

# Mapping, Visualization, and Digitization of the Geo-Referenced Information: A case study on Road Network Development in Near Real Time

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**Abstract** - All maps and data are available in the printed format to their respective departments in the 90s. Digital world changes the perspective of the thinking and focusing on the making of data into the digital format so that saving and transferring of the data to the entire world get easy. This paper is mainly emphasizing on the mapping as well as digitization of the roads/streets using the mobile application as well as web browsers. For mapping, visualization and digitization, an architecture have been developed, which consist of the mobile side for mapping, server side for storage and visualization and client side for digitization. Mapping aspect uses the GeoODK mobile application for tracing out the small streets which can't visualize at either open street map or bing map as well as on google maps. The mapped data sent on the servers which are enabled by the database for storage of data and a platform to collect the mobile data. The data which is mapped, visualized on the web browsers. That whole part is for the mapping and visualization prospect. Now, digitization aspect is for all the end users/clients, so that anyone can digitize the roads around there with some basic entries. The digitized data went to the database for the storage and then reflect back on the web browsers. By the combination of both prospective, mapping and digitization, a road network of a place has been developed.

**Keywords:** GeoODK, Road networking, Digitization, Visualization, Data collection, Spatial Information

## 1. INTRODUCTION

### 1.1. Basic Background:

#### 1.1.1. GeoODK

GeoODK stands for Geographical Open Data Kit. GeoODK provides a way to collect and store geo-referenced information [1], along with a suite of tools to visualize, analyze and manipulate ground data for specific needs. It enables an understanding of the data for decision-making, research, business, disaster management, agriculture and more. As a multi-dimensional application, GeoODK's goal is to provide an open source platform that can be expanded to address current and future needs of data collection[2]. ODK handles the form data collection process very well. But lacked the mapping components. The application with being the completely open source and its main purpose is to be customized to your needs and projects. Also, it simply aims

for a combination of mobile data collection technologies and GIS mapping as one big happy family [3]. 3 Components [1]:

- Mobile (GeoODK collect App.).
- Data Storage (Cloud) & Access (ODK Aggregate).
- Web-based form builder (Build).

GeoODK Collect is a mobile application that runs on Android smartphones. It is based on the ODK Collect but has been extended with offline/online mapping functionalities, the ability to have custom map layer, as well as new spatial widgets, for collecting point, polygon and GPS tracing functionality [4].

This mobile application allows you to collect survey-based information along with collecting spatial information. The application has offline mapping capabilities, the ability to add local map tiles as offline layers. The application can collect point, polygon, and polyline features [5].

#### 1.1.2. GeoServer

GeoServer is an open source server for sharing geospatial data. GeoServer is a Java-based software server that allows users to view and edit geospatial data. Using open standards set forth by the Open Geospatial Consortium (OGC). GeoServer allows for great flexibility in map creation and data sharing. GeoServer allows you to display your spatial information to the world. Implementing the Web Map Services (WMS) standard, GeoServer can create maps in a variety of output formats. OpenLayers, a free mapping library, is integrated into GeoServer, making map generation quick and easy. GeoServer is built on Geotools, an open source Java GIS toolkit. GeoServer can display data on any popular mapping applications such as Google Maps, Google Earth, Yahoo Maps, & Microsoft Virtual Earth [6].

### 1.2. Architecture:

#### 1.2.1. Tools and Software:

- GeoODK Mobile Application
- GeoServer
- PostgreSQL & PostGIS
- Apache Tomcat
- Apache PHP
- JavaScript
- PHP

#### 1.2.2. Description of the used Architecture:

The architecture consists of three modules (as shown in Figure 1). Modules related to the mobile application, for data gathering, desktop & server package, for the storage of data,

and client package, for the visualization and accumulation of new data.

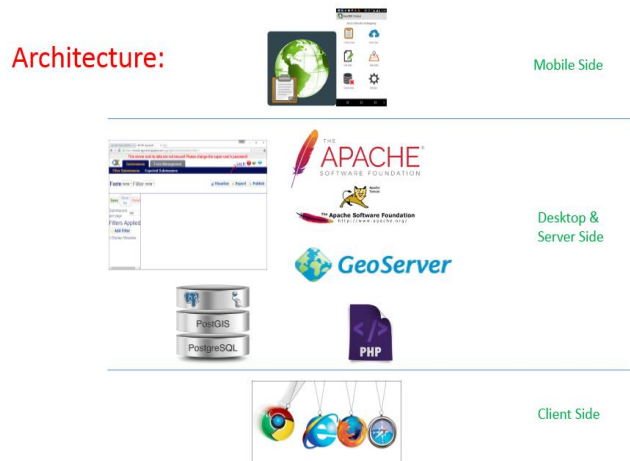


Figure 1: Architecture used for the development to deployment

### 1.2.2.1. APACHE Tomcat

Apache Tomcat, often referred to as Tomcat server, is an open source Java Servlet Container developed by the Apache Software Foundation (ASF) [7].

### 1.2.2.2. PostgreSQL & PostGIS

PostgreSQL is a powerful, open source object-relational database system [8]. As a database server, its primary functions are to store data securely and return that data in response to requests from other software applications. PostGIS is an open source software program that adds support for geographic objects to the PostgreSQL object-relational database [9]. PostGIS follows simple features for SQL specification from the Open Geospatial Consortium (OGC).

### 1.2.2.3. JavaScript

JavaScript is a dynamic computer programming language. JavaScript is the programming language of HTML (Hypertext Markup Language) & the web. It is lightweight and most commonly used as a part of web pages, whose implementations allow a client-side script to interact with the user and make dynamic pages. In JavaScript, objects are king: Almost everything is an object or acts like an object. Understand objects and you will understand JavaScript [10].

### 1.2.2.4. PHP

PHP stands for Hypertext Preprocessor. PHP is a server scripting language and a powerful tool for making dynamic and interactive Web pages. PHP has been widely ported and can be deployed on most web servers on almost every operating system and platform, free of charge. Syntax-based on the Perl, Java, and C. If work is in dynamic content on a single system then this is a good option [11].

## 2. STUDY AREA:

Dehradun is situated in the North of the India and capital of the Uttarakhand. It is part of the Doon Valley and situated in the foothills of Himalayan territory. The Ganga River in the East and Yamuna River in the West. It is well connected with the various tourist places of Himalayan regions such as Auli, Mussoorie, holy places such as Rishikesh and Haridwar [12]. It is having major educational institutes such as Indian Institute of Remote Sensing (IIRS): Remote Sensing and GIS, Forest Research Institute (FRI): Forest and Ecology, apart of this military cantonment is also situated there. Dehradun is famous for its pleasant weather. Rainy season is the most favorable season for the tourist to come around the Dehradun and feel the amazing place in the heaven of India. The major study area contains the roads of Dilaram Chawk (Rajpur road), Hathibarkala and Kalidas Road shown in Figure 2. Dilaram chawk road is a connecting road between the Dehradun and Mussoorie tourist place. It is located at the latitude 30.3357174 and longitude 78.0542484.

Hathibarkala road is originated from the circle of Dilaram chawk and passes through the military cantonment till the robber's cave.

Kalidas road is famous for the institute situated there named as Indian Institute of Remote Sensing (IIRS), Indian Space Research Organization (ISRO). It is India's most reputable organization in the field of Remote Sensing (RS) and Geographic Information system (GIS). It is having the hub of students who want to build their career in the RS and GIS. It has different departments for the various disciplines. They provide various outreach educational program for students who have an interest in the RS and GIS.

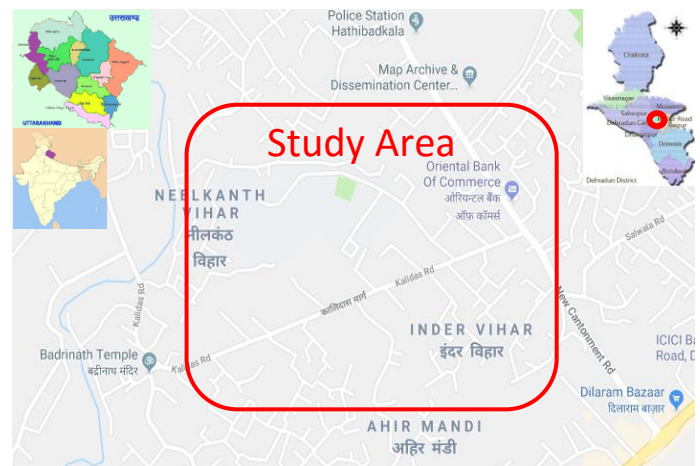


Figure 2: Study Area for the Case Study

## 3. METHODOLOGY:

### 3.1 Mobile Side processing:

#### 3.1.1 GeoODK Collect

It is a mobile application used for the collection of georeferenced information (shown in Figure 4). Initially, a blank form is fetched from the ODK Aggregate server. That blank form has some of the entries in which georeferenced entries are also mentioned. A blank form is filled and then

the form is again sent back to ODK Aggregate server (shown in Figure 3). Filled forms are also saved into the memory of the phone, so here option to upload that form directly to the ODK Aggregate is also available. Those forms are in the xml format.

### 3.1 Desktop & Server-Side Processing:

#### 3.1.1 ODK Build:

It is a part of the Open Data Kit which provides the facility to prepare the forms which used for the time of the survey.

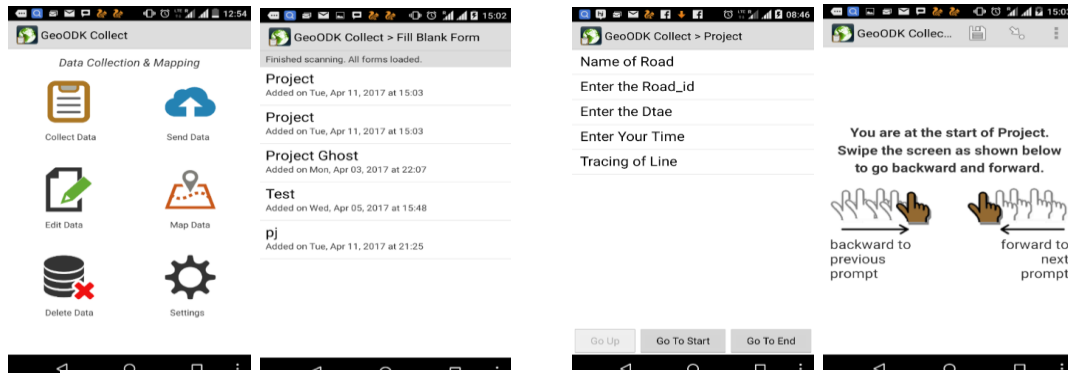


Figure 4: Mobile Application GeoODK Collect with its functionality

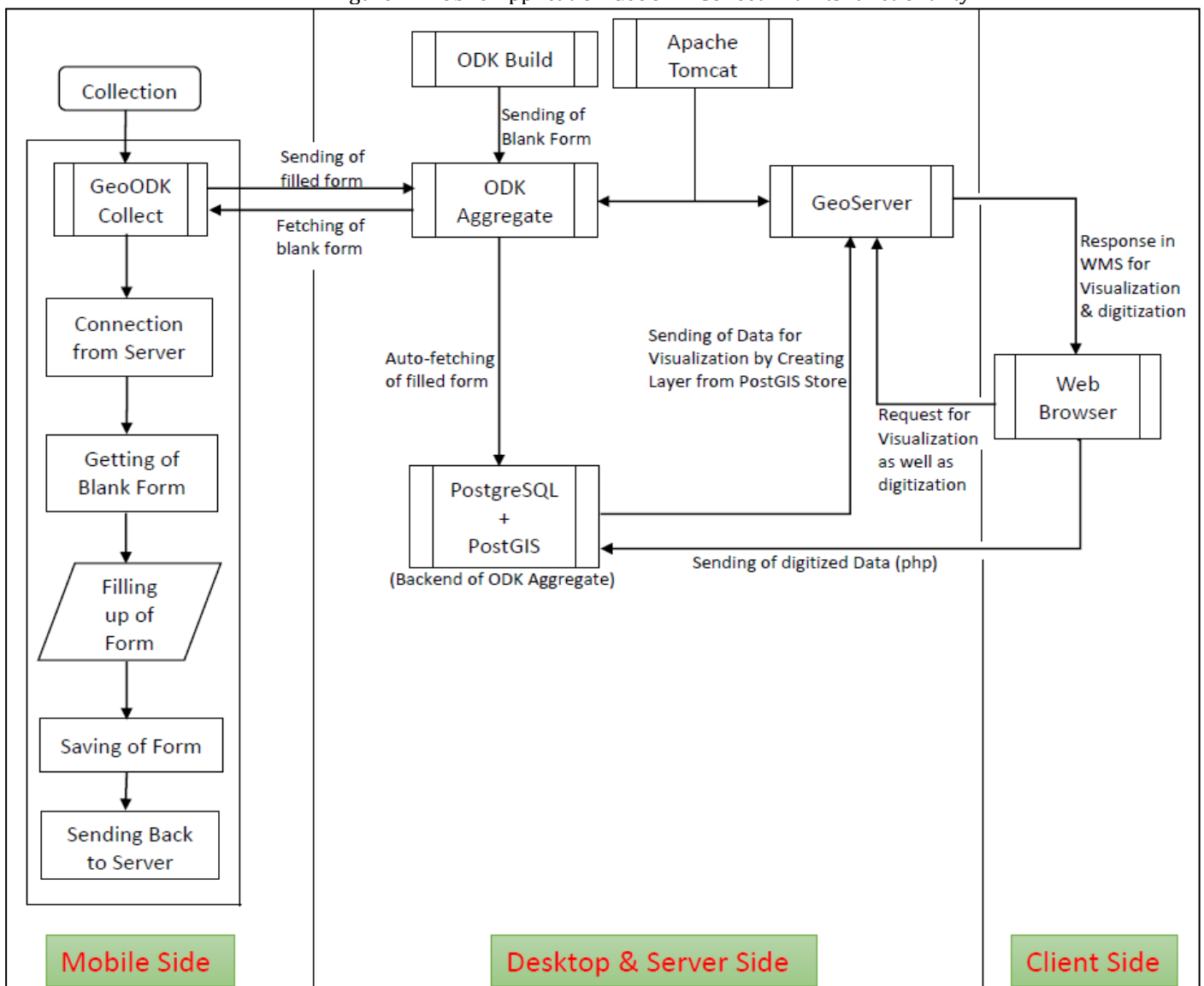


Figure 3: Adopted overall Methodology

Here forms are created and send to ODK Aggregate server. Forms can be sent directly to the server or download in the xml format.

### 3.1.2 Apache Tomcat:

Apache Tomcat is an application server. It works on Java servlet. It works as a container for both ODK Aggregate and GeoServer. Here we just copy the .war files of both ODK Aggregate and GeoServer & their deployment occurs. After deployment, they both are working on the local server of the Apache Tomcat.

### 3.1.3 ODK Aggregate:

It is the main server for the management of the blank as well as filled form. Blank form from ODK Build and Filled form from GeoODK Collect are saved here and further used for the analysis. When forms are not directly sent to the server then there is an option for manually uploading of forms. That forms are in the xml format.

### 3.1.4 PostgreSQL + PostGIS:

It is a database management system. It works on the backend of the ODK Aggregate. Whenever forms are uploaded on to ODK Aggregate, PostgreSQL automatically fetched those forms from the server and store it into the database. The server sends the georeferenced information into the coordinate system without any prefix like point, line string, polygon etc. Conversion of the coordinates into text is important because geoserver read it in text form rather than direct co-ordinates so a new table is created where coordinates are in the text form and one column of the length of road is also there.

### 3.1.5 GeoServer:

It is a web application and a GIS application software. It deploys into the application server. Here connection has been established between the PostgreSQL and GeoServer for the visualization of the georeferenced information (shown in Figure 3). Once the connection is made than the client can visualize the information. It provides some kind of services for the visualization of information:

a. **WMS (Web Map Service):** It helps to visualize the vector maps. So, the georeferenced information of the road network is visualizing. Here editing and manipulation in information is not allowed.

b. **WFS (Web Feature Service):** It provides the attribute information of layers. Here editing and manipulation of information is allowed. For editing and manipulation, WFS-T is preferred.

c. **WCS (Web Coverage Service):** It helps to visualize the raster images. Here only vector layer is present so this service is not useful here.

### 3.2 Client-Side Processing (Web Browser):

It is a client-side process. It is used for the visualization as well as digitization of the georeferenced information (shown in Figure 3).

- For visualization, the client directly sees the road network map via GeoServer.
- For digitization, purpose client has to run the HTML file which is saved at the local folder of the server.

When the client runs that file, roadmap, as well as Bing map, are visualizing to client and digitization is performed there. When any kind of digitization is done there than that digitized part will automatically save into the database and that action is reflected back to geoserver at the time of next visualization.

- For digitization, purpose scripting is done on the server side so here PHP scripting language is used while only for the visualization purpose which is of client side so there scripting is done on java platform.

## 4. RESULTS:

### 4.1. Visualization of georeferenced information:

Mapping of georeferenced data is done by GeoODK. Visualization of the mapped information helps in understanding the actual position as well as the length of the road (Figure 5). This map will be used for the visualization of the various streets, minor roads and major roads with their origin and destinations. This is just a part of the roads for the better understanding about the road data. Red circled road data contained the project\_id, name of road, road\_id, and length of the road.

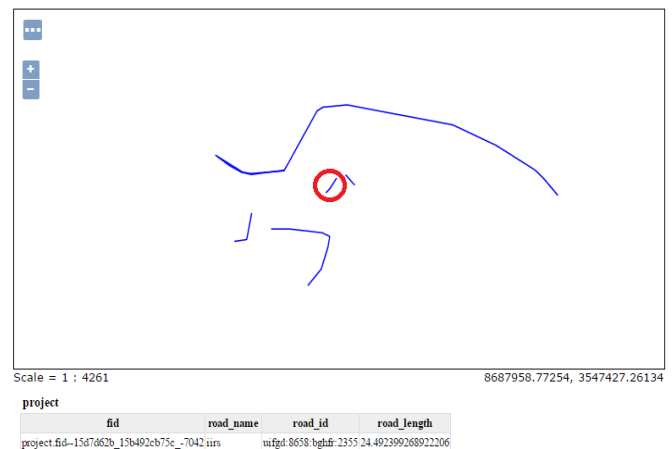


Figure 5: Map of Road network of Campus with nearby area & detail of a road

### 4.2. Mapped as well as the digitized region of road network using GeoODK and Bing map:

Mapping of the roads are done by using the GeoODK in Figure 6 but the digitization process is done by using the web browsers. For the purpose of the digitization, a base map in the background is required to identify and locate the position and distribution of the roads. So, the linking of the bing map with the map of the road layer is done for the digitization of the new major roads as well as minor roads in Figure 7. The bing map eases the work of digitization and provides the great help to locate the position of roads.



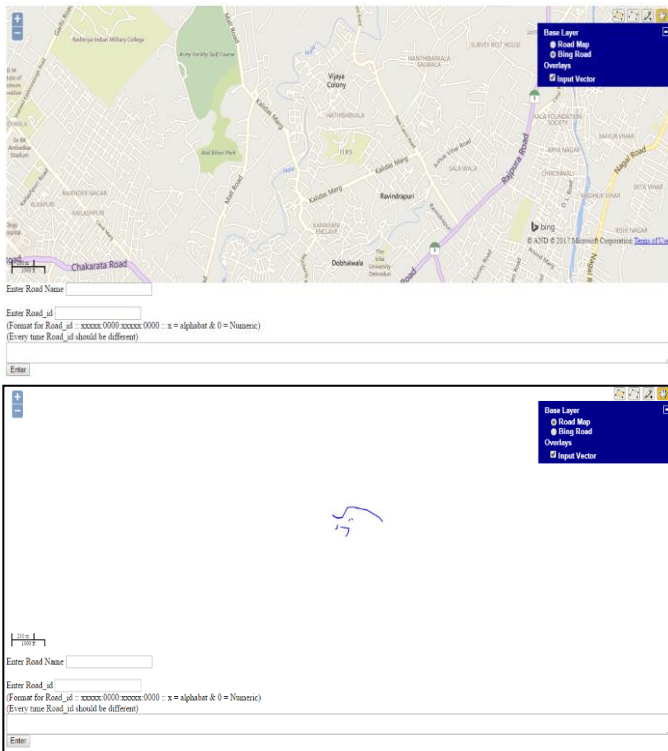


Figure 6: Before the Digitization of roads in the area

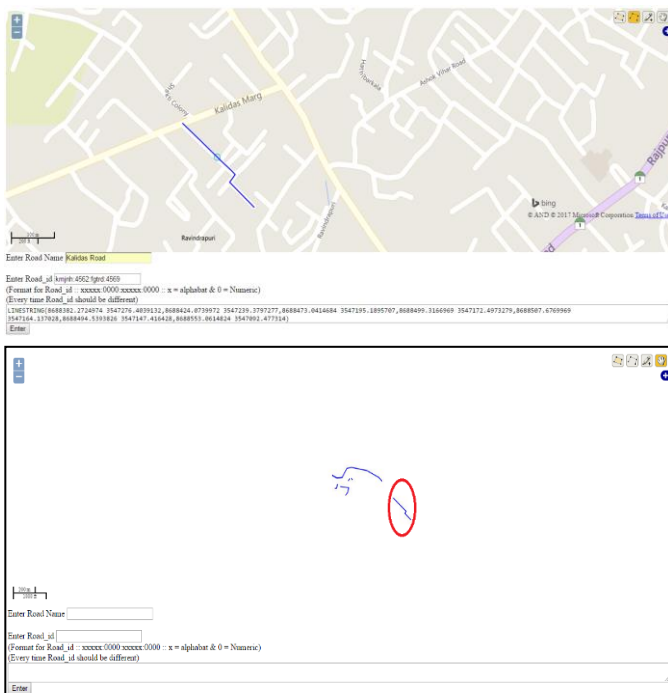


Figure 7: After the Digitization of a road at Kalidas Marg (Red Circled)

The georeferenced information directly visualizes to the clients. Clients get high benefits from the bing map to digitize the georeferenced information directly to the road layer. That digitized information will directly save into the PostgreSQL and reflect back on the road layer using GeoServer. So, after the digitization of the roads and

submission of data, automatically detect the information on to the road layer and visualize to the clients (as shown in Figure 8).

We have authorities to cross-check the information with respect to the original information. If information/digitized road is not accurate or digitized wrongly then we delete the information from the PostgreSQL and automatically erase from the road layer map.

**Map of Road Network**

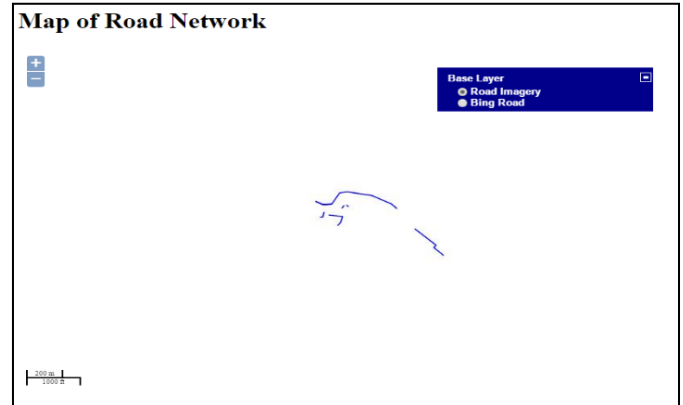
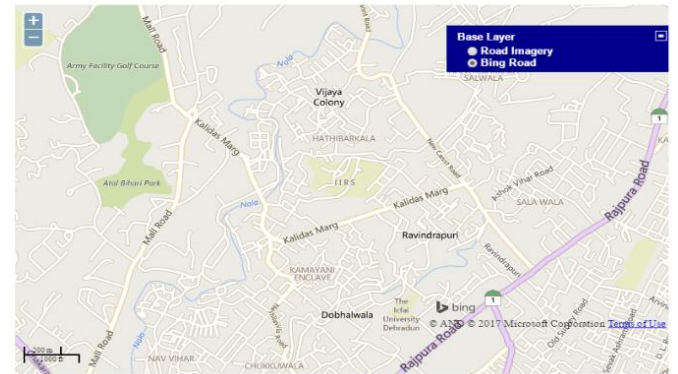


Figure 8: Visualization of the mapped as well as digitized roads to the clients

**4.4. Prepared Road Network Map:**

Road network has been developed after the completion of

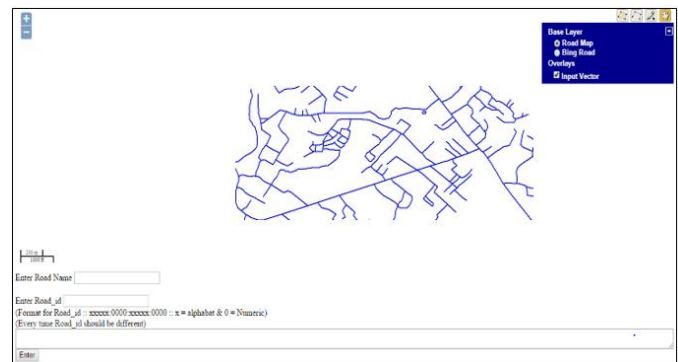


Figure 9: Final developed Road Network map of the study area

data collection and digitized, the road network contains the minor as well as major roads of the study area (as shown in

Figure 9). Visualization process helps in the identification of the routes and for the better understanding of the road network and their connectivity.

## 5. CONCLUSIONS

GeoODK collect is free/open source software for the collection of data using the mobile application on the android devices. Data collection mode is offline but required an internet connection to download a blank form & to upload the filled forms i.e. the data gathering process does not require the internet connection so without internet we can collect the whole information. GeoODK has a spatial capability to collect the point data as the other free software has but it also allows users to collect the line, & polygon data. The mapping and visualization of georeferenced information can get by using GeoODK to the web browser via GeoServer. Digitization can be done by clients/end-users using the web browsers. The digitized information visualized along with the mapped data. So, the complete information from the mapping as well as digitization appeared in the same generated map.

**Limitation:** GeoODK collect can only be used to gather new data, not edit existing information. Collected data is not having any kind of prefix so a new table has been created.

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## REFERENCES

- [1] X. Blaes, F. Waldner, and T. D. E. Maet, "GeoODK for Cropland & Crop type data collect," *Jt. Exp. Crop Assess. Monit. Sci. Me*, 2015.
- [2] GeoMarvel, "GeoODK," 2017. [Online]. Available: <http://geoodk.com/index.html>. [Accessed: 20-Aug-2018].
- [3] GeoMarvel, "GeoODK," 2017. [Online]. Available: <http://geoodk.com/about.html>. [Accessed: 20-Aug-2018].
- [4] GeoMarvel, "GeoODK," 2017. [Online]. Available: [http://geoodk.com/getting\\_started.html](http://geoodk.com/getting_started.html). [Accessed: 20-Aug-2018].
- [5] GeoMarvel, "GeoODK," 2017. [Online]. Available: <http://geoodk.com/downloads.html>. [Accessed: 20-Aug-2018].
- [6] Geospatial Foundation, "GeoServer," 2014. [Online]. Available: <http://geoserver.org/about/>. [Accessed: 11-Apr-2017].
- [7] Wikipedia, "Apache Tomcat," *Apache Tomcat*, 2017. [Online]. Available: [https://en.wikipedia.org/wiki/Apache\\_Tomcat](https://en.wikipedia.org/wiki/Apache_Tomcat)
- [8] P. Eisenbraun and M. Hagander, "PostgreSQL: About," *The PostgreSQL Global Development Group*, 1996. [Online]. Available: <https://www.postgresql.org/about/>. [Accessed: 10-Apr-2017].
- [9] P. Ramsey, "PostGIS Manual," in *PostGIS Manual*, P. Ramsey, Ed. PostGIS, 2007, pp. 3–7.
- [10] C. Lindley, "JavaScript Enlightenment," in *JavaScript Enlightenment*, 3rd ed., C. Lindley, Ed. 2013, pp. 15–16.
- [11] P. Cowburn, "PHP: What can PHP do? - Manual," *PHP Documentation Group*, 2017. [Online]. Available: <http://php.net/manual/en/intro-whatcando.php>. [Accessed: 10-Apr-2017].
- [12] Wikipedia, "Dehradun," 2018. [Online]. Available: <https://en.wikipedia.org/wiki/Dehradun>. [Accessed: 05-Jan-2018].