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INTEGRATING EXTRINSIC HOUSING ATTRIBUTE MAP TO HOUSE SEARCHING GIS BASED WEB SITE

A Case Study of Sinza

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B. Sc. Geographical Information Systems and Remote Sensing

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INTEGRATING EXTRINSIC HOUSING ATTRIBUTE MAP TO HOUSE SEARCHING GIS BASED WEB SITE-SINZA

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A Dissertation Submitted In The Department Of Geospatial Science And Technology In Partially Fulfillment Of The Requirements For The Award Of Bachelor Of Science Degree In Geographical Information System And Remote Sensing (B. Sc. GIS &RS) At Ardhi University

CERTIFICATION

The Undersigned certify that they have read and hereby recommend for acceptance by the Ardhi University dissertation titled "**Integrating Extrinsic Housing Attribute Map To House Searching GIS Based Web Site, A Case Study of Sinza**" in partial fulfilment of the requirements for the award of degree of Bachelor of Science in Geographical Information Systems and Remote Sensing at Ardhi University.

…….	……
Dr. Anastazia Msusa	Mr. Iriael Mlay
(Main Supervisor)	(Second Supervisor)
Date…….	Date…….

DECLARATION AND COPYRIGHT

I Muangirwa, Emmanuela C. hereby declare that, the contents of this dissertation are the results of my own findings through my study and investigation, and to the best of my knowledge they have not been presented anywhere else as a dissertation for diploma, degree or any similar academic award in any institution of higher learning.

……

Muangirwa, Emmanuela C.

25481/T.2020

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DEDICATION

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ABSTRACT

With the rapid development of technology and the increase of demand for efficient and user-friendly house searching platforms, this research focused on the integration of extrinsic housing attributes into GIS-based house searching website. The aim was mainly to enhance the search experience for the users by providing them with relevant extrinsic information in hand with the intrinsic to assist in making informed decision.

This research reviewed the existing literatures, studies and websites that are related to house searching platforms, GIS technology, Housing attributes and website technologies. All these reviews formed a strong foundation for understanding the existing situation and address the gap by presenting a comprehensive approach that incorporates extrinsic attributes into GIS-based house searching website utilizing the Google Maps API and MongoDB database.

The methodology used in this research employed a number of approaches which led to the development of a house searching website using tech stack that includes Node.js and Express.js for the back-end, Next.js for the front-end and MongoDB for spatial and non-spatial data storage and management, Google maps API is integrated to provide geospatial visualization and interaction capabilities.

The findings of this research contribute to the advancement of house searching platforms by emphasizing the importance of extrinsic housing attributes in decision making of the potential home buyers or renter. This would lead to increased clients satisfaction but also providing a marketing platform for the real estate firms.

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ACCRONYMS AND ABBREVIATIONS

GIS	Geographical Information Systems
HTML	Hyper Text Markup Language
CSS	Cascading Style Sheet
GPS	Global Positioning System
Js	JavaScript
JSON	JavaScript Object Notation
API	Application Programming Interface

CHAPTER ONE

INTRODUCTION.

1.1 Background

With development of internet technology and services in the past century the public has grown fond to it that services are now searched at one click. Shelter being among basic needs of life most individuals search for areas to live via the websites and some haunting around the city (Han & Strange, 2015). Web GIS is a modern GIS system that encompasses the internet and geographical information systems. Web GIS allows visual interaction with data. By setting up web server, clients can produce maps. “Since maps and charts are published on the internet other clients can view the updates, helping speed up the evaluation process” (Luqun et al., 2002).

There are multiple real estate and rental houses search websites available that assists individuals in searching for a place to stay, some being for short stay like Airbnb, Likibu, Booking.com, Vrbo and some being for long stays and even buying a house or property like RE/MAX, BE FORWARD real estate, BR real estate developers, jiji Tanzania. These websites function more less similar that is listing houses for rent with their qualifications like number of rooms, property type, property size, condition, price and location either on the map or just written.

The application of geographical information systems and remote sensing has made these websites of much importance since they assist in the remote searching, The websites are embedded with interactive maps that one can zoom in and out and pan around the map to view the location with the aid of open street maps and satellite imagery for some (Lin & Huang, 2008). But there is a gap that if it is filled then there would be a greater advantage than that in the present both to the realtors and to the clients, that is the ability to not only see the location of the house to rent but also to spatially analyze and query on the neighborhood of preference to the client thus adding marketing value to the realtors since they reach the right audience and increases the market base that is local and international (Karanja, 2017).

1.2 Problem statement.

Searching of rental houses is a challenge of its own, but searching for a neighborhood is another, also marketing a rental house to the right client is a challenge and time consuming since most neighborhood information cannot be easily explained by words. Present information systems assist in house searching but do not show the extrinsic housing attributes around the neighborhood making individuals prone to a neighborhood that does not have social services they need near their location with relation to their preference, and also most of the neighborhood information that a realtor can provide to the client to make them more interested to the house is difficult when words.

With a web based GIS system the extrinsic housing attributes and social services near the rental house can be visualized in an interactive system that can assist individuals to search for rental houses remotely basing on their neighborhood requirements, it would allow users to search for rental house based on location and a range of external factors such as access to public transportation, schools, and other amenities thus informed decisions. This is an advantage also to the realtor since they can increase interest and raise their marketing abilities since a map can tell a thousand words that cannot be easily disseminated through text and words and therefore adding value to the realtor.

1.3 Research Objectives.

1.3.1 Main Objectives.

Main objective of this research is to develop a web GIS rental house system that will be integrated with extrinsic housing attribute to assist individuals to search for rental houses based on their neighborhood preference and realtors to effectively market their properties to the right clients while bringing interested clients.

1.3.2 Specific Objectives.

1. To identify the extrinsic housing attributes most relevant to renters and realtors when searching for a rental properties.

2. To develop a GIS system that allows users to search for rental properties based on location and extrinsic attributes.
3. To integrate extrinsic housing attribute data into the GIS system in a way that enhances the search experience for users.
4. To provide sellers with tools that effectively market their properties to the right audience based on neighborhood preference and bring interested clients.
5. To evaluate the effectiveness and usefulness of the GIS rent system for both renters and realtors.

1.3.3 Research questions.

In order to address the after mentioned objectives, seven key research questions have been developed to guide this research.

1. What types of extrinsic housing attributes are most important to renters and realtors when searching for a rental Property?
2. How can a GIS system be used to effectively visualize and analyze the relationship between rental properties and extrinsic attributes?
3. How can the integration of extrinsic housing attribute data into a GIS rent system improve the search experience for users?
4. What tools can be provided to sellers to effectively market their properties to the right audience based on neighborhood preference and bring them interested clients.
5. What are the potential benefits of a GIS rent system for both renters and landlords?

1.5 Scope and limitations.

The scope of this research is based on making a Web GIS system for house searching that displays and analyze intrinsic and extrinsic housing attributes in Dar-es-salaam, Tanzania, it will include identifying the relevant extrinsic housing attributes, developing a method that would incorporate the attributes into the searching process, and assessing the effectiveness of the integrated system through user testing.

The limitation of this research is limited to housing market in Sinza Dar-es-salaam, Tanzania. The findings may not be generalizable to other cities or countries, also it is limited to the availability and quality of data this is because some extrinsic attributes such as crime rate may not be readily available or subject to errors, but also the sample size of participants this may not be representative of the entire population.

1.6 Significance of the Research.

Studies explains how housing conditions can highly influence individual's outcome in health, education, socio-political participation and labor participation, among many other aspects of life (Region, n.d.). Therefore, the house selection happens to be a very vital issue and therefore a neighborhood that well suits an individual is of great importance.

This research has an advantage related to this since it provides a web GIS application that enables individuals to search for not only a house location with their house requirements like number of bedrooms, location, property type, property size, property condition but with a neighborhood that is of best fit to an individual with respect to their preference like access and proximity to important services like ATM, road, school, religious centers and many others.

This research also has a great advantage because it does not only deal with renting the houses but also has a number of importance like assist in database management, it increases larger market base, brings about professionalism among the realtors because they become accountable and responsible to their work in the sense that incase of anything the realtors information are intact this also adds value to the realtors.

1.7 Beneficiaries.

This research has several groups that benefit, these are listed below together with the advantages they saw from this research.

- Real estate industry. These are the maintainers of the output in this research and it is of great advantage in their field since it assists to make them understand the housing market from a different and wider angle and also provides them with potential buyers with a

larger market base, but also it makes them get interested clients and through the real estate industry the growing or local agents can be empowered.

- House rentee. These are the individuals who rent houses from local and international market, and with the assistance of the output that will be produced from this research then it will assist them to search for their rental houses remotely and with respect to their neighborhood preference. The added advantage assurance with people they work with.
- Researchers. Other researchers can use the output and the research to go on with further research on how to improve the system and also to understand housing market and how web GIS has a great advantage in the real estate industry.

CHAPTER TWO

LITERATURE REVIEW.

2.1 Overview.

This chapter focuses on the scholarly articles and research studies that have been published within the past decade on the integration of extrinsic housing attributes into GIS based house searching websites. It examines the existing advancements in web GIS and their advantage in house searching websites since the integration of GIS and house searching websites has revolutionized the way users search and evaluate properties. It also defines the gap from the existing solutions and sets a course of study for this research.

2.2 Implementation of GIS technology in house searching websites.

Individuals can now search available properties like houses and apartments for rent or sale through online platforms and these are the house searching websites(Boeing et al., 2021). They provide an efficient and effective way for clients to search for real estate listings in various locations based on their preferences but also enable the real estate firms to get lead of customers in a wider base. Technological improvements and development has made house searching to be less tiring and available remotely with the ability to see the location through interactive maps (Thrall, 1998).

These house searching websites have several advantages that make them more useful than the traditional methods that are used in house searching or haunting process and all is due to technological development in the real estate industry. These that are listed below are those advantages;

1. Search filters.

Users can narrow their search based on certain specific criteria based on their preference, It can filter by location, price range, type of property, number of bedrooms, square footage and other preferences to search for properties that matches the user requirements saving the struggle of going through other properties that do not feet the user requirements or preferences.

2. Interactive maps.

Many house searching websites have maps that enable the users to view the properties location and explore with the help of various functionalities like zooming in and out, panning, searching for a specific location or addresses, toggling different layers or data layers like the terrain layer or street layer and clicking on map elements to access more detailed information. With this the user can visualize property in relation to amenities, schools, transportation and other preferences.

3. Market trends and neighborhood information.

Users need to make informed decisions before purchasing any kind of property and these type of data for local market trends like average home prices, historical sale data and market forecast and neighborhood information like the nearby facilities, crime rates and community demographics can be provided in the house searching websites.

4. Saved searches and alerts.

Users can save their search criteria for future reference and also get updated on new listings of properties that fit in their preference thus becoming time saving and convenient. These search criteria can be modified or changed at any time so that they can always match the user requirements. House searching websites enable users to get timely notifications and therefore the user become ahead of competition and increase the probability of getting property easily and quickly.

Real estate industry has witnessed a significant shift from traditional to online methods of conducting business in the past decade. The increase in demand of residential property from local to global level has prompted the development of websites to assist users in searching for houses from the local to global level thus bringing a wider base of clients to the real estate firm and expose the clients to real estate firm remotely. Due to the increase in the availability of spatial data has led to the development of geographical information systems web applications that help users to search for a rental house with the ability to see the location visualized on the map. According to (Sweeney, 2008) “A fundamental component that is missing in many real estate websites is the ability to see where the listings are located and what is in the surrounding

area or community.” And this is where geographical information systems and remote sensing plays its vital role.

There are two common categories for house attributes that are used to describe and evaluate the value, desirability and suitability of a property in real estate that the clients use to define their preference and prioritize a property from multiple thus making informed decisions, these are the intrinsic housing attributes and extrinsic housing attributes (Zeng, 2013).

2.2.1 Intrinsic Housing Attributes in Real Estate.

These are the essential and inseparable parts of a property that describes its characteristics that are inherent. These attributes describe the physical features, construction and design of a property, they are usually specific to the property and therefore not influenced by external factors like location or neighborhood. Normally these attributes include property size, Layout and floor plan like room numbers and types of the property, Energy efficiency and sustainability, building age and condition, Construction qualities and materials, physical characteristics, functionality and overall quality (Goetz et al., 2012).

2.2.2 Extrinsic Housing Attributes in Real Estate.

Extrinsic housing attributes refer to the characteristics of a property that are external to it and have an impact on its desirability and value. Some of the commonly used extrinsic housing attributes include proximity to amenities, accessibility to transportation, neighborhood quality, crime rate and environmental factors. Researches shows that these attributes play a crucial role in the decision-making process of home buyer and have a significant impact on the price of a property (Sbakhi et al., 2018).

2.3 Web GIS Advancements.

The ongoing development and enhancement of technology, tools and procedures that allow the deployment and use of GIS applications over the internet are referred to as advancements in web based GIS systems (Li et al., 2011).

2.3.1 Web GIS.

A web GIS (Geographical information systems and remote sensing) This is also known as internet GIS is a system that uses web technologies and platforms to share, analyze and visualize geospatial data and information in over the internet. Is a system that enables users to access and share geospatial data and tools through the internet. It allows its users to access and interact with geospatial information through a web interface. It is the integration of web technologies and GIS technologies to provide the users with the ability to interact with maps, geographic data and applications from anywhere at any time, through any device that has internet access (Baker, 2015). Figure 2.1below shows how web GIS works.

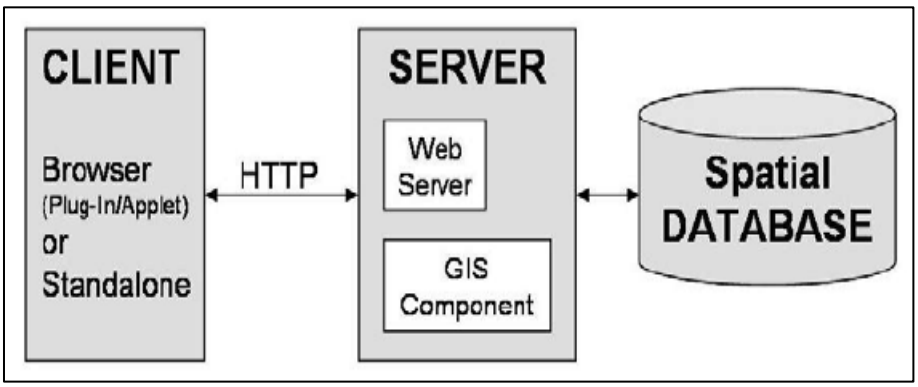

Figure 2.1 How web GIS works (Held et al., 2015)

As web GIS technology advances there are new tools and platforms that are continually being developed with time, some of the popular web GIS platforms include ArcGIS Online, Google Maps API and Open Layers. These platforms encompass a variety of features and capabilities including data management and storage, map development, geocoding and spatial analysis(Agrawal & Gupta, 2017).

2.3.2 Web Technologies in web GIS advancements.

Web technologies define various technologies and standards used to create and manage websites and web applications. They encompass a wide range of tools, programming languages, frameworks, protocols and databases that work together to deliver content and functionality over the internet.

1. Accessibility:

   Users of web-based GIS can access geographic information and analysis tools from any location with an internet connection. Due to this accessibility, there is no longer a need for specific software to be installed on individual devices, and data sharing between individuals and businesses is encouraged.

2. Interactivity:

   Interactive and dynamic mapping interfaces are provided by web-based GIS, enabling users to engage with geographic data instantly. Exploring and comprehending geographical relationships is made simple by the ability of users to pan, zoom, query, and perform spatial analysis operations directly through web browsers.

3. Data Integration:

   Web-based GIS makes it easier to combine different data sources and formats. A unified web interface allows users to access and aggregate geographic data from a variety of sources, including public and corporate organizations as well as citizen contributions. Through this connection, data discovery is improved and thorough geographical analysis is encouraged.

4. Cloud Computing:

   The development of cloud computing has significantly advanced web-based GIS. Scalable and economical options for data processing, analysis, and storage are provided by cloud-based GIS platforms. Without making major infrastructure investments, they allow customers to take advantage of powerful computing resources relationships in space. “Cloud-based mapping tools allow for the creation of very sophisticated maps that can be easily made available to others” (Peterson, 2014)

5. Web Mapping Services:

   Web-based GIS uses web mapping services, such as Web Map Services (WMS) and Web Feature Services (WFS) that enable users to access and overlay geospatial data layers from many sources. These services offer defined protocols for information exchange and interoperability between various GIS systems (Kraak, 2004).

6. Open Data and APIs:

   Web-based GIS has encouraged governments and organizations to make their geographic data publicly available for free or at a minimal cost, promoting the idea of open data.

Application Programming Interfaces (APIs) also give programmers the power to build original apps and incorporate GIS capabilities into their own software platforms for example mapping API's like Google Maps API, Mapbox API and OpenStreetMap API that offer a range of functionalities for GIS based websites (Hwang, 2005).

7. Data formats and protocols:
   Web API's often utilize standard data formats like JSON (JavaScript Object Notation) or XML (extensible Markup language) for data exchange. These formats ensure interoperability and ease of integration with the GIS-based website. Additionally API's may follow RESTful (Representational State Transfer) protocols for communication and data retrieval

The way geographical information is used has changed as a result of developments in web-based GIS, which have also increased the accessibility of GIS technology to a wider audience. These developments are still advancing quickly, spurring development and innovation across a range of industries, including urban planning, environmental management, transportation, and emergency response.

2.3.2 Web Technologies.

Tools, languages, protocols and frameworks that are used to deliver content over the internet and create and support websites and web applications are all known as web technologies. They encompass both client side and server side technologies that work together to deliver interactive and dynamic web experiences.

Some of the key web technologies include HTML (Hyper Text Markup Language) that is used in creating structure and content of web pages, CSS (Cascading Style Sheets) that is used in styling the HTML element allowing developers to control the layout, colors, font and the design aspect of the website, JavaScript a popular programming language that enables dynamic and interactive elements on the web page, HTTP (Hypertext Transfer Protocol) that is used for transmitting data between web server and web browser, API's (Application Programming Interface) these allows different software applications to communicate and interact with each other, Server side scripting languages like Node.Js, Python, Ruby and PHP are used to process requests on the server and generate dynamic web content, Databases store and manage structured data for the web

application they could be SQL or NoSQL databases, Frameworks and Libraries these are used by the web developers so as to streamline development process and finally web servers like Apache hosts websites and serve web pages to clients upon request (Jackson, 2007).

2.4 House Searching Platforms in Tanzania.

There are several online platforms that are used by individuals and organizations to search for houses, apartments or properties available for rent or for sale in Tanzania. Most of these platforms offer search filters based on intrinsic attributes such as property type, property size, number of rooms and some of them have been able to visualize the house on interactive maps that can zoom in, out and pan but other platforms do not visualize the properties on the maps and price however there is a significant gap in the inclusion of extrinsic housing attributes that potential home buyers consider crucial in their decision making process and this could be influenced by lack of proximity and accessibility analysis. Some of the popular house searching platforms includes Zoom Tanzania (www.zoomtanzania.com), Kupatana (www.kupatana.com), Jumia House Tanzania (house.jumia.co.tz), Be Forward Tanzania Real Estate (real-estate-tanzania.beforward.jp) and many others including Airbnb that is common for short stays (Sweeney, 2008).

This research aims to fill these gaps by developing a GIS-based website while considering inclusion of external factors that influence property value to the client like facilities and amenities proximity and accessibility and also focus on incorporating interactive mapping, routing, buffering and visualization features to enhance user experience and assist potential house buyers or renters to make informed decisions.

CHAPTER THREE

METHODOLOGY.

3.1 Overview.

This chapter explains the methods, data, technologies, software and techniques used and applied in this research. It describes the overall methodology from defining user requirements, System design and development to getting the expected GIS website and user evaluation. The whole process is summarized in Figure 3.1.

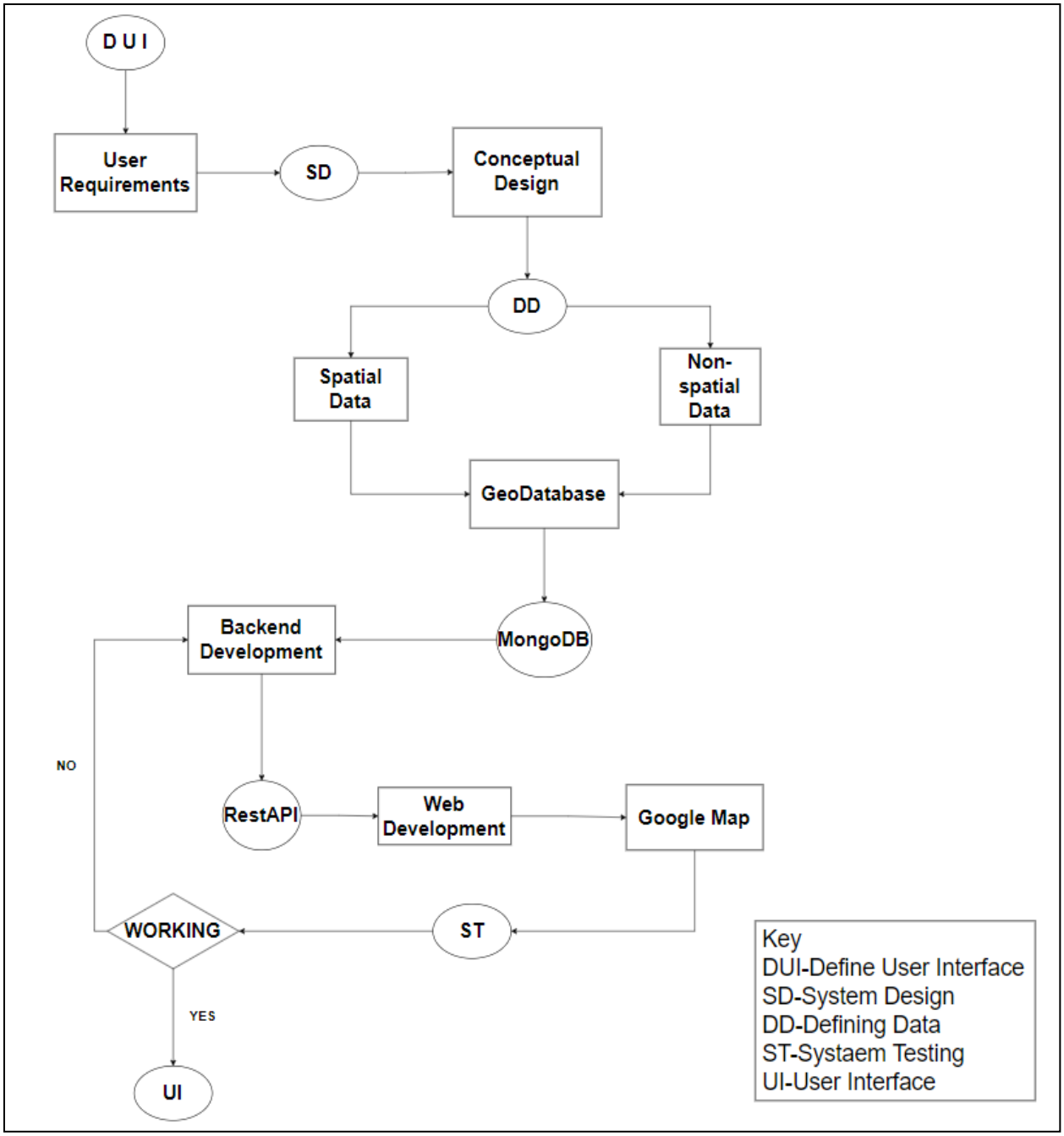

Figure 3.1 Work Flow

3.2 Study Area

The study area of this research will be at Sinza ward in Ubungo District Dar-es-salaam region, Tanzania. It is Latitude -6.7816° to 6° 46' 54" south Longitude 39.2219° to 39° 13' 19" east, the area is 3.339km^2. From the census of 2012 the population is 40,546. Sinza is known for its

diverse housing options that range from informal settlements to upscale neighborhood making it valuable study location for research on the housing and rental markets in Tanzania basing on neighborhood initial information to clients. It is a diverse neighborhood with a mix of residents from different socio-economic backgrounds, its population is predominantly composed of Tanzanians from various areas with a smaller number of expatriates and immigrants from other countries. It is a neighborhood characterized with several facilities including businesses like shops, restaurants and offices but also transportation facilities, financial facilities and health facilities. Figure 3.2 shows the study area location.

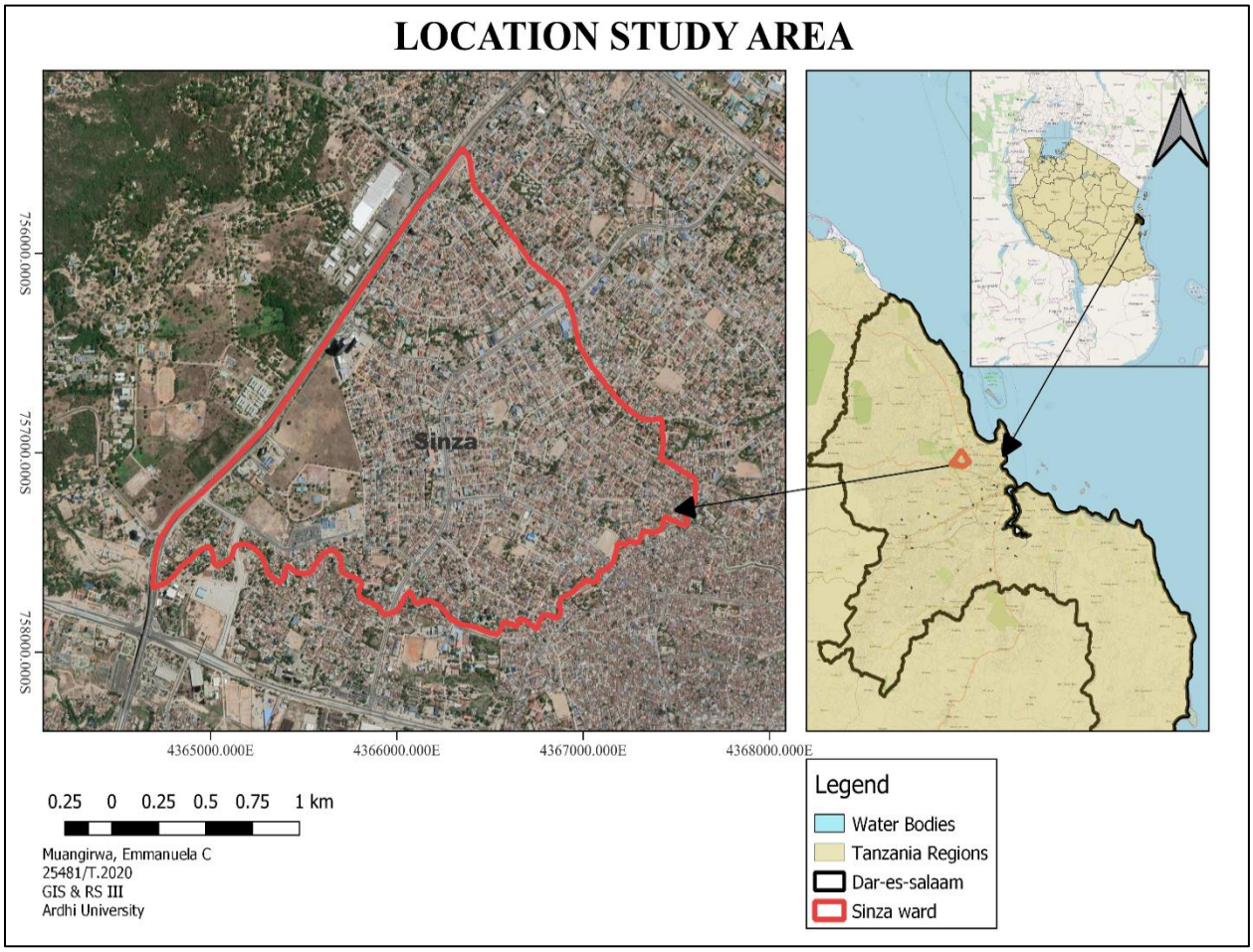

Figure 3.2 Study Area

3.3 Software and Technologies.

These are the software and technologies that were used in this research that enabled building of the GIS based website and how they were applied. These technologies and development tools were installed and set up. Table 3. *1*, Table3. *2*, Table3. *3* below shows the software, programming language and technologies that were used.

Table 3. 1 Software used

S/N	Software used	Uses
1	QGIS	This was used to develop the study area map for the research.
2	Draw.io	Used to design and draw the system architecture, work flow and system design.
3	Visual Studio Code	Used for code editing

Table3. 2 Programming languages used

S/N	Programming languages	Uses
1	JavaScript	Used to build the website.
2	HTML	Used to structure web content.
3	CSS	Used to style and for layout of the web content.

Table3. 3 Technologies used

S/N	Technologies used	Uses
1	Google Maps API	The API is integrated to both client side and sever side to enable map interactions and visualization. Provides several functionalities including geocoding, closest facility search, place search and routing functionality.
2	MongoDB	NoSQL Database used for storing and managing spatial data and non-spatial data for the website.
3	Mongoose package	For connecting Backend with MongoDB
4	Express.js	Java script Backend library and Node.Js framework used to build APIs for the website
5	Next.js	It is a Java script frontend library used for Designing Frontend user interface
6	Tailwind CSS	It is a CSS framework and was used in styling Frontend user interface HTML elements.

3.4 Defining User Requirements.

In the development process of this system or website defining user requirements was a crucial step. This was done through interviewing and discussion with real estate firm and agent also through surveys with the potential clients this was with the use of google forms and the sample of it is shown in Appendix A. The response was then analyzed qualitatively and quantitatively

depending on the response using excel sheet so as to understand the user requirements. Through this there was an understanding of the user preference, behaviors, motivations and pain points when it comes to have leads on potential clients, posting of properties to potential clients and searching of properties online considering external preferences.

But also there was observation on how the existing searching websites are utilized, what they serve, what they do not serve and what is expected to be improved from them so as to develop an improved house searching website that has added advantages to clients, real estate firms and agents. And with this what was noticed was the need of adding the preference buffer of location of facilities close to the listed property and showing the route and distance to a specific facility thus making the maps more interactive and dynamic.

3.5 System Design.

Designing of the system based on considering the user requirements, also planning and structuring the components and functionalities of the website in such a way that it achieves the objective of this research. There are two main designs performed that are Web Architecture and Defining data model.

3.5.1 Web Architecture.

The web architecture has several parts that are Database, Backend, Frontend, Google Maps API, External APIs and data sources.

The frontend components requests data from the backend that retrieves necessary information from the database and external APIs, The backend processes and prepares the data and sends it back to the frontend for display. The database stores, retrieves and manages the property listings data, while the external APIs provides the additional extrinsic data and the Google Maps API enables the functionalities within the frontend. Figure 3. 3 illustrates the web Architecture also known as the system diagram.

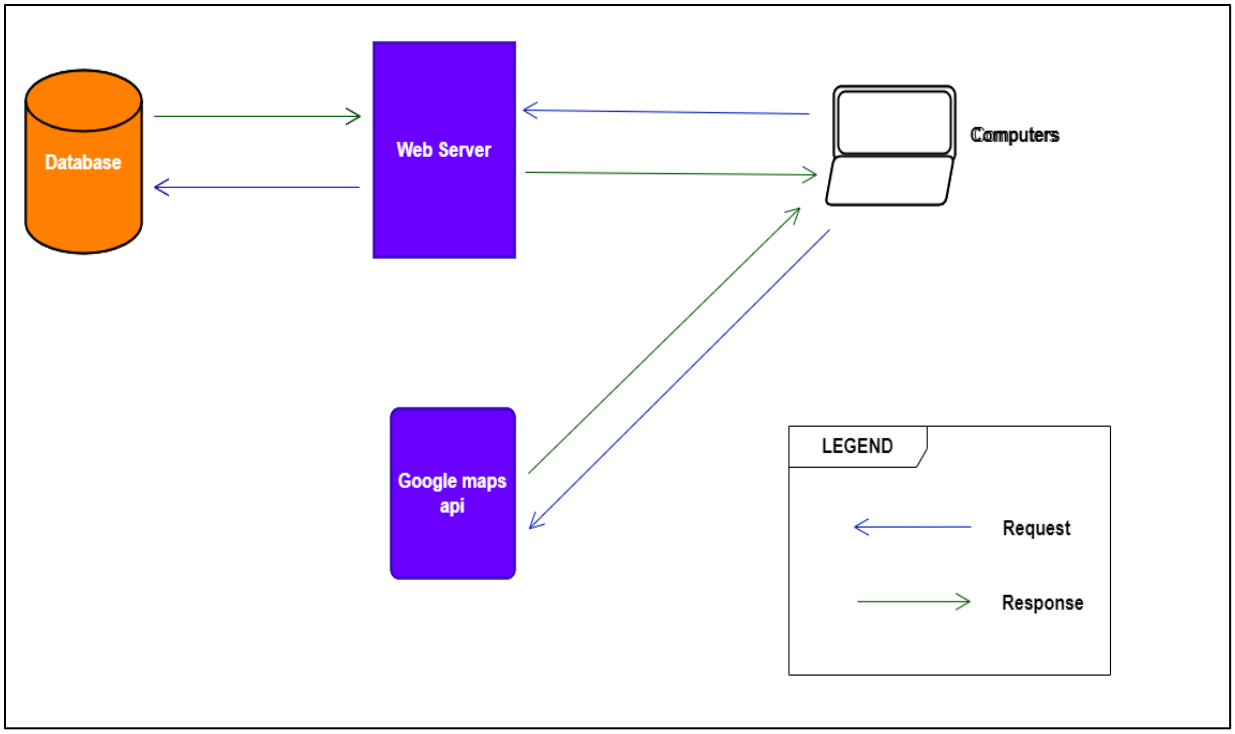

Figure 3. 3 System diagram

3.5.2 Defining data model.

The data model of this research involved structuring and organizing the geospatial data related to rental houses, extrinsic attributes sourced from google maps, users and their relationship. This was done by first identifying the entities, attributes, their relation and structure of the data. The *Table3. 4* below shows the data model.

Table3. 4 Defining Data Model

Entity	Attributes	Relationships
House	Address, Price, Payment duration, Location, Description, Type and Pictures	- House is posted by one agent - House is requested by many clients -

Agent	Name, Email, Phone number, Password and Picture	- Agent posts many houses - Agent communicates with many clients
Client	Name, Email, Phone number, Password and Picture	- Client requests many houses - Client communicates with many agents

The structure of the data model explained in the *Table3. 4* is illustrated in Figure 3. 4 below.

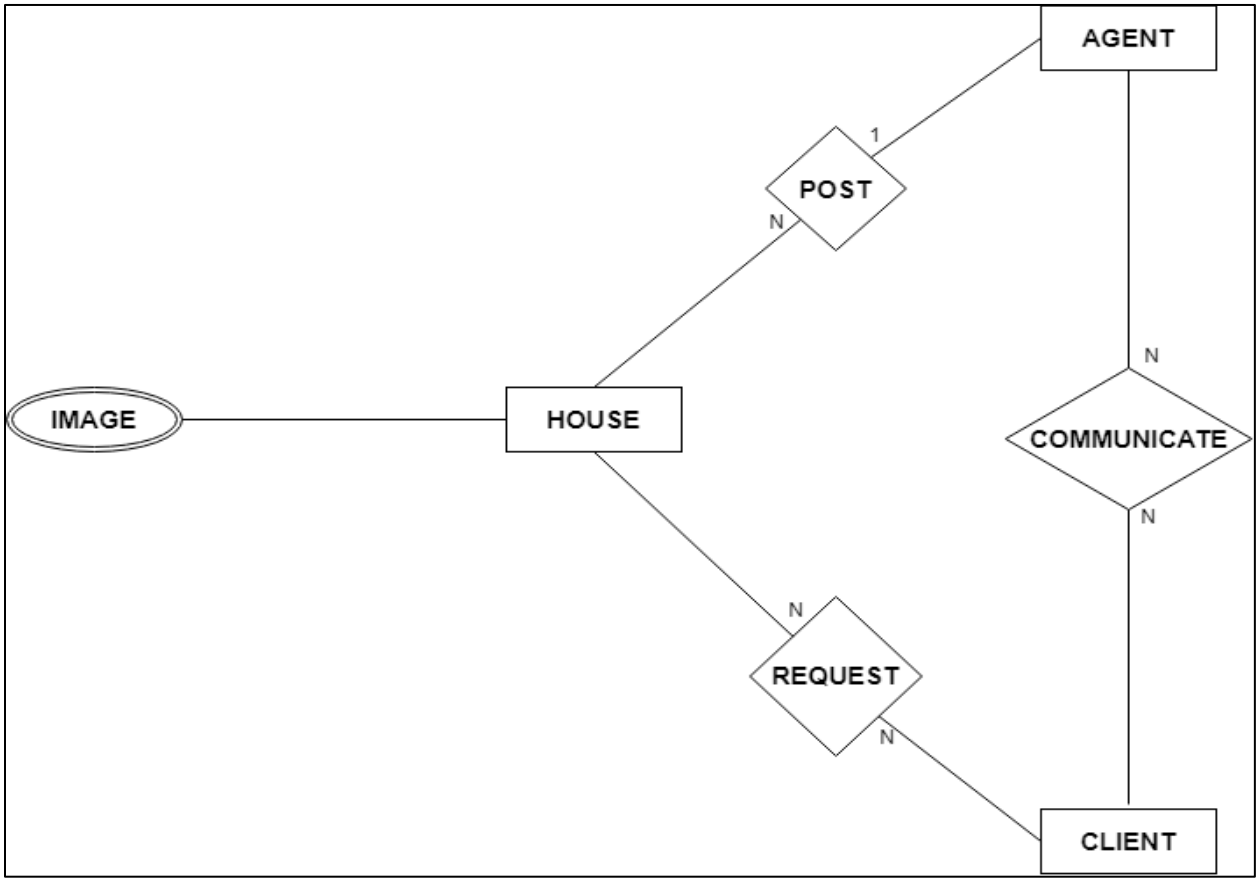

Figure 3. 4 Data structure

3.6 Data Collection.

In this research data that was collected was the data of rental properties located at Sinza ward in Ubungo district Dar-es-salaam Tanzania. Since the system after it is developed it has the capability of collecting its own data for the start data was collected using KoboCollect application that was installed in the phone then was connected to the kobotoolbox server to download the project form for collecting data that was designed in the kobotoolbox and deployed the sample form that was used to collect data is shown in Appendix B. Figure 3. 5 below shows the Excel form that was designed to be used in the collection of house data.

type	name	label	hint	default	required	parameters
start	start					
end	end					
username	username					
deviceid	deviceid					
phonenumber	phonenumber					
select_one ww2dy56	Property_Type	Property Type	Select the property type	House	true	
decimal	Number_of_rooms	Number of rooms	Enter number of rooms in the property		true	
select_one fz4hz53	Rental_period	Rental period	Enter the stay in duration in which the clients will be paying		true	
decimal	Price	Price	Write the price of the property		true	
geopoint	Location	Location	Record the geographic location of the property		true	
image	Images_of_the_property	Images of the property	Take images of the property		true	max-pixels=1024

Figure 3. 5 Data collection form

The House data that was collected included the spatial information and other attribute information including property type if it is a house, an apartment, single room or self-contained, then number of rooms, rental period and price range, the *Table3. 5* below illustrate the data, source, format and use of the data that was collected.

Table3. 5 Data Collected and their Sources

Data Attribute	Source	Format	Use
House Coordinates	Kobotoolbox (GPS	Latitude, Longitude	Plotting house

	field)		location on map
Address	Kobotoolbox (Text field)	Text	Displaying house address
Price	Kobotoolbox (Numeric field)	Numeric	Defining property cost
Payment Duration	Kobotoolbox (Numeric field)	Numeric	Specifying payment period
Description	Kobotoolbox (Text field)	Text	Providing property details
House type	Kobotoolbox (Text field)	Text	Defining property type
Pictures	Kobotoolbox (Image field)	Image	Showing visual representation of the property

After the development of the system the real estate agents can collect the house data information using it through the post functionality once they have registered themselves as agents and have profile accounts. The post function opens a web page that provides the agent with the ability to provide the attribute information for the property, image and set the location.

3.7 Database Development.

The database that was used was MongoDB and it stores both spatial and non-spatial data. Spatial data in MongoDB is stored in GeoJSON format and supports various geospatial query operations and methods that allow performing spatial query This database is useful especially since it is used in the development of website that will be having large number of data (Kozielski et al., 2019).

MongoDB Compass that is a graphical user interface was used to create new MongoDB database for the project, then the database was connected to the backend using mongoose library in the Express.js server file where the connection parameters such as database URL, username, password and other configurations were made. Figure 3. 6 below show the Database with house location data and their attribute information in MongoDB Compass.

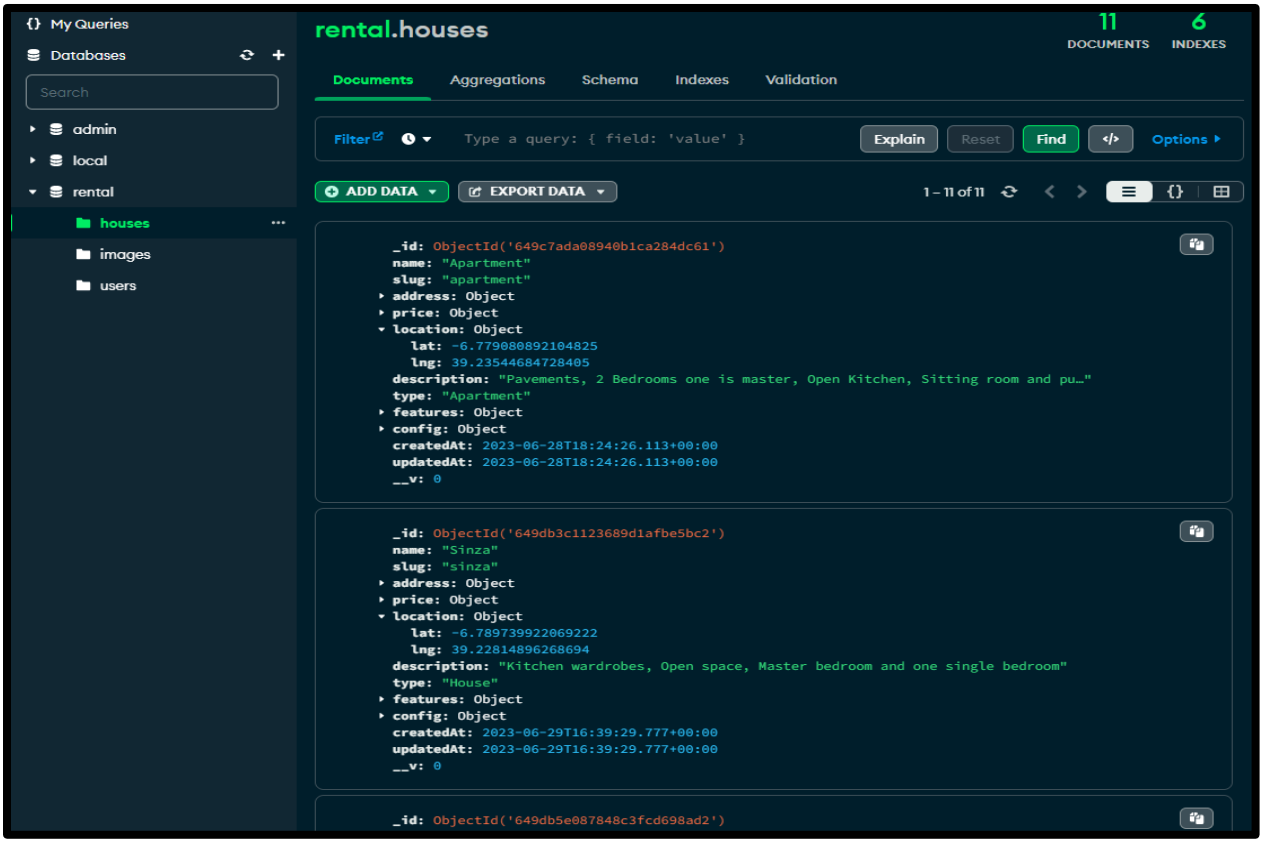

Figure 3. 6 Spatial Database

With the use of mongoose library data models were defined to represent entities and schemas were defined. There after CRUD operations were performed by implementing necessary routes and controllers in Express.js to handle CRUD operations for interacting with MongoDB, the end points for creating, reading, updating and deleting data from the database was defined. Thereafter was integrated with Next.js and relationships were handled by implementing logic.

3.8 Backend Development.

In the sever-side components and logic implementation for the website the technology that was used was Express.js framework. First the project was setup and then the server was created then routes and handlers for different endpoints of API were defined. Middleware functions were then added so as to process request data, handle authentication, log requests and others, handled requests and then was connected to MongoDB using Mongoose library.

With Representational state transfer application programming interface (REST API) it enables communication and data exchange between different systems over the internet.

3.9 Website Development.

For the frontend development Next.js, CSS, HTML and JavaScript technologies and languages were used. Pages, components and style sheets based on the User interface design were created and features such as property search, property listings, user registration/login, profiles and posting. The Source codes of this website are attached in the CD and the system requirements to run the website are illustrated in Appendix C.

3.10 Google Maps API.

Google Maps API was integrated to the website to display the properties and their location on the map, the API was used to geocode property addresses and retrieve location-based information. Then map makers and information windows were implemented all these were done so as to provide additional property details when it is clicked. The extrinsic attributes obtained from the Google maps API and their corresponding fields in MongoDB.

3.10.1 Integrating of Google Maps API.

The API key was obtained from Google Cloud Console so as to enable API access, it is a unique identifier for the website and it grants the access to the Google Maps API services. There after followed by embedding the Google Maps JavaScript library to the React code of NextJs by using the package @react-google-map/api. It provides the necessary functions and methods to interact with Google Maps services.

After embedding the GoogleMap component from the package, the initial settings that are the center point and zoom level were defined. Also, according to the website's functionality the zoom level depends on the property posted extent. There after markers were added with respect to the house posted or present in the database and also added event listener to pop up an icon that shows information of the house when the marker is selected.

3.10.2 Place searches.

Using google maps search from google maps places API, any place can be search and if there is any property in that particular place, the results will be rendered as markers on the google map. Figure 3. 7 below shows how place search was enabled in such a way that if an individual searches for a location it can display rental houses if they are available in the database.

```
{properties.length > 0 &&
  properties.map((property) => (
    <Marker
      key={property._id}
      position={property.location}
      title={property.name}
      icon={{
        url: "/home_marker.svg",
        scaledSize: new google.maps.Size(25, 35),
      }}
      onClick={() => handleOpenInfoWindow(property._id)}
    >
      {id === property._id && (
        <InfoWindow onCloseClick={() => setId("")}>
          <div className="w-[250px]">
            <div className="px-1 flex flex-col justify-between">
              <div>
                <h4 className="font-bold sm">{property.name}</h4>
                <p className="text-xs">
                  {property.address.ward}, {property.address.street}
                </p>
                <p className="text-xs">
                  {property.address.district}, {property.address.region}
                </p>
              </div>
              <div>
                <strong className="□text-primary">
                  Tsh {property.price.amount} / mon
                </strong>
              </div>
            </div>
            <Link
              className="absolute right-5 bottom-3 bg-gradient-to-b □from-primary/70 □to-primary ■text-white font-semibold px-4 p
              href={`/${property.slug}`}
            >
              View
            </Link>
          </div>
        </InfoWindow>
      )}
    </Marker>
  ))}
```

Figure 3. 7 Place search functionality

3.10.3 Closest facility and buffer functionality.

The closest facilities can be obtained within the provided range from the google maps places API. By enabling the places API, google maps is capable of providing details about the nearest facility searched like ATM, Hospital etc.

After initializing Google map using google maps places services API the google maps directions API was used to calculate the closest facility from the house location to multiple facilities around the buffer zone distance that was calculated in meters and then if there was a close facility to the house buffer zone their markers would display.

Figure 3. 8 below shows the function responsible for obtaining the nearest facilities from the nearest place within the provided buffer range.

```
const nearByFind = () => {
  const service = new google.maps.places.PlacesService(
    //@ts-ignore
    mapRef.current
  );
  if (!property || !type || !mapRef.current || !service) return;
  const request = {
    location: property.location,
    radius: range, // Distance in meters
    type: [type],
  };

  //@ts-ignore
  service.nearbySearch(request, (results, status) => {
    setLoading(true);
    if (status === google.maps.places.PlacesServiceStatus.OK) {
      if (results && results.length > 0) {
        //@ts-ignore
        setPlaces(results);
        placeCount(results.length);
      }
    } else {
      setPlaces([]);
      placeCount(0);
    }
    setLoading(false);
  });
};
```

Figure 3. 8 Closest facility and buffer functionality

3.10.4 Routing Functionality.

The google maps API service provides the routing service. By enabling the places API, google maps is capable of providing possible routes and calculating the distance and time for the routes. The system will provide latitude and longitude of the two locations to google maps and google maps return time, distance and route.

Using Google Maps direction API the route between the house and the selected closest facility within the buffer was calculated. Figure 3. 9 below shows the markers which when clicked, the direction polygon line is drawn onto the map.

```
{places.length > 0 &&
  places.map((place) => (
    <Marker
      key={place.place_id}
      position={place.geometry?.location}
      title={place.name}
      onClick={() => fetchDirections(place.geometry?.location)}
      zIndex={900}
      icon={{
        url: "/places_marker.svg",
        scaledSize: new google.maps.Size(25, 35),
      }}
    />
  ))}
{directions && (
  <DirectionsRenderer
    directions={directions}
    options={{
      polylineOptions: {
        zIndex: 50,
        strokeColor: "#197",
        strokeWeight: 5,
      },
    }}
  />
)}
```

Figure 3. 9 Routing functionality

Figure 3. 10 below shows the card that renders the directions information provided from the google maps API after the marker is clicked to obtain directions from the house to the selected closest facility in the buffer area.

```
{directions && (
  <section className="mt-3">
    <div className="w-full text-center rounded-lg p-3 bg-gradient-to-r from-background to-secondary/20 relative z-10">
      <h3 className="font-semibold text-lg transition-opacity text-primary">
        Directions Information
      </h3>
      <div className="flex">
        <div className="w-1/2">
          <h4 className="text-start font-bold text-primary">
            Distance
          </h4>
          <p>
            About{" "}
            <span className="text-secondary font-bold">
              {directions.routes[0].legs[0].distance?.text}
            </span>
          </p>
          <p>
            <span className="text-secondary font-bold">
              {directions.routes[0].legs[0].distance?.value}
            </span>{" "}
            meters
          </p>
        </div>
        <div className="w-1/2">
          <h4 className="text-start font-bold text-primary">
            Driving Time
          </h4>
          <p>
            About{" "}
            <span className="text-secondary font-bold">
              {directions.routes[0].legs[0].duration?.text}
            </span>
          </p>
          <p>
            <span className="text-secondary font-bold">
              {directions.routes[0].legs[0].duration?.value}
            </span>{" "}
            seconds
          </p>
        </div>
      </div>
      <button
        onClick={() => setDirections(undefined)}
        className="px-2 py-1 bg-primary rounded text-white mt-3 hover:opacity-90"
      >
        Clear Directions
      </button>
    </div>
  </section>
)}
```

Figure 3. 10 Direction and Distance functionality

3.11 System Testing.

This involved evaluating the whole system functionality, performance and usability. The system link was shared with some individuals to see if its functionalities are okay and if it is user friendly.

It was shared with some agents that helped to post few properties and also was shared to potential clients to navigate around the system. There were some issues that were corrected and therefore made the website much better than before.

Also tried to put false information to see if the system will send an error message and it was successful this is shown in Figure 3. 11 below.

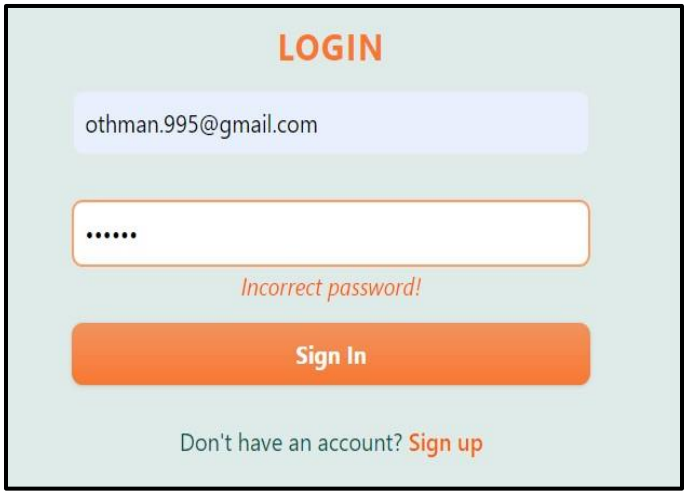

Figure 3. 11 System Testing

CHAPTER FOUR

RESULTS AND DISCUSSION.

4.1 Overview.

This chapter presents the results that were obtained from the procedures and methodologies of the research implemented and the discussion in this chapter is presented basing on the objective of this research that was Integrating extrinsic housing attributes to house searching GIS based website.

4.2 User Requirements.

From the user requirements that were identified in this research the following are the results findings.

Survey findings: Most of the potential clients consider extrinsic housing attributes in their housing decision process. Client user desire comprehensive information on facilities that are nearby the house to be rented.

The research found out that 76.9% of the respondents have shown the need of a GIS based website that helps to search for rental house considering neighborhood preference. This is shown in Figure 4. 1 below.

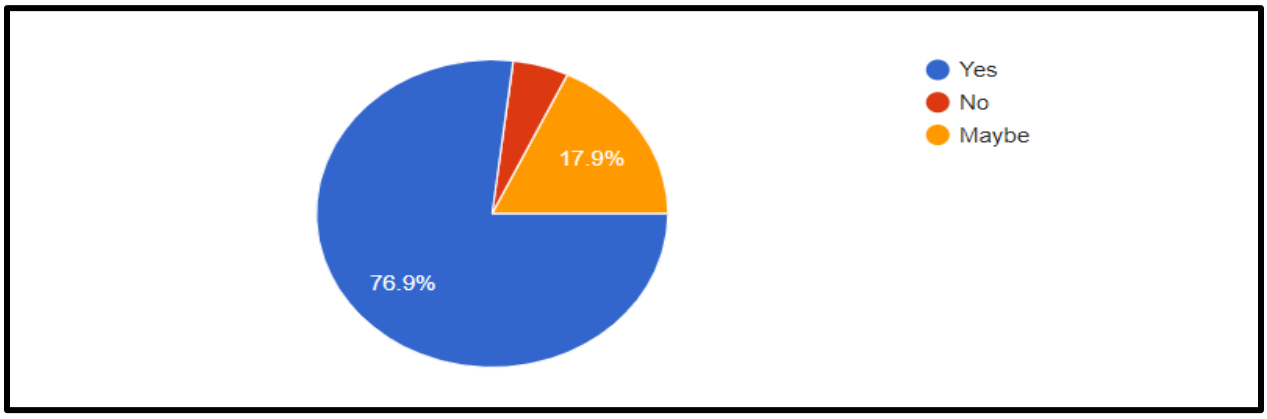

Figure 4. 1 Need of GIS website showing neighborhood proximity

Discussion findings: Real estate firm get most of client leads of in websites with more property description. Agent user desire platforms with more property description advantage. *Table 4. 1* below shows the user requirements.

Table 4. 1 User Requirements

S/N	Functionality	User
1	House Search	Client
2	Viewing house details	Client
3	Viewing closest facilities	Client
4	Map Visualization and interaction	Client and Agent
5	Contacting Agent	Client
6	Responding to client inquiries	Agent
7	Managing house listing	Agent
8	Creating an account	Agent and Client

4.3 System Design.

The system was designed and enabled to have the conceptual idea and understand the architecture and structure of the system so as to make it reach its requirements. Figure 4. 1 below shows the system diagram or architecture.

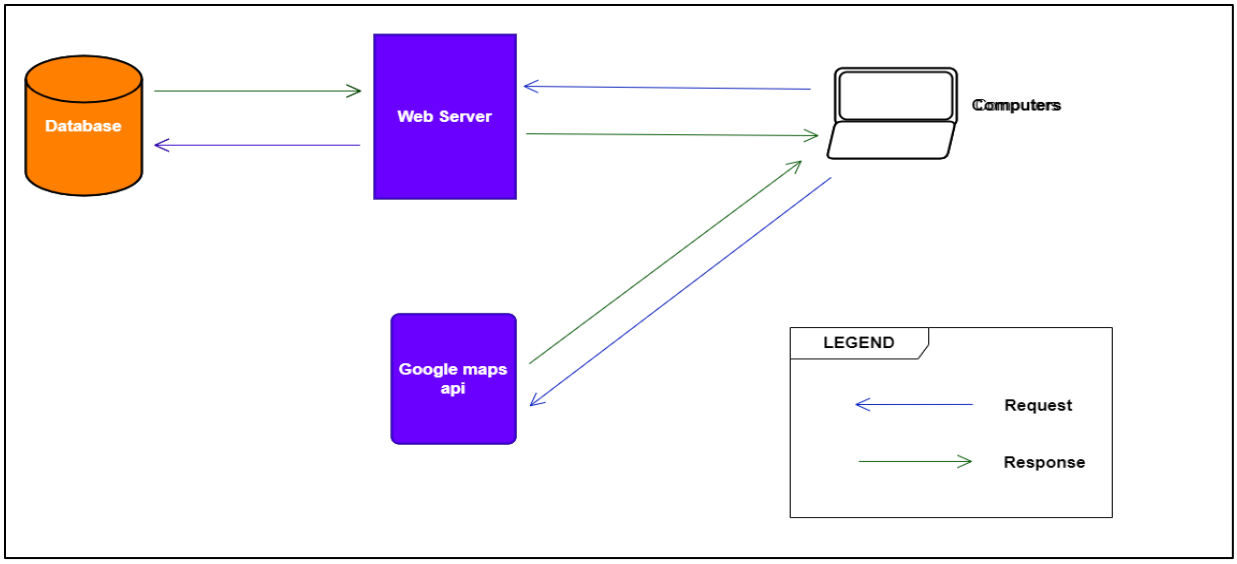

Figure 4. 2 System diagram

This system has several parts including the Database, Webserver, Google maps API and the user interface. The user interacts with the website through the web browser then it sends request to the webserver that could be of viewing map, searching of house, finding closest facility in a certain diameter or calculating routes distance from facility to house. The web server processes these requests and communicates with the database to fetch or update data, if the request involves mapping or location services it will make request to the Google maps API and it will respond and the browser will display the response to the user. If the request needs to be sent to the database it will be requested by the web server then communicated back.

Figure 4. 3 below shows how House data, agent and client are related to each other, how they are organized and how their structure supports the websites functionality.

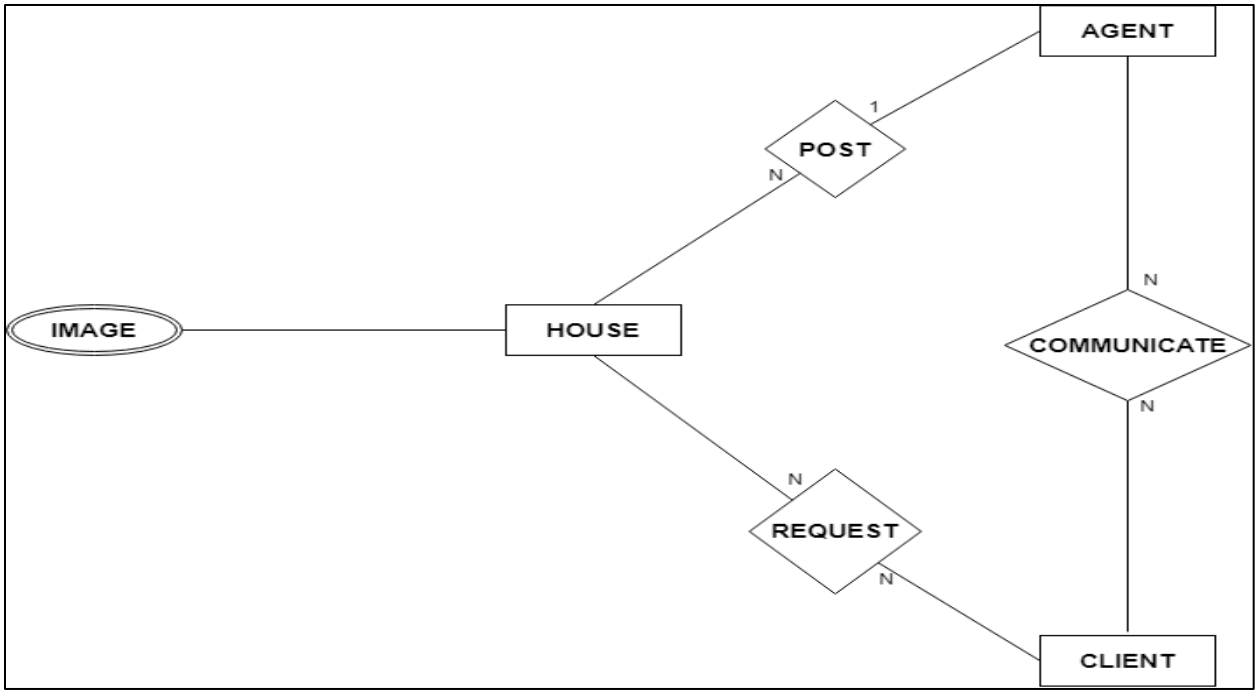

Figure 4. 3 Data structure

The website has three main entities being House, Agent and Client, The house has one to many relationships with the agent meaning many houses can be posted by one agent. House has a many to many relationship with the client meaning many clients can request many houses in the system. Client and agent have many to many relationships meaning many clients can communicate to many agents.

4.4 GIS based website.

As from the specific objectives of this research, developing a GIS system that allows users to search for rental properties based on location and extrinsic attributes and providing sellers with tools that effectively market their properties to the right audience based on neighborhood preference and bring interested clients. The user manual of this website is shown in Appendix D. The result was a GIS-based website and it is available via this link https://rentaltz.vercel.app/

The website has the ability to perform place search, here a client can search for a location that they need so as to look for rental houses present in the area. If there are rental houses posted in that area they will be displayed on the map once the location is searched. Also individual can

specify other attributes like the type of property, number of rooms, payment duration period and price range that they prefer along the place search. Figure 4. 4 below shows the ability to search for rental house based on Location and attributes.

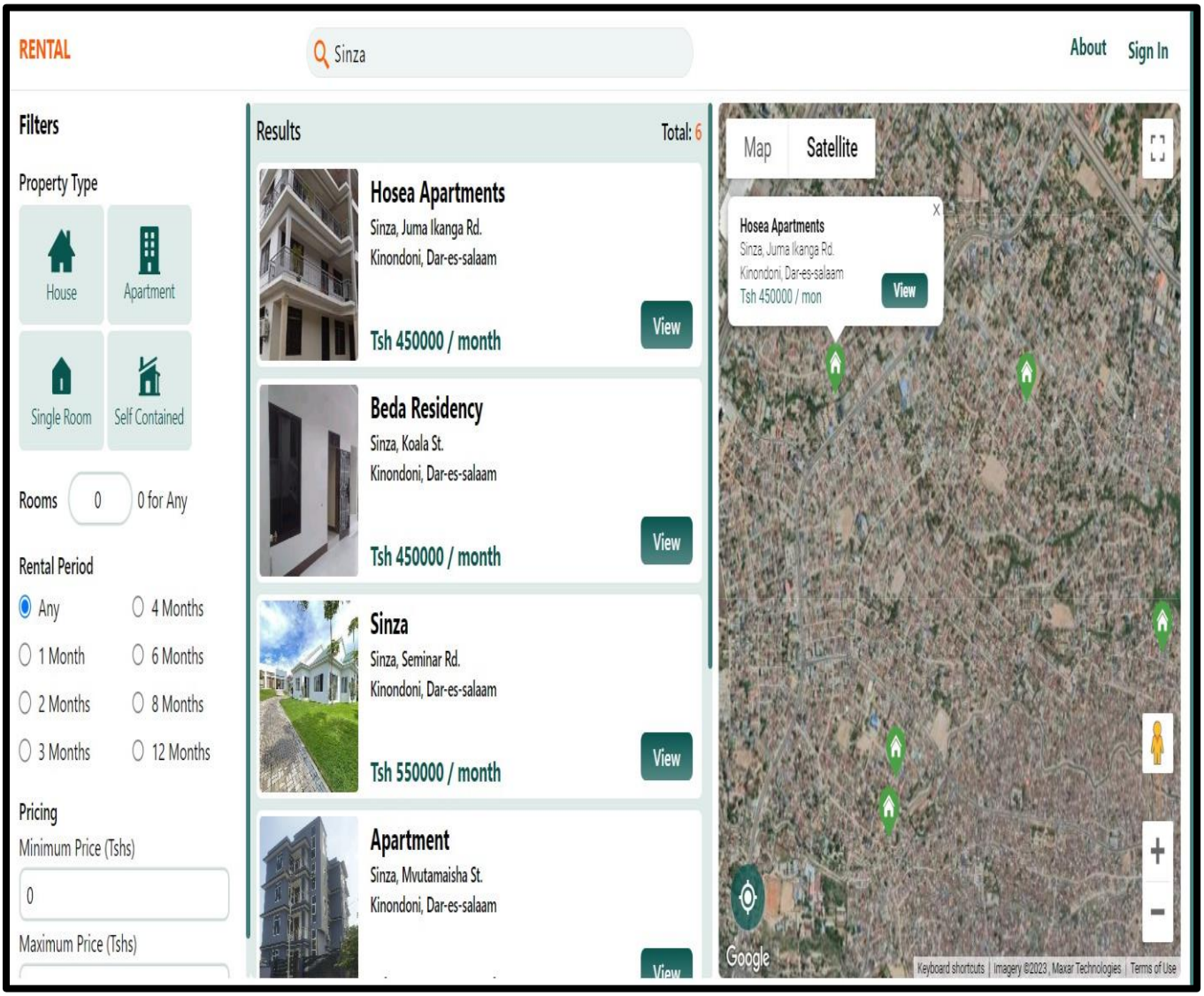

Figure 4. 4 Location searching based capability of the GIS website

The website provides the ability to search for closest facility near selected house with buffer range defined by the user basing on their preferences and also showing the route to specific facility and calculating of the distance in meters and kilometers together with driving time from the house to the facility. Figure 4. 5 below shows the proximity and accessibility capabilities of the system.

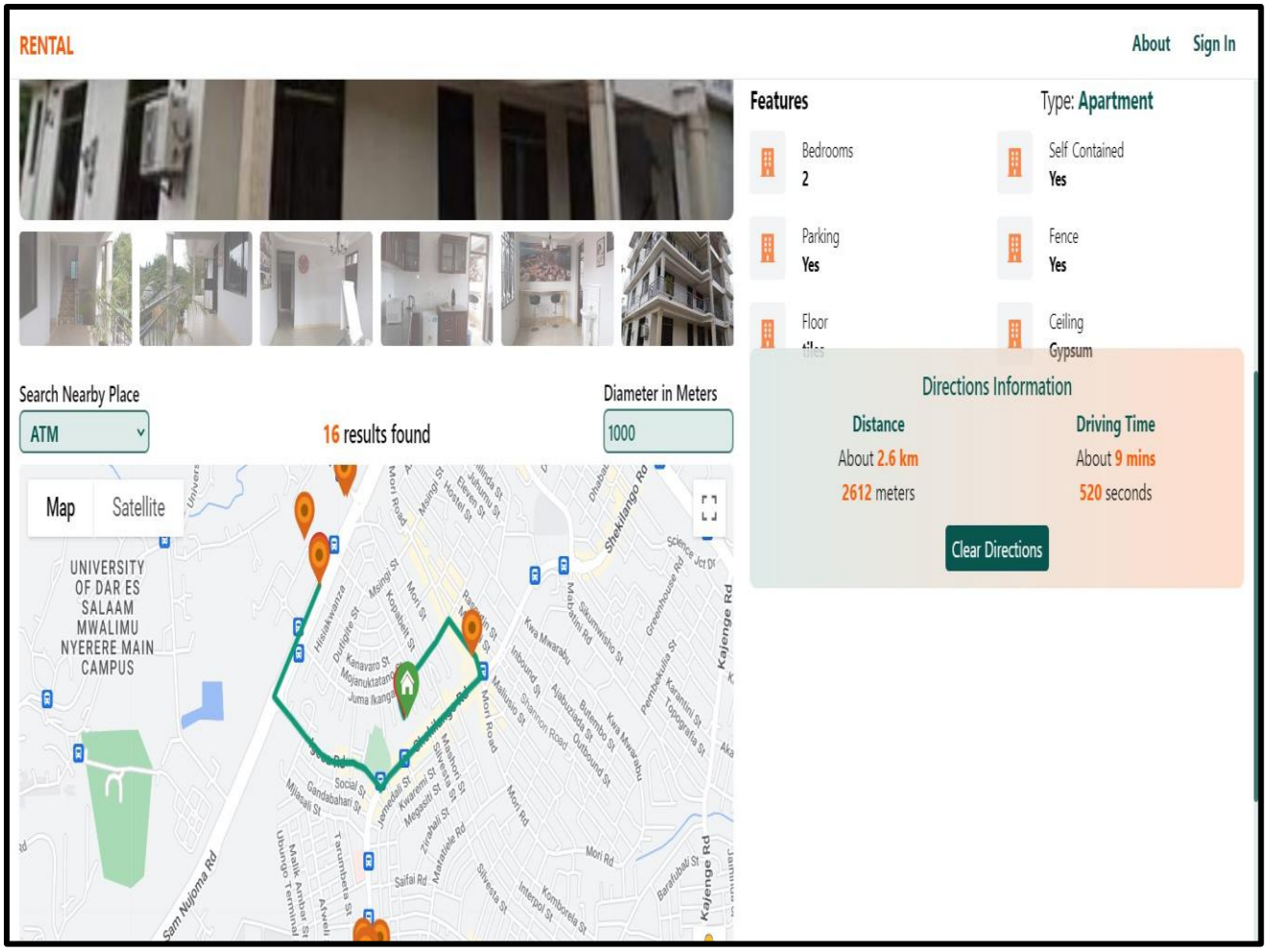

Figure 4. 5 Proximity and accessibility to facilities capabilities of the GIS website

The website also enables the agent to post houses with their spatial information alongside the non-spatial information. It is possible to pick current location or set location in forms of latitude and longitude so as to provide the geographical information of the house. Figure 4. 6 Below shows the geocoding capabilities to input spatial information of rental houses.

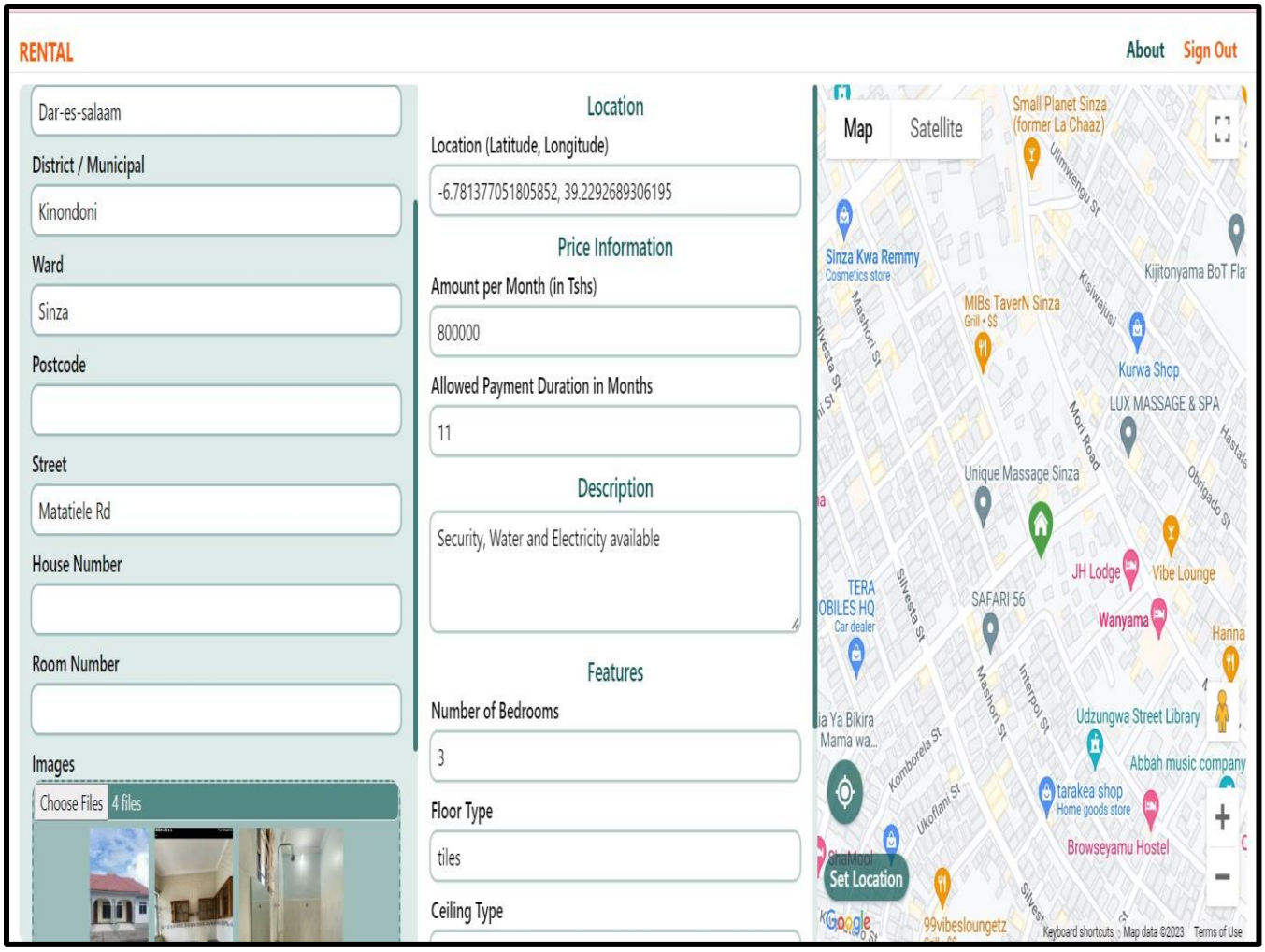

Figure 4. 6 Geocoding capabilities to input location of houses

From the Survey findings among of the attributes that potential clients consider to make decisions so as to rent or buy a house include Location of the property, Price range, Bedroom numbers, Type of the house, Outer space specifications like parking, garden and fence. These are intrinsic housing attributes. In the GIS-based website they were defined and visualized as shown in Figure 4. 7 below.

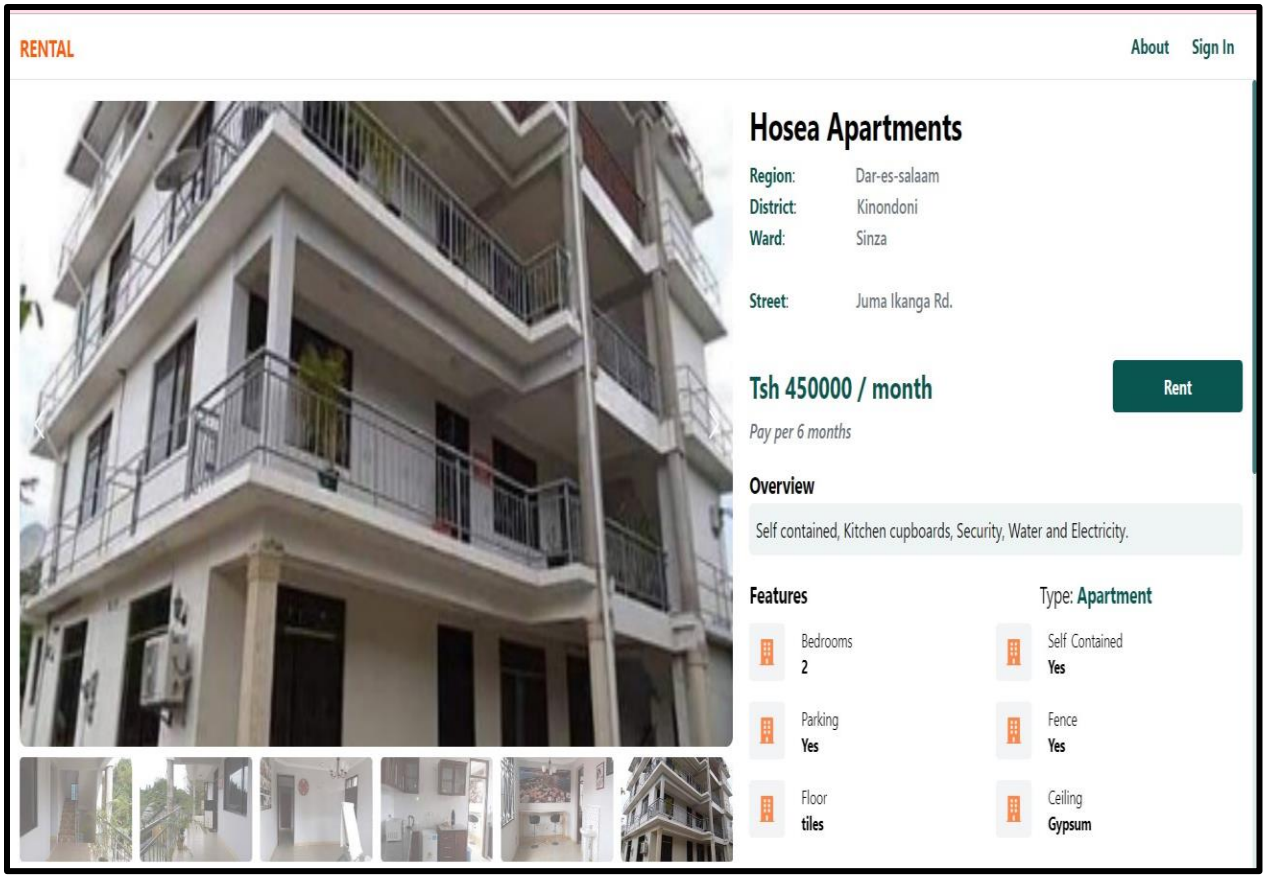

Figure 4. 7 Attributes of the house

For The Agents and Clients who would like to be getting updates on new property listings they can create an account by registering themselves and sign in. The clients will not have the ability to do any kind of updating or editing in the website that viewing the properties, communicating with the agent and saving posts that they like of need to visit later, with the Agents they can post, and edit if the property is vacant or occupied and communicate with their clients. The registration page is shown in Figure 4. 8

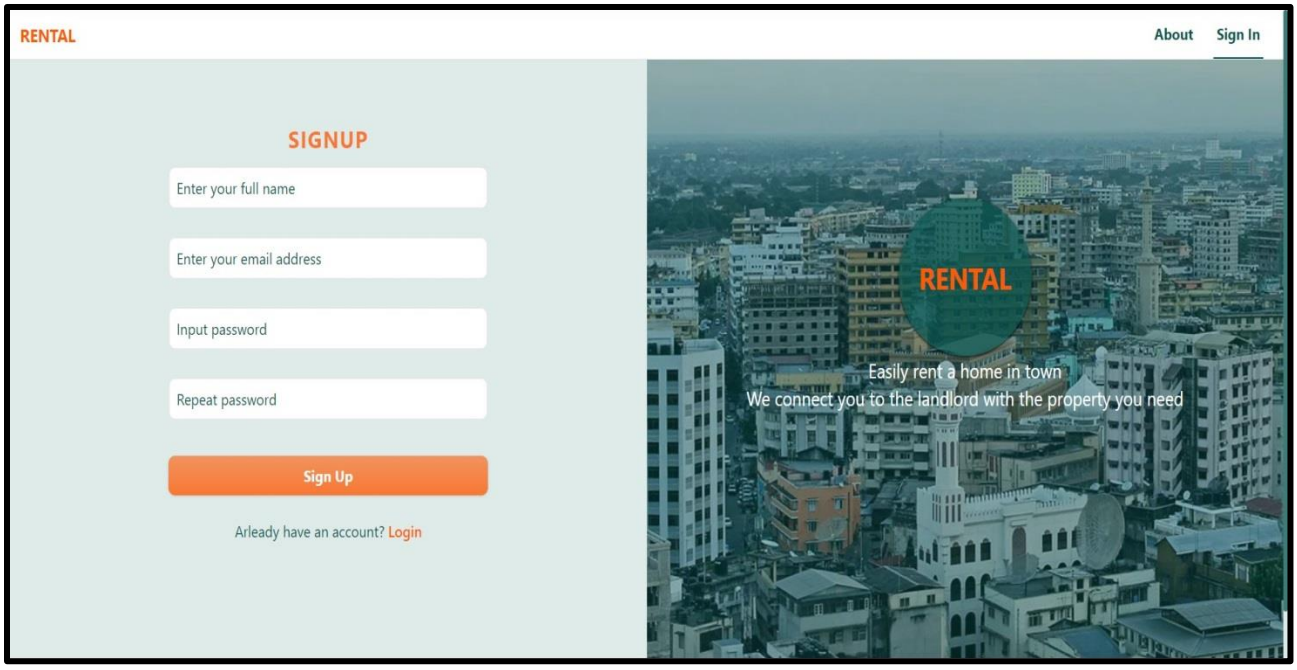

Figure 4. 8 Registration page

The Login page for the website is shown in Figure 4. 9 below

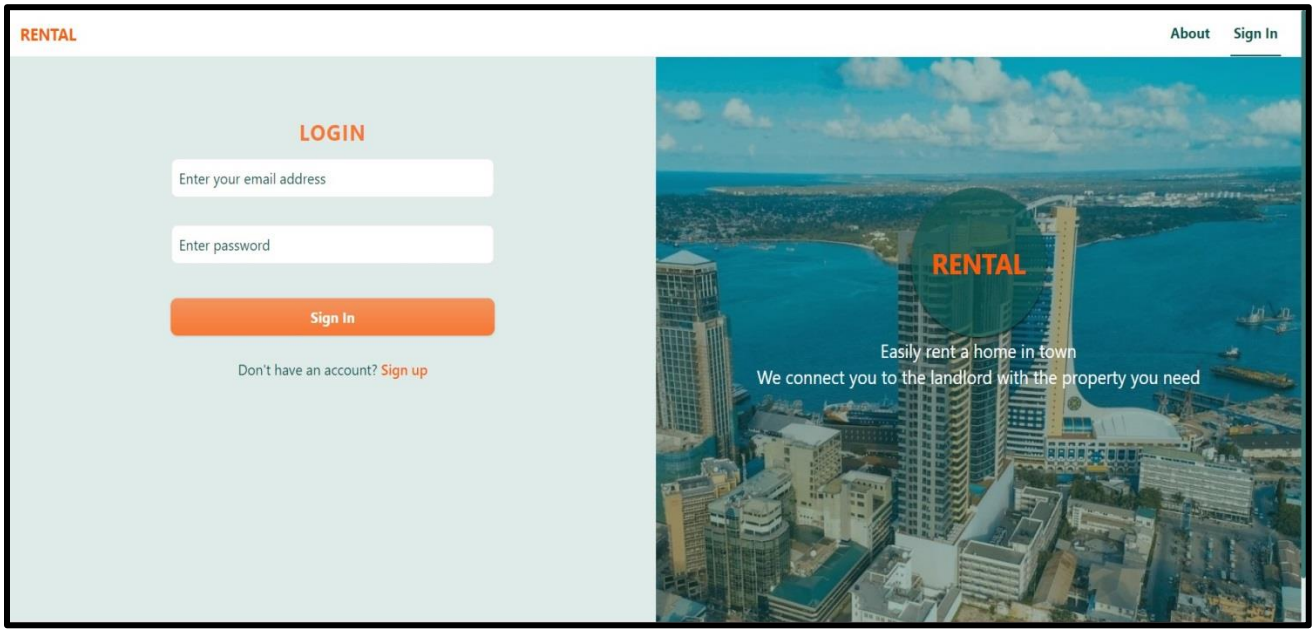

Figure 4. 9 Log in page

4.5 Discussion.

This research has a significant implication for the real estate industry and house searching process. In this part the findings and implications of the research are discussed.

The results indicate that there is a strong demand for considering extrinsic housing attributes in the house searching process, this is to say that more information on the external factors that affect the value of the property should be highlighted so that the clients can make informed decisions. This aligns with previous research that highlights the importance of neighborhood characteristics in housing decisions (Karanja, 2017). The high number of respondents that values the proximity to amenities and transportation reflect the importance convenience of accessibility in housing choices.

The research results has provided a GIS based website that has the ability to search for rental houses considering closest facilities to the rental house in a preferred buffer zone in meters, it also provides the ability to calculate distance in meters and kilometers, route and driving time from the house to selected facility around the buffer zone. It can also perform location searching functionality and also geocoding functionality that enables posting of location or spatial information of the rental house.

The results also suggest that the integration of extrinsic housing attributes into GIS-based house searching websites can add an advantage to the existing system by enhancing decision making process for users since they can make informed decision on their expected properties in relation to their preferences by evaluating the properties basing on the comprehensive information about the surrounding environment. The House searching GIS website can be accessed by using this link https://rentaltz.vercel.app/ .

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS.

5.1 Conclusion.

A GIS-based house searching website that integrate extrinsic housing attributes was developed and the findings have shown its importance this is because there is a strong user demand considering these attributes and highlight their impact on decision making process.

By incorporating extrinsic housing attribute information the house searching platforms can assist the users to make more informed choices that consider their lifestyle preferences and priorities. Also the realtors will be getting lead of customers from a wider base that is globally and market their properties more potentially.

5.2 Recommendations.

For this research the following are the recommendations that are suggested. The first is refining user interface so as to develop an interface that is more user friendly in such a way that the users can easily explore and access extrinsic housing attribute information and interact with the website. The second is addition of other extrinsic housing attributes apart from facilities and amenities that will add neighborhood information such as crime data that can provide safety and security information of the neighborhood and demographic data like population density, age distribution, income levels and employment rates so as to help the users understand the social and economic dynamics of the neighborhood.

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Appendix A

RESEARCH SURVEY SAMPLE.

Rental house search GIS based website Dissertation research survey

This is a survey to get user requirements that will help in developing a website to assist clients in searching of rental house with the ability to show them proximity and accessibility of the house to amenities like transportation, markets, schools, hospitals etc. And also helping rental firms and agents to get a lead on potential clients in a wide base.

* Indicates required question

1. Have you used a website to search for rental house before *

Tick all that apply.

- [ ] Yes
- [ ] No

2. If 'No' how do you search for rental house

3. Do you think a using a website that helps you search for a rental house considering your neighbourhood preference is useful?

Mark only one oval.

- ◯ Yes
- ◯
- ◯

No

Maybe

4. How important are the following neighbourhood criteria for you when searching for * a home?

Tick all that apply.

	Very Important	Somewhat Important	Not Important
Proximity to public transportation	☐	☐	☐
Proximity to schools	☐	☐	☐
Proximity to Shopping/entertainment	☐	☐	☐

5. Other neighbourhood criteria you consider when searching for a rental house (please specify)

6. How important are the following features in a home?

Mark only one oval per row.

	Very Important	Somewhat Important	Not Important
Number of bedrooms:			
Number of bathrooms			
Outdoor space (e.g. yard, Balcony)			

7. Other home features you consider when searching for a rental house (please specify)

8. What is your preferred method of contact with customer service when using a website ?

Mark only one oval.

- Email
- Phone
- Text messages
- Other: _____

Appendix B

KOBOCOLLECT FORM FOR INITIAL DATA COLLECTION.

6/29/23, 12:39 PM Rental properties

Rental properties

Property Type

Select the property type

- ◯ House
- ◯ Apartment
- ◯ Single room
- ◯ Self-contained

Number of rooms

Enter number of rooms in the property

_____

Rental period

Enter the stay in duration in which the clients will be paying

- ◯ Any
- ◯ 1 Month
- ◯ 2 Months
- ◯ 3 Months
- ◯ 4 Months
- ◯ 6 Months
- ◯ 8 Months

12 Months

Price

Write the price of the property

_____

Location

Record the geographic location of the pr operty

_____

latitude (x.y °)

_____

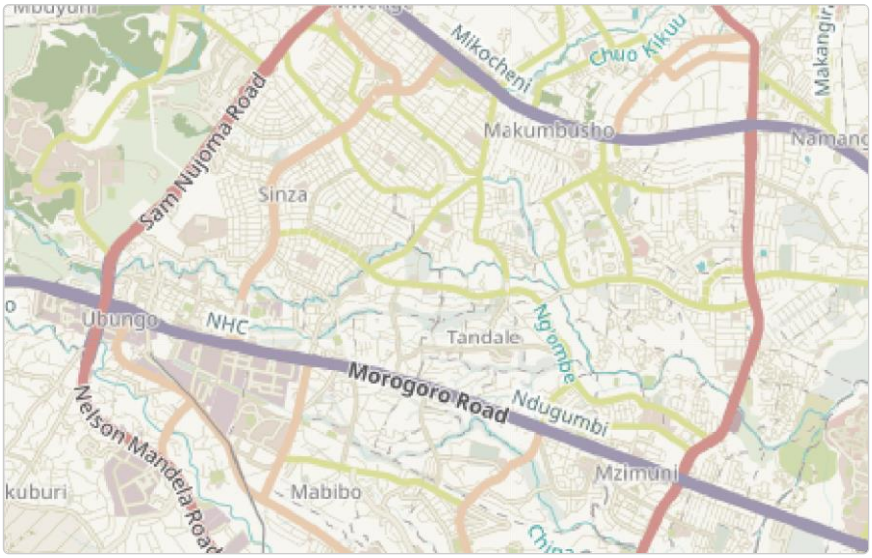
longitude (x.y °)

_____

altitude (m)

_____

accuracy (m)



_____

Images of the property

Take images of the property

Click here to upload file. (< 5MB)

Appendix C

HOUSE SEARCHING WEB-BASED GIS SYSTEM CD.

This appendix provides an overview about the attachments included in the CD and instructions for utilizing the codes so that it can run in other computer environment.

1.0 Attachments included.

The attachments include the research report pdf, source codes for the front-end and back-end of the website and the data used in this research.

The research report is in pdf format it details the background, problem statement, objectives, literature review, methodology, findings, discussion, conclusion and recommendation of the study.

Front-end source code of the website includes the HTML, CSS, and JavaScript files responsible for the user interface and interactions, it interacts with the backend to display and manage data.

Back-end source code of the website includes the server-side scripts, routes and configurations necessary for data processing, API calls and communication with the front-end.

Data folder holds the data that was used in this research including excel sheet with houses data, house data shapefile and Excel sheet of survey data. These were used in the implementation of this research.

1.2 System Requirements.

Before attempting to run the website's source codes the computer should meet the following requirements.

Node.Js should be installed in the computer since the websites back-end and front-end were developed using Node.Js. It can be downloaded and installed from the official Node.Js website (https://nodejs.org/)

1.3 Running the website.

To run the website locally in the computer first navigate to the front-end source code directory in the command prompt or other terminal window then start the front-end development server by running the following command (npm start or yarn start). There after access the website by opening the browser and navigate to the provided URL after starting the front-end development server. For further details and specific commands refer to the README files.

Appendix D

HOUSE SEARCHING WEB-BASED GIS SYSTEM USER MANUAL.

LIST OF FIGURES.

1.0 Introduction.

The House searching GIS based website that integrates extrinsic housing attributes to assist potential house buyers or clients to search or haunt for houses and rental properties considering their lifestyle preference or the neighborhood that they would prefer the house to be having for example proximity and accessibility to Markets, ATM's, Transport systems, Schools and other Amenities.

1.2 System Structures.

This GIS based website has several functionalities and are as defined below;

i. Location searching based capability of the GIS website.
ii. Proximity and accessibility to facilities capabilities of the GIS website.
iii. Geocoding capabilities to show location of properties that assist in posting of property.
iv. Viewing house attributes.

1.3 Contact Information.

To get access to use this house searching GIS based website should reach the developer through the email emmanuela.kagemlo@gmail.com or the phone number +255693937280

1.4 Starting to use the system.

This system has two users that are the Potential house buyer or client and the Agent. This guideline will show how both parties will navigate through the website.

Open the website from any web browser like Chrome, Mozilla Firefox, Microsoft edge and Google through the link https://rentaltz.vercel.app/ by typing it on the browser address bar like shown in figure C.1 below

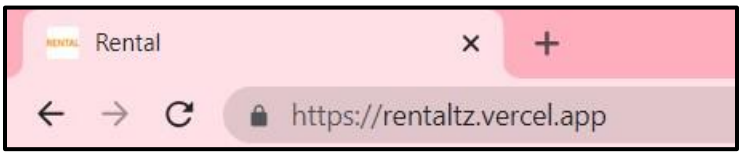


Figure C. 1 Browsing house searching GIS based website

The home page will appear were users can search for house based on preferred attributes and location, User can view the properties basing on the search query on the map. This page is shown in figure C.2.

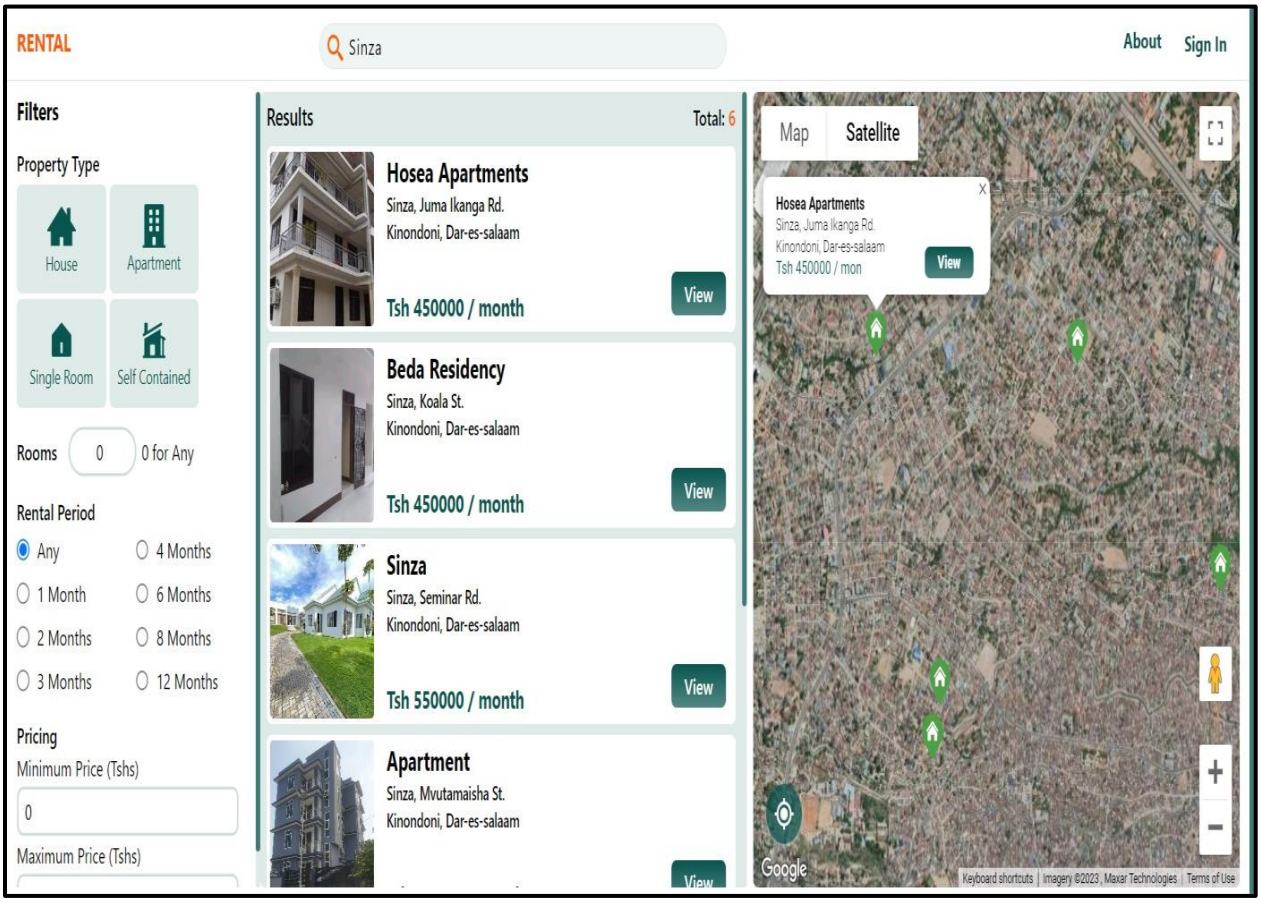


Figure C. 2 Home Page

Client can view the property by selecting the view icon as shown in figure C.2 and can then view the detailed information of the property, this is both intrinsic and intrinsic attribute information will be displayed. Client can set diameter distance from the house to facilities in meters and check the proximity and accessibility by selecting the facilities and it will show the route, distance and travel time. All this is shown in figure C.3 and Figure C.4 below.

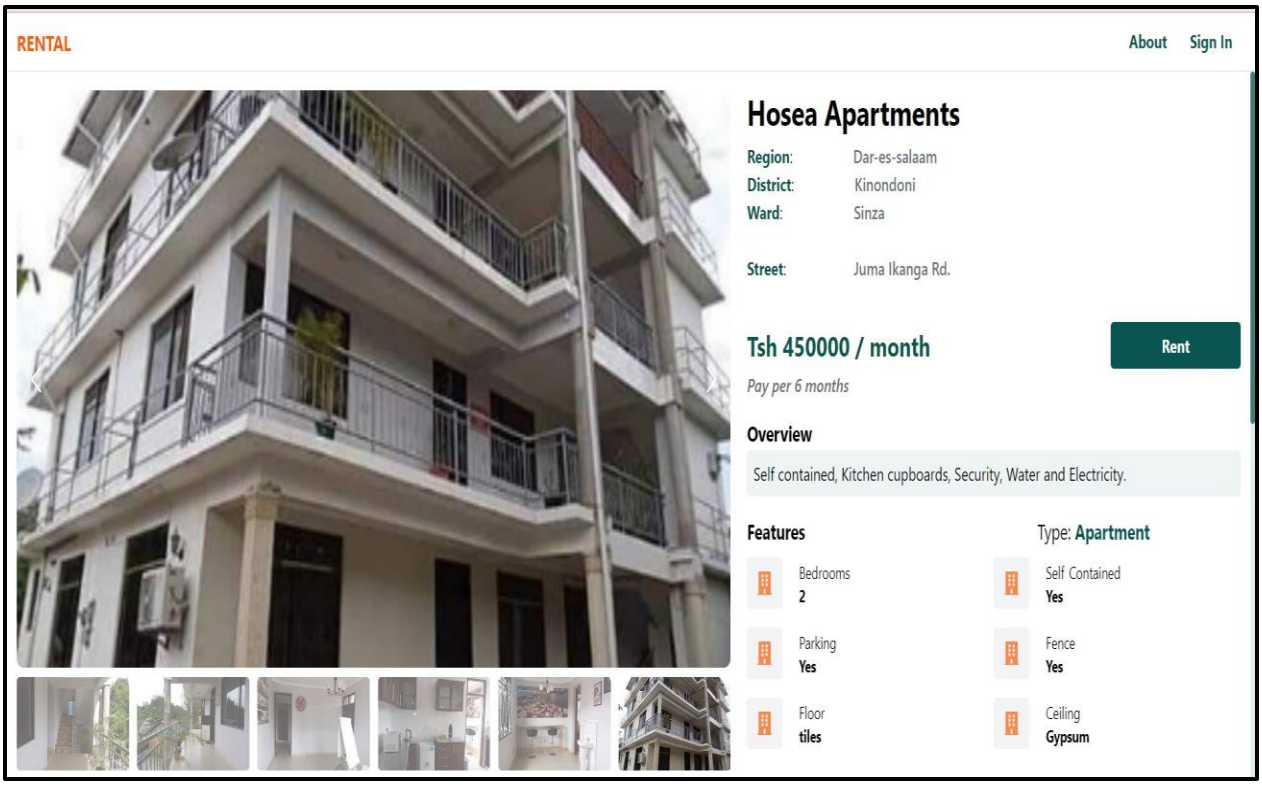


Figure C. 3 Attribute Information

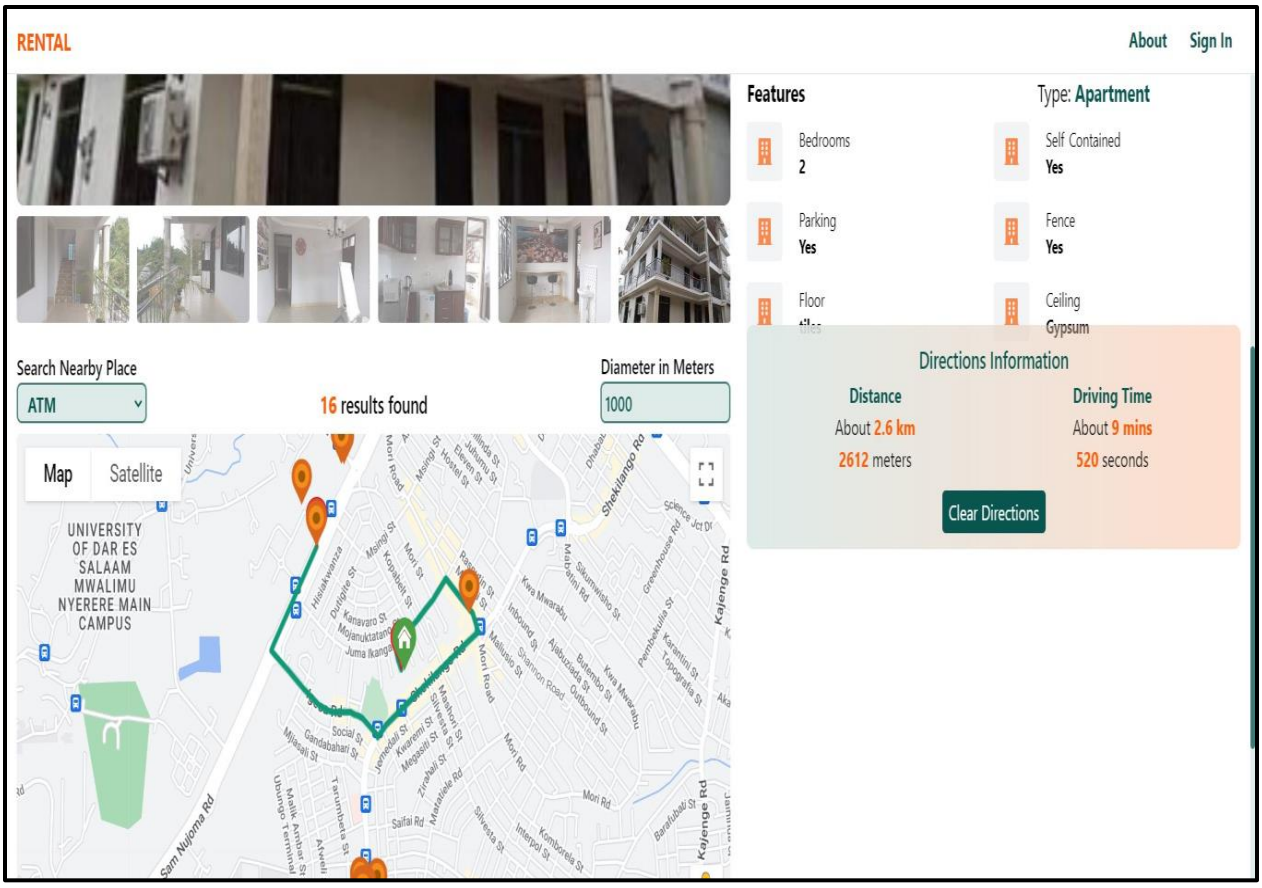


Figure C.4 Proximity and accessibility to facilities

If the client would like to create an account so as to be getting updates on new listings they can register and sign in in the system.

To register select the sign in button on the top right then select sign up to register information and create an account. Figure C.5 and Figure C.6 shows the registration and sign in forms.

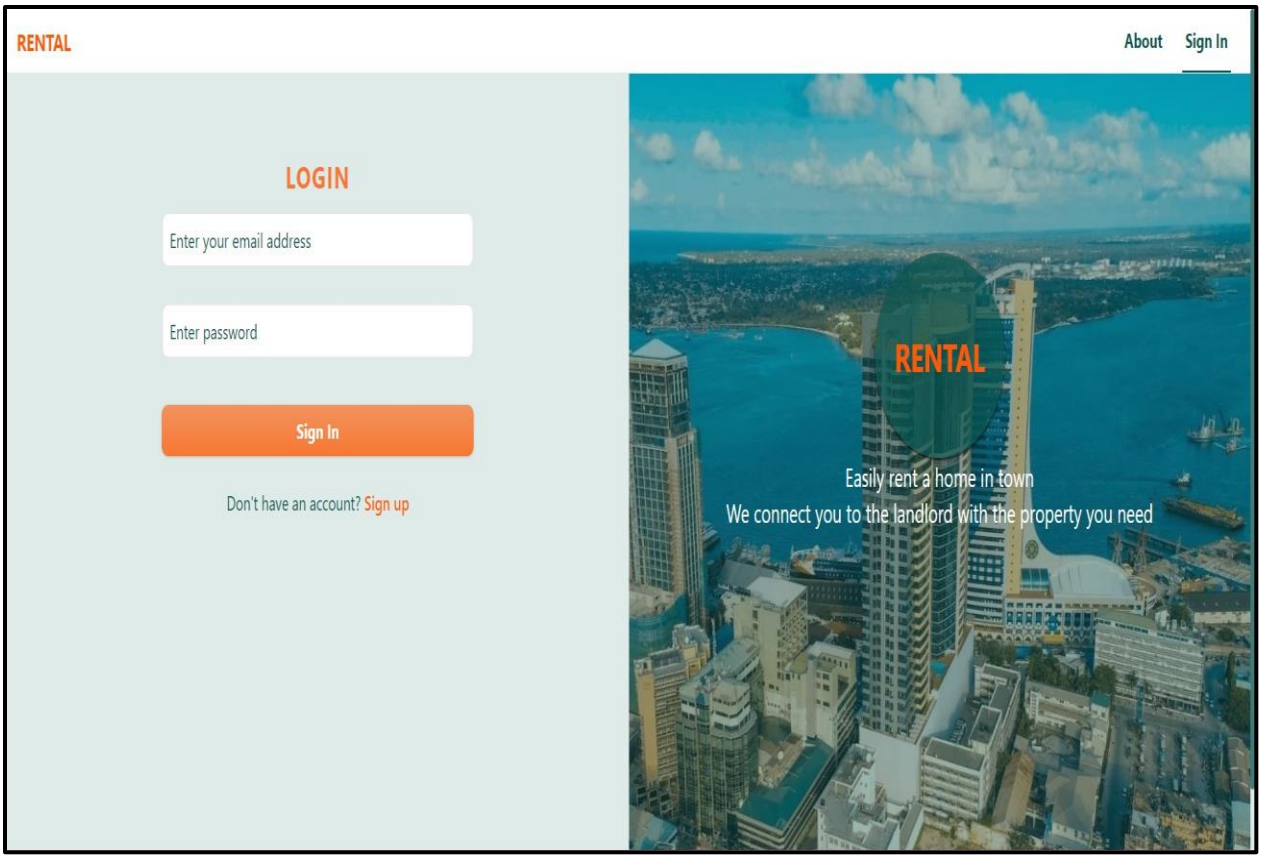


Figure C.5 Log in page

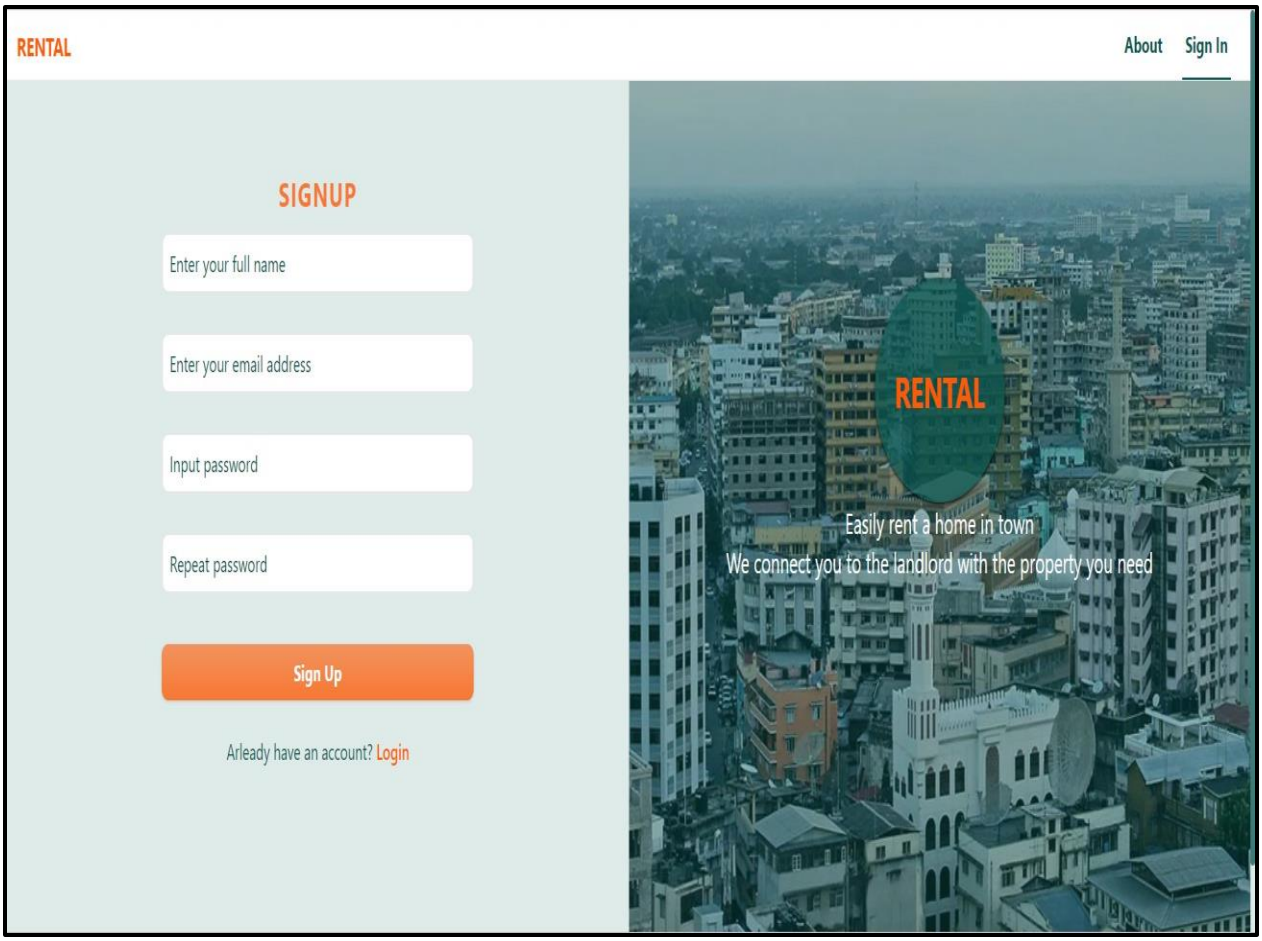


Figure C.6 Registration page

Users of this website can view their profiles by selecting top right icon that shows their profile picture of username abbreviation after they have sign in to the website. This is shown in figure C. 7 and figure C.8 below.

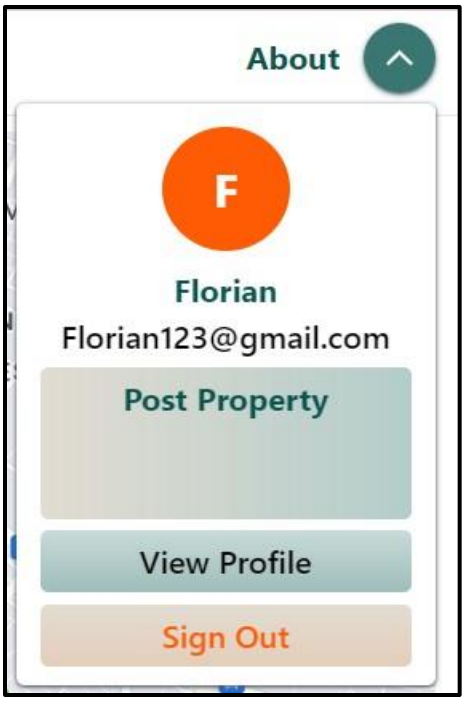


Figure C.7 Agent profile icon

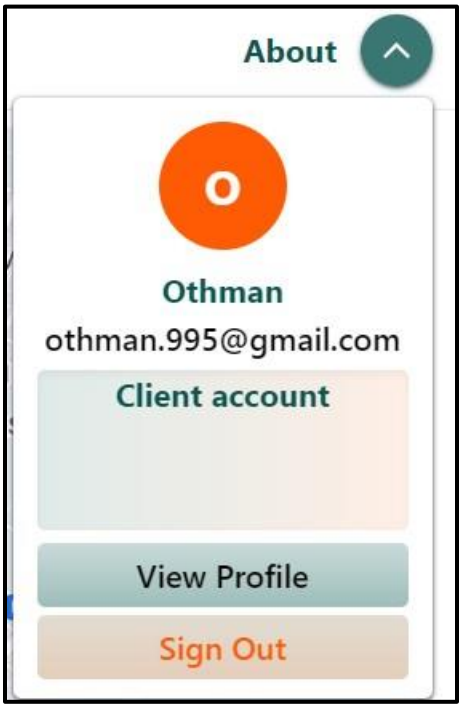


Figure C.8 Client profile icon

In case of any changes or updates the registration information can be updated, this can be done in the profile page of both users and agent. This can be done by selecting the edit profile icon and the icon to edit information will pop-up this is shown in figure C.9 below.

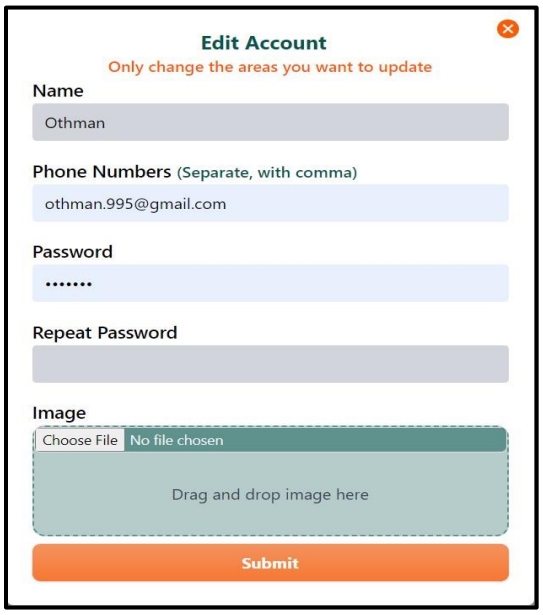


Figure C.9 Account Edit Icon

Agents can make their accounts agent based after registering by selecting the register icon in the become agent panel as shown in the figure C.10 then accept the terms and conditions as shown in the figure C.11.

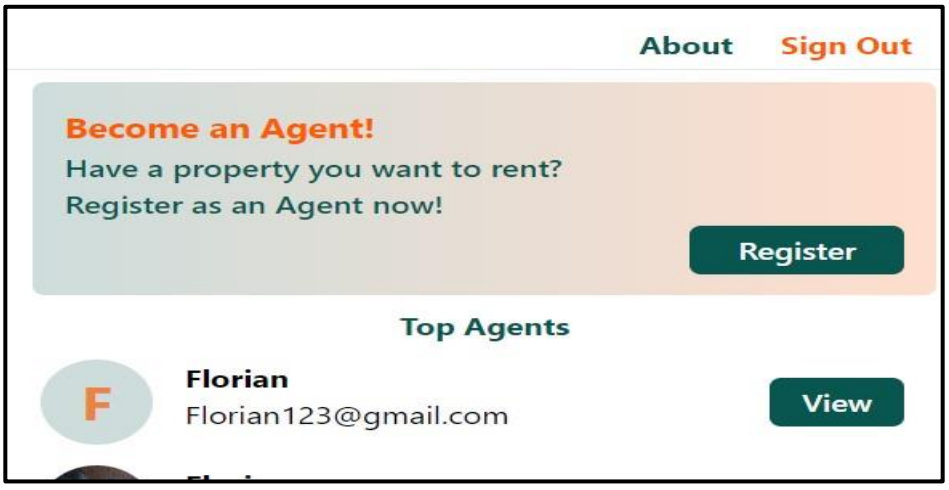


Figure C.10 Agent register icon

Figure C.11 Agents terms

Agents can post their properties in the website by selecting the post icon on their profile or profile icon shown in figure C.7 and it will direct to the posting page as shown in figure C.12.

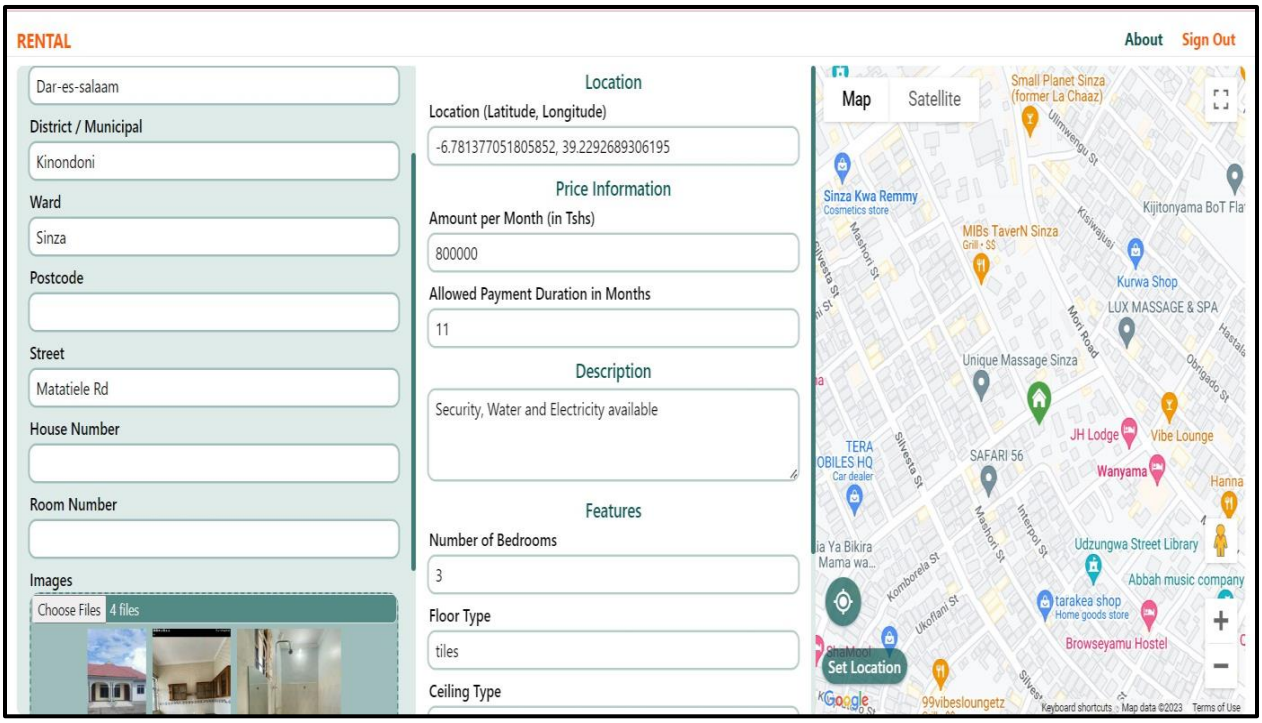


Figure C.12 Posting page