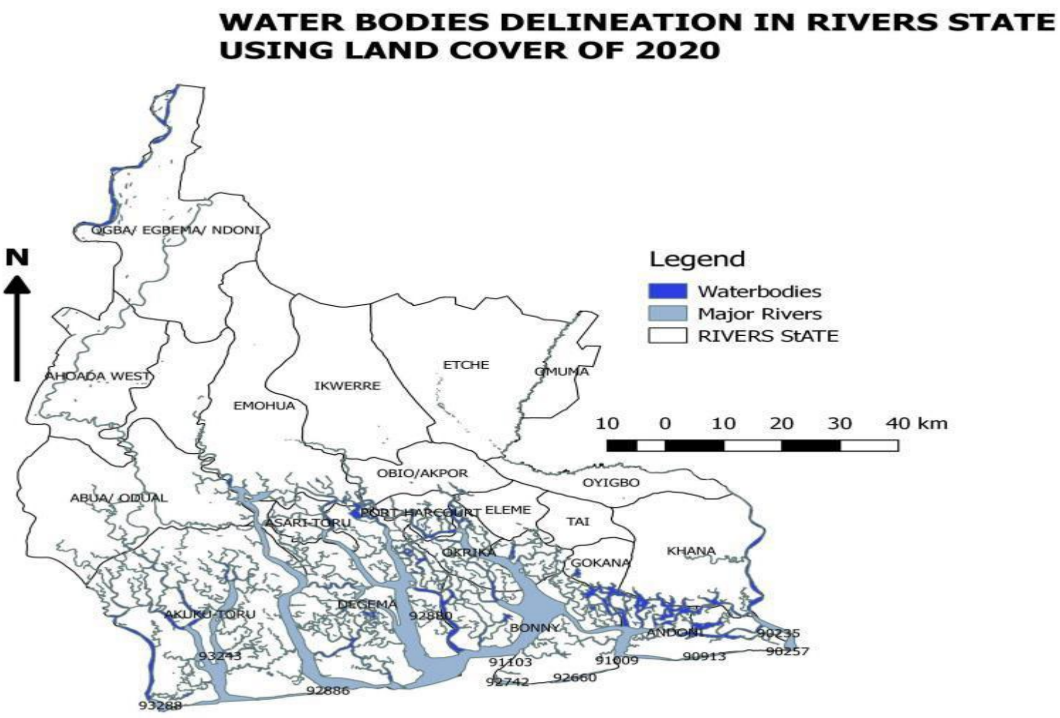

Fig 5: Water Bodies delineation in Rivers state for 2020

Table 1
Table 1: Land Cover distributions of water bodies in Rivers State in 2020
Source: Author research outcome

Land Cover	Area in m²
Cultivated Land	1582994700
Forest	4230202500
Grassland	876561300
Shrub Land	77616000
Wetland	2556892800
Water bodies	476049600
Artificial Surfaces	338642100
Bare Land	104840100

4. Conclusion

In this study, the Globalland cover 30 dataset was used to identify water bodies in Rivers state. Through the use of mosaicking, masking, and vectoring raster data techniques, along with the unique value query tools in QGIS, an analysis was conducted to determine the sizes of the water bodies. The results showed that the inland waters covered a total area of 476,049,600 square meters, while the Major Rivers encompassed a vast region of 558,684,000 square meters. Utilizing Remote Sensing Landcover data is recommended for consistent spatial-temporal mapping of water bodies. This will assist in precisely delineating and monitoring shoreline changes and erosion along the inland water boundaries of Rivers State and Nigeria overall. Riparian Boundaries is steadily increasing. Remote sensing facilitates the acquisition of broad and frequent information, while GIS offers powerful spatial analysis capabilities.

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