Real-Time Land Use and Land Information System in Homagama Divisional Secretariat Division

Kumara Jayapathma J. H. M. S. S., Dampegama S. D. P. J.

***Abstract*—**Lands are valuable & limited resource which constantly changes with the growth of the population. An efficient and good land management system is essential to avoid conflicts associated with lands. This paper aims to design the prototype model of a Mobile GIS Land use and Land Information System in real-time. Homagama Divisional Secretariat Division situated in the western province of Sri Lanka was selected as the study area. The prototype model was developed after reviewing related literature. The methodology was consisted of designing and modeling the prototype model into an application running on a mobile platform. The system architecture mainly consists of a Google mapping app for real-time updates with firebase support tools. Thereby, the method of implementation consists of front-end and back-end components. Software tools used in designing applications are Android Studio with JAVA based on GeoJSON File structure. Android Studio with JAVA in GeoJSON File Synchronize to Firebase was found to be the perfect mobile solution for continuously updating Land use and Land Information System (LIS) in real-time in the present scenario. The mobile-based land use and LIS developed in this study are multiple user applications catering to different hierarchy levels such as basic users, supervisory managers, and database administrators. The benefits of this mobile mapping application will help public sector field officers with non-GIS expertise to overcome the land use planning challenges with land use updated in real-time.

***Keywords*—**Android, Firebase, GeoJSON, GIS, JAVA, JSON, LIS, mobile GIS, real-time, REST API.

I. Introduction

IT is more important than ever to obtain timely and reliable land use information from a variety of decision-making processes at various levels within and between countries [1]. All kinds of human activities and needs are based on land and hence land is considered a very valuable resource and if it is not properly managed there will be conflicts [2]. The effective implementation of any land administration system requires the support of various government agencies and private sector organizations. Land administration is often seen as the responsibility of the central government. As a result, the unauthorized involvement of local authorities and the private sector is unacceptable as quality control becomes more complex [3]. Land tenure owns the State and private sector in Sri Lanka likewise other countries. There are 50-100 laws related to the aspect of land administration in Sri Lanka.

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The role of Land Administration in Sri Lanka is mainly administered by the public sector. The Ministry of Lands and Land Development plays a key role in land administration. Generally, in the public sector, there is no real-time data updating for the LIS. In this situation, the land use data are highly redundant and outdated. The traditional paper-based update method to the centralized database system in LIS is a very slow-going process.

Many loopholes in the public sector LIS such as redundancy of traditional data collection method, inaccurate data, and insecurity of information, unlinked data in land use data updating, low knowledge of GPS equipment among field officers in charge of data collection, not utilizing digital maps and GIS Cloud-Based Database Systems, non-availability of the user-friendly database for LIS were highlighted during the research study. It is therefore essential to find a way to get potential methods, as Mobile GIS tools can support data standards from functions that simultaneously control data entry by field workers by synchronizing with mobile and databases [4]. Recently, there has been an increase in the collection of field data through the use of smartphones and cellular mobile communication devices due to GPS and wireless networking technologies. Obtaining location information in the field is the first task of collecting geographic data [5].

This paper focused on reaching the main object as storing and continuously updating the land use and land information data to the cloud-based database system using the Sri Lankan map in real-time.

II. Literature Reviews

A. Land Information System

LIS is a mapping system of the land parcel or cadaster. There are multiple purposes of including the land market, advancement with economic and land planning on maintaining state aims with reliable information of land [6]. LIS consists of spatially referenced data of lands in GIS. It includes spatial data representation of the land, with an important attribute for integration with the information systems.

LIS is a legal administration and economic decision-making tool that supports planning and development which comprise a database of land aspirational data directed to a specific area, and a process of techniques for systematic update processing and distribution [7].

B. Land Administration in Sri Lanka

Land administration owns key components related to the land management system. The function of land registration provides the acquirement, enjoyment, and removal of entitlement in the land [3]. Land administration in Sri Lanka is incomplete geographically and established ordinarily and institutionally. The land administration of Sri Lanka was controlled by more than 39 active land laws since 1985.

Probably, a fragment of land ownership can be classified as public and private. Public owned about 82% of the land and 17.7% is privately owned. 27% of farmers have been landless [8]. There are many institutions that are involved with land administration as per a complex set of legislation.

The Ministry of Land and Land Development has the main responsibility as a key institution in land administration. Under the Ministry of Land and Land Development the Survey Department, Land Settlement Department, Land Commissioner General's Department, Land Use Policy Planning Department, and Land Reform Commission are mandated with different tasks of land management. Besides, there are Registrar General's Department, National Physical Planning Department (which was established under the Ministry of Urban Development, Construction and Public Utilities), Urban Development Authority, Valuation Department, and Mahaweli Authority which also have key roles in land administration.

C. Mobile Cloud Computing

Mobile cloud computing is simply an infrastructure that takes place outside both mobile devices, both database, and data processing. Data storage is carried from mobile phones to the cloud [9]. This includes mobile GIS applications, mobile commerce, mobile travel, and mobile healthcare [10]. Mobile cloud computing technology is an integration of mobile computing and cloud computing. Cloud computing relies on sharing network resources at a high level and helps reduce those management and economic costs. Hardware-enabled technology facilitates parallel computing through distributed computing and web services [11]. Inputs are provided as internet services and are provided by shared hardware and software systems in large data centers. These models disable computer resources and mobile devices and pay for services as you go on and demand [12]. Mobile cloud access allows developers to create applications specially designed for mobile users.

D. Android Studio, GeoJSON and Firebase

Android studio libraries with integrated firebase and GeoJSON objects are designed for mobile applications. Android Studio allows to improve application performance with the UI interface feature with a toolkit as an Integrated Development Environment (IDE). It is based on IntelliJ IDEA, a Java IDE for software, which includes code editing and developer tools [13]. A GeoJSON file format is an open standard format that contains both geospatial data and attributes data. The GeoJSON model extends from the JSON standard model. The GeoJSON-file typically ends with a GeoJSON-suffix. The GeoJSON file contains more information about the geographical conditions and properties. Therefore, the GeoJSON format does not require any other special files. The model uses for popular GIS software such as ArcGIS, QGIS, Tableau, and the Spotzi Map builder. This is used for development purposes [14]. Firebase is a Backend-as-a-Service. It provides developers with a variety of tools and services to develop quality applications, grows their user base, and make a profit. It is built on Google's infrastructure. Firebase is classified as a No SQL database and stores data in documents such as JSON [15].

E. Related Works

Mainly, the Survey Department of Sri Lanka was initiated in 2007 to establish the LIS with supportive service established to facilitate the spatial data community with updated land information.

The survey Act No. 17 of 2002 mandates the registration of land titles in the country and power the surveyor General to be the chief authority responsible for obtaining, storing and exchanging any kind of land-related data for land maintenance. The Survey Department of Sri Lanka (SDSL) has been collecting spatial data from AutoCAD drawings in digital format since 1990 intending to finalize the results of a traditional printed survey plan. By 2008, the land title registration act was fully operational under the "Bimsaviya" project [16]. However, the rights to all private lands in Sri Lanka were not registered and not well documented geographically as they were not mapped in cadastral maps [17]. Gampola Zone in the Kandy District of Sri Lanka developed an Integrated Geographical Buffering System (IGBS) for property taxation. This is used for land acquisition, storage, and valuation and obtaining taxation information compilation of complete tax reports and spatial data drawing analysis, and preparation of land valuation [18].

Global LIS applications are highlighted from the range of land registrations to property mapping. WOSSAC has used liquid and high-resolution satellites to identify a suitable land bank in Malaysia for the application of bio-fertilizer derived from palm oil [19]. And also, the LIS project with technical support from the Indian institute of information technology and management was initiated by the Kerala state land use board with the help of a web-based GIS system [20]. And so on, Mexico has developed the Cancun-federated Geographic Information System to increase property tax collection revenue with the use of Aerial photography, GPS devices, and capture images of the property [21]. A case study of the Tarkwa Nsuaem Municipality in Ghana developed a Geo-Property Tax Information System (GPTIS) for property tax records with the use of Visual Basic, Map object, Google Earth API, and Database file [22].

III. Method of Designing and Modeling

The system architecture of the methodology is a Mobile GIS that is used to develop a Google mapping application with a real-time update support tool. It incorporates Mobile GIS on the cloud with Firebase for the real-time situation on the land use and LIS.

A. Study Area

Homagama Divisional Secretary Division (DSD) is an area located 24 km away from Colombo town in Sri Lanka. It is located in Latitude: 6.8440 and Longitude: 80.0024 (Fig. 1). Department of Land Use Policy Planning already digitized the land-use type of Homagama DSD. It includes a built-up area of 7256 ha, agricultural area 3894 ha, forest area 338 ha, and bare lands 328 ha (2018). It consists of 121 sq. km and possesses 81 Grama Niladhari Divisions. Hence, the Homagama DSD was selected as the study area. Homagama is an area where land-use types are constantly changing in the western province of Sri Lanka.

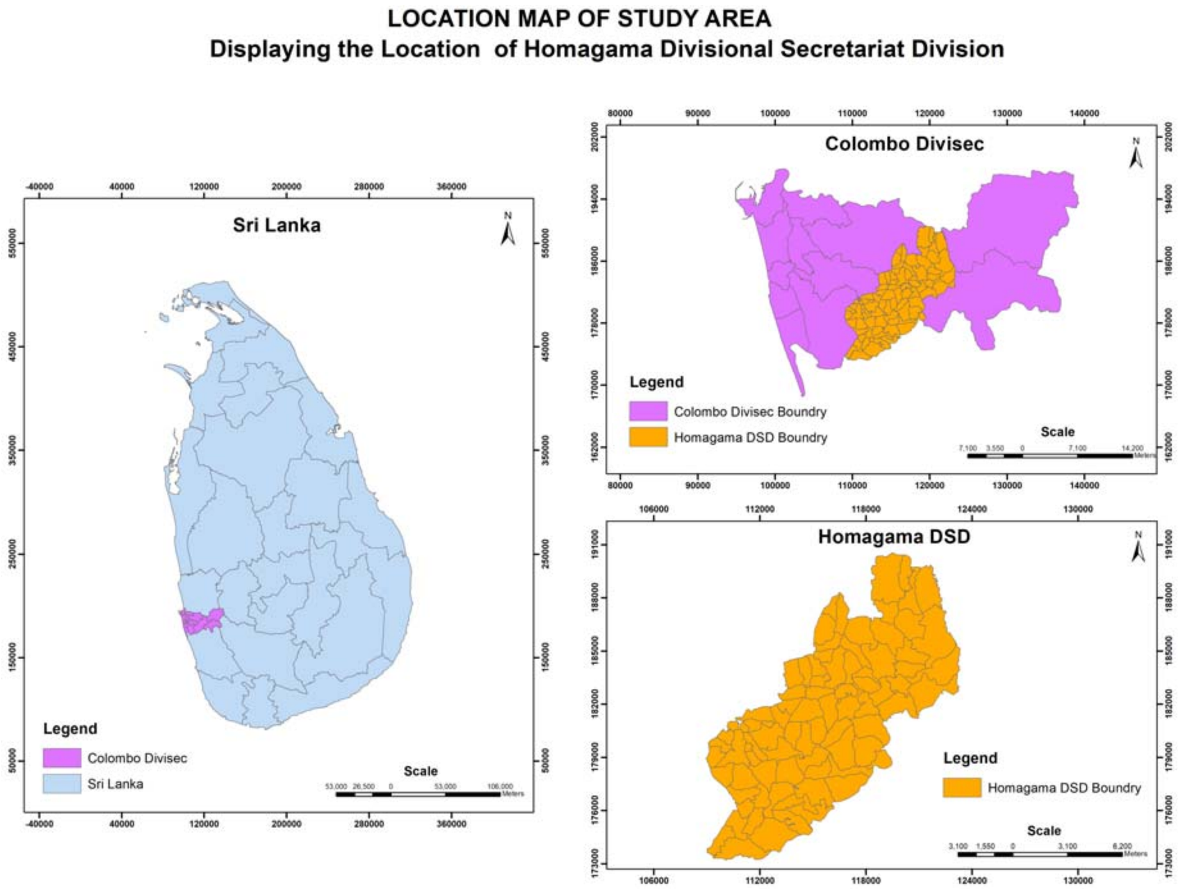

Fig. 1 Study Area of Homagama DSD

B. Project Purpose

The real-time mobile platform is mainly created as a potential requirement of land use and land information data updating in real-time with design and modeling the prototype model of a Mobile GIS land use and LIS system. This app allows the public sector field officers to access more information about the specific land use and land information data with geo-location details when selecting any of the parcels on the map view list and coordinate tab. Thereby that would provide more accurate information on lands to the user through the LIS in real-time. Project App named as RealTimeDroid.SL.

C. Requirement and Specification

The design of this project is an integration of updating a real-time LIS among multiple users on a single platform. It relies on three main areas: architecture design, model design, backend design, and user interface design. Before, creating a mobile app required selecting a related environment with a feasibility study to determine whether this project is feasible or not. This project covers the feasibility study pertain to technical and data availability.

D. Technical Feasibility

Technical feasibility is the process of validating the functionality of the technical characteristics for the implementation of designing a project. Thereby, this application is selected to develop an app from a native app than a hybrid app. Therefore, it was preferred to develop an app from Android Studio. Android Studio is an IDE dedicated to Android development integrated with Android SDK. Table I shows 86.19% of phones have the Android OS in Sri Lanka Apr.2019-2020.

To be compatible with an average mobile platform, the software was developed on Dell computer hardware/software Tools and Nokia 7 plus android mobile phone hardware/ software tools. The software included Android Studio 4.0, Java SDK 11.0.4, Java JDK, and Arc GIS 10.4.1 to convert shapefiles into the GeoJSON layer.

TABLE I
MOBILE OPERATING SYSTEM MARKET SHARE SRI LANKA APR. (2019 – 2020) [23]

Mobile Operating System	Percentage
Android	86.19%
iOS	13.13%
Windows	0.33%
Nokia unknown	0.15%
Series 40	0.07%
Unknown	0.04%

E. Data Availability

In terms of data availability, this app interrelated with Google map API and need land cadastral or land parcel to demarcate the land. There was no geographic cover for all privately held land in Sri Lanka. All such lands are not registered and not mapped on cadastral maps. So, it was decided to identify land boundaries by comparing with 1:50,000 maps and 1:10,000 maps with shapefile. Updated shapefile in major land use of Sri Lanka (2018) was also used [24]. Selected Shapefiles are converted to the GeoJSON and overlay on Google map enables the user to update the attribute on google map.

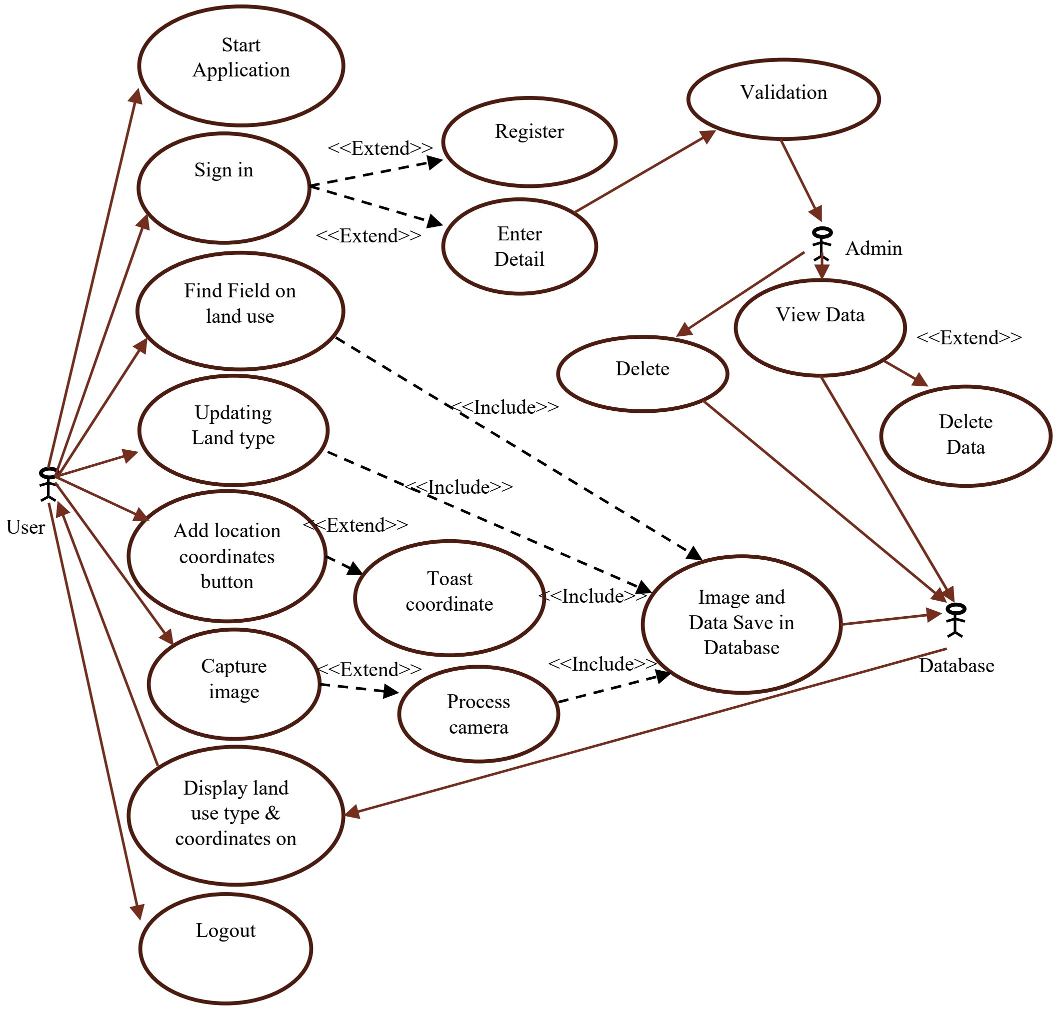

Fig. 2 UML Use Case Diagram

F. Functional Requirements

Functional Requirements follow a series of actions to achieve the objectives. Functional Requirements define the specific function of the mobile app or its component, and the user should be able to react with the functions of the application. This describes an input to the software system, its behavior, and outputs. The process is shown in a Functional Specification Diagram from the user side components:

- User Sign up: Users should be able to sign up;
- User Login: Users should be able to log into the system;
- User Logout: Users should be able to logout of the system;
- Admin login: Admin should be able to login into the system to manage users;
- Create Layer Activity: System must develop Splash and Main Activity for user-friendly method;
- Interrelating Google base map with layers: The system must select the base map in Google API to overlay

shapefile with attributes as GeoJSON;

- Update land use type of field: The user should be able to select the type of land use from the display list on Google map;
- Show coordinate on the location of land: The user should be able to choose a location on land the system will toast on coordinates on a map;
- Click the Take Picture button: The user should be able to click the picture button to capture unutilized land;
- Create and connect with Firebase: The system must create a cloud-hosted Database using Firebase to save data in real-time.

G. UML Use Case Diagram

The UML use case diagram shows a series of activities and behavior of software function correlation with the user. Fig. 2 shows the user and admin and also the database as an actor and the set of actions shows as the use case. And so on, the database connects with the User, Admin, and System functions:

- User should follow the initial steps as - start application, sign in, sign out, find the type of land use, update land use, add location coordinate button, capture image on lands, at the end-user displays stored land-use types and coordinates on the map;
- Admin should perform in steps - respond and validate the User sign up registration. When the user signs-up, the system extends as a register and enters detailed components. Thus, the admin can view data and authenticate to delete data or delete a user. And also, when the user selects the type of mismatch lands admin can delete and check its validity;
- The database should perform in steps- all activities in this process link with the database system. It responds to user and admin activities. When the coordinate link with map, the database responds and extends to the system an include image and data save and displays data on real-time to the user with the formulated method.

H. Sequence Pro Diagram

Fig. 3 illustrates how to model the flow of activities and events between the different components of the application. In this series of processes of the application, several components were identified. The first being the UI which is directly linked to the mobile app component is responsible for sending the RESTFUL request of the app as Firebase Authentication, Google Maps, and Firebase Database. The flow of activities is seen in the following components:

- Firebase Authentication is responsible for authenticating the user;
- Google Map Activity is responsible for overlay attributes in land use data show on the base map of Google API;
- Camera Activity is responsible for capturing images of unutilized land and returning to the main menu;
- Coordinates activity is responsible for showing Current Latitude and Longitude coordinates on lands and returning to the main menu;
- Firebase Real-time Database is responsible for storing the land use data, image, coordinate, objects, and their related information.

I. System Architecture Design

A design model of this project includes the following packages:

- Java code package: This consists of all java-based source code of the application;
- Resource package: This includes media, XML layouts, and project other values.

J. Client-Side

Client-Side means the Front-end-service. Client-Side is focused on the user interface and experience and provides the following capabilities:

- UI design tools - Android Studio;
- SDKs to access device features - Java Script, XML, GeoJSON;
- Cross-platform accommodations/support - Native API.

K. Server-Side

The next step is the server-side of mobile, which means a Back-end service. Back-end tools pick up where the front-end tools leave off, and provide a set of reusable services with the following capabilities:

- Integration with back-end systems;
- User authentication authorization;
- Data services.

When creating this mobile app with the real-time concept it was chosen database as Firebase with its real-time option.

The Firebase Database model functions with data to send instantly to the server application. This can be useful because the database monitors change more than the query application. The Firebase Database model is formulated with an authentication feature. The model uses a No SQL Document Database stored in JSON Tree structure format.

L. Front End and Back End Architecture

In this project, architecture consists of the serverless architecture using the back end as a service. And also, Firebase formulates managing server-side logic and state. Fig. 5 shows a native mobile GIS model of the server-side and client-side. It means diverse mobile GIS applications have significant settings and additional components. Android SDK tool kit is a control system environment. APK Analyzer, Configure Builds, Fast Emulator, Visual Layout Editor. It may become stand-alone units with Android IDE and Java. The Google Maps platform predicts accuracy, flexibility, reliability, and relationships with developers, so it helps to enable API or SDKs plan.

The next section introduces a mobile GIS application for environmental monitoring tasks which employs to firebase database communicating with over REST API. In this Server-side, components comprise the Firebase Database with the authentication and the real-time database and the storage facilities. The retrieved data in the database can be accessed and displayed through the REST API to the client.

IV. Implementation and Use of Mobile Application

Mobile platform discusses how the implementation of mobile GIS applications is operated and used. This presents the use of utilities of the method of implementation with Front End and Back End Components.

A. Design View of Real-Time Land Use and LIS

Fig. 4 illustrates the final project with Modern UI Card view design activities on Wireframe. Splash activity and main activity combine with four main activities as user side. The next show two activities as a compass and measurement to additional field survey supportive tools, for the user. The first view shows as a Splash Activity. It means first entity contact with client user. It relies on the identification part in terms of the property of the app. Next, the user presented with the main activity using active tabs. Hence, the user can follow the given guidelines from the help activity.

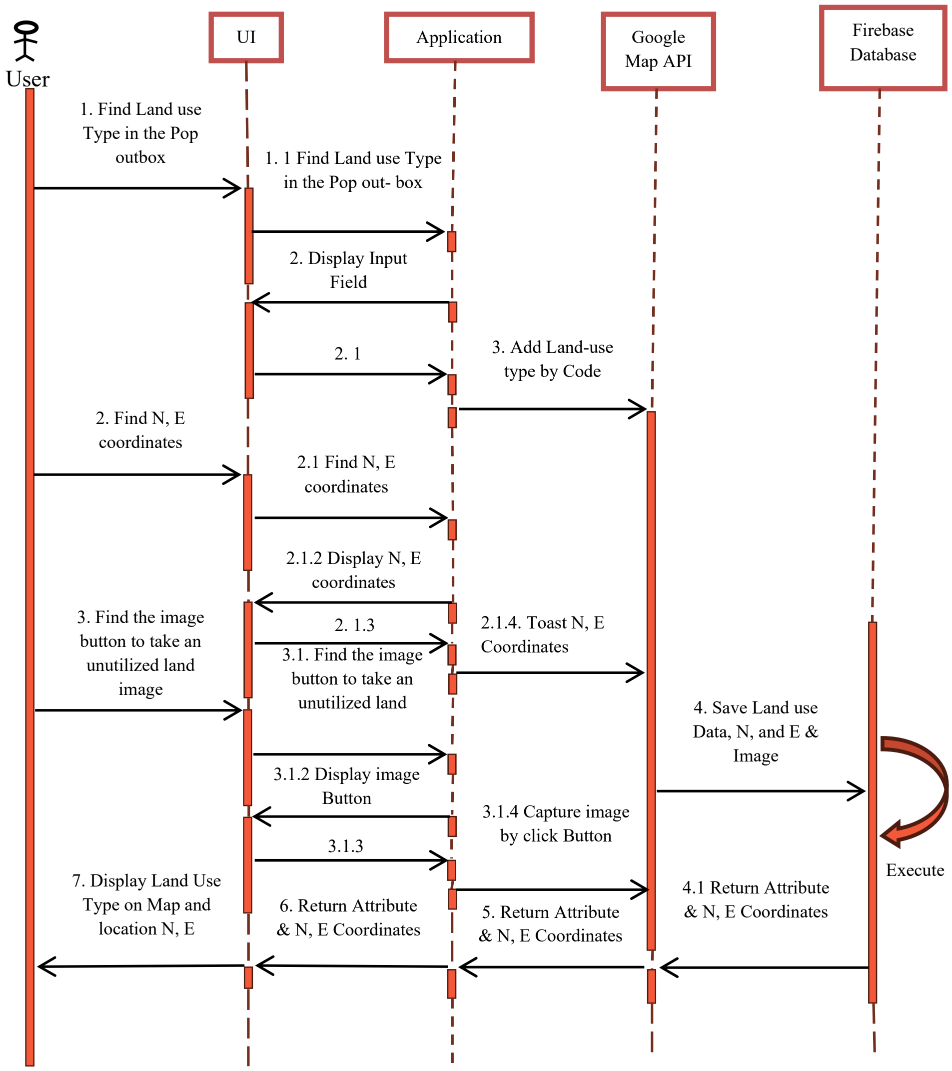

Fig. 3 Sequence Pro Diagram

B. Client-Side Components Implementations

Client-side components are based on delivering and controlling most of the resources and services consumed by the client. Furthermore, the user actively connects with the main activities. Mostly the client works with user Login activity, Map View activity, Get Coordinates activity, and also the Take Picture activity.

C. Setting up User Login and New User Sign up Interface Design

Fig. 6 shows the Sign in and Sign-up Activities. User Login is the first section of the app to be familiar to the user as a get access key to Real-Time Land use and LIS portal. Before starting a login portal, it is required to get authentication from the Firebase Database with Login Activity.

Throughout the Sign-up activity, all new users need to create a new account before accessing update a Land-use query pane in the Map View activity. Mainly, when the user is unable to create an account successfully, the admin denied access to all activities in Real-Time Land Use and LIS which shows a toast message as a “valid email address required”. Because access path command as an email and Password authentication was given previously. Thereby, it is essential to create a password with at least six characters and an email of any name which characters used in @ Gmail, Hotmail, Yahoo mail and in Full Name with a maximum of twenty characters and valid Phone Number.

D. Setting up Map View Activity

Map View activity is the main section in client-side components. Google map API activity is bound throughout this section (Fig. 7). Next, it is necessary to a get Google map API Key to embed to android Manifest Metadata by creating an account with the Google Cloud Platform Console.

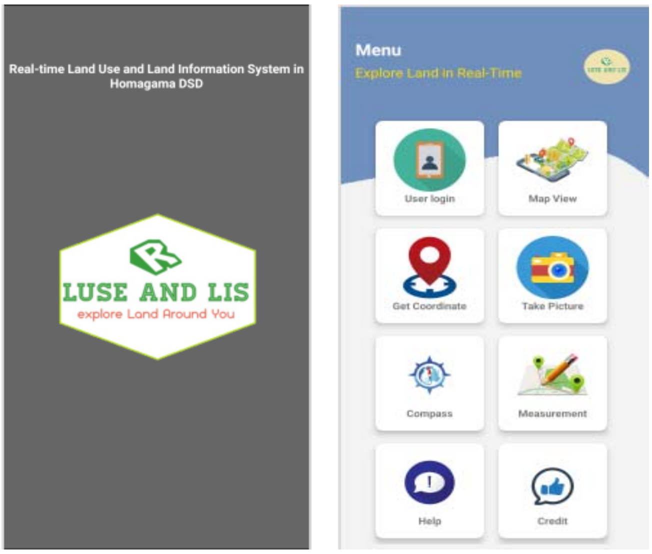

Fig. 4 Design View of Land use and LIS Activities

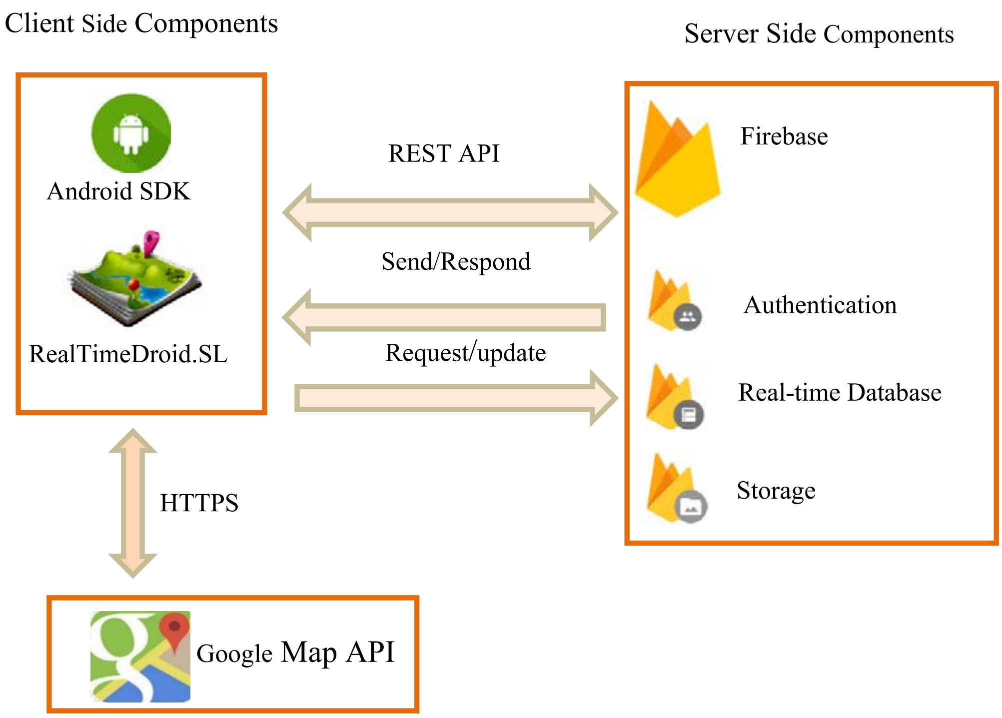

Fig. 5 Client Side and Server side components

The Maps Embed API request URL is as follows: https://www.google.com/maps/embed/v1/MODE?key=OUR_API_KEY&parameters. The following JavaScript shows the use of latitude and longitude in the Homagama location to display in the Google map:

```
Private void getDeviceLocation () {
Log.d (TAG, "getDeviceLocation: getting device current location");
LatLng homagama = new LatLng (6.8440, 80.0024);
moveCamera (homagama, DEFAULT_ZOOM);
}
```

E. How to Capture Attribute Data

Fig. 8 shows in screen capture details that pertain to the step of update land parcels with functions. The application was used in the field when the user participates in real-time on land with the app on the mobile phone. During the geospatial field survey, the user application facilitates the selection of types of maps on the action bar presented. Then land parcel is displayed on a map in red color to indicate that the plot data are empty.

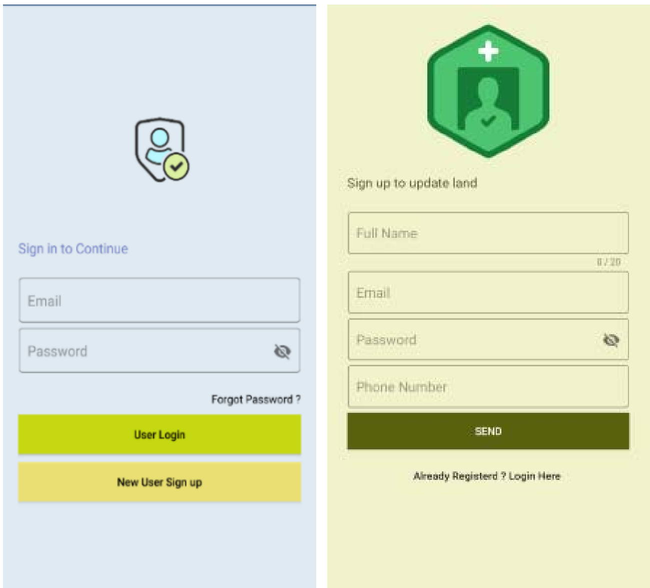

Fig. 6 New User Sign in and Sign up Interface

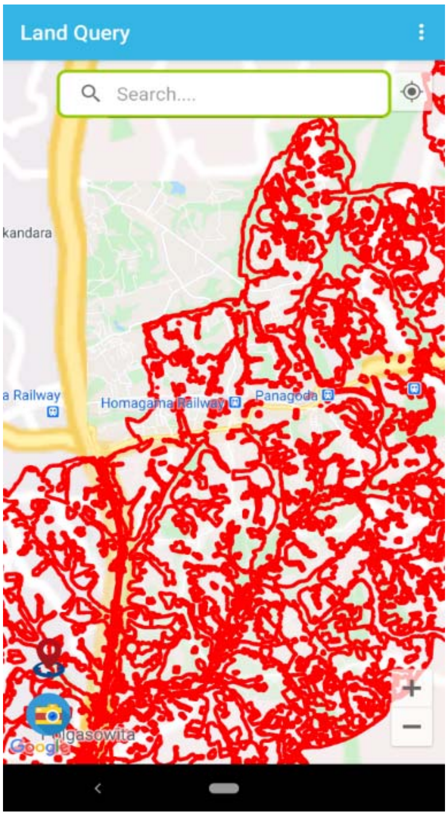

Fig. 7 Map View Pane with Google map API

The empty lands Parcel changes to a blue color when edited. Initially. Initially, users need to enable location permission before accessing map activity. The app allows permission for the mobile phone user to access the device location to navigate the current place. After enabling internet on mobile and no internet connection it will display an alert message for the user to mention that a map activity works with an offline editing facility. The user in the field with the app needs to select a hybrid map or appropriate option with visualizing plots in zooming level. The Land related data on the pop-outbox show up in the updating. First, the plot Id number is shown, so the user does not need to edit. The owner name and the remarks fields are available for adding if needed. After that, the user allows selecting the available lands code from the display drop-down list. If it is necessary the user can take a picture from the Take Picture button in the main menu or shortcut button on the map according to the display toast message as below. Then the user can select ownership code from the presented drop-down list. Validation checks are performed to ensure that data are entered correctly by the admin. When the user entered data successfully, it changed the display of a parcel from red to blue. When the ok button is clicked, the data record is saved into the Real-Time database with a toast message as a "plot saved".

F. Setting up Coordinate Activity

Fig. 9 shows the screen for the Map Using GPS option. At first, the user needs to access the device location through location permission enable. Fig. 9 (c) shows a GPS blue marker as the current location. When the user moves on the app, the Blue marker also moves with accuracy. And next shows a retrieval location display to the user from the fourth image on a Screenshot. Fig. 9 (e) shows additional details as the current plot latitude and longitude, altitude, accuracy, and speed values to the user without saving to Firebase Database. Then Fig. 9 (f) shows when the GPS reception is poor, the user capable of known location values add to the present latitude and longitude field on the map. The added values are saved to the Firebase Database with shows the toast message as a "Location Updated".

G. Setting up Camera Activity

Fig. 10 shows the camera activity functions with the key of the BLOB image by converting the JPG or PNG. This module captures and gets the information for the unutilized land image on plots. The app allows permission for the mobile phone user to access the Camera activity with enabling Media access and so allows the user to use the Capture button or Gallery button to capture the land image. Land Coordinates are generated in the shown text box. At the next, the user allows uploading images by adding text to the given text view. The added images and coordinates are saved to the Firebase storage.

V. Real-Time Land Use and LIS Activities with Results and Database

Fig. 11 shows that the user successfully creates a new account with sign-up activity. Then with the help of email and password, the sign-in activity authorized the user to the Land-use portal. Also, the admin manages the account with the permission of Firebase authentication rules and the Firebase Database results.

Fig. 12 shows the property on the plots screen that is used to save land property attribute data on the client side. This presents an updated land in blue color and pop-out box with the edited plot in detail. Users can edit this attribute with the permission of Admin and get updated in a Firebase Database in real-time.

Fig. 13 shows the camera activity linked with land attribute data in Google map activity. When the land parcel is tapped on the map it displays a toast message to take a picture of underutilized land. Hence, the user takes a picture on a capture button via enable camera view or take the image from a gallery on phone storage with name on a text view. Geo-tag coordinates display the activity in the current location. When a captured image is uploaded it shows a toast message as "an image is uploaded". Then, the image is sent to the database storage with a retrieval facility.

Fig. 14 shows the tree type details on the image in coordinates, image URL, and specific name in the Firebase Database.

VI. Discussion

The results of the mapping show that the concept of real-time processing can be used more efficiently and accurately for land use and LIS data. Real-time data enable users to capture on-location data. Using a cloud-based instead of using paper will minimize errors in updating map data on the location. As the printed map is obscure, using GOOGLE MAPS in real-time will allow users to get more accurate and reliable information in a shorter time. The benefits of this mobile mapping application will help public sector field officers with non-GIS expertise to overcome the land use planning challenges in real-time. Location photos, location coordinates, and land use and LIS data update through the firebase database on the location, so users can save time and effort. This application can be developed and used by mobile developers, especially as it can be created at a low cost.

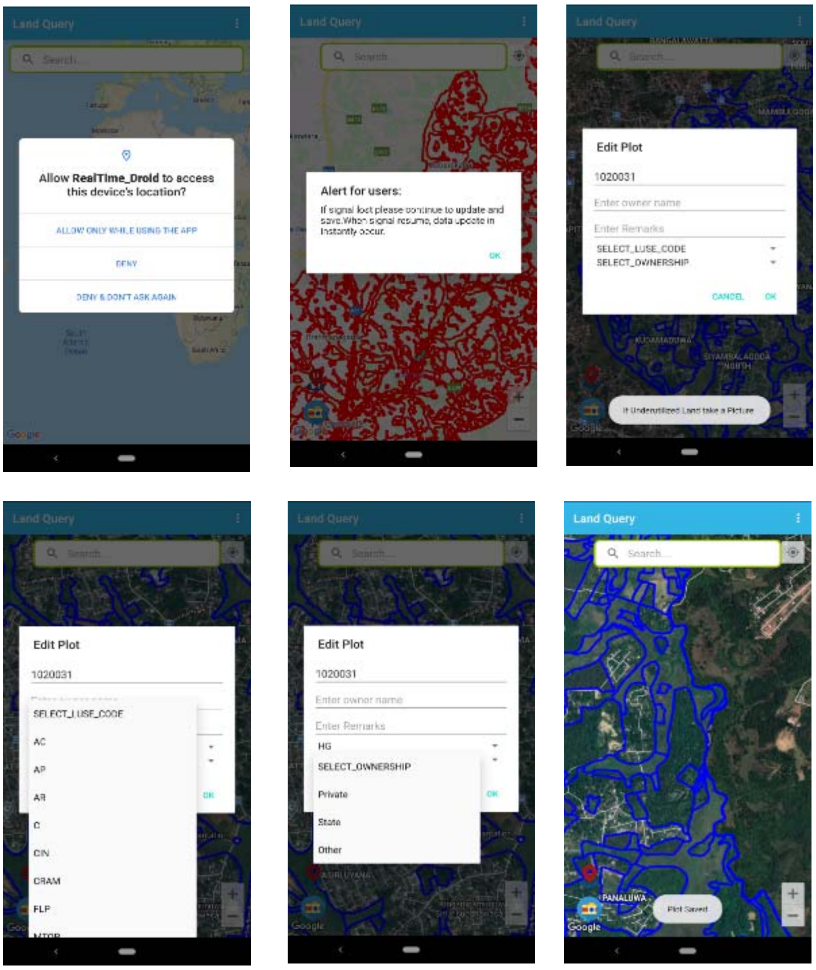

Fig. 8 Real-Time submission with Basic mobile functions

(a) (b) (c)

(d) (e) (f)

Fig. 9 Coordinate Activity pane of the Mobile side

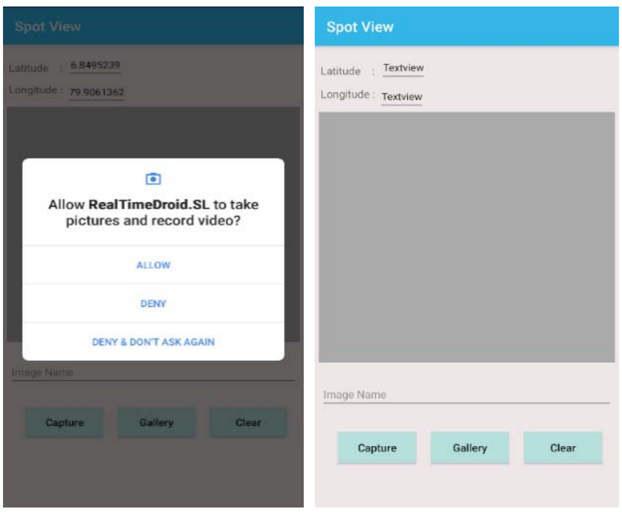

Fig. 10 Media access permission Dialog box and Spot View camera activity

VII. Conclusion

This study presents the development of the Real-Time Land Use and LIS in Homagama DSD application. The review shows that storing and continuously updating the land use and land information data can be accomplished without a paper-based method in the field. Therefore, this enables to reach a specific objective that the cloud-based system for real-time updates could be used with the tree type JSON format and facilitates to export to the excel format for any development requirements. The Firebase was specific to the user in offline editing when GPS or mobile network coverage is lost. It also enables multiple field officers to log into the system simultaneously and update the area of the land use and detail instantly without any server delays. Maintenance and updating are also important with lesser complications due to these systems. Thereby, this app facilitates to link to work with Arc GIS and QGIS software. This real-time mobile application could become fully operational with the public sector field officers regarding the land use and LIS mapping with efficiency.

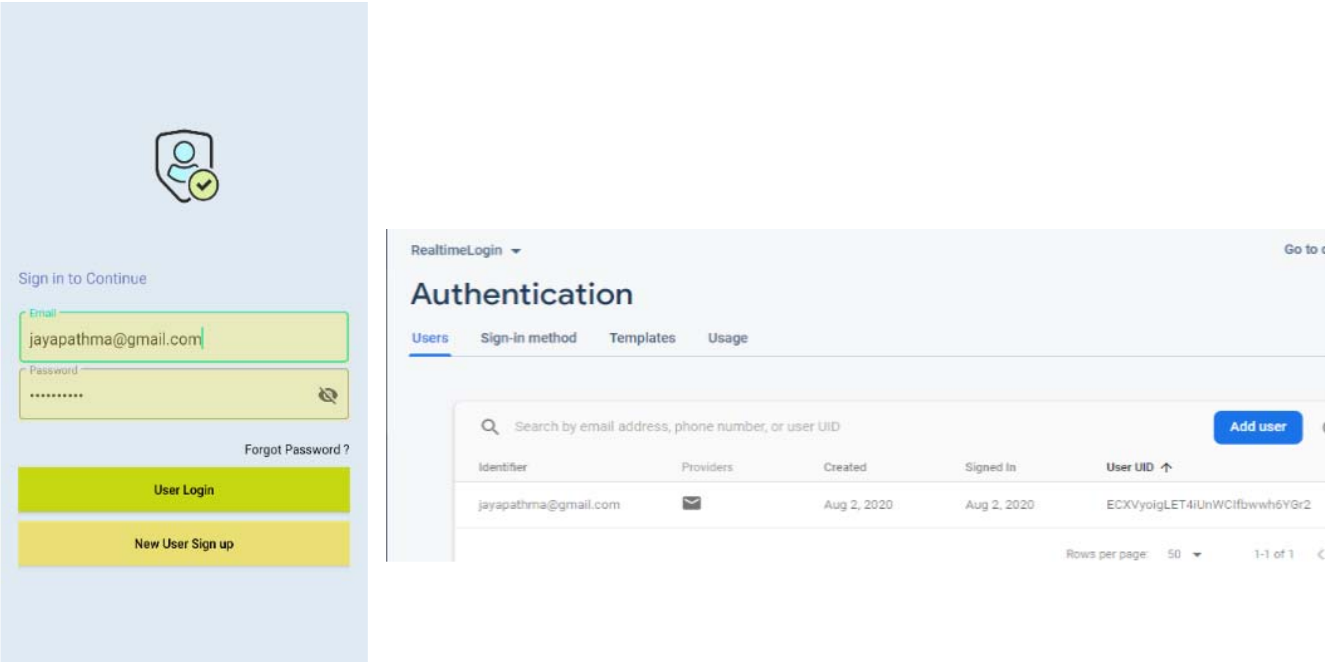

Fig. 11 Login Activity with email and password and user account in a Firebase Authentication

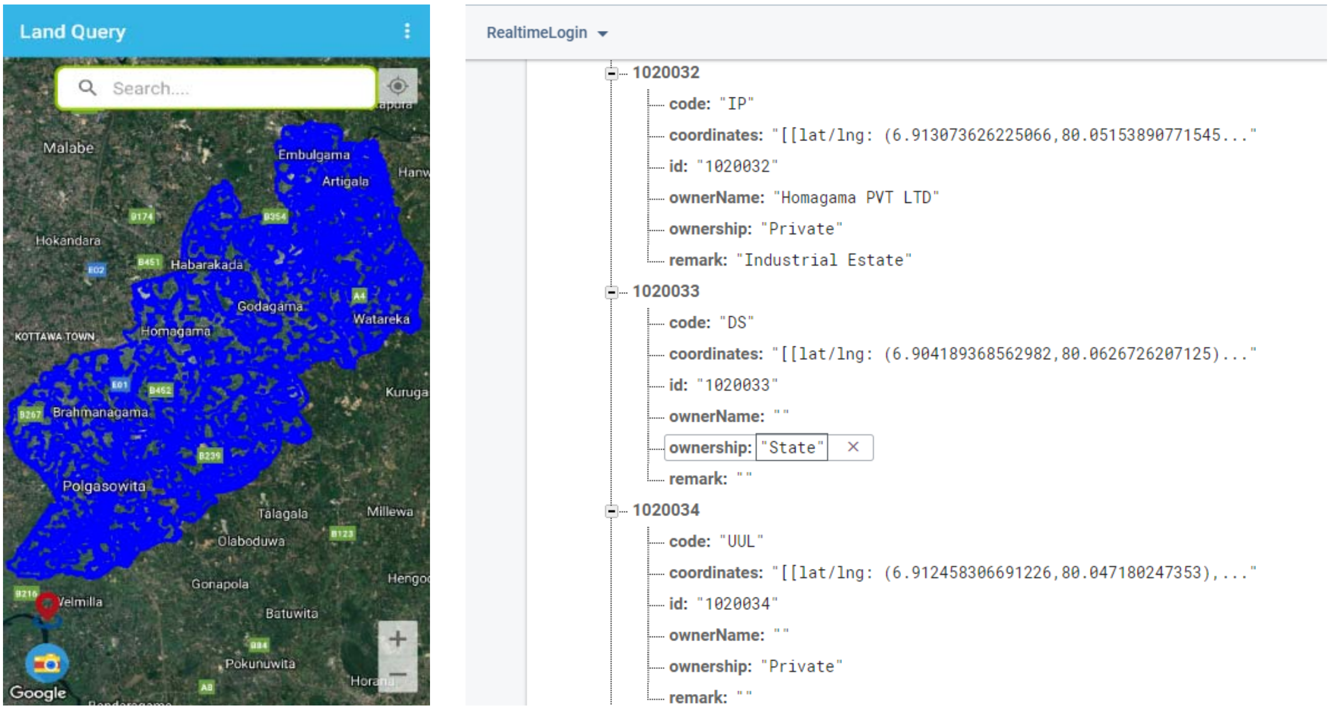

Fig. 12 Plot data as a Tree type in the Firebase Database

Fig. 13 Saved image detail in the Firebase Database

Fig. 14 Uploaded image retrieve from Database

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