South African Journal of Geomatics, Vol. 14. No. 1, February 2025

A web-based GIS application to optimize the customer onboarding for a utility company

Margaret N. Munywoki[1] , Kaveer Singh[1]

[1]Geomatics Division, University of Cape Town, Cape Town, South Africa, kaveer.singh@uct.ac.za

DOI: https://dx.doi.org/10.4314/sajg.v14i1.3

Abstract

A web-based GIS application was envisioned to optimize Kenya Power and Lighting Company's (KPLC) existing internal manual paper-based workflow process for new electricity customer connections in Mombasa County. The web-based GIS application was developed using the waterfall methodology which follows a sequential and systematic flow of processes. The web-based GIS application was named Jiconnect Web App. It could streamline the online customer registration process for power supply to their premises. Jiconnect was used to optimize workflow for onboarding new electricity customers. It was tested in various constituencies of Mombasa to ensure that it was functional and reliable. The potential integration of Jiconnect with existing internal manual paper-based workflow indicated that the web-based GIS application could benefit KPLC because it offered a cost-effective solution that saves time and resources.

1. Introduction

It is vital for institutions to maintain up-to-date spatial data records of their operations in an ever-changing world. Organisations are currently harnessing the power of GIS in their day-to-day operations to improve time and resource efficiency, as well as to increase productivity (Gerardus, 2022). They are leveraging the low cost of setting up and maintaining web-based GIS to carry out utility audits, asset management, network analysis, and customer management (PwC, 2023; Munywoki & Singh, 2023, Gerardus, 2022).

Every organization strives to optimally employ its limited resources to achieve maximum returns. The major task for utilities is to plan for supply to customers in the most optimal and resource-efficient way. To cut down capital costs and increase reliability, engineers at the utilities leverage the analytical tools of GIS to automate many of their functions (Meehan, 2022, Munywoki & Singh, 2023). The use of web-based GIS further enhances customer satisfaction and Enterprise GIS provides an integrated system where every stakeholder in the utility company can monitor what others are doing and is thus able to make informed decisions (Fu & Sun, 2011).

GIS is a powerful tool for decision-making in a distribution network since it supports the processing of large amounts of data and allows for the interpolation of decision issues in a geographical dimension for model synthesis (Gemelli, 2013). An enterprise GIS provides an integrated and interoperable environment in which the individual departments/functions of an enterprise create, access, view and analyse data and information relevant to their tasks (Dasgupta, 2010).

Customer satisfaction and revenue generation are crucial for the success of utility companies, as their distribution networks end at the customer's premises. However, the increasing demand for utility services has strained company resources, leading to frequent system breakdowns and prolonged restoration times (Meehan, 2022). Additionally, billing and revenue recovery has become challenging owing to the expanding geographical spread of customers (Sowmya & Jitendra, 2016). To address these challenges, utilities can benefit from an up-to-date GIS system. Amongst other benefits, utilities can identify transformers nearing capacity, efficiently allocate personnel for billing and revenue collection, pinpoint faults for the timely dispatch of emergency teams, and provide advance notice of faults or planned outages to prevent damage to customers' devices.

Kenya Power and Lighting Company (KPLC) underutilizes GIS for the new connection process that is largely manual and paper-based. This can result in errors and delays with the incorrect transcription of client information or loss of documents (Munywoki, 2021). Design & Construction (D&C) is one of the core departments at KPLC which is tasked with the receipt of new customer applications, the design of a suitable power route for supplying the customer, and the actual construction of the power supply as per the proposed design, depending on location and the existing infrastructure. The department is composed of five sections, namely, Business Development, Design, Wayleaves, Construction, and FDB/GIS Section, which are expected to work seamlessly to ensure that the customer has a power supply within a period of 21 days from the day of application (Munywoki, 2021).

This study demonstrates how a web-based GIS application could be used by the utility company to improve efficiency in their new customer connection process. This application could be integrated with the existing KPLC systems and offer an alternative to the normally manual/semi-manual processes within the new customers' connection framework to ensure that the customer has a power supply within a period of 21 days. The D&C department comprises multiple sections, each with distinct responsibilities, and their seamless collaboration is critical to ensuring that customers receive power within the stipulated 21-day timeframe. Unfortunately, manual and paper-based processes within the new customer connection framework have impeded the department's efficiency (Munywoki, 2021). The proposed web-based GIS application displays several benefits, including proper resource allocation, improved decision-making, and enhanced customer service.

2. The Study Area

Mombasa County is located along the coastal region of Kenya. It covers a land area of 229.86 km2 and a water mass of 65 km2 (Figure 1). The county is divided into six constituencies, namely, Changamwe, Jomvu, Kisauni, Nyali, Likoni, and Mvita. Most of its population have access to internet-enabled smart mobile phones and are literate; hence, they will easily understand how to navigate on the web-based GIS application. The area is currently experiencing major growth in formal housing, with the majority of the old Swahili houses being replaced with modern structures that require new/additional electricity connections (County of Mombasa, 2023).

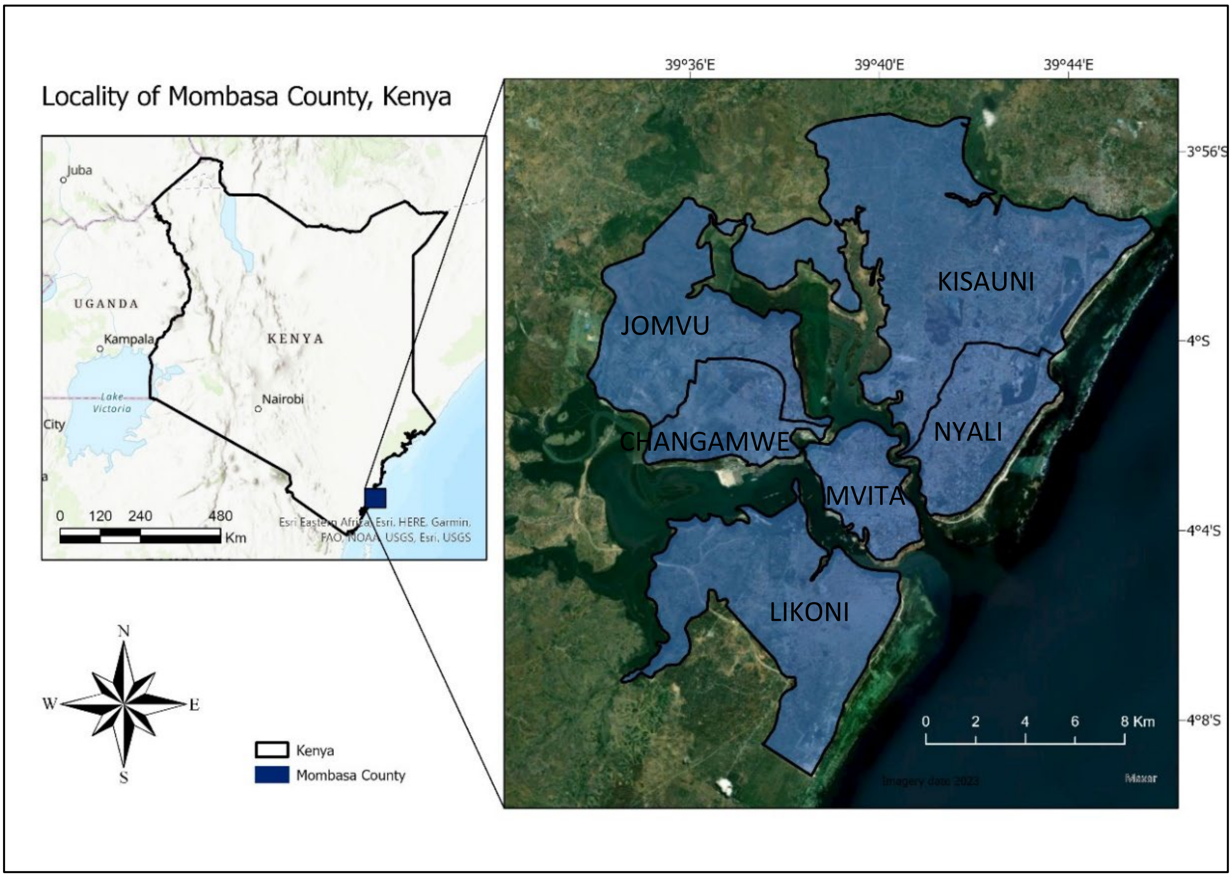

Figure 1: Mombasa County, Kenya

3. 3 Methodology

The study determined that the waterfall methodology would be the most applicable for developing the web-based GIS application. The waterfall method uses a sequential and systematic flow of processes (Figure 2). Each stage in this methodology must be completed before proceeding to the next stage, ensuring that errors are not carried forward.

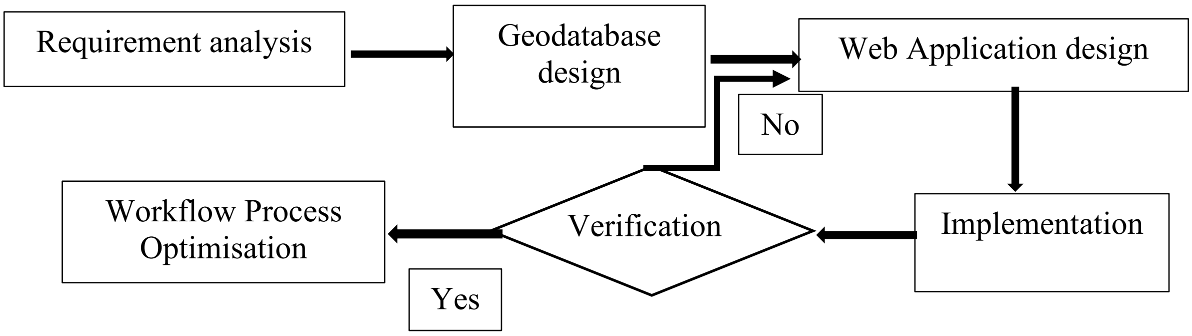

Figure 2: The methodology flow

3.1. Requirements Analysis

The existing customer connection framework was evaluated to identify its major shortcomings, which would inform the design of a web-based GIS application that meets all user needs. These shortcomings were then used to formulate the system requirements document. These requirements were clustered into functional modules with each module being independent of the other and capable of examination within the external model framework (Figure 3).

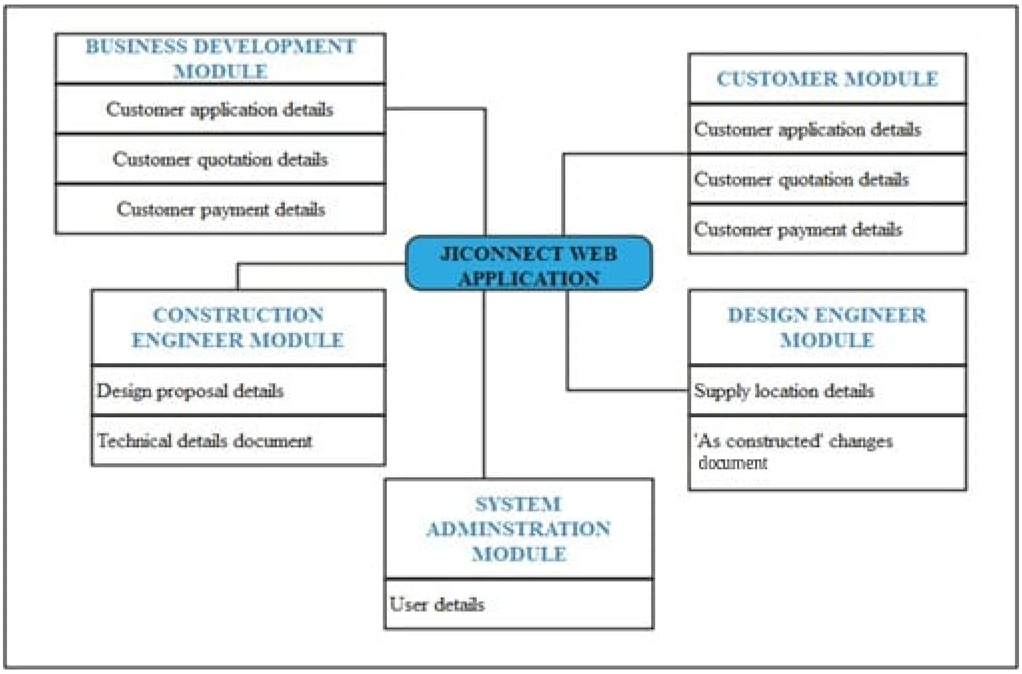

Figure 3: The external model of the '*JICONNECT WEB APP*'

3.2. Design

The web-based GIS application development features the design of a web application and a geodatabase. The application is accessible through a URL link and can run on various browsers and devices. It uses the device's GPS and location features. These datasets consist mainly of a digital online base map, county administrative demarcation data, a list of inquiries for supply forms, and supply forms. There is already an existing geodatabase in the company hosting the electricity network infrastructure. As such, there was no need to duplicate the network in this new geodatabase.

3.2.1. Geodatabase Design

An object-oriented relational geodatabase was developed to store customer application details, proposed designs, supporting documents, and notes from the design and construction engineers (Figure 4). The Geodatabase design phase involved organizing spatial and non-spatial data, defining relationships between entities, and establishing rules and constraints for the datasets. PostgreSQL was chosen as the preferred RDBMS owing to its compatibility, scalability, user-friendliness, and community support. The geodatabase consists of various datasets, including customer details, application details, appliance details, county details, constituency details, ward details, supply location details, raster imagery, PDF documents, and text documents.

The design process was divided into two stages: conceptual modelling and logical modelling.

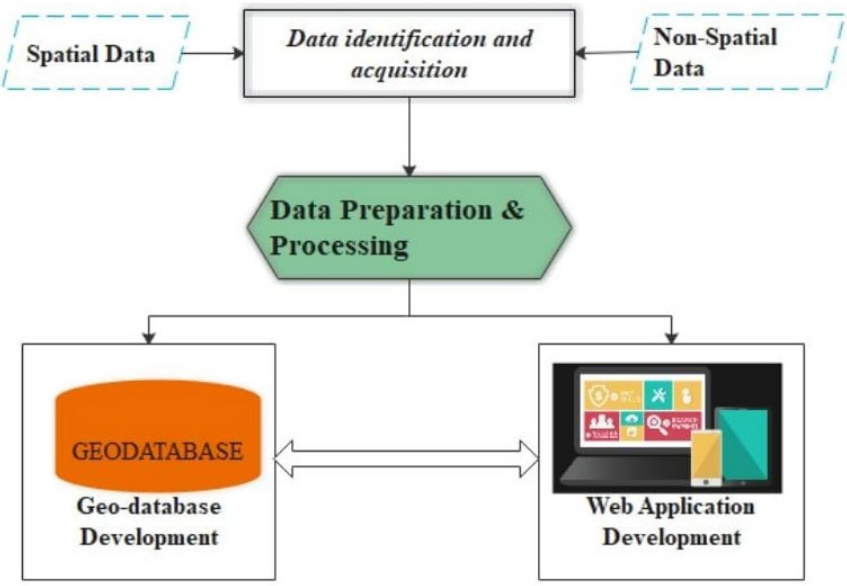

Figure 4: Geodatabase design process

Conceptual modelling focused on defining the system's components and addressing functional requirements. Entities, attributes, and relationships were established, and tables were designed to store datasets. Primary and secondary keys were assigned accordingly. Logical modelling involved defining a relational database model to implement the system. Each attribute in the database tables was assigned a data size and type, and rules and constraints were defined for proper data storage, input, update, and retrieval. The attribute types for each table are presented in the database (Figure 5).

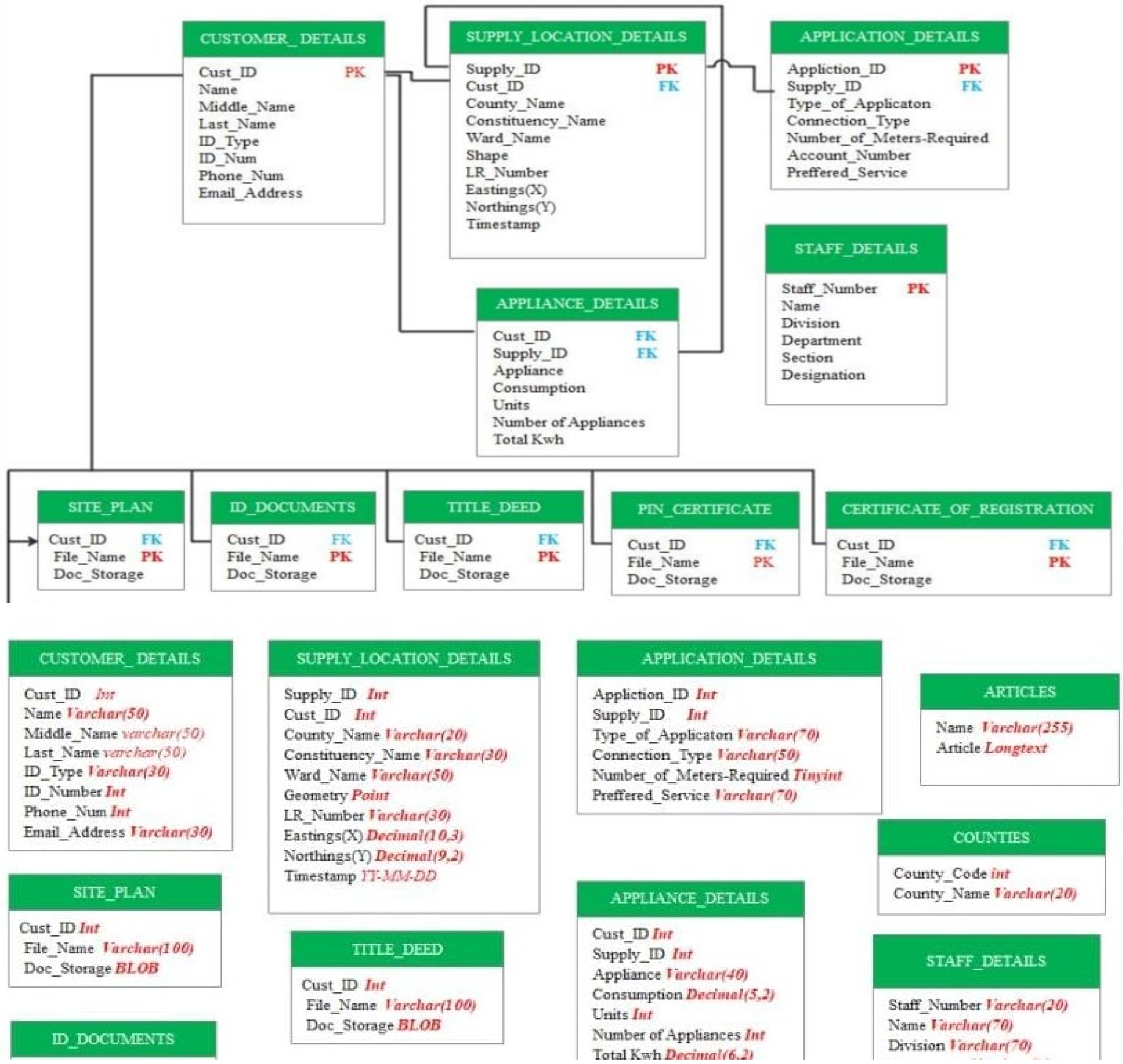

Figure 5: The customer relational model

3.2.2. Web Application Design

The web application is the visual representation of a web-based GIS system. Its design is centred around creating an appealing and user-friendly experience. Mockflow Wireframe Pro software was used to meticulously design the user interfaces for each module. This included the organization of icons, colours, and graphics to match the final appearance of the completed application. This approach facilitated visual inspection to ensure the inclusion of all required functionalities.

3.3. Implementation

During this phase, the design was implemented, resulting in a fully functional application. The design architecture was put into action, and the individual components were developed, undergoing module unit testing to ensure their functionality. The implementation phase was divided into back-end and front-end tasks.

The back-end implementation involved geodatabase and application development, as well as server configuration, which remained hidden from the clients. The clients interacted with the application solely through queries. The software used for back-end development included Django Restful API, SQLite3, and PostgreSQL.

On the other hand, the front-end focused on creating the user interface, which was executed on the client's browser (Figures 6 and 7). The software used for front-end development was ReactJS and React Styles Components. After each unit component had been tested, all units were integrated to form a complete product that was ready for testing.

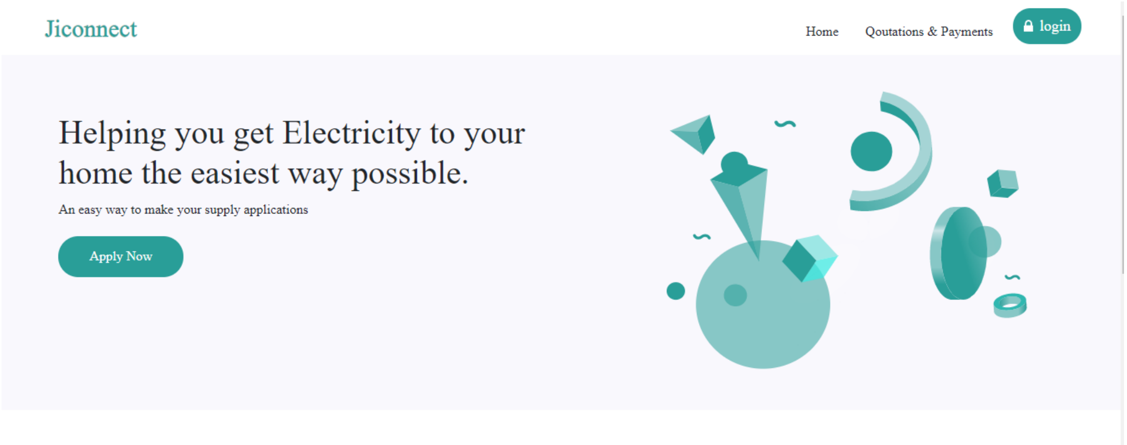

Figure 6: showing Front-end of Landing Page before Login

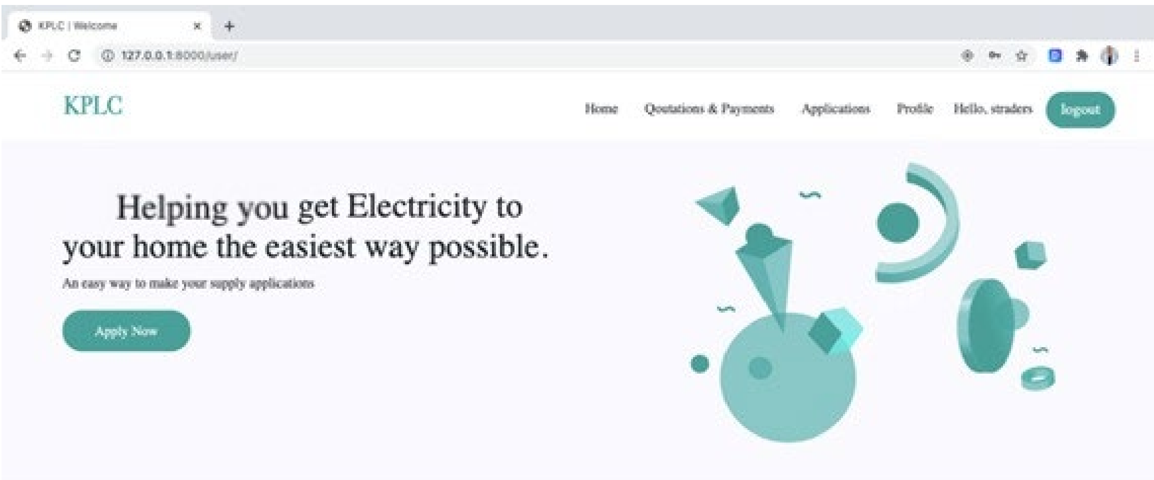

Figure 7: showing Landing Page after Login

3.4. Verification

In the integration stage, various components of the web application, such as the geodatabase, web application, and web server, were combined to form a unified system. The application files were then transferred from the local host computer to the Digital Ocean Spaces cloud storage.

This cloud storage was chosen for its scalability, user-friendly interface for developers, and cost-effectiveness in handling the large data storage and retrieval components.

To ensure its functionality, performance tests were conducted on this integrated system. A total of 40 sample customer application sites were selected from five different zones within the county These were based on the level of development of the electricity infrastructure and the presence of telecommunication towers.

These samples were collected from across the five constituencies of Mombasa County (Table 1). It is important to note that the customer details used for testing purposes were fictional and not representative of any real applicants. In preparation for the site visits, a document containing the customer details was prepared for input during the sample collection phase.

Table 1: Application testing across Mombasa and within its constituencies

Zone	Area	No. of samples	Type of application
1	Mwakirunge	10	New connection
2	Jomvu	5	Re-routing
3	Likoni	10	Group application
4	Nyali	5	Temporary Supply
5	Tudor	10	Additional load & meter separation

3.5. Maintenance

The application was published, shared, and tested on the Digital Ocean Spaces cloud host. The chosen geodatabase had the capability to store both spatial and non-spatial data and to handle large datasets. After undergoing testing across Mombasa for validation of its functionalities and accessibility, the Jiconnect Web-based GIS application could be used by customers. To enable customer registration, digital forms and access to user-device location and storage functions were implemented. The web application was connected to the PostgreSQL geodatabase, facilitating the transfer of information. The application was aimed at enhancing efficiency in the new customer connection process.

4. Results

The study yielded two sets of results, namely, the expected benefits resulting from the integration of the web-based GIS application to the electricity utility company and observations from the field-test verification process.

This research outcome was measured at the end of each stage by comparing the obtained results against the target concept document. This made sure that development was on track and avoided the hurdle of not being able to go back and edit anything once the application was in the testing stage. The comparison also made it easy for one to have a periodic forecast of the expected results by analyzing the input data. This SDM proved to be quite effective time-wise as each phase was processed and completed − one at a time – thereby avoiding the confusion that can result from concurrently processing separate phases.

Jiconnect is accessible on any mobile device, laptop, or desktop through any web browser (Figure 8). It features a common registration/login interface that redirects users to their respective modules on the basis of their user details. The Github link to the code repository is: https://github.com/Maggie-Ngeli/Jiconnect-web-based-GIS-App-Project.git

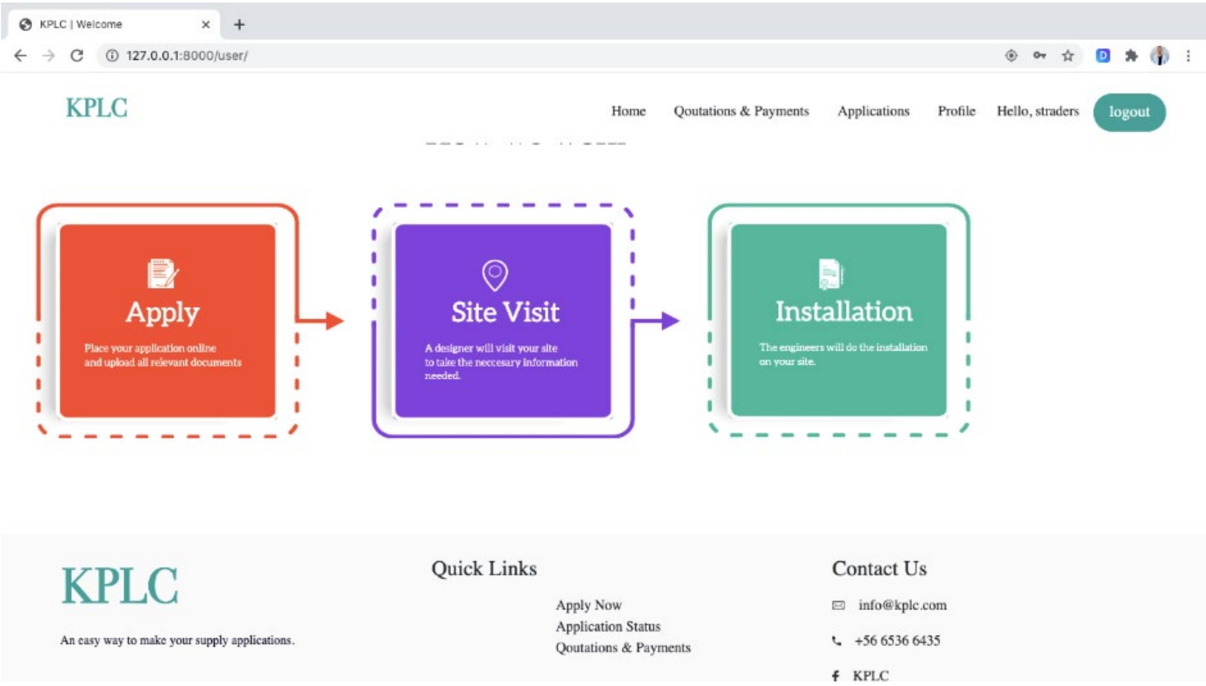

Figure 8: Jiconnect application

Utility company personnel are pre-registered by the systems administrator and categorized according to their sections and roles. Each person is then provided with login credentials and a password that needs to be reset on their first login. Customers, on the other hand, are required to register the first time they access the web-based GIS application and can change their passwords as needed.

The web-based GIS application comprises five user modules that are customized to meet the specific requirements of each user.

1. Customer Module: This module provides a user interface for customers to submit digital supply inquiries, record their supply location, upload relevant documents, sign forms, view job quotations, and update contact details. The module automatically captures customer location details and allows for the tracking of job progress.

2. Business Development Module: This module is used by business development personnel to review and verify customer applications before sending them for approval. It allows them to check the completeness and accuracy of the application, view uploaded documents for verification, and upload customer quotations for viewing and downloading.
3. Design Engineer Module: Design engineers can access supply location details, view coordinates, and visualize them on a map. They can enter technical details in the field and forward them to office engineers for further design work.
4. Construction Engineer Module: Construction engineers can view and download design proposals for customer installations. They can make notes on changes made during construction and send them to the relevant team for updates.
5. Systems Administrator Module: This module is used by the systems administrator, typically an IT personnel member, to manage users of the web-based GIS application, specifically utility company personnel. The administrator can create user profiles, assign credentials based on roles, and delete users who are no longer part of the business process.

These modules collectively facilitate the efficient management of customer inquiries, application verification, design engineering, construction, and systems administration within the utility company's operations.

A timesheet was used to track the time required for various tasks, such as recording customer details, uploading supporting documents, and submitting them (Table 2). It was observed that recording customer details took longer in areas with fewer telecommunication towers compared to areas with medium to high tower coverage. This was due to the need to determine the optimal location for recording coordinates with good internet reception. Additionally, uploading supporting documents was slower in areas with slower internet speeds. The development of a web-based GIS application aimed to improve the efficiency of the new customer connection process by integrating this application with existing systems (Table 3).

Table 2: Time taken to record customer information per site

Area	No. of Samples	Time for Field Work	Avg. Time per Sample
Mwakirunge	10	5 Hours	30 minutes
Jomvu	5	2 Hours 20 mins	28 minutes
Likoni	10	4.5 Hours	27 minutes
Nyali	5	2 Hours	24 minutes
Tudor	10	3 Hours 20 mins	20 minutes

Table 3: Comparison between the current semi-manual process and the automated process

Activity	Current Process	Web-based GIS Application Process
Customer Information Recording	Takes an average of two working days for customers to submit their forms.	Takes an average of 26 minutes for customers to fill in digital forms and upload supporting documents.
Customer Registration	Customer applications are recorded on submission in a black book.	Customer applications are sequentially logged into the system, providing a digital record of all applications with a date stamp.
First Insertion of Customer Information	The business development clerk manually copies details from hardcopy forms.	Customers are responsible for recording and uploading their information, reducing errors, and eliminating the need for manual input by clerks.
Site Visit Planning	The design engineer relies on customer contact details and route sketch maps.	The application records customer supply location automatically, improving accuracy and aiding in site visit planning.
Turnaround Time for Quotation and Contracts	The customer visits the office after seven days to collect quotation and supply contract forms.	The customer is notified via email when the quotation is uploaded, payment is made online, and proof of payment is uploaded on the application.
Job Contracting and Progress	The business development clerk physically inspects and verifies contract forms.	The customer submits a signed digital contract form, which is quickly verified and forwarded to the construction and metering section.
Access to Design Proposal and Commissioning	The construction engineer relies on FDB personnel to fetch and print design.	Construction engineers can view and download design proposals on the web application, make notes, and forward them for amendments, facilitating a collaborative process.

5. Discussion

Previously, manual paper-based processes caused delays in the new customer connection process. The web-based GIS application streamlines the customer registration process for electricity supply to their premises (Figure 8). The integration of this application in the customer connection could lead to increased efficiency (Table 3). The web application could facilitate optimal customer information recording within the utility business process structure that is time-saving and reliable (Table 3). It could also allow process monitoring, such as to ascertain the number of applications submitted within a specific period and the average processing time for each module (Figure 3). This analysis could assist management in identifying bottlenecks and areas of improvement in the workflow.

Additionally, the web-based GIS application provides valuable insights for staff performance evaluation. Management can monitor the use of resources and assess the output of individuals in the business process chain (Figure 3). This allows for investigations into underperforming employees and the implementation of appropriate solutions, such as facilitating human resource distribution and assigning individuals with expertise in handling different types of customer applications to specific areas. This could reduce friction between employees and customers resulting from misunderstandings.

6. Conclusion

The main objective of the study was to develop a web-based GIS application called Jiconnect. The application aimed to record and share customer connection data. The development process involved using open-source web development software to create the GIS application, allowing customers to upload their connection data and share it.

Future research should focus on exploring the reliability and feasibility of developing a native web-based GIS application for capturing new customer information that can function offline. This would eliminate the dependency on internet connectivity and speeds for customers when filling out and submitting their connection information.

Also, another interesting avenue for research would be adapting the code such that it can be easily adapted to other instances of utility service application such as town planning, building permits, electricity, and water connection.

7. References

County of Mombasa, 2023. Annual Development Plan 2024/2025. Viewed 20 September 2024, < chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/ https://www.mombasaassembly.go.ke/wp-content/uploads/2023/11/Final-Msa-ADP-2024-25.pdf>

Dasgupta, A. 2010. 'An Introduction to Enterprise GIS'. *Geospatial World*. Viewed 3 May 2020, < http://geospatialworld.net/articles/an-introduction-to- enterprise-gis/>.

Fu, P. and Sun, J. 2011. Web-based GIS: Principles and applications. New York, USA. ESRI press.

Gemelli A., Mancini A., Diamantini C. & Longhi S. 2013. GIS-Supported Decision Making. In: GIS to support Cost-effective Decisions on Renewable Sources. London: Springer. DOI: https://doi.org/10.1007/978-1-4471-5055- 8_2

Gerardus, B. 2022, *GIS applications* (Second Ed), 5STARCooks. Kindle version.

Meehan, B. 2007. Empowering electric and gas utilities with GIS: Case studies in GIS. Redlands, California. Esri Press.

Meehan, W., Brook, R.G., Wyland, J. 2022. Geographic Information Systems in Energy and Utilities. In: Kresse, W., Danko, D. (eds) Springer Handbook of Geographic Information. Springer Handbooks. Springer, Cham. https://doi.org/10.1007/978-3-030-53125-6_28

Munywoki, M.N. & Singh, K. 2023. Application of GIS to monitor infrastructural development in Mombasa County, Kenya. *South African Journal of Geomatics, Vol. 12. No. 2.*

Munywoki, M.N. 2021. Integrating a web-based GIS in the optimization of the customer connection process for utility company: a case of Kenya Power; Lighting Company, Ltd., Faculty of Engineering and the Built Environment, School of Architecture, Planning and Geomatics. http://hdl.handle.net/11427/36035

PwC, 2023. Digital Trends in Maintenance & August 2023 Asset Management. Viewed 20 September 2024, https://www.pwc.co.za/en/assets/pdf/maintenance-and-asset-management-2023.pdf

Sowmya, A. & Jitendra, A. 2016. Implementing power distribution system using geographic information system. Proceedings of the Third International Conference on Emerging Technologies in Computer Science & Engineering (ICETCSE 2016).17-18 October 2016. Pennsylvania, USA: International Journal of Computer Science and Information Security (IJCSIS). 221-224.