



Current Condition of the Iya in Benin City, the Gates and Future Preservation Strategies

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Accepted: 10 July 2025 / Published online: 21 August 2025
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Abstract This paper investigates the preservation and morphology of the Inner City Iya of Benin in southern Nigeria, Edo State. The Iya have been the focus of research in the 1960s and 1970s by archaeologists Graham Connah and Patrick Darling. Since then, urban development has grown rapidly spreading out across the wider Iya network and damaging the earthworks. Already more than half of the Iya within Benin City vanished. Digital archaeology methods pose new opportunities for cost-effective and rapid

documentation and monitoring of the remaining Iya. Based on these results and maps, the paper proposes strategies for future preservation. Future preservation of the Iya is only possible by working together with the communities of Benin. Further, the first new survey of the Benin City Iya since the 1960s provides for the first time a detailed plan and archaeological discussion of one of the gates of the Benin earthworks.

Archaeological time period: 14th to 19th Century AD.
Country and region discussed: Nigeria, Edo State, Benin City

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10437-025-09630-y>.

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Résumé Cet article étudie la préservation et la morphologie des Iya Intérieure du Bénin, au sud du Nigeria, Edo State. Les Iya ont fait l'objet de recherches dans les années 1960 et 1970 par les archéologues Graham Connah et Patrick Darling. Depuis lors, le développement urbain s'est rapidement étendu à l'ensemble du réseau d'Iya et a endommagé les travaux de clôture. Plus de la moitié des Iya de Benin City ont déjà disparu. Les méthodes d'archéologie numérique offrent de nouvelles possibilités de documentation et de surveillance rapides et rentables des Iya restantes. Sur la base de ces résultats et de ces cartes, l'article propose des stratégies pour la préservation future. La préservation future des Iya n'est possible qu'en travaillant avec les communautés du Bénin. En outre, la première étude de l'Iya de Benin City depuis les années 1960 fournit pour la première fois un plan détaillé et une analyse archéologique de l'une des portes des travaux de clôture de Benin.

Keywords Nigeria · Earthworks · UAV · Mapping · Preservation

Introduction

In the framework of a partnership between the Museum of West African Art (MOWAA) and project Edolcation of the German Archaeological Institute (DAI), new research investigates the preservation and morphology of the great Iya (Moat) of Benin. The earthworks in Edo State, known locally as Iya and Iyala in the Benin and Esan areas respectively, consist of an extensive cellular system of ditches and ramparts that historically enclosed and connected more than five hundred settlements across both the Benin and Esan territories. It is estimated that all earthworks together are around 16,000 km long and cover an area of around 6500 km² (Darling, 1984). Two inner circuits, the Inner City Iya and the Outer City Iya, encircle the historical core of Benin City. They are no discrete enclosures but are part of the cellular network of Benin Iya (Connah, 1975). Though, these two defensive enclosures differ in size from other earthworks outside of the old city, that define historical rural communities. Already in the 1960s, Benin City expanded beyond the Inner City and Outer City Iya. The Iya were the focus of research in the 1960s and 1970s by archaeologists Graham Connah and Patrick Darling.

Beside the Iya of Benin, multiple earthworks and enclosures of cities exist throughout Nigeria. Examples of such earthen enclosures are Old Oyo and the Sungbo Eredo, that is the largest single enclosure so far found (Soper & Darling, 1980; Darling, 1998; Chouin, 2012; Aremu, 2016; Lasisi 2017; Chouin & Lasisi, 2019). At the Sungbo Eredo, the Mission Archéologique Ife-Sungbo used aerial LiDAR to document the Sungbo Eredo and surroundings (Chouin et al., 2023), underlining the potential of such a method. Getting through the dense vegetation during ground surveys requires to cut down the plants, making it necessary to deploy a bigger team and posing a difficulty (Connah, 1967; Darling, 1984). The laborious surveys through such vegetation and reduced visibility affect the accuracy of measurements on the ground (Connah, 1972; Darling, 1984). Thick vegetation makes it even difficult to investigate earthworks with remote sensing on satellite or aerial imagery from drones or airplanes (Chouin, 2012). LiDAR has the capabilities to penetrate the canopy of tropical vegetation in southern Nigeria and to generate bare earth models of high accuracy revealing

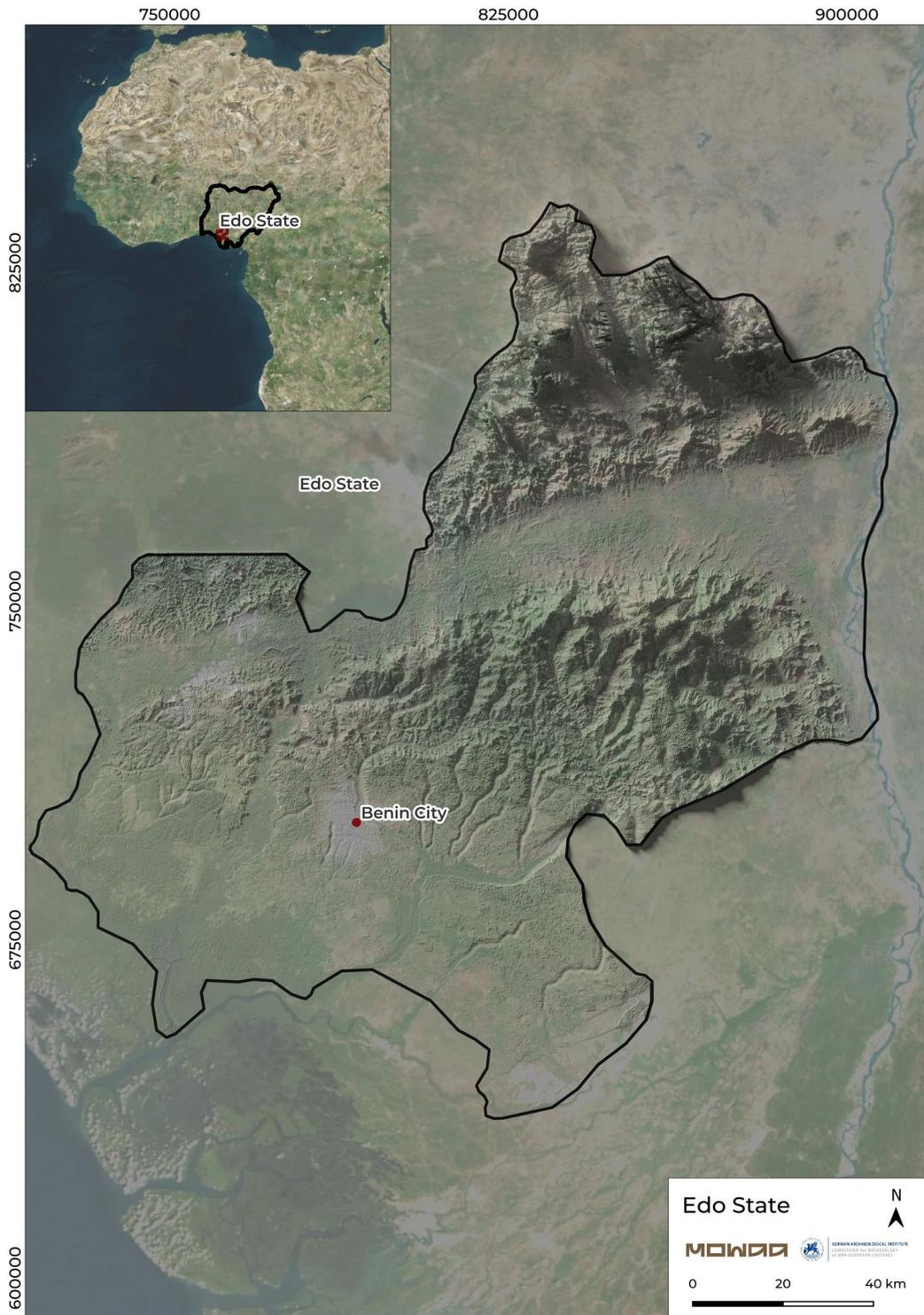
potential archaeological structures hidden under the vegetation (Chouin et al., 2023).

All earthworks face similar challenges of preservation and instigate research questions like chronology and their precise extent.

The paper builds on the previous research outlined in the next chapter and investigates the current preservation of the Iya of Benin City, structural details and discusses future strategies to protect this historical monument.

Research History

The great Iya of Benin were the focus of previous research by Graham Connah (1967) who was the first archaeologist to publish his investigation of the Iya (Fig. 1), providing further analysis in his monograph about the archaeology of Benin City (Connah, 1975). Before Connah, John Goodwin led excavations in Benin City, documented the architecture of the Benin Kingdom and shortly refers to the Iya (Goodwin, 1957). Goodwin never published the full extent of his documentation, but Evans (2025) presents new interpretations and data based on the archival material of Goodwin. As well as mapping the Inner Iya, Connah mapped a large network of Iya that extended to the north, west and south in the hinterland of the historic city. Ten years later between 1973 and 1977, Patrick Darling surveyed approximately 1500 km of Iya (Darling, 1984). Darling's work in the 1970s is to date the most extensive survey, revealing the extent of the interconnected earthwork system in present-day Edo State and collecting oral traditions connected to the Iya. Darling (1984) surveyed the Iya east of the Ikpoba River which Connah had not studied. Contemporaneous to Darling's field research are the published reports by Roese (1981) about the earthworks on the grounds of the Nigerian Institute for Oil Palm Research, around 25 km north of Benin City. Roese (1981) summarized the extensive results of Darling and Connah and the reports of early traders. Darling's research revealed various threats to the Iya such as clay mining and urban expansion. The Benin Iya—along with Sungbo Eredo, another set of monumental earthworks 190 km to the west—were placed on Nigeria's tentative World Heritage Site list in 1995. Darling and Agbontaen-Eghafona (Darling & Agbontaen-Eghafona, 2014) called for reform



Graphic Design: J. Hubert | Satellite Imagery: Google, Maxar, Airbus, Landsat, Copernicus | WGS 84 / UTM 31N

Fig. 1 Edo State in Nigeria. Iya were investigated at Benin City

of state and federal legislation to improve protection and management of the Iya and to apply for full nomination on the UNESCO World Heritage list (still pending).

The above-mentioned studies of the Iya are the most recent. Darling and Connah so far are the only investigations measuring and describing the Iya. In addition, historical sources give important insights into the Iya of Benin. Roth (1903) presents a colonial perspective and brings together the reports of early traders travelling to Benin City between the fifteenth and eighteenth century. The first European travellers were merchants from Portugal, the Netherlands, England, and France. They described the city as located on a plain, encircled by deep ditches that are over 6 m wide and just as deep (Roth, 1903). Ryder (1969) published a more balanced view describing the contacts between the Benin Kingdom and Europe. From the European travellers, Duarte Pacheco Pereira provides the oldest written mention of the Iya of Benin (Connah, 1967). Later a source called “DR,” who might be Dierick Ruiters (Connah, 1967), provided more details and mentions tall trees as part of the Iya and wooden doors (Connah, 1967; Roth, 1903). Olfert Dapper who never visited Benin City himself (Connah, 1967) brings together the observations of Dutch writers and his own direct informants (Ryder, 1969). While Dapper’s text regarding trade has valuable information, his description of the town and the Iya including a depiction is inaccurate (Connah, 1967; Roth, 1903). Jean Francois Landolphe and members of his crew give the most detailed description of the fifteenth to eighteenth century merchants of the Iya. They describe a rampart made of earth surrounding the city and a ditch next to it, thick vegetation, and gates (Connah, 1967; Landolphe & Quesne, 1823; Roese, 1981; Roth, 1903; Ryder, 1969). The mentioned descriptions of early European travellers are not always correct and in regards of the Iya influenced by their perception of walls and defensive architecture (Connah, 1967). Later colonial sources document the oral traditions connected to the Iya (Read & Dalton, 1899; Talbot, 1926) and mention historical accounts of their construction. While Read and Dalton (1899) write that Oba Oguola constructed the Iya of Benin City, Talbot (1926) reports the alternative that other Obas like Esigie or Ewuare commanded the construction of the earthworks.

Jacob Uwadiae Egharevba is the Nigerian Historian who did important historical research on the Kingdom of Benin on several topics including the Iya (Egharevba, 1968). Until today, the work of Egharevba (1968) is a primary source for history of the Kingdom of Benin.

From other fields, Maduka (2014) reports thoughts about the preservation of the Benin Iya. His work is a first systematic analysis about how the public thinks about preserving the Iya of Benin (Maduka, 2014). Onwuanyi et al. (2021) analyze the spatial character of the Iya within the modern urban space of Benin City. Kaplan (2008) discusses the current meaning of the Iya for Benin City, their importance for cultural identity in Nigeria and how colonialism affected the monuments.

All these previous works give detailed information about the extent of the Iya of Benin and explain their meaning for the history of the Kingdom of Benin and the cultural identity of modern Benin City, underlining the importance of preserving the Iya of Benin.

When systematic and published research of the Iya started in 1960s, the results underline the importance of preserving the Iya of Benin and identified threats. The main threats at that time linked to the urban expansion of Benin City (Connah, 1967; Maduka, 2014) were sand extraction for road repairs and bricks, flattening the ramparts or filling up the ditches to gain space for buildings or because of mechanized plowing (Chouin, 2012), accelerated erosion and silting of the ditches from the drainage of streets, intensification of agriculture and cutting gaps into the Iya to make way for streets (Connah, 1967, 1975; Darling & Agbontaen-Eghafona, 2014). Further threats to the Iya are using them as dumping ground for refuse (Darling & Agbontaen-Eghafona, 2014; Maduka, 2014). Another identified issue is the encroachment of building onto the Iya (Darling & Agbontaen-Eghafona, 2014), impeding access, maintenance, and integrity of the Iya. Despite the environmental threats to the Iya, the lack of implementing existing legal protection and continued low resources for heritage authorities poses a threat to the Iya of Benin (Darling & Agbontaen-Eghafona, 2014). Another threat is the vanishing connection between the monuments and communities living close to them, hindering their interpretation and preservation (Chouin, 2012).

Previous research mentions the connection between sacred groves or trees, shrines, and the Iya. Bradbury cited by Darling (1984; Evans, 2025)

and Darling and Agbontaen-Eghafona (2014) report that during the deepening of the Iya around Benin City by Oba Ewuare, aban (charm pots) were buried at the gates, transforming them into ada (junctions between the realms of the living and the dead). Men do not cross the ada because of their spiritual power (Darling & Agbontaen-Eghafona, 2014). In his main monograph about the Iya of Benin and Ishan, Darling (1984) collected and discussed traditions linked to the Iya. Among other things he mentioned the ikhimwin trees that the avbiogbe (surveyors) of the Oba used to mark the boundaries of communities that correlate to the Iya. Shrine groves could be observed at junctions of Iya outside of Benin (Darling, 1984). The connections of shrines, significant trees, and sacred groves to the Iya and especially the gates within the Iya are reported by other authors as well (Evans, 2025; Goodwin, 1957). This shows how the Iya, trees, groves, and shrines are entwined to form spiritual barriers (Fig. 2).

Methods

For investigating the Inner City Iya of Benin, the project applied six groups of methods in three years. It is the first time that archaeologists applied methods of digital archaeology to conduct research on the Iya of Benin. The use of geoinformation and digital archaeology methods has become increasingly important for researchers, providing access to areas that are difficult to reach. Access to affordable equipment is supporting the use of digital methods (Earl et al. 2014; Davis & Douglass, 2020; Gokee & Thiaw, 2020).

Remote Sensing

The initial phase of investigating the Benin Iya involved reviewing published surveys and maps (Connah, 1975; Darling, 1984; Federal Surveys Nigeria 1967 Survey Sheets kindly provided by EDOGIS). Federal Surveys Nigeria created a map in 1967 of Benin City that was not digital available until EdoGIS

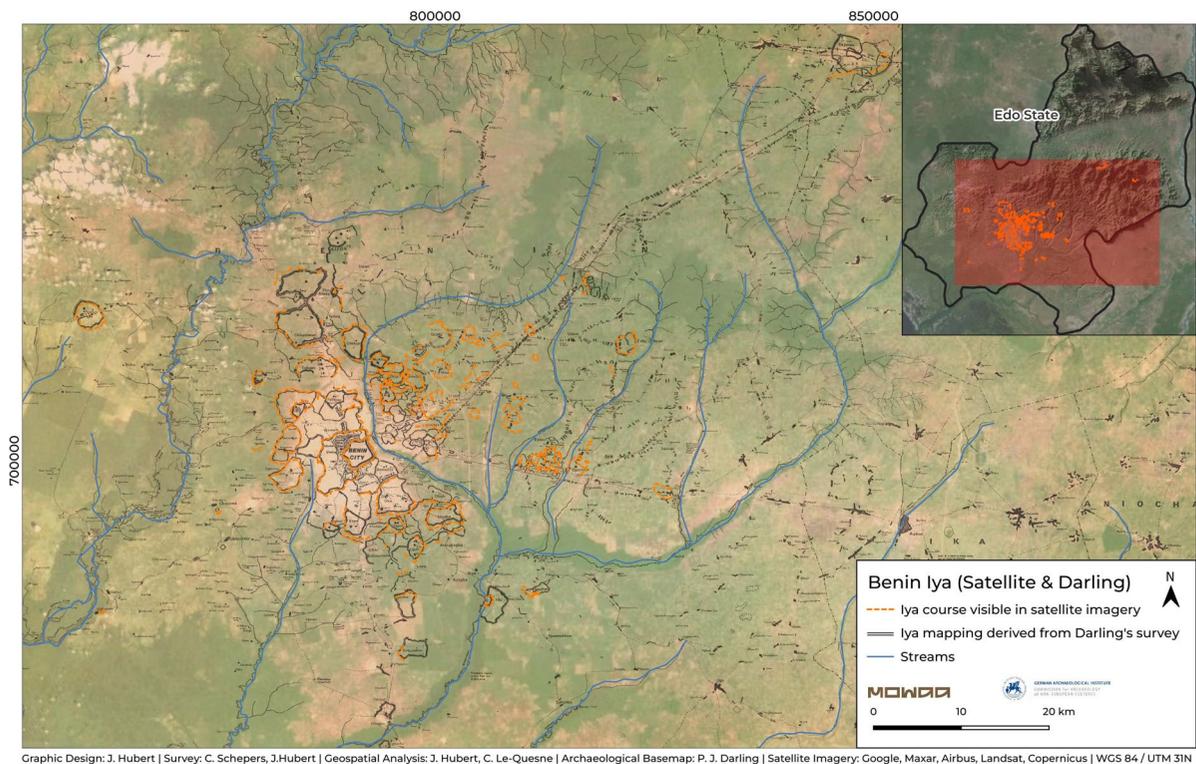


Fig. 2 Overview of the Benin Iya showing the map of Darling (1984, black lines) and results of the remote sensing in this study (orange)

started to digitize their archives. Several sheets are comprising the survey map that are not all available yet. EdoGIS is the federal geographic information of Edo State, Nigeria. These by EdoGIS digitized maps were georeferenced in QGIS, then embedded into a satellite image (Maps Data: Google; ©2024 Maxar Technologies; ©2024 CNES/Airbus; ©2024 Airbus). The outlines of the Iya on the existing maps were cross-referenced with satellite imagery to identify differences. The result is a composite map illustrating the Iya in a vector format.

The attribute table of the vector files contains text from the maps and spatial descriptions. The descriptions refer to structural details of the Iya, shrines, trees, and the observations of the researchers in the field.

RTK GNSS/GPS

For GPS measurements with an accuracy of around 2 cm, Edolcation used two multi-band RTK GNSS receivers manufactured by Emlid, model REACH RS2+. Advantages of GNSS for investigating the Iya are the quick availability of precise measurements, light equipment, and relatively low costs (Hill et al., 2019).

Challenges in an urban environment like Benin City include signal interference from electronic devices, multipath distortion due to tall buildings, limited line of sight, and hindered LoRa (Long Range) antenna usage for transmitting coordinate corrections.

Because of the challenges, Post-Processing Kinematic (PPK) is a suitable technique, involving the collection of raw GNSS data during fieldwork and processing with precise base station data to enhance positioning accuracy (Suab et al., 2020).

While PPK is effective for geotagging images and gathering ground control points, real-time integration with QField poses an issue due to less accurate, uncorrected rover coordinates. The Ntrip method resolves this issue. Ntrip, a cloud-based service, transfers corrections from base to rover via the internet instead of radio transmission like LoRa. Emlid offers a free Ntrip caster service. The base station and rover communicate continuously through sim card and mobile internet, enabling centimeter-accurate mapping of archaeological features in the QField app

during the survey (Montagnetti & Guarino, 2021; Peinado Guevara et al., 2022).

UAV Survey

In Benin City, Edolcation deployed the Mavic 3 and Mavic 3E with an RTK attachment by DJI. The latter UAV allows for the use of Pix4D to pre-program a flight plan. The RTK module receives real-time coordinates through an NTRIP mobile internet connection from the base station at Afe Miracle Close in Benin City.

The UAV flew at an altitude of 150 m above street level resulting in a ground resolution of around 3 cm per pixel. The survey team used rooftops atop tall buildings to ensure undisturbed signal transmission.

The UAV survey took 19,923 pictures of which 11,278 were geotagged and 8645 pictures were georeferenced by ground control points. Based on these pictures, a mesh was generated with Reality Capture. The mesh was the base for an orthographic aerial image and a digital elevation model of the city center of Benin and the Inner City Iya.

Additional flights with a DJI Matrice 300 RTK and a Zenmuse L1 LiDAR enabled the creation of a bare earth (digital terrain model) covering a 4.2 km length of the inner Iya.

Ground Truthing

The data from remote sensing and the UAV survey guide enhanced the ground truthing process. The Edolcation team conducted the ground truthing on foot to document the condition of the Iya, to clarify structural details of the Iya in areas with unclear aerial imagery and to take additional GPS measuring points in areas in no flight zones. The main tool to document the observations was QField (Montagnetti & Guarino, 2021; Peinado Guevara et al., 2022).

During the ground truthing, researchers documented the type of feature, mostly ramparts. Ditches present a greater challenge, being impacted by erosion and refuse dumping, making it difficult to discern their original state and size.

Images taken with the smartphone were stored within the attribute table. Additional photographs with a camera aided the documentation. The team used four categories to describe the condition of the Iya:

Good preservation: Sections of the rampart are in excellent condition and structural stability, with minimal signs of deterioration or damage and little to no littering and waste dumping.

Fair preservation: Small portions of the rampart miss structural integrity and require maintenance, with minor signs of wear or damage and littering of single waste objects.

Partial preservation: Iya display noticeable signs of deterioration and damage. Areas often show a high degree of littering and are used as refuse tipping grounds.

Severely damaged: Portions of the rampart experiencing significant degradation, structural collapse, or complete loss, making them barely recognizable as parts of the original earthworks. A high to extremely high degree of littering and waste dumping often occurs.

Ground truthing focused on accessible sections of the Iya to collect and validate remote sensing data. Besides the Iya, the documentation included the location of significant community shrines and trees. Any change of the Iya's course was documented. Abrupt gaps due to construction work or erosion are the most common change of the Iya. GPS measurements were taken to define the start and ending point of the Iya between those gaps, changes of direction or shrines and trees. Based on these results of the ground truthing the ramparts were divided into different sections.

Community Engagement

The first step in the community engagement process involved contacting the Representatives of the Communities living besides the Iya or who are in other ways connected to the Iya like Chiefs, Priests, Elders, and Youth Representatives. Questions during the visits centered around the history of the communities, the community shrines, important trees, city boundaries of the communities, oral history, what the communities expect from the project and preservation of the Iya. Later, this data was combined with archival maps and results from ground truthing surveys. The dialogues were important to discern which data about the Iya Edolcation is allowed to share and in which way it would be allowed to use the data (Fig. 3). All data are visualized as spatial data and integrated in

the project GIS. The GIS data then were shared with the community's representatives.

Geographic Information System

The GIS used for the Edolcation surveys is QGIS (QGIS.org 2024), an open-source software. The GIS of the project stored all information from the remote sensing, UAV survey, and ground truthing. The vector, raster, and project data are saved in the GeoPackage format. This GeoPackage was transferred to the mobile GIS app QField. QField features On-Site Data Collection, Real-Time Positioning, Photographic Documentation, Offline Functionality, and real-time collaboration by sharing updated maps and data with team members remotely.

The primary geometry type is polygons describing the Iya, other historical sites and boundaries of the city communities. Lines follow the course of the Iya. Points denote specific landmarks like shrines or trees. After collecting field data with the mobile GIS, the new data is transferred into the central GIS repository for further processing and analysis. The outcomes of the survey are then illustrated in geospatial maps.

Results

The results of the surveys present the current preservation of the Inner City Iya, including a detailed description of the earthworks of Benin. With the information about the current condition of the Iya, it is possible to identify the most pressing threats to the monument and to suggest strategies for future conservation. The conservation of the Iya is only possible with participation and engagement of the Communities living along the Iya of Benin.

Current Condition of the Iya

A total of 18 sections were established and help to distinguish and describe the various parts of the Iya system. The first section is situated in the northeast of the Inner City, directly next to Ikpoba Slope. The 18 sections are numerated counterclockwise and divided by gaps around 500 m or bigger into three bigger groups. Sections 1 to 9 are in the north of the Inner City, running from east to west between Ikpoba Slope and Evbimwen Street. Sections 10

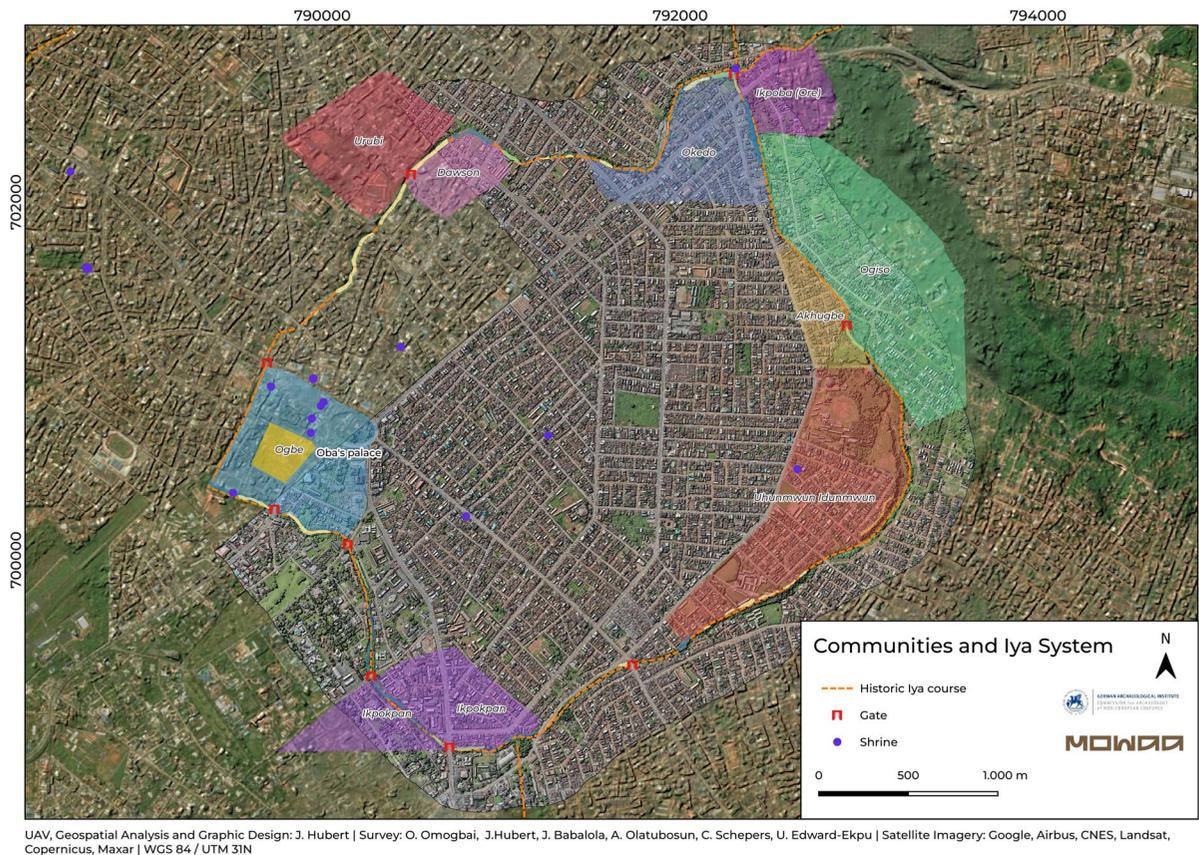


Fig. 3 Map showing community boundaries, tangible heritage, and the historical course of the Iya as indicated by Connah (1975)

to 15 are in the southeast between the Oba's Palace of Benin and Third East Circular Road. Sections 16 and 17 cover the southeast of the Inner City between Sakponba Road and the corner Murtalla Muhammed Way, Aigbedion Street. The last Section 18 is situated east of Section 1 at Ikpoba Slope close to the Slaughter Market.

The initial section near the Okedo community is significantly deteriorated, with about 120 m of Iya intact but heavily contaminated due to proximity to landfill. After a 420-m gap, the Iya in **Section 2** shows slightly better condition but is structurally compromised by earth extraction, with surviving rampart heights ranging from 2 to 3.5 m. **Section 3** suffers from tipping refuse on them and debris, though the western portion maintains good integrity at heights up to 3.6 m, while the eastern side is lower at 2.6 m. **Section 4** was in excellent condition, likely due to its proximity to a school, with

minimal pollution and heights up to 4.2 m. **Section 5**, however, has been extensively flattened or removed, with only small remnants of the rampart remaining, spanning 180 m at just 1 m high.

Section 6 has a well-preserved southwestern side, standing at 7.1 m and stretching 264 m, but has been deteriorating significantly towards the northeast, reducing to 3 m in height. The entire length is littered with refuse. **Section 7** shows further degradation, with a height of approximately 6.3 m along a 270-m stretch, interrupted, and compromised by nearby buildings and refuse. **Section 8**, despite being one of Benin's highest surviving sections of the Iya at 7.5 m and spanning 415 m, faces severe pollution, dumping, erosion, and threats from encroaching buildings (Fig. 4). Finally, **Section 9** reveals no identifiable remnants along a 420-m stretch, leaving only a 42-m fragment at 6 m high, which is damaged and heavily littered.

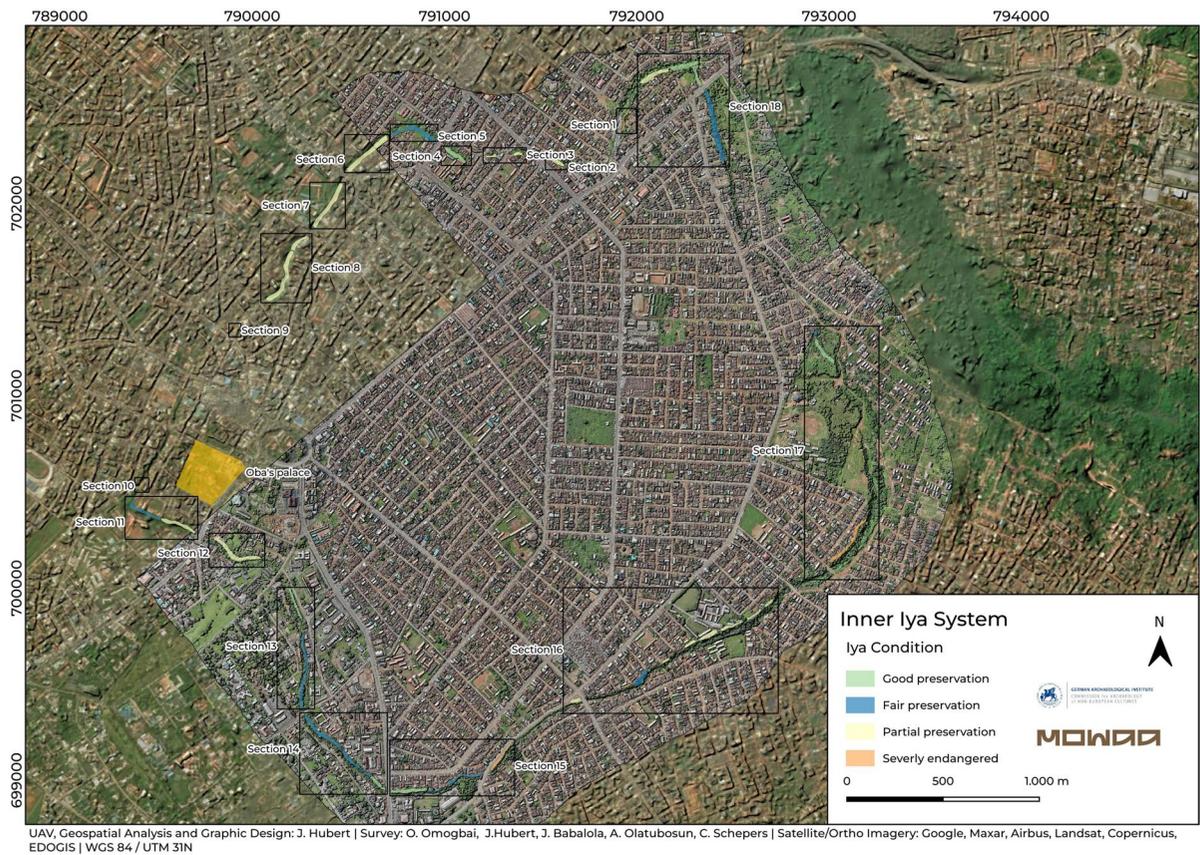


Fig. 4 Map illustrating the sections and condition of the Iya. To ease reference to distinct Iya and their conditions, the area was partitioned into separate sections. Maps of sections available in Supplementary Information

Between **Sections 9 and 10**, a 955-m gap in the rampart leaves only the ditch as a reminder of the Iya system, likely destroyed by nearby construction activities.

In **Section 10**, a small 26-m fragment of the rampart, standing 2.5 m high, remains amid residential construction and moderate littering. **Section 11**, a 400-m stretch near the palace, starts with robust structural integrity and cleanliness at 10 m high but deteriorates eastward with increased littering.

Section 12, part of a previous beautification project, spans 285 m with varying heights from 2 to 4.5 m. Despite being relatively clean, structural stability is compromised. **Section 13** has two parts: a 170-m stretch with minimal trash and a height of up to 4 m, and a 385-m overgrown portion with heights over 5 m, suggesting good preservation due to limited accessibility.

Section 14, segmented by artificial channels, includes a 255-m northern portion used for agriculture, threatening the rampart's integrity. Despite a clean environment, construction and agricultural activities endanger the structure. A metal figurine of a leopard is situated next to the agricultural field on the Iya in this section. It resembles the style of leopard figures, called Ekpen, in Benin art. The figurine could be linked to the spiritual aspect of the Iya and a shrine, but further details are not known. The remaining parts of Section 14 are in good to fair condition due to dense overgrowth limiting access.

The condition of the earthworks in **Section 15** ranges from good to severely damaged. Notably, the area between Benin Sapele Warri Road and Third East Circular Road is in a state of good to fair preservation, allowing for accessibility and exploration.

In contrast, the east of this section is generally in poor condition, with a substantial part of the Iya

system damaged or destroyed, likely due to street construction and erosion.

After a gap in the Iya system in the south-west of **Section 16**, an approximately 60-m section of the earthworks remains, reaching up to 4.9 m in height from street level.

On the whole remaining stretch of Section 16, only one rampart of 100 m long is fairly preserved, whereas the others are just partially preserved. The height from street level to top of the Iya is around 3.5–4 m. Due to the building of a drainage system, the ramparts in this section are heavily eroded leading to numerous gaps in the Iya.

Section 17 is characterized by strong erosion leading to a complete destruction of the Iya in many parts of this 1.5-km-long stretch. In the south of Section 17, a severely damaged part of the Iya remains. The primary cause of destruction is erosion from a drainage canal constructed in place of the original Iya in the 1990s. The drainage canal is deeper and broader than the original ditch and helps to direct rainwater downwards to the Ikpoba River.

Along the 200-m stretch in the north of Section 17, the Iya system is well-preserved. This preservation is due to its location being unaffected by the water drainage channel, which ends southeast of this part of the Iya. From ground level to the top of the Iya, it measures between 2.5 and 3.5 m in height. Positioned on a plateau, the distance from the top of the Iya to the deepest point of the ditch is between 9 and 10 m. There is little to no litter.

The Iya within **Section 18**, part of the Okedo community, is at the northeast of the Benin Inner City Iya. The west–east orientated rampart and ditch in the north of this section are visible and surrounded by thick, primary vegetation. The primary vegetation at the site is a sacred grove including a shrine dedicated to the Obas of Benin. The sacred significance of the site helps protect the Iya to this day. The DTM in this area (Fig. 7) shows the rampart beneath the foliage, revealing that it is narrower compared to other parts. Unlike other parts, this narrow construction appears intentional. There is a small gap, suggesting a possible original gate (Urho in Edo) leading through the Iya. The earthwork here is in a good condition, with nearly no litter.

From a total length of 12.4 km, only around 6 km of the earth walls remain intact. These are around 48% of the original length, which means more than

half of the original course of the ramparts have vanished. In total, 2.91 km of these remaining earth walls are in a good or fair preservation state. This means that around 47% of the remaining inner Iya system is in a presentable form right now, while 2.2 km or 36% show partial preservation. Especially in the west, the remaining parts are of decent structural integrity, but the littering and waste dumping degrade the Iya in these areas. Around 1 km or 17% are severely damaged. These ramparts have sustained extensive damage, with large portions of their structure obliterated (Fig. 5).

Challenges and Strategies for Preservation

Edolcation surveyed approximately 12.4 km of the Iya. The airport prohibits UAV flights in an area of 2.346 km² on the west side of the inner circuit. Intensive ground truthing with more ground point measurements than in other areas has compensated for the lack of aerial data in the airport area.

Upon comparing samples from various sites along the Iya, differences in elevation become apparent. In the east, Sections 15–18, the ramparts are lower in height compared to those in the west. The average height of the ramparts on the east side is 3.35 m, with heights ranging from 0.6 to 5.8 m. In contrast, the ramparts to the west, in Sections 1–14, average 4.17 m in height, with values ranging from 1.0 to 10.0 m.

Four primary threats to the preservation of the Iya were identified during the ground survey:

1. Increased human interference is particularly obvious in the eastern section, where historic ditches have been repurposed for drainage and led to erosion. Runoff rainwater has further deepened the ditch.
2. Refuse on the ramparts and ditches poses environmental and health risks due to contamination of water and soil, while also degrading the cultural and historical significance of the site, impacting its value as a heritage destination. Sections with waste can be found all along the inner Iya. Some areas are more affected than others.
3. Construction activities are causing destruction to the ramparts and ditches by building upon their original locations and utilizing sediments from the Iya as construction material.



Fig. 5 Categories of preservation. **A** Good preservation. **B** Fair preservation. **C** Partial preservation. **D** Severely damaged

4. Repurposing of the Iya by incorporating commercial spaces.

Especially in the western part of the inner Iya, pollution is a significant problem. This issue is due to the high concentration of businesses in this area, which use the Iya as a dumping site. In contrast, the primary issue in the eastern part of the Iya is erosion, mainly caused by the artificial rainwater drainage system built by the city.

Over time, the traditional use of the Iya within Benin City as a barrier for defense, boundary-marking, and ritual has shifted. Today, the Iya of Benin City serve modern purposes such as flood control, farming, soil mining, refuse dump, and building construction. The state government has redirected floodwaters into the Iya to manage flooding. This strategy has not solved the problem but has led to substantial damage to the Iya. Flooding has washed a large amount of silt into the Iya, filling the ditch and reducing its depth over time (Fig. 6). Flooding has led to massive gully erosion and destruction in some parts of the Iya such as the Iya in the Uhumwun Idunwun community. These threats have led to a series of

conservation interventions since at least the 1980s by NCMM, Benin Moat Foundation and government ministries. To strengthen the awareness again, a campaign by MOWAA in partnership with DAI, NCMM, government ministries, and agencies was launched.

Expanding Strategies for the Conservation of the Benin Iya

Given the critical challenges facing the Benin Iya, a multi-faceted approach is required to ensure their preservation. Building on the analysis of the main causes of deterioration of the Iya mentioned above (point 4.2) and the strategy proposed, a few key areas could strengthen ongoing efforts.

Highlighting Cultural Identity and Community Significance

The Benin Iya are not just architectural or historical landmarks; they are symbols of the Benin Kingdom's resilience and legacy. Their conservation is intrinsically linked to the cultural identity of Benin and its people as shown by the community's engagement.

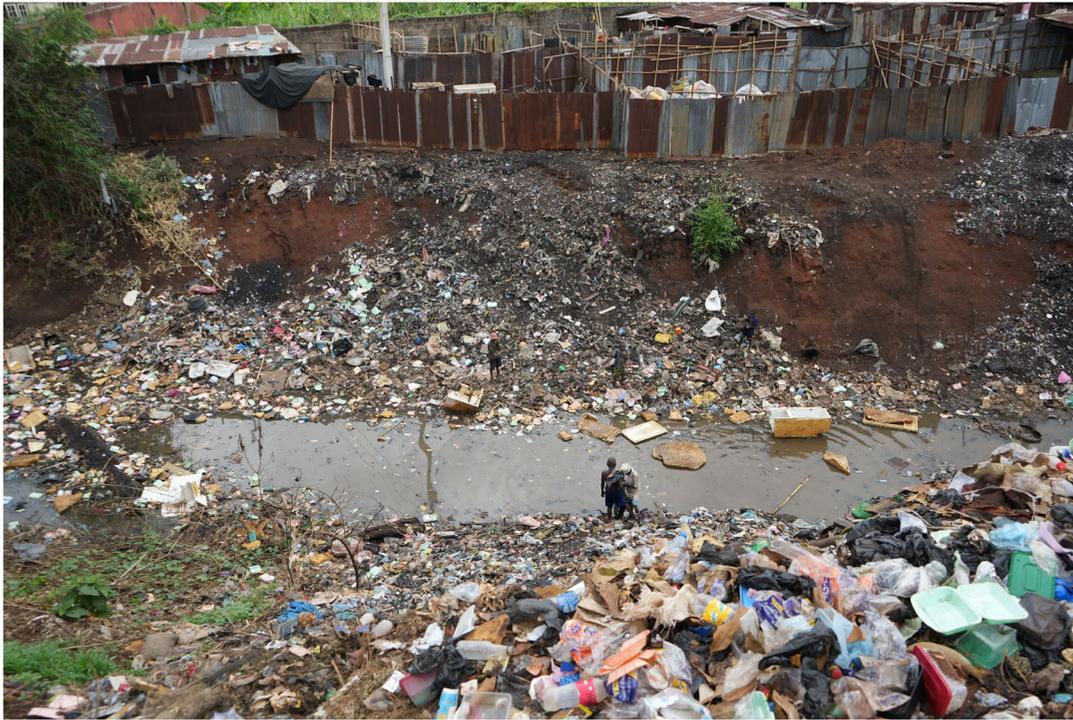


Fig. 6 Section 8 of the Iya affected by refuse

This goes beyond physical preservation—protecting the Iya means safeguarding the stories, traditions, and historical memories that define modern Benin (Kaplan, 2008; Maduka, 2014). By framing the Iya as cultural keystones, we can reinforce their relevance to future generations.

A strategic preservation effort should incorporate initiatives to promote awareness among the local and national population. Educational programs in schools, guided tours, and cultural exhibitions focused on the Iya could amplify their significance (Fonseca et al., 2024). Additionally, rituals or local traditions linked to the Iya should be encouraged and possibly revived, connecting heritage with everyday life.

Strengthening Legal Protections and Policy Enforcement

Although some legal frameworks are in place, they need reinforcement. The current preservation laws must be reviewed and adapted to the modern challenges facing heritage conservation in urban settings. A well-structured plan is necessary to integrate

the Iya into urban planning. Establishing a designated heritage protection zone with strictly enforced building regulations and legal setbacks from the Iya would ensure that any future construction respects the boundaries of these earthworks. Stronger collaboration between local, national, and international bodies would be required to make the Iya eligible for UNESCO World Heritage status, to raise international awareness and increase the level of protection (Darling & Agbontaen-Eghafona, 2014).

Fostering Community-Based Conservation Efforts

Community involvement is vital in heritage preservation, as local populations often serve as the first line of defense against degradation. Community-driven programs, where locals play a central role in maintaining and monitoring the Iya, could ensure more sustainable preservation. Collaborating with local leaders, artisans, and cultural associations to organize workshops on the history and significance of the Iya will foster a sense of ownership among residents.

In addition, forming community-based task forces to clean and protect the Iya, especially in areas affected by pollution, could be effective. These task forces could receive financial support from government and non-governmental organizations while being integrated into broader educational campaigns about heritage protection. In addition to cleaning the Iya, it is necessary to find other spaces that are suitable for managing refuse.

Leveraging Technology for Conservation and Monitoring

The use of innovative technologies like drones, GIS, and 3D visualization has already proven invaluable in documenting the condition of the Iya. Expanding these efforts through long-term monitoring initiatives would allow for real-time data collection and analysis. Drones could continue to survey areas that are otherwise difficult to access, while GIS-based systems could help map out detailed changes in the landscape and condition of the Iya.

Such technologies could also be integrated into more community mapping projects. Involving local communities in the documentation process not only empowers them but also ensures that preservation efforts are more deeply rooted in local knowledge and practices. This way digital archaeology methods can be used for public engagement and sharing new results with the public (Fonseca et al., 2024).

Sustainable Tourism as a Conservation Tool

Sustainable tourism offers a unique opportunity to both raise awareness and generate income for preservation efforts. The Benin Iya could be incorporated into eco-tourism routes that emphasize historical, cultural, and environmental education. These tourism initiatives should be designed in collaboration with local communities to ensure that the benefits—both economic and cultural—are distributed equitably.

Currently, a few families living next to the Iya offer historical information to visitors and walking tours on the ramparts but walking the ramparts or ditches is in instances difficult because of thick vegetation or deep refuse pits. Fixed schedules, fixed prizes, a list of tour operators and formalized offers do not exist regarding the Iya. There are tentative, informal attempts to

make the Iya accessible but an efficient system easy to understand for tourists is lacking.

Developing sustainable tourism plans could involve partnerships with tour operators, local governments, and international heritage organizations such as ICOMOS. A portion of the funds generated from tourism could be reinvested into ongoing maintenance and conservation programs.

Community Engagement, Community Shrines, and Iya

The Oba of Benin has customary jurisdiction across much of the traditional Kingdom of Benin which is centered on Benin City. In present-day Edo, the state government requires anyone who wishes to acquire land to get it surveyed by EdoGIS which provide a Certificate of Occupancy while the Ministry of Urban and Physical Planning gives the planning permission. When applications are in the vicinity of the Iya, by law these approvals should require a buffer of 15 m from the earthworks (E.S.L.N. 35 of 2015). Notwithstanding this, the encroachment of the Iya has been alarming over the years.

Proud of their heritage, communities play a key role in heritage management in Benin, as in the wider region, protecting monuments such as the Benin Iya. Engagement with the communities must therefore be a paramount aspect of any conservation strategy. Understanding community structure, how they interact with their cultural heritage, and participatory engagement in community events were key aspects of the research. This project interacted with various communities within the inner Iya such as Uhunmwun Idunmwun, Ogiso, Ikpoba, Akhugbe, Ikpokpan, Ofumwegbe-Iyaro, Edo Street, 3rd ICC Street, Okedo, and Ogbe-Ezoti (Fig. 3).

A number of these communities have their origins before 1897, including Uhunmwun Idunmwun, Ikpokpan, Ikpoba, and Ogbe-Ezoti. The Uhunmwun Idunmwun and Ikpoba communities continue to practice ritual rites in the Iya, e.g., linked to native chalk. Uhunmwun Idunmwun is known for the mining and production of native chalk from outcrops within the Iya used in traditional spirituality and their Olokun shrine.

The Olokun shrine of Uhunmwun Idunmwun is one of the major community shrines within Benin and actively used for worship. The Oba still performs

rituals in the Olokun shrine which is the oldest in the city. Besides the Olokun shrines of Uhumwun Idunwun Community, numerous personal Olokun shrines exist in Benin City. Information about Uhumwun Idunwun Community was provided by Odionwere L. Onaiwu, Chief O. Ehidiuwa, M. Ibude, and S. Onaiwu.

North of Uhumwun Idunwun Community at Ikpoba Slope are situated Okedo Community and Ikpoba (Ore) Community. A shrine within a sacred grove marks the boundary between both communities. The shrine, referred to as Okedo shrine, belongs to the Oba of Benin and possibly marks a historical gate (Urho) of the Inner City Iya and is adjacent to a big tree on top of the rampart. This section of the Iya is covered by several tall trees and thick vegetation. According to O. William of Okedo Community, an ancient road ran on top of the Iya and through a door situated at the side of the sacred grove. At time of the survey, the community decided to not share further details about the shrine. Information about Okedo Community was provided by O. William, O. Monday, E. Usiohen, G. Igbinoken.

Other sections of the Iya run through communities that developed in the late twentieth century, such as Ofumwegbe (Iyaro, Dawson) Community. Ofumwegbe Community is situated in the northeast, inside the Inner City Iya. Outside the Iya along the same section of the Iya Urubi Community is located. Originally, the area was forested and not accessible. Over the past century, Ofumwegbe Community has moved into this area. Ofumwegbe Community is now an economic hub of the city with its proximity to the new Benin market and Lagos Street. It contains many shops selling building materials and is a terminus for interstate transportation. The Iya in this community is also known for its very high rampart and deep ditch. Ground truthing shows it has the highest height from street level compared to another Iya within Benin. The Iya is the boundary between Ofumwegbe and Urubi Community. The Community refers to this Iya section (Fig. 4, Sections 6 to 9) as “Iya Oghe Ero,” meaning the Iya of Ero family and then developed into Iyaro. This shows the role of the Iya for naming the community and therefore for their identity. Before construction of the Dawson-Iyaro Road that now cuts through this Iya, there was no ancient road and therefore probably no gate. Information for Ofumwegbe

Community was provided by Odionwere Izevbogie, O. Ero. C. Obaseki, O. Obaseki and E. Iyamu.

The study has recognized the importance of local communities in archaeological and heritage management projects to participate and contribute to the preservation of the Iya. Actions are required to raise awareness and promote conservation efforts to address the damaging effects of neglect and misuse of the invaluable historical earthworks in Benin City.

Discussion of the Gates

Nine gates provide entrance through the Inner City Iya to Benin City according to tradition (Egharevba, 1968). The number of gates might differ from other forms of gateways through the Iya. Nowadays, no gate structures are visible because the construction of roads destroyed any evidence (Connah, 1967). What remains due to the road constructions are gaps within the earthworks. In most reconstructions and descriptions, the gates are situated at those gaps in the Iya (Roese et al., 2001). Connah assumes that both ends of the Iya at the gaps originally had timber revetting (Connah, 1967). Dapper in 1668 noted that a timber palisade was surrounding the city (in Roth, 1903, in Roese, 1981, in Connah, 1967). A partial coverage of the Iya with timbers at the gates might be the reason for wrongly assuming a whole palisade encircling the city (Connah, 1967). Reconstructing the pre-colonial city plan, Roese et al. (2001) mention more than nine possible gates. Nine formal gates with names are known from oral history and their approximate location (Igbe, 2017a,b). The precise location of the gates and any description of additional gates or gateways through the Iya are not documented.

The Dutch reported as “DR,” who might be Dierick Ruiters, described the gates around 1600 and writes that they are made of wood, guarded and could be shut (first published by De Marees, see Van Dantzig & Jones, 1987; Roth, 1903; Connah, 1967). Dierick Ruiters further described the Iya as high rampart with a deep, broad ditch full of high trees (De Marees, see Van Dantzig & Jones, 1987; Roth, 1903; Connah, 1967; Roese, 1981). Thick vegetation on top of the ramparts that makes them inaccessible even for animals is mentioned by Landolphe and his crew in the eighteenth century (Connah, 1967; Landolphe & Quesne, 1823; Roese, 1981; Roth, 1903). The account of the capture of the Benin Kingdom in 1897

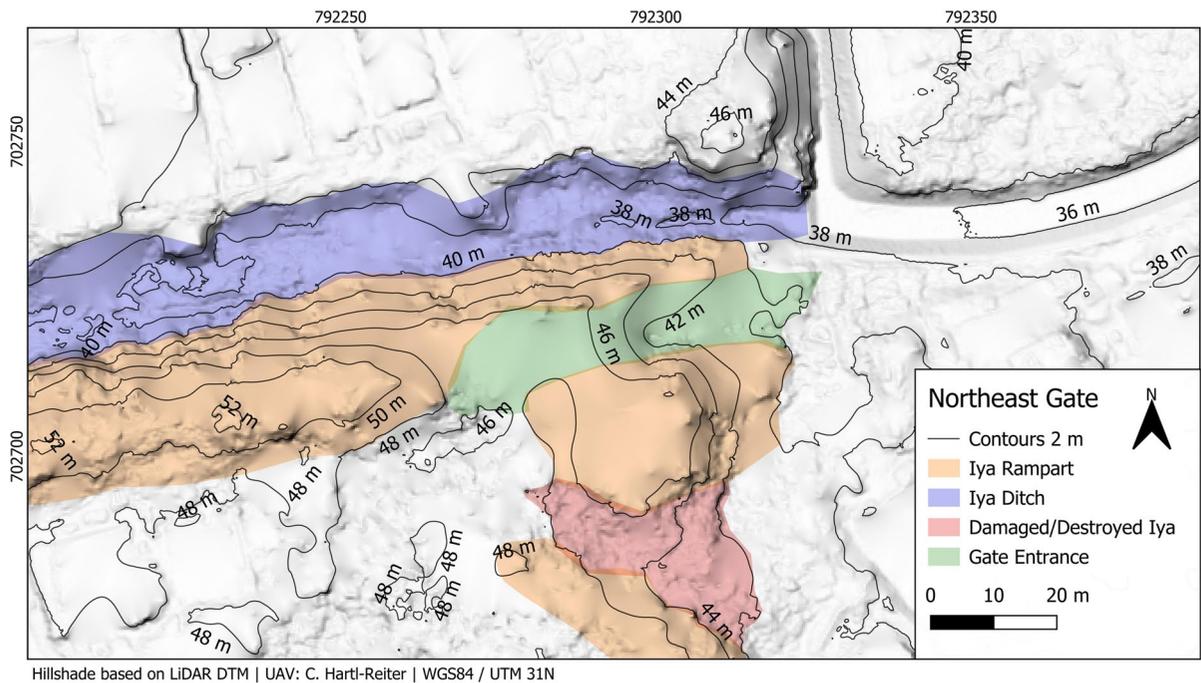


Fig. 7 Northeast Gate at Ikpoba Slope between Okedo and Ikpoba Community

by Reginald Bacon also mentions the forces encountered a causeway over “a ravine” (Bacon, 1897, p. 80) approximately twenty feet deep and behind it “a stockade erected between two high banks through which the path ran” (Bacon, 1897, p. 80) as they advanced into Benin. This seems to describe an Iya with banks flanking a gateway, similar to the entrance described below (Fig. 7). No plan, no drawing, no pictures, or no description of pre-colonial Bini historians of the construction to close the gate is published so far. Overall, the precise construction details of the gates are unknown.

The mapping of the Iya in this study does not resolve the issue of the gates but it provides clarification and ideas based on structural observations.

In the area between Ogiso Community and Akhugbe Community, a gap exists between preserved sections of the Inner City Iya. There is no road cutting through here. On both ends of the Iya on the sides of the gap are huge growing trees. The big trees indicate structural integrity of the Iya for a relatively long time. At this location, it is not known if the two trees have a significant meaning. There are examples of trees being sacred and marking the borders between communities like the ikhimwin trees (Darling, 1984).

At the Ivbiyeneva Urho according to tradition two brothers lived next to the road and when they died, two big trees remained, referring to the two brothers and the gate (Igbe, 2017a, b). It seems possible that single trees have a significant meaning like indicating boundaries corresponding to the Iya and protecting a gate (Evans, 2025). Compared to other gaps with roads through them, the ends of the Iya are not as sharp. Roesse et al. (2001) assume a possible gate at this location and our survey supports this possibility.

Further to the north between Ikpoba (Ore) and Okedo Community, the gate is usually situated on Ikpoba Slope, Benin-Auchi Road (Egharevba, 1971; Roesse et al., 2001). North of the road the rampart of the Iya is in a good condition and exhibits a steep cut (Fig. 4, Section 18). Road construction cut through the Inner City Iya at this point, possibly destroying any evidence for a gate. The remaining Iya leads north towards a sacred grove with a shrine belonging to the Oba of Benin. It then turns west and vanishes. Parallel to it is another rampart of the Iya together with a ditch. This is the area where Outer City Iya and Inner City Iya join (Connah, 1975; Egharevba, 1971). From north to south, the whole area shows a sequence of outer ditch and rampart followed by

another ditch, then by the inner rampart and the inner ditch. The ground between the two ramparts slopes upwards towards the Inner City Iya. Like the configuration between Ogiso and Akhugbe Community, a big tree is growing within the sacred grove on top of the Inner City Iya at this point. A map of community boundaries dating before the construction of the drainage (Darling, 1984, M14) shows that the area was not a simple T-junction of the Outer and Inner City Iya. It exhibits a more complex structure that is closer to the results of the drone survey and ground truthing (Fig. 7). If the ascending path leading to the top of the Inner City Iya and through it is not a modern occurrence of erosion, then it is a gap through the Iya. A gap with an ascending passageway and accompanied by two parallel ramparts. According to the Okedo community, an ancient road ran on top of the rampart and connected Benin City to the villages across Ikpoba River. The road led through a door situated at the site of a sacred grove. The door was closed every day at dawn (O. William, Okedo community, personal communication, February 2024). The primary vegetation, morphology of the Iya, spatial configuration, old survey maps and the information provided by O. William show that the passage between the two ramparts seems to be the precise location of a gate, probably the Akpakpava Urho (Igbe, 2017a, b).

A recent review of Goodwins documents about his archaeological research in Benin City shows that in the 1950s the Ivbiyeneva Urho (Igbe, 2017a, b) was still recognizable and excavations there yielded finds that further underline the connection between the Iya gates, significant trees and shrines as shown by buried charm pots (Evans, 2025). The situation at the Ivbiyeneva Urho at Sokponba Road is similar to the current condition of the above-mentioned gateway between Ogiso and Akhugbe Community (Roese et al., 2001) and Akpakpava Urho north of Ikpoba Slope (Fig. 7).

The Iya at Uhunmwun Idunmwun Community has completely vanished in some parts and other parts exhibit big gaps. A comparison with maps from the 1960s shows that these gaps are the result of road construction. The community confirms that before street constructions there were no gaps. Another feature affecting the Iya is an erosional gully that appeared during the last 60 years. Further the maps from the 1960s show that the location of the Uhunmwun Idunmwun gate as suggested by Roese et al. (2001) is wrong. Igbe (2017a, b) writes that the gate

is in the area of nowadays Immaculate Conception College. The map (Fig. 4) shows two gaps around Immaculate Conception College that further add to the possibility of a gate there. Ground truthing in that area and further archaeological prospections are needed to clarify the gate situation here.

Current Condition of the Iya and Future Protection

Previous research about the Iya of Benin answers archaeological questions like the stratigraphy (Connah, 1975), their extent (Darling, 1984) and morphology of the Iya. There is much work still to be done on the Benin Iya system, especially to clarify their chronology. Recent work on the Iya at the Azura power plant suggests that its origins may lie in the twelfth or thirteenth centuries AD, potentially earlier than the Inner Iya described here, dated by Connah to the fourteenth century. The charcoal for this single C14-date derives from wall remains covered by the later construction of the Iya near reservation Road and is therefore only a terminus post quem (Connah, 1968). The error margin is with 105 years (Connah, 1968) relatively high compared to recent radiocarbon dates. Furthermore, the data is not calibrated. Connah retrieved the sample from a cut him and his team made through the Iya in 1963 (Connah, 1968). The first C14 calibration curve was published in 1967 (Suess, 1967). Modern methods and sampling would deliver better results, but it needs multiple samples from different sections of the Iya and a good understanding of their stratigraphy. Another issue is a slight plateau in the calibration curve for this time resulting in two probable time-ranges.

Connah, working in the early 1960s, already recognized serious threats to the conservation of the moats (Connah, 1967). What is clear from this study is the immediate and serious threat to the survival of the Iya as a recognizable monument.

To protect the Iya, the Federal Department of Antiquities in 1961 declared the Earthworks of Benin a National Monument (Darling & Agbontaen-Eghafona, 2014). In 1964, the issue was raised that up-to-date mapping is important for managing national monuments (Darling & Agbontaen-Eghafona, 2014). In the late 1980s and throughout the 1990s, the National Commission for Museum and Monuments applied at UNESCO to nominate the Benin Iya as World Heritage (Darling & Agbontaen-Eghafona, 2014),

adding it to the list of Nigeria's Tentative World Heritage sites in 1995. A variety of efforts to preserve the Iya has been continuing ever since (Darling & Agbontaen-Eghafona, 2014).

The most recent maps by Darling in his published PhD Thesis (Darling, 1984) are 42 years old. Since then, the built-up area of Benin City has more than tripled (Odeyale, 2023) but research on the Iya has stopped. Various studies since this time have drawn attention to their plight (Onwuanyi et al., 2021). Others underline the importance of the Iya as protection of the Benin fauna (Egbon & Osabuohien, 2022), as a green space (Onwuanyi & Nwodo, 2024), as a tourist attraction (Darling & Agbontaen-Eghafona, 2014; Onwuanyi et al., 2021; Onwuanyi & Nwodo, 2024) and as cultural identity for Benin (Kaplan, 2008). This study adds to the previous research to underline the importance of the Iya and presents the use of UAV, GPS, GIS Integration and 3D visualization as methods for continuous monitoring.

When Connah carried out the first survey of the Benin Iya in 1964, it was damaged but still largely complete. Today, out of 12.4 km, only 6 km of the Inner City Iya survives. Over 60 years, this equates to the loss of more than 100 m each year. At that rate, that means, in just over 50 years, the whole Inner City Iya will be gone. If, as seems likely, the rate of deterioration proves to be exponential like the growth of the urban built-up area of the city (Odeyale, 2023), the great Inner Iya of Benin could have disappeared in less than 25 years.

Conclusion

This study shows the advantages of using 3D photogrammetry and LiDAR with UAV for documenting and monitoring earthworks within a tropical forest environment, comparable to the application of LiDAR in tropical forests in South America and South-East Asia in the past 20 years (e.g., Prümers et al., 2022). Aerial LiDAR is clearly an approach that should be applied to the entire network of the Benin Iya—indeed a LiDAR survey across the forests of southern Nigeria would undoubtedly change our understanding of the archaeology of the region.

The results of the Edolcacion surveys underline the accelerating deterioration of the Benin City Iya and the urgent need for a conservation management plan

to preserve them in the long-term. This could potentially form the basis for a long-overdue UNESCO World Heritage Site nomination. Our surveys provide the detailed information that serve as base and that are a first step to developing such a plan. This would require leadership from the National Commission for Museums and Monuments (NCMM), working with the Royal Palace of Benin, the Edo State Government, Benin communities, and other stakeholders. As our work has shown, genuine engagement with and support from the local communities who live beside the Iya is crucial. It is important to consider the earthworks in the city development plans and to enforcing the heritage protection laws while conducting awareness campaigns towards the encroachment of the earthworks to prevent further destruction and unauthorized developments near the Iya. For many citizens of Benin City, the Iya has deeply rooted historical and spiritual associations which it is critical to understand and respect in any future management proposals.

Despite the irrefutable evidence that we have presented here for the long-term degradation of the great inner Iya of Benin, there is still hope. The Iya is one of the last visible vestiges of the power of the ancient Kingdom of Benin, having surrounded and protected the palace and the city that served it for more than half a millennium. There is still enough of the earthwork left to enable a complete circuit to be preserved and made into an amenity for citizens and tourists. A recent masterplan for the city center envisaged a linear park running the length of the Inner Iya, connecting and contextualizing the surviving sections of rampart and ditch. Such a vision is still—just—achievable if all the key stakeholders engage with and support it.

The earlier work of Connah and Darling are pioneering in showing the extent and importance of the Benin earthworks. Because of aerial imagery and D-GPS, this study provides more accurate maps of the Iya. Based on previous research and in combination with the community reports, this study finds one gate between Okedo and Ikpoba Community at the junction of the Outer and Inner City Iya. It is an ascending pathway in between two ramparts from the lower Ikpoba riverbed outside the city towards the higher elevation within the city boundaries. These are the first structural details of a gate in the Inner City Iya of Benin, so far one of only two remaining gates.

Acknowledgements The authors extend their gratitude to the National Commission for Museums and Monuments (NCMM) for supporting the research in Benin City. The work would not have been possible without the participation and support of the following archaeologists during the fieldwork. For their help during the surveys, the authors would like to thank Diya A., Ovie R., and Jacobs B, Uranta O. For photographs and help during the surveys, the authors thank Adeshina O. Special thanks for the helpful collaboration go to O. Disu and P. Okafor. The authors thank EdoGIS for sharing aerial imagery of Benin City. For administrative support, the authors thank M. Müller, S. Schlegel, D. Morgenstern, A. Wilczek, U. Hämmerle-Haslachner, V. Erhard, C. Zametzer, K. Odigie, and J. Abolo-Tedi. The authors are grateful for the comments of three anonymous reviewers.

Funding Open Access funding enabled and organized by Projekt DEAL. This research was funded by the Federal Foreign Office of Germany. Satellite Imagery was partially provided by ©DigitalGlobe, Inc. 2023, provided by European Space Imaging, License: ©MAXAR 2023. Open Access provided by University of Cologne through the DEAL funding scheme.

Data Availability The survey results depicting the Iya condition are presented in Fig. 4 and the descriptions of 4.1. Maps of the single sections from the survey are in the Supplementary Information. Further data might be available upon request.

Declarations

Competing interests The Authors declare that they have no conflict of interest.

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