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APPLICATION OF MOBILE GIS IN GEO-TOURISM IN LOKOJA KOGI STATE

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ABSTRACT

Over the years, the need to diversify Nigeria's economy became imperative. Various sectors were looked into in which Tourism was not left out. Therefore, the need to spatially identify the locations of these ancient relics as well as tourist centers became important to make it handy at any point in time. The study, therefore, looked at the application of mobile GIS in Geo-tourism; a case study of Lokoja, Kogi State, Nigeria. It covers tourism destinations within Lokoja, Kogi State, and how the application of Mobile GIS was employed in the study to model accessibility to these points of interest using Geographic Information System Route Network analytical tools and Geotrigger functions. This is because the network analysis capability of GIS plays an important role in mobility as it provides mobile users with an interactive map of the transportation network and enables the users to discover the different alternatives and places of interest providing a spatial decision tool and knowledge in real-time. Geographic coordinates for all the various tourist' destinations were picked with their corresponding attributes to build a geodatabase using ArcGIS Online software. 50meter buffer were used to create Geofences around the Point of Interest, in other to notify tourists when they have entered or exited a point of interest. The result of this research work was presented using ArcGIS Field Map and ArcGIS Web AppBuilder, these software applications were used to create a digital map of Geo-tourism destinations within the study area. It is strongly recommended that this system be implemented in the state to give tourism and the state unprecedented economic growth. It will also serve as a decision-supporting tool for sustainable tourism planning, impact assessment, visitor flow management, and tourism site selection

KEYWORDS: Geographic information system, Geo-tourism, Geofence, Geotrigger, Mobile GIS

1.0 INTRODUCTION

In the 1990s and 2000s geo-tourism was being characterized in England and Australia by academic researchers as essentially 'geological' tourism. However, in the United States of America, the National Geographic Society was taking a broader 'geographic' stance (Tourtellot, 2000). In research undertaken by the Travel Industry Association of America for the National Geographic Society, a broader definition of geo-tourism was expounded (Stokes et al., 2003). It argued that it had identified at least 55.1 million Americans who could be classified as 'sustainable tourists' or

'geotourists'. Geo-tourism was defined as providing culturally authentic travel experiences that protect and preserve the ecological and cultural environment. Their view was that geo-tourism embraced a wider remit than just its geological component, that is, it included a range of niche forms of tourism such as cultural tourism and ecotourism. It stated that 'geo-tourism is defined as tourism that sustains or enhances the geographical character of a place – its environment, culture, aesthetics, heritage, and the well-being of its residents' (National Geographic, n.d.). The National Geographic Geo-tourism Charter (National Geographic, n.d.) emphasizes sustainable aspects of tourism such as appropriate planning, destination protection, conservation of resources, interactive interpretation, tourist satisfaction, and community benefit, and these are aspects of the Charter that have received widespread support. Tourism is one of the most rapidly increasing business sectors in the world and the success of this business sector varies from country to country depending on different policies, the ability to develop sufficient infrastructure to support, the ability to manage and create market and overall marketing through the whole world about the product. Many countries depend on the tourism sector for their economic growth. Since tourism has a geographic component there is no better way to enhance tourism in a country or state than the use of Geographic Information Systems (GIS). The use of GIS as a basis for a system related to tourism is reasonable as the majority of touristic information is spatially related. The GIS system allows for the combined presentation of various data types and allows the user to determine the distances between various points of interest (Verka and Njeguš, 2008). A more modern form of the GIS approach is the introduction of mobile GIS or multimedia GIS. Mobile GIS is an integrated software/hardware framework for the access of data and services through mobile devices via wired or wireless networks. (Eleiche, 2004.). According to the functionalities and usages, mobile geographic information systems (Mobile-GIS) extend traditional desktop GIS beyond the offices and allow individuals and organizations to localize, collect, store, visualize, and even analyze geospatial data in both field and office environments. Mobile GIS applications can either store collected datasets in the offline mode and then upload to a GIS server or a cluster later on, or directly update features to existing Web GIS services on the cloud server infrastructure in real-time via mobile devices. (Gao and Mai., 2018). It has the power not only to deliver geospatial data to the mobile user anywhere and anytime but also, to personalize the geographical data and enable the capture of the geographical dimension of the personal information and the ease of interaction with geographic coordinates.

Promoting, planning, implementing, managing, and marketing tourism in Lokoja has not been an easy task and this is true for tourism at any level in any country. To maintain all aspects of tourism in a planned, sustained, and economically sound way, computing, and IT technologies and facilities are necessary in this modern world. GIS- a special analytical tool that can be helpful in the promotion and management of Lokoja Geotourism in different ways. There are several cultural and historical Tourism attractions in Lokoja, Kogi state that will keep visitors streaming all year round as well as top-class hotels for tourists who come to see its treasures. when visitors are visiting tourist sites, information on the location and related services is important during and before such a trip is made. Also, a visitor may want to know the shortest route to reach the destination of interest and also check for the nearest facility within a specified distance or time to his or her current location (route-time-location optimization; (Abubakar et al, 2017).

Due to the lack of an accurate Geographic Information Retrieval system as regards tourism, most tourists are discouraged from exploring these tourist locations within the state, this in turn hampers the positive impact that tourism is meant to have on the development of the state.

Lokoja tourist destinations remain under-explored thereby having little or no significant contribution to the state economy or the country at large. This study applied a mobile Geographic Information System to assess the spatial location of tourist sites in Lokoja, Kogi State, Nigeria, giving a comprehensive understanding of the importance and the need for a Mobile Geographic Information System for Promoting, planning, implementing, managing, and marketing Lokoja tourism destinations.

2.0. THE STUDY AREA AND METHODOLOGY

2.1 THE STUDY AREA

The study area is located between Latitudes 7º 45'N and 7º 51'N and Longitudes 6º 41'E and 6º 45'E, within the lower Niger- Benue trough in Central Nigeria. Founded by William Balfour Baikie according to European historical records, although there have been indigenous people living in the area for thousands of years. Lokoja was the capital of the British Northern Nigeria Protectorate and remained a convenient administrative town for the British colonial government after the amalgamation of Northern and Southern Nigeria Protectorates into one nation called Nigeria in 1914.

It is the 4th biggest city in Kogi and is the capital of Kogi State. The city accommodates a population of 60,579, the weather records are as follows: Temperature is 85˚F (29˚C), Wind Speed at 4 mph (6 km/h), and 67% Humidity. (World Atlas, 2015). Besides being an important commercial settlement, Lokoja was selected for the first British consulate in the interior (1860–69) and the military headquarters for Sir George Goldie's Royal Niger Company (1886–1900). Formerly the capital of Kabba province, Lokoja was part of Kwara from 1967 to 1991 when it became the capital of Kogi state. Some of the historical sites in Lokoja include; Lord F.J.D. Lugard's office and residence (1901), which is now Kogi State Government House. The first primary school in Northern Nigeria, the Crowther Holy Trinity primary school was founded in 1865 in Lokoja through the efforts of early Christians such as late Bishop Ajayi Crowther and one

pastor John. The burial ground of Bishop Ajayi Crowther is located within the premises of the school. Magazine Hill in Lokoja, a storehouse for military ammunition by the Royal Niger Company and African Frontier forces, has also served as a police station and as a jail yard for accused persons from the native town. Bank treasury of the first ever conventional bank in Northern Nigeria, the Anglo-African Bank (Lugard Bank), was established in 1905. United African Trading Company (U.A.C). Constructed warehouses for the import and export of their goods and vacated them in 1963. The first military church in Northern Nigeria, built of burnt bricks in 1905, is located along Muritala Mohammed Road, Lokoja. The first prison yard in Northern Nigeria. Lord Lugard's senior staff quarters (five of them). One of which currently accommodates The Kogi State Tourism Board, Lokoja. These were and still are prefabricated buildings from Britain. They were assembled without using nails and mounted on stilts at different locations in Lokoja, one of which now accommodates the Kogi State Hotels and Tourism Board, Lokoja. The first hospital in Northern Nigeria (1900), is now being occupied by the Kogi State Council for Arts and Culture, Lokoja. Lokoja is the capital city of Kogi State, in central Nigeria, and is a port on the Niger River. (Ebiloma, 2019)

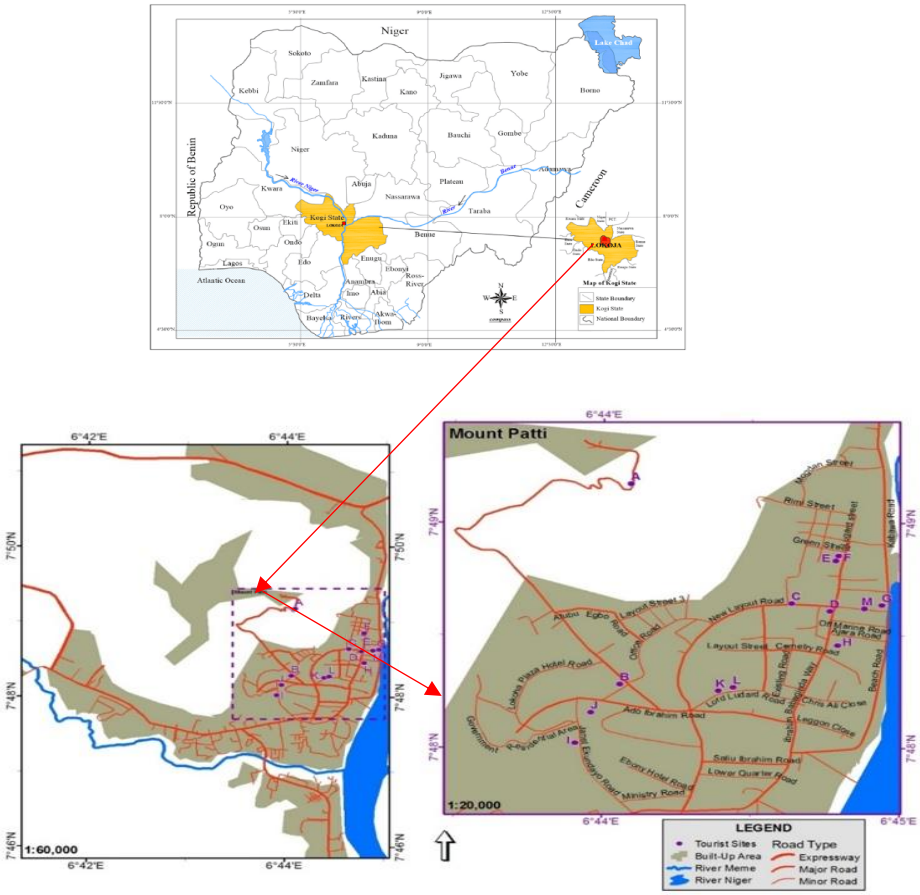

Figure 1: The map of the study area
Source: Modified from (Abubakar, Ocholi, and Idoko, 2017)

2.2 METHODOLOGY

2.2.1 METHOD OF DATA COLLECTION

The study made use of both primary and secondary datasets, the primary data which includes the coordinates of the Geotourism sites was acquired through the use of Global Positioning System (GPS) devices.

i). The coordinates of the Geotourism destinations within the study area are presented in Table 1.

Table 1: Geotourism Destinations

Name	Latitude (dd)	Longitude (dd)
1st Primary School	7.81389	6.74644
1st Prison Yard in Northern Nigeria	7.80261	6.73275
Club 1901	7.80468	6.73437
European Cemetery	7.80759	6.74657
Grave of Deposed Emir of Kano	7.81032	6.74806
Iron of Liberty	7.81424	6.7466
Kogi State Tourism Board	7.80424	6.7399
Lugard House (Government House)	7.80034	6.7319
Lugard Rest House	7.81953	6.73495
Lugard Save	7.81014	6.74613
National Museum	7.80448	6.74074
Spot of Royal Niger Company	7.81072	6.74397
UAC Warehouse	7.81057	6.74905

Source: Author's Lab Work, (2022)

ii). The secondary data used for this study include the existing Base map of Lokoja converted to digital form and Geo-referenced using coordinates of known points.

iii). Other secondary sources of data were obtained from journals, papers, and the internet.

Software

The software used in executing this study includes ArcGIS Online, ArcGIS Field Maps, ArcGIS AppStudio, and ArcGIS Qt API (QML) code. The following Application Program Interface (API) was also used in building the model for the study, ArcadeExpression, FeatureFenceParameters, FenceGeotrigger, FenceGeotriggerNotificationInfo, FenceRuleType, GeoElement, Geotrigger, GeotriggerFeed, GeotriggerMonitor, GeotriggerNotificationInfo, ServiceFeatureTable and SimulatedLocationDataSource

2.2.2 CREATION OF GEODATABASE

The base map was digitized to retrieve features of interest, the coordinates of points were grouped as Facilities, Services, and Tourism destinations and a feature class for each and their corresponding attribute fields were created using ArcGIS

2.2.3 CREATION OF GEOTRIGGERS

Geotriggers let you monitor your GIS data in real-time and receive notifications when specified conditions are met. The most common type of notification is when a device (such as a cellphone) enters or leaves an area. A Geotrigger defines a condition that you want to monitor as the device location changes. For monitoring conditions based on a spatial relationship, ArcGIS Runtime provides the FenceGeotrigger class.
In this research, a fence geotrigger was used to represent a condition such as "Inform tourists when they come within 50 meters of one of tourist destination".
The ArcGIS Qt API (QML) code creates a simulated location data source that follows a provided route polyline. One can also configure a simulated location data source with a velocity (in meters per second) and the time of day (useful when considering traffic conditions).
The location data source is used to configure a Geotrigger feed as well as the map view's location display.

ArcGIS Qt API (QML)

```
// Create a new simulated location data source.
    SimulatedLocationDataSource {
        id: simulatedDeviceLocation

        function startSimulation() {
            // The simulated location will move across the provided polyline.
            setLocationsWithPolylineAndParameters(routeLine, simParams);
            mapView.locationDisplay.dataSource = simulatedDeviceLocation;
            // Enable location display on the map view using the same simulated location source.
            mapView.locationDisplay.start();
        }
    }

    SimulationParameters {
        id: simParams
        startTime: new Date()
        velocity: 100 // Meters/Second
    }

    // Create a new Geotrigger feed with the simulated location source.
    LocationGeotriggerFeed {
        id: locationFeed
        locationDataSource: simulatedDeviceLocation
    }
```

Figure 2: ArcGIS Qt API (QML) code to create simulated location data source: Source; Author's Lab Work, (2022)

2.2.4 CREATING A FEATUREFENCEPARAMETERS TO WORK WITH FEATURES.

The FenceParameters are used to monitor target areas, including an optional buffer distance. With this workflow, the fences were made visible on the map. The fences used in this project are based on; Features from a FeatureTable that can be filtered by attributes and/or geometry. Features allow you to monitor online and offline data that can be shared across the Esri ecosystem. These features are used when the condition makes use of authoritative data that you share with your map or scene.

The following code was used to create a fence geotrigger using the simulated location feed set up previously. The fence features come from a feature table of service areas defined by drive time with a buffer of 50 meters applied. Specifying a rule type of "enter" means notifications will be triggered when the fences are entered, but not when exited.

ArcGIS Qt API (QML)

```
// Create parameters that define the fence features and a buffer distance (meters).
    FeatureFenceParameters {
        id: fenceParameters
        bufferDistance: 50
        featureTable: driveTimeServiceAreas.featureTable
    }

    // Create a geotrigger with the location feed, "enter" rule type, and the fence parameters.
    FenceGeotrigger {
        id: fenceGeotrigger
        feed: locationFeed
        ruleType: Enums.FenceRuleTypeEnter
        fenceParameters: fenceParameters
    }
```

Figure 3: ArcGIS Qt API (QML) code to create parameters that define the fence features and a buffer distance, Source; Author's Lab Work, (2022)

2.2.5 SETTING UP A GEOTRIGGER MONITOR OR LISTEN FOR EVENTS

Once the geotrigger is defined, it is ready to start monitoring it. The geotrigger itself just defines what you want tourists to be notified about. To check for when things happen (conditions are met), pass it to a geotrigger monitor.

Whenever the geotrigger monitor is in a started state, the GeotriggerNotificationInfo class provides information such as the location where the condition was met, it can zoom into this position by updating the viewpoint for your map view or scene view.

When a GeotriggerNotificationInfo is received then it displays a message to the user to tell them what happened. Tourists could take other actions, such as selecting a feature on the map or routing to a location.

2.3 PERFORMANCE CONSIDERATIONS

You can factor GPS accuracy into your geotriggers using FenceGeotriggerFeedAccuracyMode. This creates a polygon representing the area of uncertainty around the reported location, and this polygon is used to check if a geotrigger condition is met. The limit of what you can monitor depends on device specifications. For example, mobile devices with reduced memory capacity can handle fewer fences than ones with higher capacity.

Geotrigger notifications can be affected by several factors including signal strength, the accuracy of GPS data, and the frequency of position updates, to ensure accurate notifications, the intended speed of travel as well as your device's accuracy when creating fences should be considered.

Since the distance between position updates is greater when traveling at higher speeds, creating a larger fence should be considered. The methodology flowchart is presented in Figure 4.

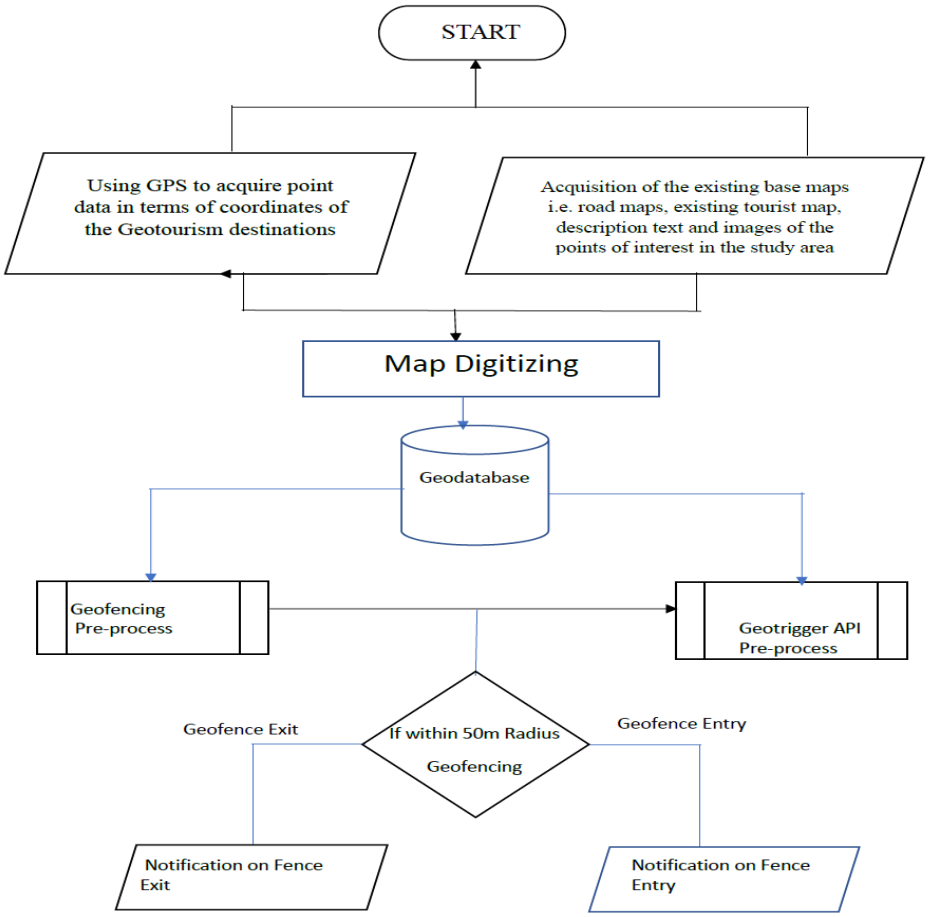

Figure 4: Methodology Flowchart

3.0 RESULT AND DISCUSSION

3.1 NOTIFYING TOURISTS WHEN THEY HAVE ENTERED OR EXITED A POINT OF INTEREST

Figure 5. shows a Geotrigger event with an ON enter and On exit message, Geotrigger ArcGIS API uses the user's current device's location and the Tourist Point of interest feature layer to query tourism destinations within a 50m distance radius, once the user location is within the geotrigger monitor buffer, the Tourism Destination buttons will appear. Clicking on the buttons will open a pane displaying the Geotourism destination available information.

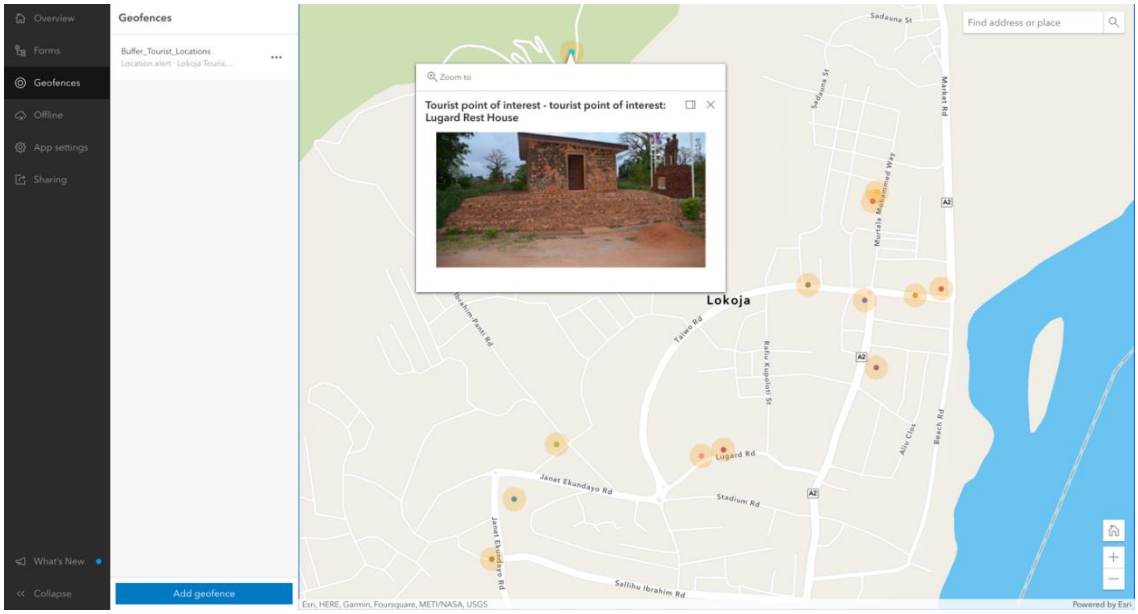

Figure 5: Geofence buffer radius with "On Enter" and "On Exit" Messages.
Source: Author's Lab Work, (2022)

3.2 BEST ROUTE ANALYSIS

The ArcGIS Network Analyst extension as implemented in the study helps in solving common network problems, such as finding the best route across the city, finding the closest facility, and identifying a service area around the Geoturism location. Network Analysts can find the best way to get from one location to another or to visit several locations. The locations can be specified interactively by placing points on the screen, entering an address, or using points in an existing feature class or feature layer. If you have more than two stops to visit, the best route can be determined for the order of locations as specified by the user.

But "best route" can mean different things in different situations. The best route can be the quickest, shortest, or most scenic route, depending on the impedance chosen. If the impedance is time, then the best route is the quickest route. Hence, the best route can be defined as the route that has the lowest impedance, where the impedance is chosen by the

user. Any valid network cost attribute can be used as the impedance when determining the best route. Two use cases were implemented in the study.

In Figure 6, the first case uses time as an impedance. The quickest path is shown in dotted white-black and has a total length of 5.19 kilometers, which takes 13 minutes to traverse.

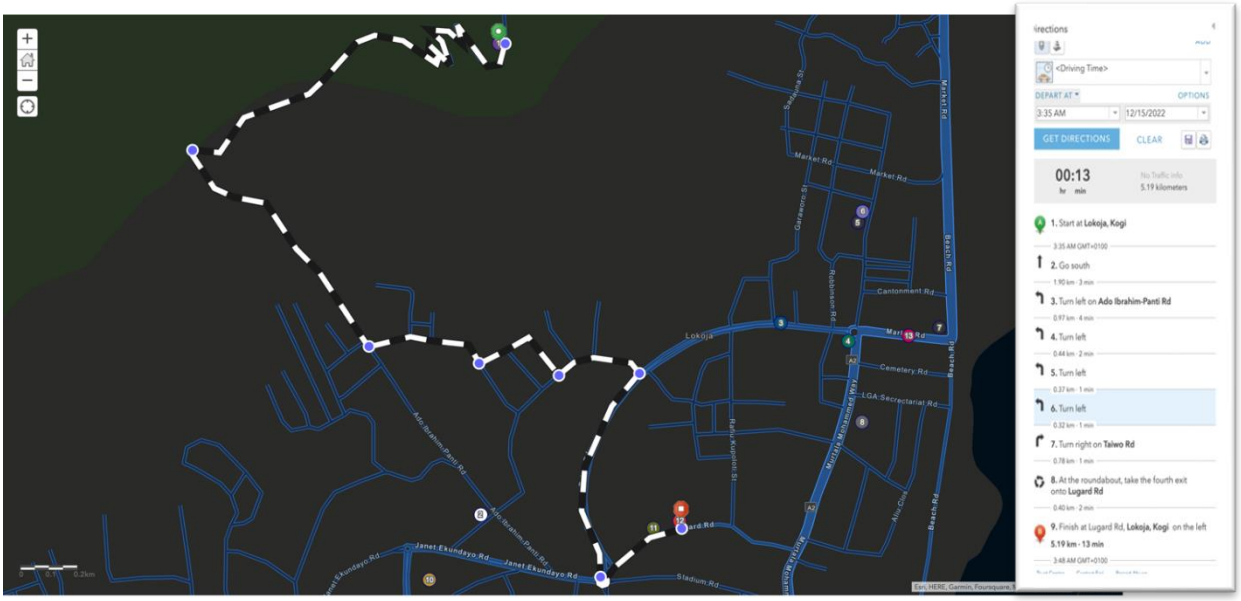

Figure 6: Route between Lugard Rest House Mount Pati and National Museum Lokoja Using Time-Base Cost Attribute, Source, Author's Lab Work, (2022).

In the next case, distance is chosen as the impedance. Consequently, the length of the shortest path is 4.7 kilometers, which takes 13 minutes to traverse.

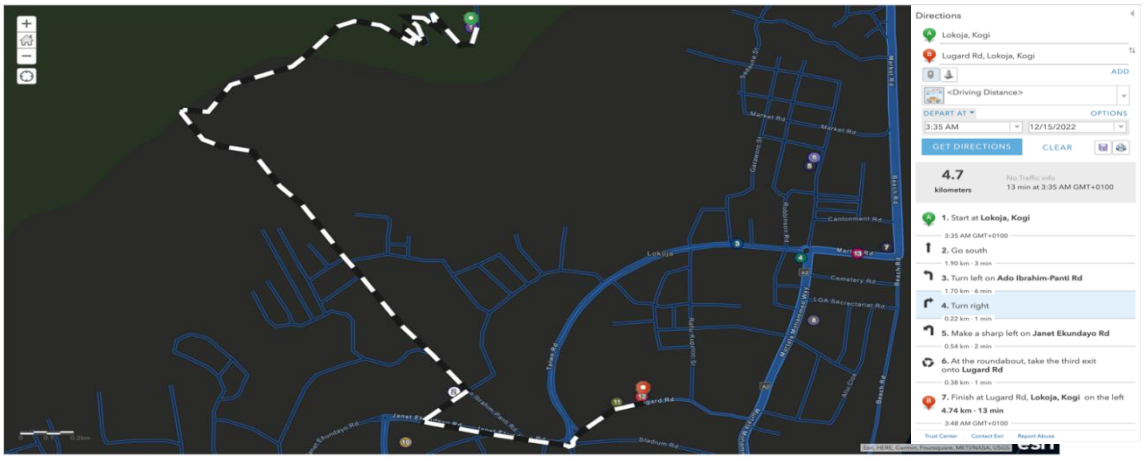

Figure 7.: Route between Lugard Rest House Mount-Pati and National Museum Lokoja Using Distance-Base Cost Attribute, Source, Author's Lab Work, (2022).

Along with the best route, Network Analyst provides directions with turn-by-turn maps that can be printed, as shown in figure 8.

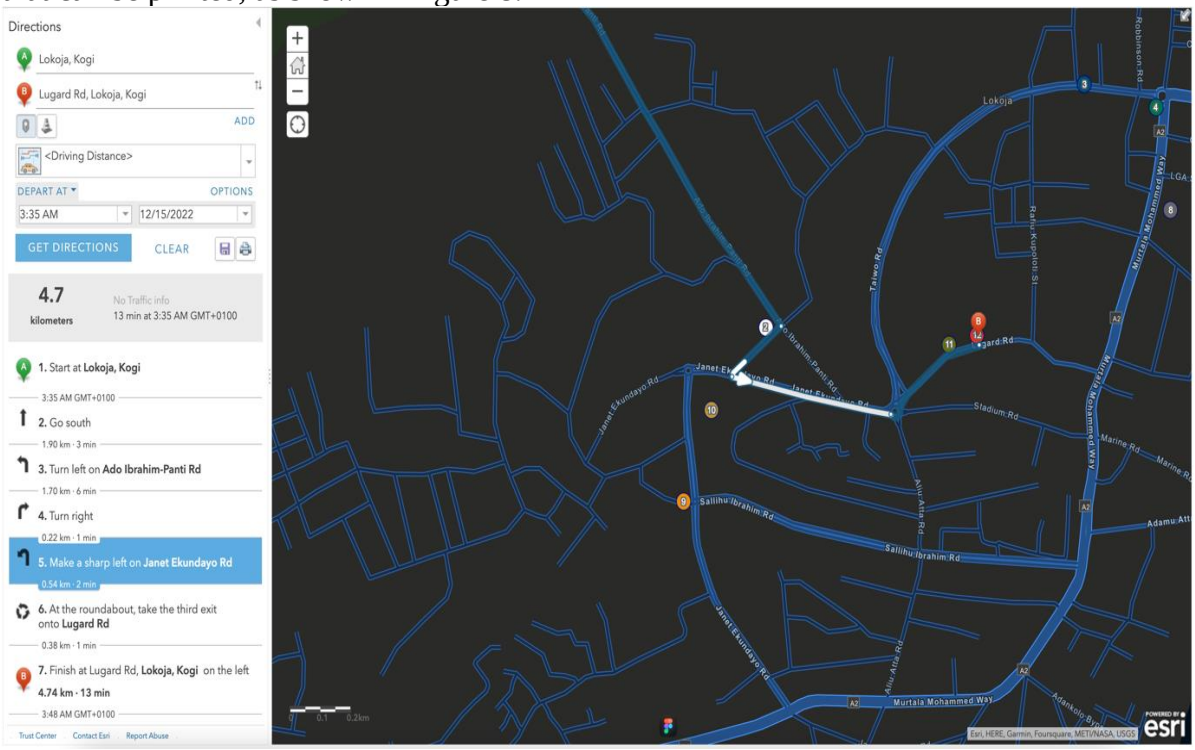

Figure 8: Best route, Network Analysis showing directions with turn-by-turn maps, **Source:** Author's Lab Work, (2022).

3.3 LOKOJA GEOTOURISM DIGITAL MAP

Figure 9, shows the Mobile ArcGIS Field Map Showing Lokoja Tourism Destinations and Legend the result of this research is hosted on ArcGIS and can be accessed on a mobile device through ArcGIS Field Maps, which is the go-to field app, powered by field maps. Because it is built on ArcGIS, everyone—whether in the field or the office—will benefit from using the same data.

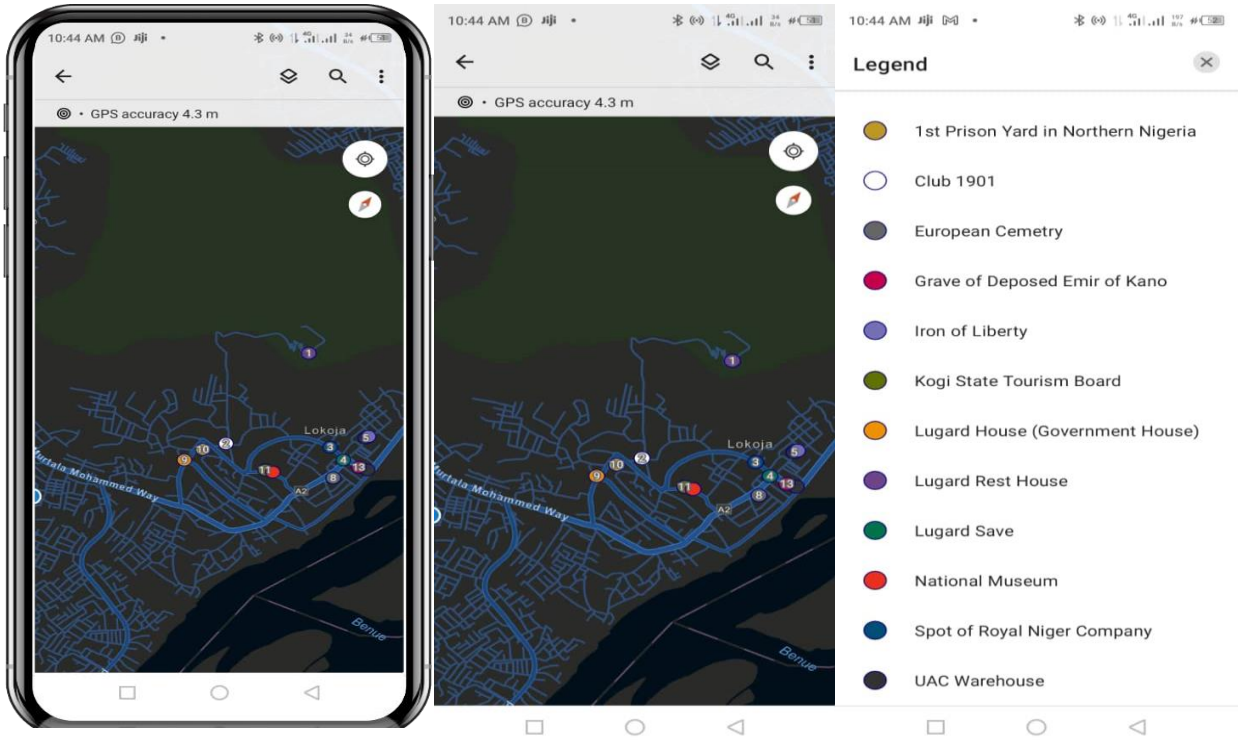

Figure 9: Mobile ArcGIS Field Map Showing Lokoja Tourism Destinations and Legend, Source, Author's Lab Work, (2022).

Lokoja Geotourism Digital Map will help tourists explore and get quicker access to tourist locations using their mobile devices, push messages or notifications can also be sent to the user's mobile phone as a way of marketing the geotourism destinations.

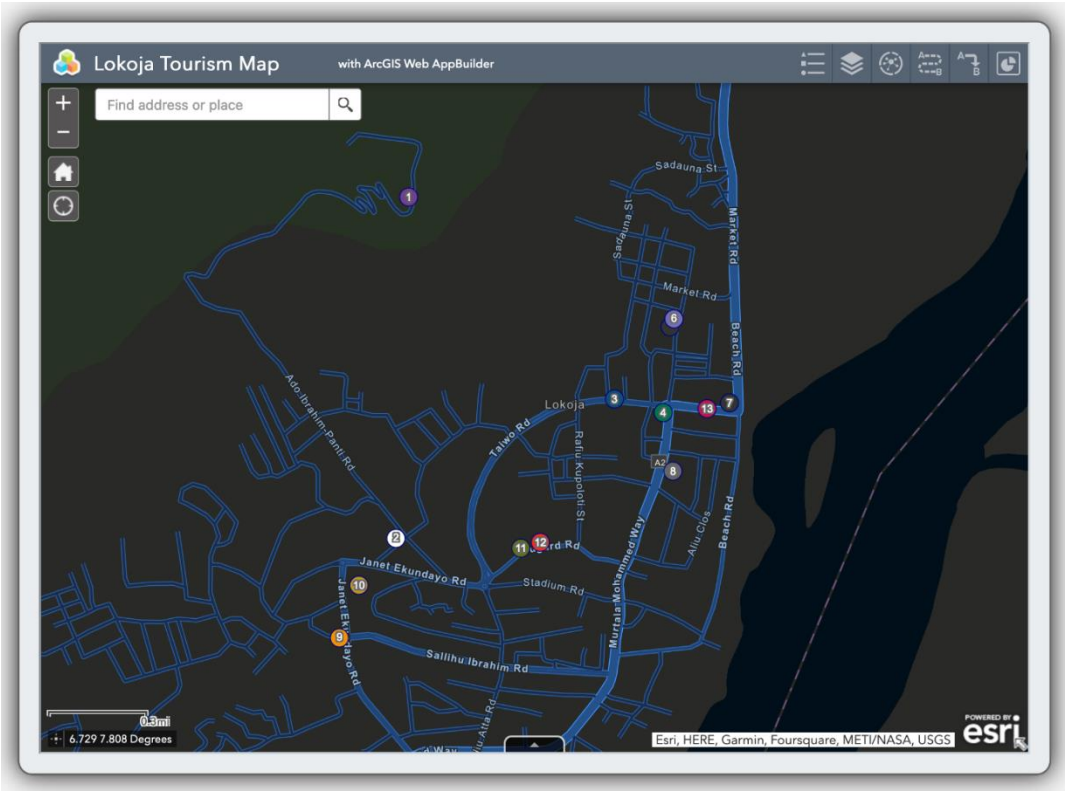

Figure 10: Lokoja Geotourism Digital Map, Source; Author's Lab work, (2022)

4.0 CONCLUSION

This project puts Geo-tourism destinations in Lokoja on mobile phones, with the understanding of Mobile Geographic Information Systems and their application in tourism, it is believed that if this research project is implemented, tourism in the state will experience a giant step and in the long run boost the economic activities within the state as more people become aware of the tourist locations in the state through the application of Geographic Information System.

The results of this research project have revealed that presenting tourism information in a Mobile GIS environment would offer an unparalleled platform for the management and promotion of the tourism industry in the state and country at large. Tourism agencies, stakeholders, and policymakers in the industry would have convenient access to comprehensive information and thus serve as a great source of motivation to boost the performance of the sector. An adequate incentive can thus be assured for efficient marketing and promotion. Moreover, difficulties in updating existing graphical tourist guides and maps could be eliminated. The process would now become less expensive, easier, and less time-consuming. The result of this project could serve also as input for a comprehensive information base for tourism in Lokoja. So as a whole, it can be said that Mobile GIS is a useful and efficient tool for sustainable tourism development and for building a smart city.

4.1. RECOMMENDATION

It is recommended that this system be implemented to give tourism and the state unprecedented economic growth. It will serve as a decision-supporting tool for sustainable tourism planning, impact assessment, visitor flow management, and tourism site selection. A dedicated GIS-enabled tourism mobile app for the state should be created to give tourists quick access to the various tourism destinations in the state. It is also recommended that the Kogi State Cultural and Tourism Board create a digital Geo-tourism map to eliminate difficulties in updating existing graphical tourist guides and maps.

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