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Development Of Web-Based Land Information Sharing Using Social Tenure Domain Model In Slipway Community, Central Monrovia B, Liberia

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Abstract: An effective land regulation system is crucial for good governance, especially as Liberian communities such as Slipway continue to face persistent land-related challenges. To address this, the study used the existing analog cadastral map to identify land tenure types and contentious parcels. A geospatial database was then developed along with a web-based land information sharing system built on the Social Tenure Domain Model (STDM). The methodology involved collecting both spatial and non-spatial data in Slipway, with an application designed using PHP (Hypertext Preprocessor) and Apache (Apache HTTP Server) for the user interface, the STDM plugin (Quantum GIS) for cadastral operations, and PostgreSQL as the database. The research results identified 133 parcels on the cadastral map, covering a total area of 1,077,396 square feet. Of these, eleven (11) parcels totaling 93,130 square feet had no identified owners. One hundred and twelve (112) parcels, representing 799,184 square feet, were private properties. Six (6) parcels, or 122,994 square feet, were under dispute, and the remaining three (3) parcels, totaling 62,089 square feet, were public land. This information enabled the creation of a social tenure relationship table, which allows users to add parties and spatial units, make queries, and upload documents. Key features such as user authentication, a search form, and an interactive map were integrated into the system. The final product is a geospatial database and a web-based platform for land information sharing that enables users to query, register, and update parcel-related data.

Keywords : Slipway, Cadastral map, Land tenure, Contentious parcels, Database, Social Tenure Domain Model, Platform, Interactive map.

Résumé : Une régulation foncière efficace est cruciale pour une bonne gouvernance, d'autant plus que des communautés libériennes comme Slipway font face à des problèmes fonciers persistants. Pour y remédier, notre étude a utilisé la carte cadastrale analogique existante afin d'identifier les types de tenure et les parcelles litigieuses. Nous avons ensuite développé une base de données géospatiale et conçu un système de partage d'informations foncières en ligne basé sur le Modèle de Domaine de Tenure Sociale (STDM). La méthodologie a impliqué la collecte de données spatiales et non spatiales à Slipway, avec une application développée en PHP (Hypertext Preprocessor) et Apache (Serveur HTTP Apache) pour l'interface utilisateur, le plugin STDM (Quantum GIS ou QGIS) pour les opérations cadastrales, et PostgreSQL (système de gestion de base de données relationnelle objet utilisant le langage SQL, Structured Query Language) comme base de données. Les résultats ont révélé 133 parcelles couvrant 1 077 396 pieds carrés et ont permis l'élaboration d'une table des relations de tenure sociale. Cette table permet aux utilisateurs d'ajouter des parties et des unités spatiales, d'effectuer des requêtes et de télécharger des documents. Des fonctionnalités clés comme l'authentification des utilisateurs, un formulaire de recherche et une carte interactive ont été intégrées au système. Le produit final est une base de données spatiale et une plateforme web de partage d'informations foncières qui permet d'interroger, d'enregistrer et de mettre à jour les données relatives aux parcelles.

Mots-clés : Slipway, Carte cadastrale, Tenure foncière, Parcelles litigieuses, Base de données, Modèle de Domaine de Tenure Sociale, Plateforme, Carte interactive.

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I- INTRODUCTION

In the rapidly growing urban area of Monrovia, Liberia, land administration faces major challenges that hinder sustainable development [1]. Population growth is driving increased demand for housing, infrastructure, and commercial expansion, which in turn exacerbates the complexity of land tenure and governance. The development of a web-based land information portal using the Social Tenure Domain Model is justified by the need to electronically address numerous spatial issues that remain difficult to manage under Liberia's current analog land administration system. Like other urban areas in the country, the Slipway community in Monrovia struggles with several pressing issues. These include the lack of recognition for informal land rights despite many of them having been granted by municipalities and local authorities before, during, and after the Liberian civil war. Additional challenges involve a deficient land information system, delays in processing land requests, multiple or overlapping sales and allocations, document falsification, unauthorized land assignments, land use abuse, and parcel encroachments. These problems stem from limited access to modern land administration technologies, unclear tenure systems, overlapping claims, and minimal community involvement [1]. Although many studies have explored land issues in Liberia [2];[3];[4], few have focused on designing web-based land information systems that integrate both formal and informal land rights. This research therefore aims to develop a user-friendly land information portal based on the Social Tenure Domain Model to enhance land governance and resolve these challenges in Liberia. The study seeks to create a geodatabase and develop a web-based GIS portal using STDM to improve land resource management in a fair and effective manner, while promoting equitable access to land within the Slipway community in Central Monrovia. To achieve this, the project focuses on three main components: identifying land tenure types and contentious parcels in the study area; designing a geospatial database based on STDM; and developing an online land information portal tailored to the community.

Plate 1 presents an aerial view of Slipway Community, located in Monrovia, Liberia.

Plate 1. Slipway Community

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- **Study area**

Slipway is an informal settlement located in Central Monrovia B, in Monrovia, Liberia. Covering an area of 0.057 square kilometers, it is home to approximately thirty thousand residents, about 70% of whom are youth. The community presents a unique case due to its blend of formal and informal land tenure structures, making it a strategic area for addressing land governance issues with potentially significant impacts on economic growth and development [5]. Moreover, selecting Slipway as the study area allows for a focused and controlled evaluation of interventions, offering valuable insights for possible replication in other parts of the city or similar urban zones across Liberia [1]. Geographically, Slipway lies along the banks of the Mesurado River between coordinates 6° 18' 1.8" N latitude and 10° 47' 48.8" E longitude, and is bordered by several other communities, including Centennial Area to the west, the Mesurado River to the north and east, and Crown Hill and Rock Spring Valley to the south.

Figure 1 shows the map of Slipway, located in Central Monrovia B, in Monrovia, Liberia.

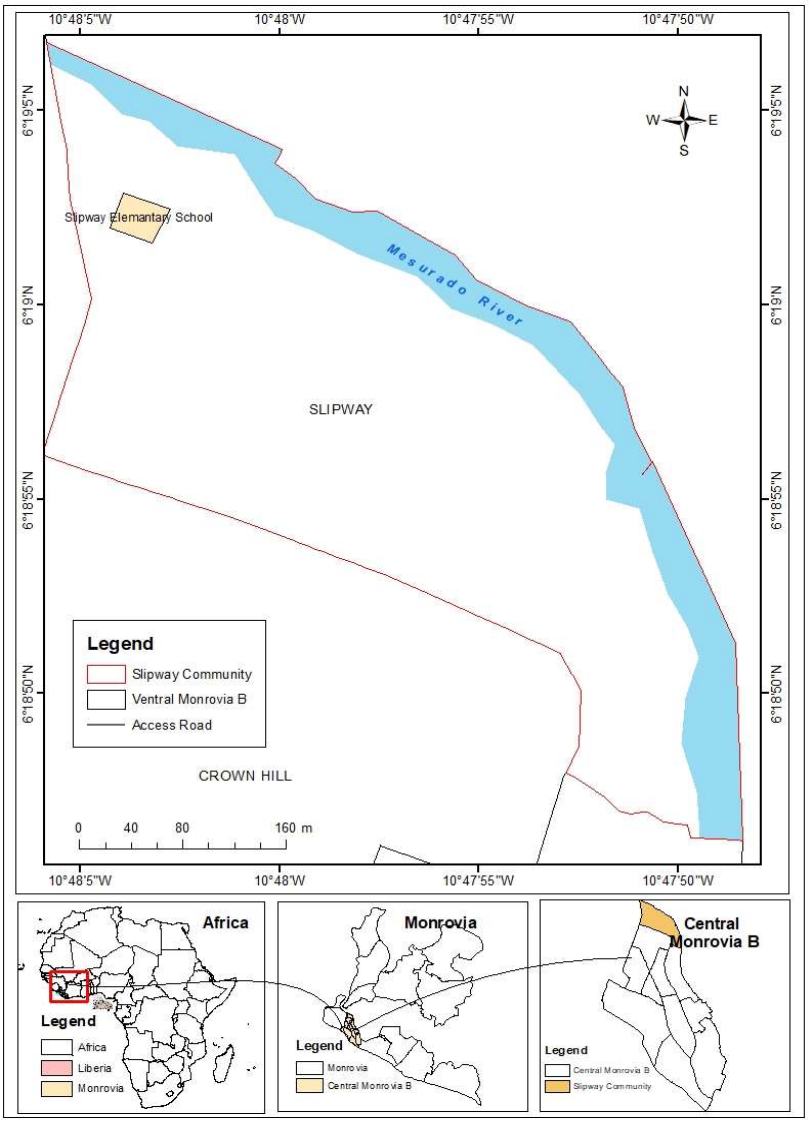

Fig.1. Slipway Community, Monrovia, Liberia

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II- MATERIALS AND METHODS

A- MATERIALS

Various materials and tools were utilized for this project, including a dataset, hardware, and software. These include an adjudication map of the study area that displays land parcels and their attributes. Also, STDM (QGIS Plugin), PostgreSQL, and PostGIS were employed, along with the Leaflet library, Apache Server (for PHP), and Visual Code (for text editor). A research design workflow flowchart was adopted to provide a clear understanding of the various steps involved in this project.

Figure 2 illustrates the research design workflow, adopted to provide a clear understanding of the various steps involved in the project.

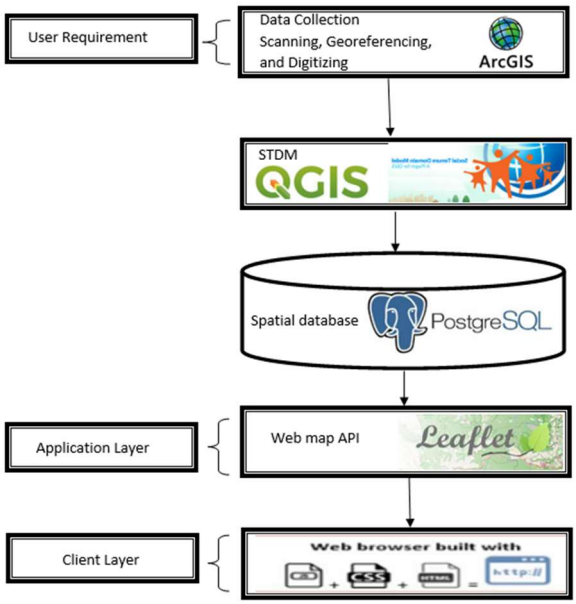

Fig.2. Flowchart for System Development

B- METHODS

a- Identify Land Tenure Types and Contentious Land

The cadastral map was obtained from the Liberia Land Authority, scanned and imported into ArcMap, and geo-referenced. After the georeferencing processes, the map was imported into QGIS and digitized. After the digitization process, the data was imported back to ArcMap, where the various land tenure types and contentious land were identified.

b- Create Geospatial Database

- **STDM**

In order to create a geospatial database using STDM, the first step is to log in to the STDM platform from QGIS to set up a directory. From there, a profile is created and managed with associated entities. Each entity is named and defined, and customized by adding columns and lookup values. Social tenure entities are setup, each entities involved is setup in the social tenure relationship and saved as configuration before adding records for each entity and uploading supporting documents. After establishing our social tenure relationships, we design the parcel document and generate the final version.

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c- Develop Web-Based Land Information Portal

The development of a web-based land information portal involved several stages, one of which was the web map visualization and coding phase. This phase entailed the display of cadastral maps from a PostgreSQL database named "STDM". The geolocation information containing geospatial coordinates of each lot digitized from STDM was retrieved from the table. Non-geospatial data such as owners' details, lot size, and number were also obtained from the relevant table in the same database. This data was then embedded into a web-based portal and displayed on a browser using HTML, PHP, JavaScript, and Bootstrap CSS through the use of Apache server. The procedure involved setting up the server environment, creating the web portal structure, and creating an API endpoint that fetches data with geolocation from the "pro_lot" table in the PostgreSQL database. Additionally, custom CSS was used for styling.

III- RESULTS AND DISCUSSION

A- RESULTS

a- Land Tenure Types and Contentious Land

The results showed 133 parcels within the cadastral map, covering a total area of one million seventy-seven thousand three hundred ninety-six (1,077,396) square feet. Eleven (11) parcels, with a combined area of ninety-three thousand one hundred thirty (93,130) square feet, had unidentified owners. One hundred and twelve (112) parcels, totaling seven hundred ninety-nine thousand one hundred eighty-four (799,184) square feet, were private. Six (6) parcels, representing one hundred twenty-two thousand nine hundred ninety-four (122,994) square feet, were under dispute. The remaining three (3) parcels, covering sixty-two thousand eighty-nine (62,089) square feet, were public.

Figure 3 presents the map of the cadastral plan of Slipway.

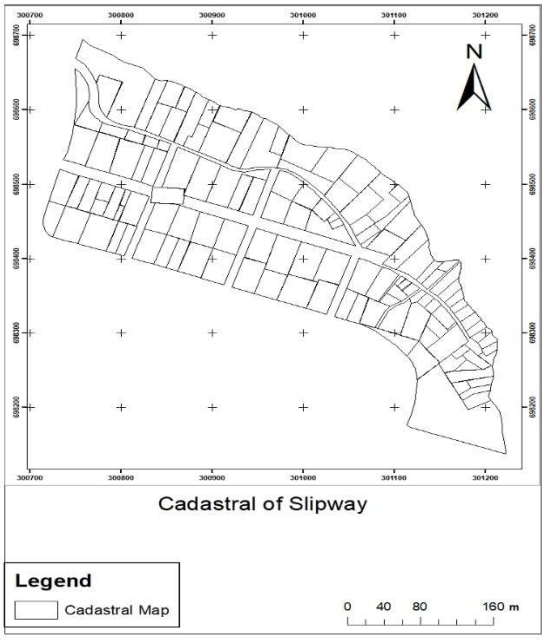

Fig. 3. Cadastral of Slipway

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Figure 4 shows the parcels with unidentified owners (parcel without owner).

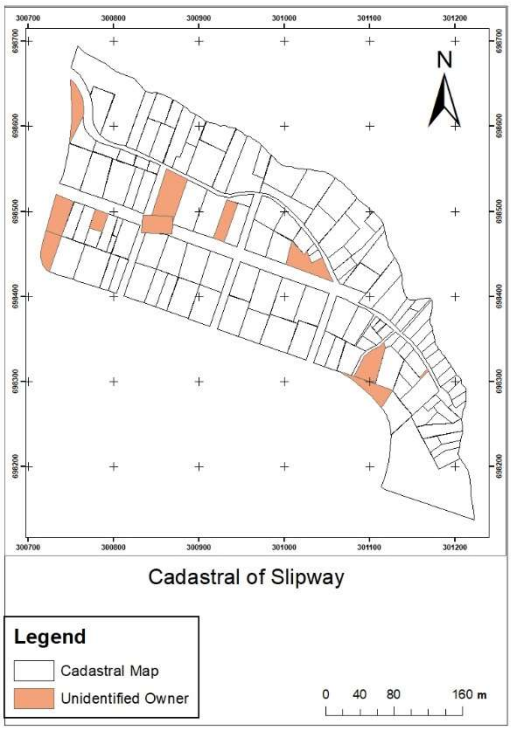

Fig.4. Unidentified owner

Figure 5 below presents the public parcels of Slipway.

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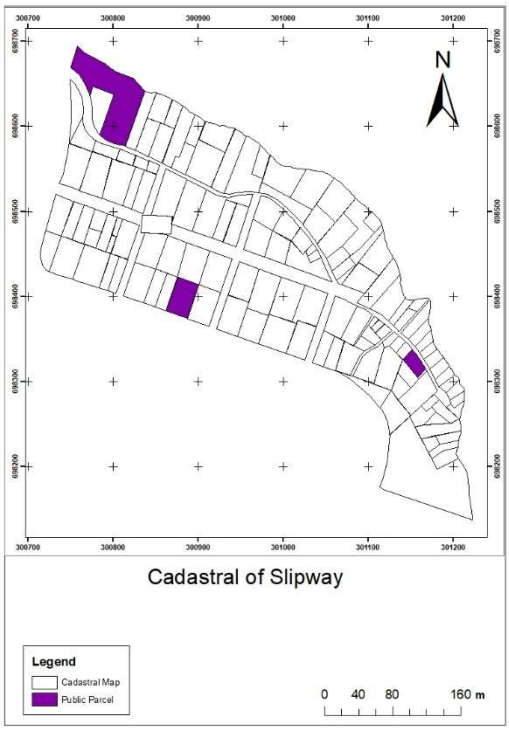

Fig.5. Public parcel

Figure 6 shows the disputed parcels of Slipway.

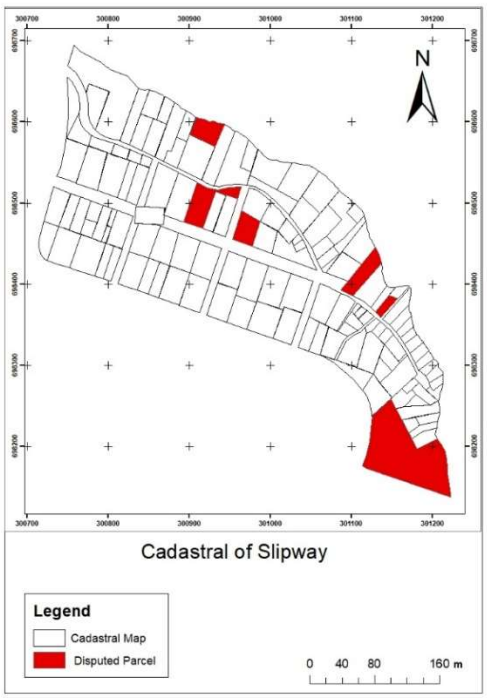

Fig.6. Disputed parcel

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Figure 7 provides a visual representation of the private parcels located within the Slipway community.

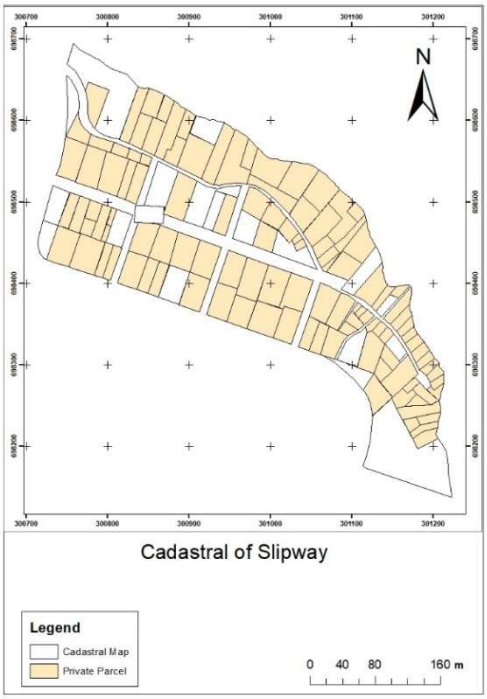

Fig.7. Private Parcel

Figure 8 illustrates the various land tenure types along with the disputed parcels within the Slipway community.

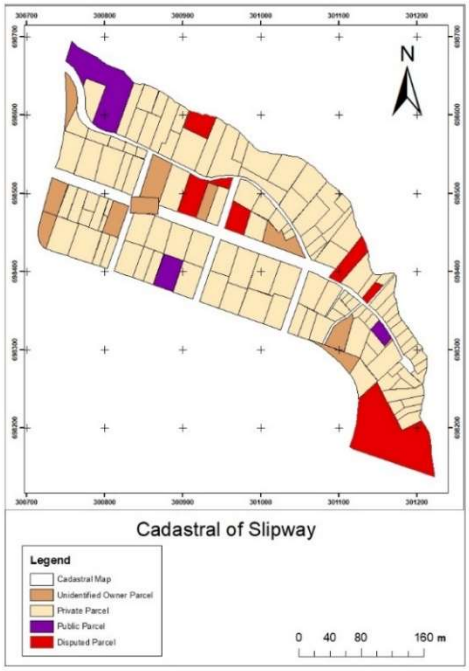

Fig.8. Land tenure types and contentious land

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b- STDM (QGIS plugin)

The Social Tenure Relationship table stores data on the relationships between individuals and spatial units, including the type of social tenure relationship, the percentage share of tenure, and supporting documents. To create a new social tenure relationship, users can access the New Social Tenure Relationship module, which allows them to add parties and spatial units, select relationship types, specify tenure validity periods, and upload relevant documents. Users also have the option to select multiple party records and add several documents for each document type. To launch the New Social Tenure Relationship module, users can access it through either the Entities menu or the View Social Tenure Relationship module. Once inside, they can select party records and document types, upload documents, and set the tenure validity periods. The module is designed to support multiple parties and documents, enabling users to create unique entries for each party. It also includes flexible options for selecting multiple parties and uploading multiple documents per document type.

Figure 9 displays the profile of social tenure relationships within the community.

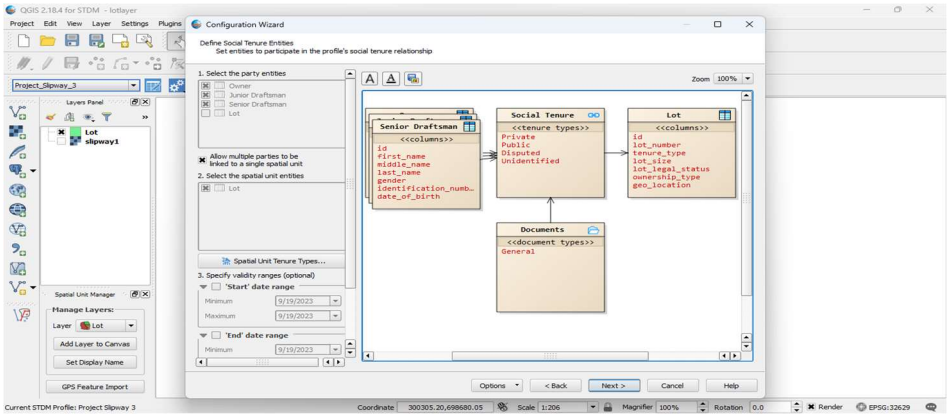

Fig.9. Showing the profile tenure relationship

Figure 10 illustrates the customized STDM data profile, tailored to reflect the specific spatial and non-spatial attributes of the study area.

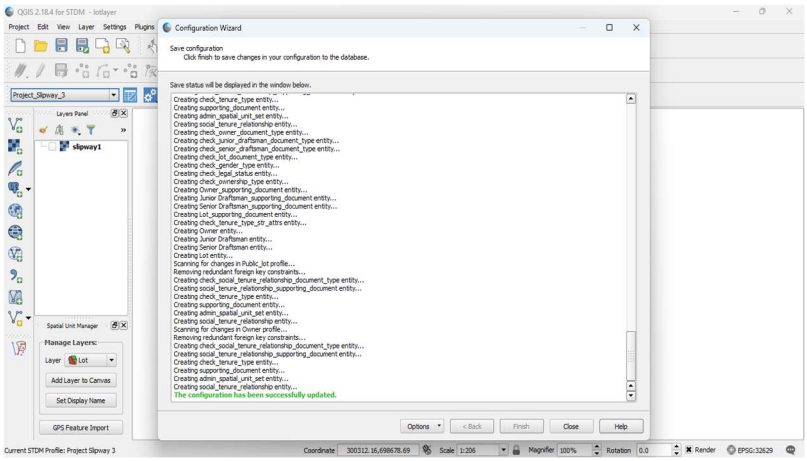

Fig. 10. Showing the customized STDM data profile

Figure 11 displays the records of landowners registered within the Slipway community.

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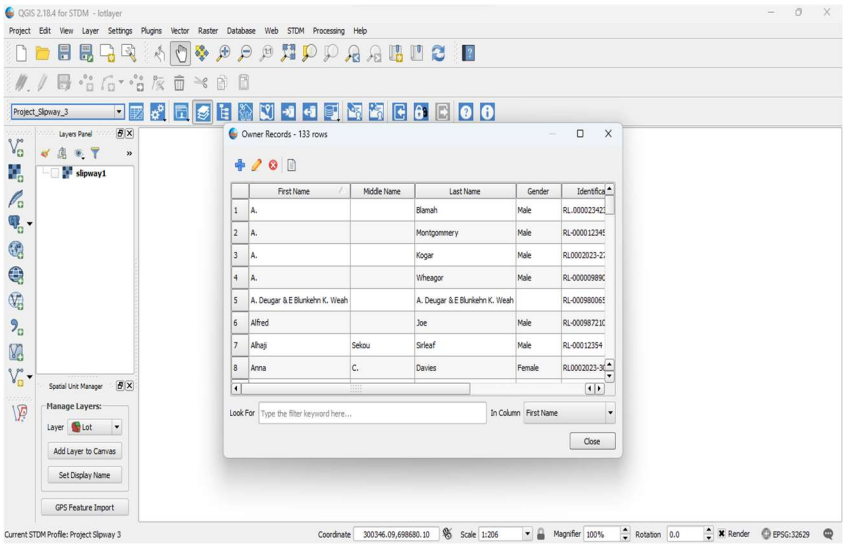

Fig. 11. Showing the owners records

Figure 12 presents the lot records categorized by owner and their corresponding social tenure relationships.

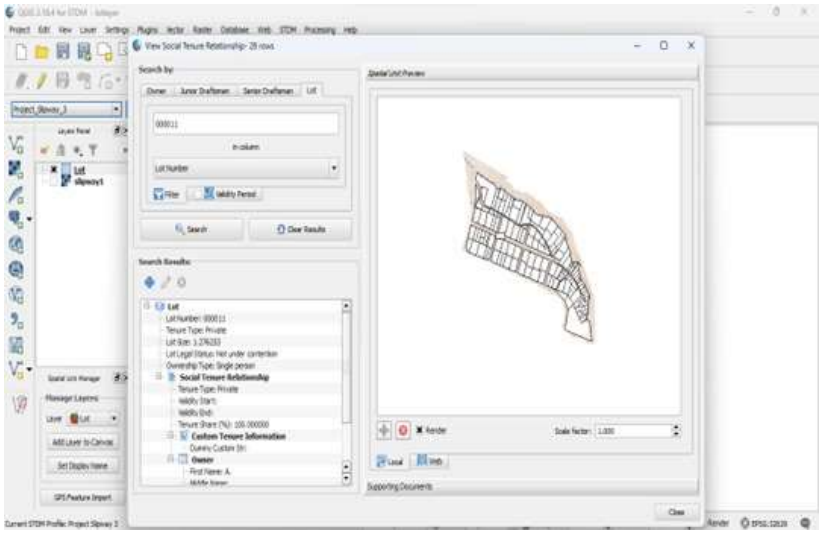

Fig.12. Showing lot record per owner and social tenure relationship

Figure 13 displays detailed information on the spatial entities within the Slipway community, including location attributes, boundaries, and associated tenure records.

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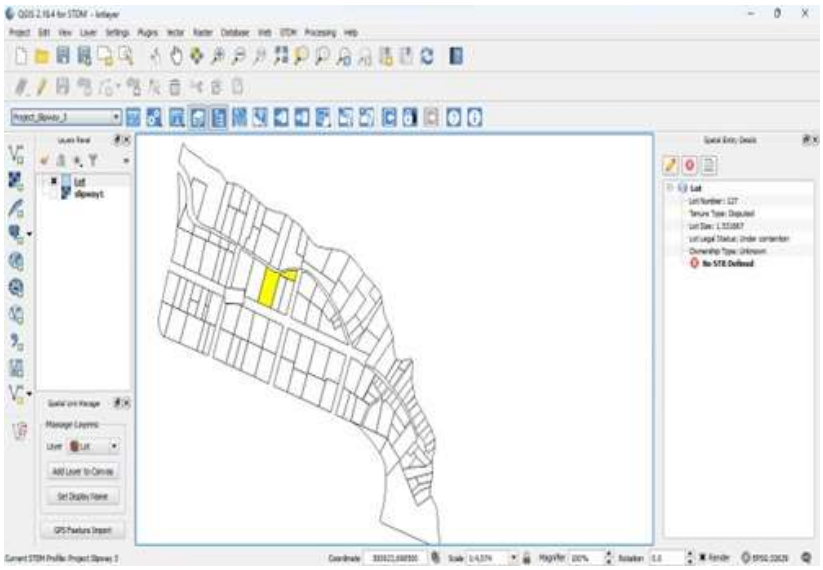

Fig. 13. Showing the spatial entity details

c- Develp web-based land information portal

- **System Application and Functionalities**

This web-based portal using STDM offers various capabilities, tools, and functionalities. The capabilities of this system include user authentication, ensuring that only logged-in users can access the dashboard. The dashboard also provides a search form that allows users to search for landowners by name. Additionally, an interactive map is included, which allows users to zoom in and out and displays markers representing land lots or locations. Clicking on a marker displays a pop-up with information about the landowner associated with that location. The system also allows users to log out securely using a logout button. The tools used in this system include Leaflet, a JavaScript library for interactive maps, Bootstrap for styling and layout, PHP for session management, user authentication, and handling form submissions, and PostgreSQL for retrieving geolocation data about land lots and landowners. JavaScript is also used for client-side interactivity, including initializing the map, adding markers, and fetching data from the server via API endpoints. Overall, this dashboard offers a user-friendly interface for managing land-related data, including searching for landowners and visualizing their properties on an interactive map. It makes use of a combination of front-end and back-end technologies to provide these capabilities to users.

- **System Development**

To create a geospatial database of my study area using the STDM, we followed several key steps and processes. Firstly, we designed the database schema using the STDM framework, which involved defining tables, fields, relationships, and data types that accurately represented the spatial features and attributes of the study area. Once the schema was designed, we imported the prepared data into the database and linked the spatial and non-spatial data correctly. Using the STDM, we modeled the spatial relationships and behavior of the features in the study area and implemented spatial rules and constraints to ensure accuracy. To document the details of the geospatial database, we also created metadata records that included data sources, data quality, and any transformations applied to ensure data traceability and transparency. To ensure the database's accuracy and consistency, we validated it by checking that the spatial data conformed to STDM standards and that any defined constraints were met. Finally, we integrated spatial queries and analyses through the STDM plugin in QGIS, enabling us to extract meaningful insights and answers to research questions.

Figure 14 illustrates the structural layout of the web-based portal, detailing its functional components, user interface elements, and system integration features.

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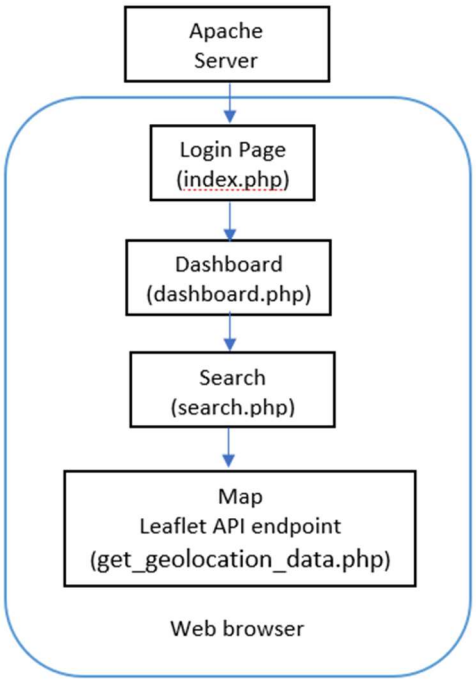

Fig. 14. Showing the web portal structure

Figure 15 shows the login interface of the web portal, featuring input fields for username and password along with a dedicated login button.

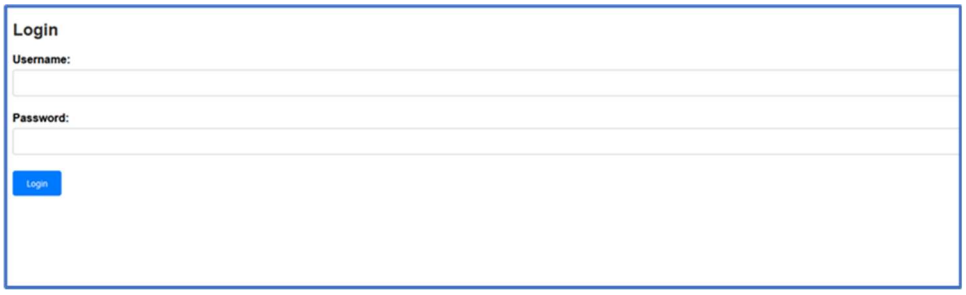

Fig.15.Showing the login page of the web portal

Figure 16 displays the owner search interface of the web portal, featuring a searchable land map, a name-based query bar, and a detailed list of landowners, including first and last names.

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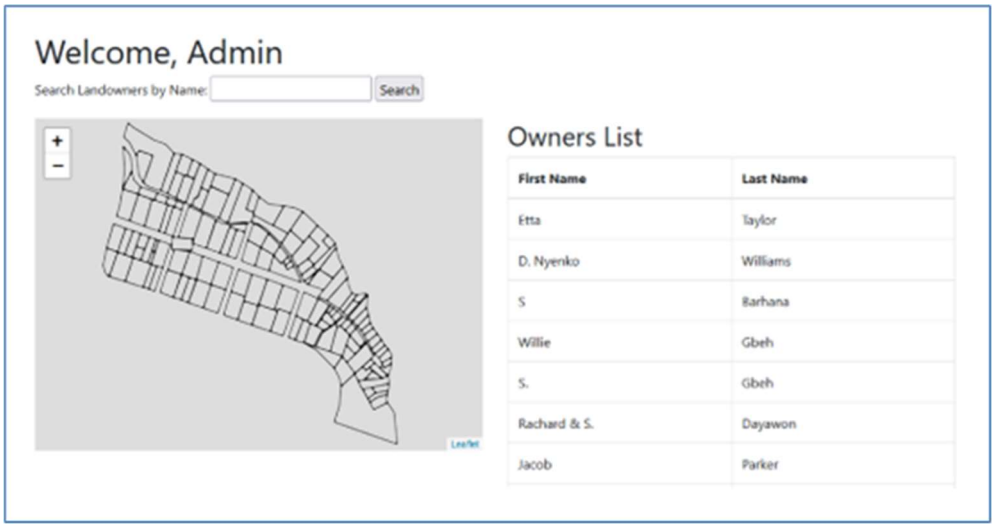

Fig. 16. Showing the dashboard of the web portal

B- DISCUSSION

Ensuring safe tenure and improving land management practices can be achieved through the Social Tenure Domain Model (STDM) integration into an online land information distribution platform. The purpose of this program is to facilitate discourse surrounding the deployment of standardized land-related data and its conformance with the prerequisites of the Social Tenure Domain Model (STDM). The platform enhances the accuracy and timeliness of information through the enhancement of data gathering and protocol updating procedures. The system enhances the ease of access and involvement of several stakeholders in data sharing, hence fostering community engagement and encouraging public participation in decision-making procedures.

The platform effectively tackles concerns related to data ownership and rights by acknowledging customary and informal land rights, while also prioritizing data security and privacy. The primary aim is to strengthen the capacity of local authorities and stakeholders in efficiently utilizing and overseeing land data, while adhering to established legal and regulatory frameworks.

The countries of the Netherlands, Sweden, Kenya, Ghana, Nigeria, Senegal, and Côte d'Ivoire have successfully deployed web-based land information systems in order to effectively tackle land tenure concerns, enhance land administration processes, and promote greater tenure security. The Nigerian Land Administration System (NLAS) exemplifies a web-based platform that effectively incorporates the principles and concepts of the Social Tenure Domain Model (STDM).

Senegal has implemented aggressive measures to promote the utilization of digital land information systems and improve land governance. Initiatives aimed at enhancing governance and accessibility of land information have been conducted by organizations such as the Agence Nationale de l'Aménagement du Territoire (ANAT).

The incorporation of Spatial Temporal Data Mining (STDM) into digital platforms presents a comprehensive strategy for effectively tackling intricate land management challenges and guaranteeing secure property rights. The design web-based land information sharing using social tenure domain model as way of improving land administration and governance in Slipway Community, Central Monrovia B, Liberia can be compared to other research works. For example, in Indonesia, Lampung Cirt where similar research work was undertaken and driven by the need to provide better public services for the citizens Currently, the system provides information of public service locations category by the citizens logging on housing information [6].

IV-CONCLUSION

In conclusion, this study has demonstrated the potential of a web-based land information portal using the Social Tenure Domain Model in Slipway Community, Central Monrovia, Liberia. The findings underscore the significance of accessible land information in enhancing land tenure security, community empowerment, and sustainable development.

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