APPLICATION OF WEB-BASED MODEL IN LAND POOLING: A CASE STUDY OF SYANGJA, GUTHIM

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ABSTRACT

Nepal is a developing country with more than 70% of people engaged in agriculture contributing approximately 31% to GDP. Agriculture is not so easy in Nepal due to uneven topography and sloppy land that causes problems in using modern farming techniques that has left Nepal a way far behind in agricultural development. Land pooling is a suitable way of developing agricultural land. Due to land pooling, the traditional means of agriculture can be replaced by modern tools and methods. The problems like irrigation, access to roads, less production, unscientific habit of cultivation, etc. can be easily overcome by this technique. This report gives an overview of how the land pooling techniques can be effectively applied in resolving the problems of Ganeshpur village, Syangja District and how the information can be displayed via a web-based model.

The primary & secondary data essential for the project were collected from the field survey & Survey Department respectively and that information were utilized to plan the plot doing various analyses following all the guidelines required for land fragmentation. The final result along with the parcel & parcel owner information will be displayed on a web-based platform. Web based models help in understanding and creating a common platform for visualizing, sharing data, information about the parcels. The dissemination of information is done through web mainly using Leaflet and Django. The location and attribute information of any plot can be obtained with one click in the system. There will be a login system to access the admin view on the web. The admin has an ability to add, update or delete the data of the system according to the need of time. The user can surf our land pooling web application without logging into the system. They have the privilege to view different shapefiles and raster files of parcel and plots in different base layers. This system also facilitates as a medium to connect farmer with the user by giving an ability to add a product of respective plot. Since land pooling is a major project of nation, it is the most necessary project for both government as well as private organizations for planning, updating and visualizing the plot of certain area.

1 INTRODUCTION

1.1 Background

Land pooling, more commonly known as land readjustment, is a technique that involves acquiring fragmented plots belonging to many different landholders, consolidating the various plots into one area, subdividing this area in an orderly and planned manner, and redistributing plots back to the original owners. Land pooling is an effective tool for combined farming, it is either called Jagga ekikaran or Chaklabandi in Nepali. (Shrestha, n.d)

The Urban Development Act 2045, Para 12 (2) states that land pooling can be carried out in any part of the town planning area with the consent of a minimum of 75 percent of the landowners. Even difficult and dispersed areas in the urban fringe can be served through land pooling. Since Nepal is a developing country, land pooling is the most suitable way of developing agricultural land. The new crops, higher intensity of cultivation, an extension of areas, and modern means of production affected sustainability.

Generally, in the agricultural sector, farmers pool their lands together to create large plots and carry out combined farming, which would bring the expertise of entrepreneurs and business principles into farming. The profit can be divided among the landowners based on their land percentage. Due to land pooling, the traditional means of agriculture can be overcome or replaced by modern tools and methods. Many resources for agriculture development like irrigation canals, roads, market places can be maintained where farmers will be treated with respect and dignity due to which productivity also increases.

This project mainly concerns the use of GNSS technology (DGPS), android smartphone, and GIS software (QGIS, ArcGIS) for surveying, mapping, designing, and field layout of land parcels. This practice shows the implementation of land pooling in bringing modernization in agricultural practices in Nepal targeting a large group of indigenous farmers which mainly focuses on designing the wide agricultural plot accessible for irrigation, road services in the sloppy terrace farming regions. (Sharma, 2020)

1.2 Rationale

Agriculture is the backbone of the Nepalese economy. The agriculture sector of Nepal contributes approximately 33 percent of the GDP and employs an estimated 78% of the total labor force. Therefore, agriculture plays a very important role in the Nepalese economy. The factors that are responsible for our agricultural backwardness are Traditional farming, Lack of proper irrigation system, Lack of transport and market, Unscientific and undemocratic distribution of land, Overpressure of manpower, Poor economic condition, Lack of research activities, Lack of modern farming techniques, etc. (Brainly, n.d.) So, if we could solve these problems with proper land use policy and modern techniques, proper advancement and growth in the agriculture sector can be brought into effect. Land pooling helps to solve these problems in maximum order. So, these are the motivating factors for our project "Application of the web-based model on land pooling".

1.3 Objectives

The general objective of this project is to develop a web-based model for land pooling.
The specific objectives of the study are:
- To implement web mapping techniques on land pooling.
- To prepare a digital database for a web-based model.
- To determine the area of land to be distributed to the landowner after land pooling on a proportion basis.
- To develop the road & irrigation network connecting to each plot.

1.4 Study Area

Our study area lies on a small portion of Ganeshpur village. Ganeshpur is a village in Syangja District in the Gandaki province of Nepal. The study area has an area of 158086.9 m². It extends between 28°8'16" N to 28°8'30.5" N latitude and 83°51'4" E to 83°51'33" E longitude. In terms of terrain, the study area lies in the hilly region of Nepal. The elevation value ranges between 845 m to 907 m.
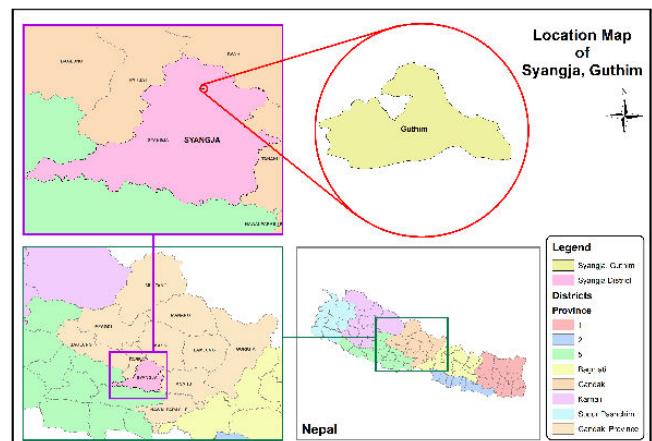

*Figure 1 :Location Map of Study Area*

1.5   Scope of Study

High land fragmentation and accelerated rate of conversion of agricultural land are major challenges for the food security of Nepal. Realizing the ineffectiveness of previous efforts to manage these problems, the government of Nepal has adopted a land-use policy in 2012. Land use policy 2012 has proposed classical regulation tools for controlling land fragmentation and conversion of agricultural lands such as land pooling, land classification, zoning, and tax/incentive-based discrimination (Paudel, 2013).The Nepal Government itself and different provincial governments have kept Land Pooling as a major priority for agricultural growth in Nepal. Gandaki Province has already started doing land pooling in different areas. As we know land pooling requires a lot of processes and going through the same process again and again will be a time-consuming process. So, our project "Application of web-based model on Land Pooling" if completed and expanded suitably for carrying out real projects, will help the provincial & central government to carry out land pooling effectively & efficiently in a short duration in a web-based platform.

2   DATA & SOFTWARES

The data used in project are point data collected in field using Geomax Zenith DGPS Receiver (Primary data) and the cadastral map from Survey Department, Syangja (Secondary Data). The softwares used in the project are ArcGIS, QGIS, Visual studio code, Geoserver etc. HTML, CSS, Javascript, Python (Django Framework) are used as programming languages in the project.

3   METHODOLOGY

The detailed methodology of the project is described below:
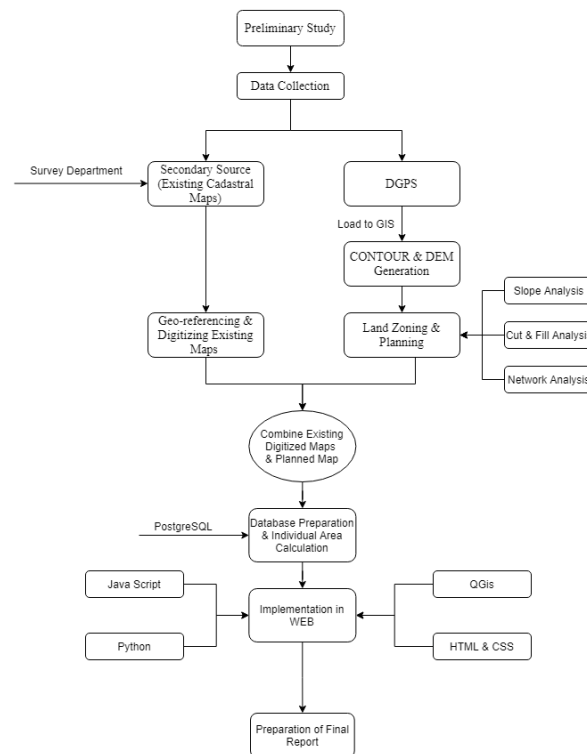
Flowchart 1: Detailed Workflow of the project

3.1   Preliminary Study

Areas with small parcels, areas deprived of development due to the lack of use of advanced agricultural technology, and methods were considered for land pooling. Existing land use, the physical situation of each plot and ownership details were prepared along with an engineering survey and design through detailed measurements and surveys of the project area. The area of each plot, shape location and available facilities were identified.

3.2   Data Collection

The data required for conducting the project were collected using different techniques like DGPS surveying and digitization techniques. Mainly two types of data were collected. Those were:

3.2.1   Primary Data Collection: Those data which are collected on the ground by first-person are primary data. The data were collected by Real-Time Kinematic (RTK) method using the Geomax Zenith 35 Pro GNSS Receiver and post-processed. The survey was carried out to prepare final maps at 1:3000 and with a contour interval of 1m.

3.2.2   Secondary Data Collection: The data which are acquired from secondary sources are secondary data. For this project, the secondary data was obtained from the District Survey department, Syangja. The records of the landholding were not made available from the District Land Revenue Office as it was confidential to share the data about the parcel owner. Along these lines, we needed to work ourselves to make faker(dummy) quality information about the parcel owner.

3.3   Data Processing & Analysis

The essential information acquired from DGPS field studying was handled for mistake amendment. The handled information was then stacked into ArcGIS for various analysis purposes. The DEM and then contour were produced from the point information. The contour, slope analysis & network analysis was done to get ready new plots. The new plots were then georeferenced with the current parcels (auxiliary information) to adjust them. The cut-fill analysis was performed to figure the volume of cutting and filling to be done in the study area. The information handling and analysis assignment can be portrayed in detail beneath:

3.3.1   DEM Creation & Contour Generation: A digital elevation model (DEM) is a 3D computer graphics representation of elevation data to represent terrain, commonly of an earth surface. DEMs are used often in geographic information systems and are the most common basis for digitally-produced relief maps. Contouring in surveying is the determination of the elevation of various points on the ground and fixing these points of the same horizontal positions in the contour map. Contours are usually prepared from the DEM raster or TIN.
The information gathered from the field was stacked in ArcMap 10.3.1 with x,y, and z esteem. The boundary of the study region was digitized utilizing the gathered information and base map. Utilizing the stacked information, Topo to Raster feature in ArcMap 10.3.1 was utilized to make raster DEM of the area then it was clipped by the area boundary to make DEM of the necessary territory. The acquired clipped DEM was used to create a contour of 1m interval utilizing feature Contour in ArcMap 10.3.1.

3.3.2   Land Plot Designing: A land plot is a tract or parcel of land claimed or intended to be possessed by some owner(s). The possible owner(s) of a plot can be one or more person(s) or another legal entity, such as a company/corporation, organization, government, or trust. Land zoning (plot design) was done following guidelines provided by Nepal Government for Land Pooling. The plots were designed considering factors such as slope, road network, canal network, area of the plot, length of the plot, and so on.

Slope analysis: The average slope of a terrain feature can conveniently be calculated from contour lines on a map. The more the contour lines in a plot, the greater will the slant between the two plots and the other way around so we kept a contour gap of 3-6 m for the production of a better plot.

Network analysis: Network analysis is carried out to ensure that each & every plot has access to essential networks such as roads, canals, etc. This analysis is done after the completion of the creation of all plots inside our boundary & also ensures that the cost is minimum & all the plots have access to those networks.

3.3.3   Generating POI: A point of interest specifies, at minimum, the latitude, and longitude (Easting or Northing) of the POI, assuming a certain map datum. The vertices of the readjusted plot are the required point of interest in the context of our project. It is required in the project to lay out the plot in the real field. The required points of interest were generated using ArcGIS.

3.3.4   Calculating Zonal Statistics & DEM after Land Zoning: Zonal statistics in this project give the elevation value of each plot designed as above. Initial DEM and the land plot features were used to calculate zonal statistics of the designed plot using the feature Zonal Statistics (Spatial Statistics Tool). These zonal statistics could visualize the DEM after the readjustment of the land in the real field.

3.3.5   Cut Fill Analysis: The Cut Fill tool summarizes the areas and volumes of change from a cut-and-fill operation in every plot.The initial DEM and DEM after land zoning generated previously were used to analyze the cut-fill of the study area so that the existing parcel could be converted into the readjusted parcel (new plot design). This process was done using the Cut-Fill feature in ArcGIS.

3.3.6   Georeferencing & Combining Existing Parcel with New Plot: The newly designed plot feature slightly deviates from the already existing parcel. So, the existing parcel was georeferenced with a new plot with the help of known coordinates provided by the Survey Department to align the new plot with the existing parcel
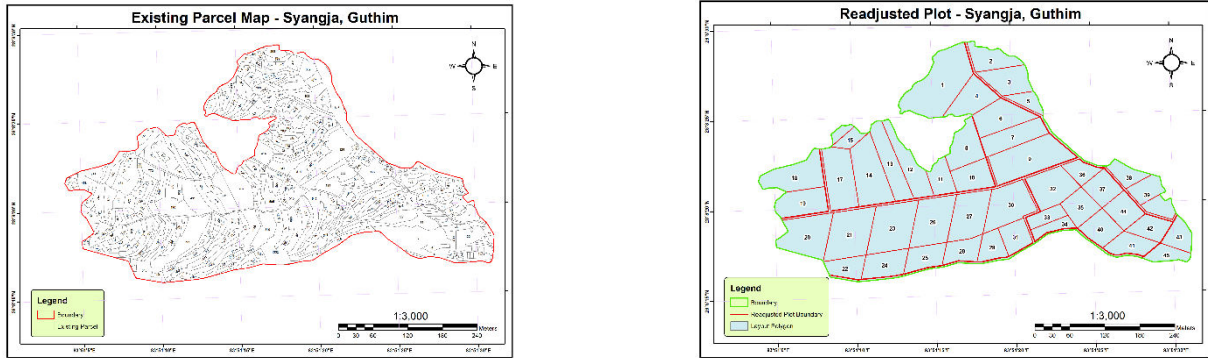
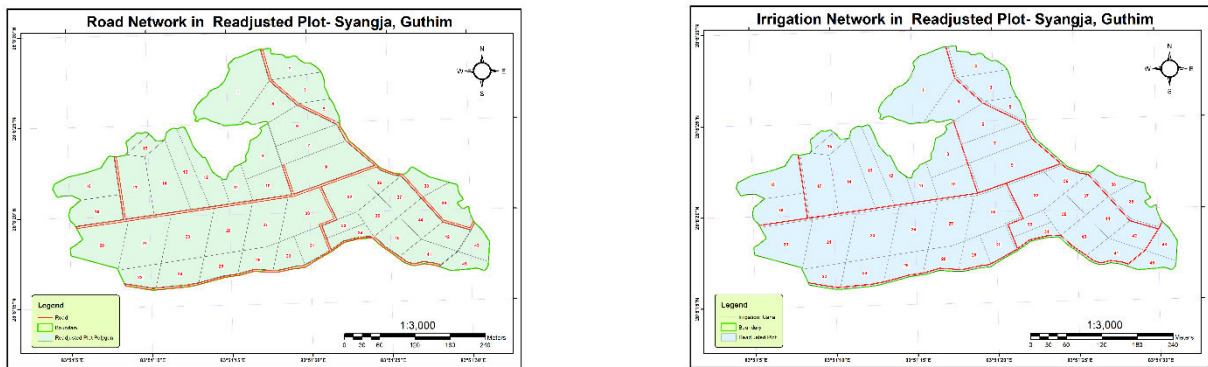*Figure 2 : Existing Parcel Map (Left) & Readjusted Plot Map (Right) of Syangja, Guthim*

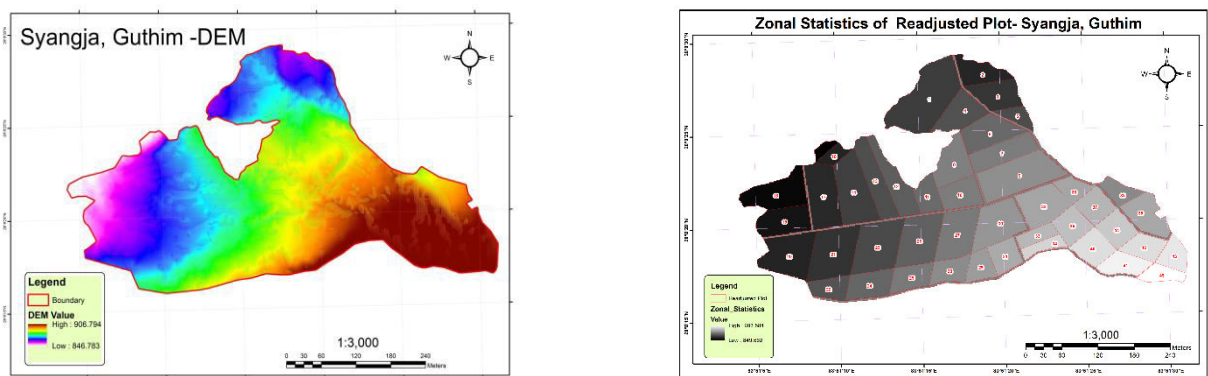*Figure 3: Road Network (Left) & Irrigation Network (Right) in Readjusted Plot*

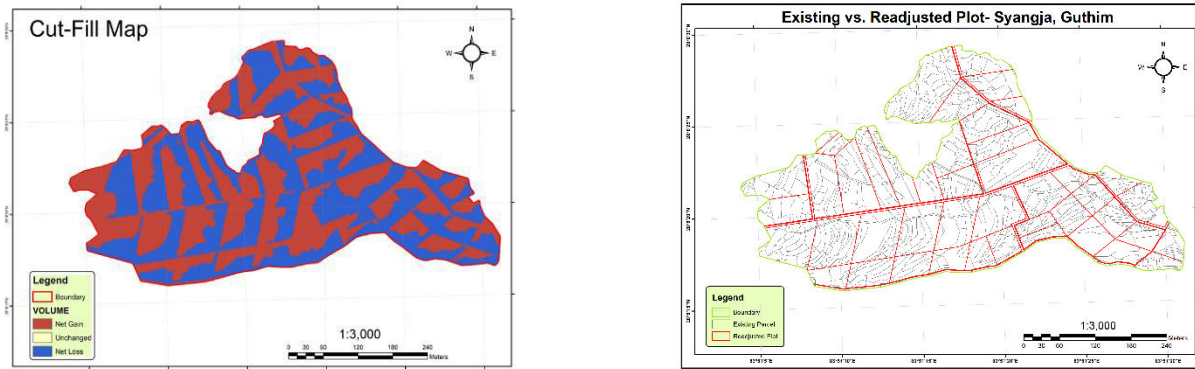*Figure 4: DEM generated using collected data (Left) &Zonal Statistics of Readjusted Plot (Right)*

© Survey Department, Syangja

Figure 5: Cut-Fill Map of Study Area (Left) & Existing vs. Readjusted Plot (Right)

3.4   Database Preparation & Area Calculation

After the decision of contribution ratio, the final cadastral map was prepared in consultation with the landowner with the exact sizes of plots to be returned to the landowners. The new plot numbers and areas were assigned to them. Then the database was prepared using PostgreSQL, PostGIS, MS-Excel. New database was prepared based on the proportional distribution of land to each parcel after deducting the area of land covered by the basic infrastructures like road, irrigation canals, etc. Database related to original parcels; distributed plot was exported from ArcGIS to Post GIS. Later, various relational database was prepared through pg Admin using query language. These databases were used as backend as per the requirement of the application.

3.5   Implementation In Web

The land pooling associated with spatial and not spatial databases was visualized on the web with the help of different web techniques. Different languages were used to develop the web-based land pooling system. The thematic layers were made using different frontend and backend techniques. HTML, CSS, JavaScript, JQuery (a JavaScript framework) languages were used for the frontend. For the backend, Django (the Python framework) was used. We used Leaflet (JavaScript framework) for the graphical user interface (GUI).

4   RESULTS

The complete web GIS-based Land Pooling System is explained below:

4.1   Components of the System

4.1.1   Admin View: The default work window is meant to be for a client. Admin can log on to the system through nav-bar by clicking on the login button. The username and password for administrators are already provided by the developers. This helps in the security of the system since only authenticate users can log on to the system. Inside the system, administrators can add another person as an admin, he/she can change the password of the system. He /She can add, update or delete the data of the system according to the need of time.

4.1.2   User View: The user can surf our land pooling web application without logging into the system. They have the privilege to view different shapefiles and raster files in different base layers. Users are also granted access to basic functionalities.
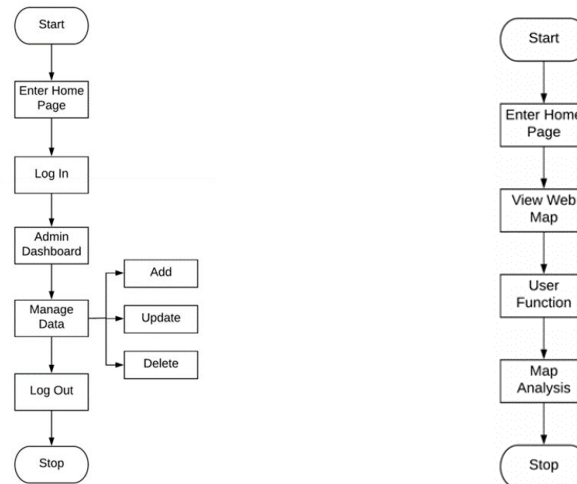
Flowchart 2: Admin View(left) & User View(Right) of Web-application

4.1.3   Base Map Layers: The web GIS-based land pooling application consists of an Option dialogue box which consists of different panels like Base Layers, Shapefiles, Raster Files, and How to use Manual. The base layers panels contain 4 base layers. Any base layers can be selected by clicking on the radio selector in front of each layer or the user can manually type the name for the available layer and search for it. The user can also control the opacity of the base layer by sliding the slider. Also, the user has the option to add the default base layer and remove all the layers. The base map layers used in this project are:
- OpenStreetMap
- Satellite Imagery
- Map box
- Water Color Painting

4.1.4   Shapefiles and Raster files: The shapefiles and raster files panel on the Options window provides all the shapefiles and raster files related to the land pooling along with an opacity controller of each layer and a small check box on their left side. The checkbox of the selected layer turns blue which can be done by clicking on the box. The different shapefiles and raster files available on the system are:

Parcel: The parcel layer leads to the old parcel map of our study area on the map frame. This layer contains attribute information along with its spatial orientation which can be extracted by clicking on the required feature of the parcel. There were 512 parcels in our study area. All parcels were given a unique parcel number with their respective owner's name. All parcels have a definite area

Plot: All parcels are reshaped to a large parcel also known as plot using different analysis such as contour analysis, network analysis, etc. There are 45 parcels reshaped from 512 parcels in our study area. One plot can have many owners dividing the plot area in proportion. This layer also contains attribute information along with its spatial orientation which can be extracted by clicking on the required feature of the parcel.

Road Network: The Road network layer shows the road network of our study area connected to all plots. While clicking on the network element, information about the feature window opens which shows the corresponding latitude and longitude of the selected point and other attribute information.

Irrigation Canal: The Irrigation Canal layer shows the water network of our study area connected to all plots. While clicking on the network element, information about the feature window opens which shows the corresponding latitude and longitude of the selected point and other attribute information.

Point of Interest: The point of Interest layer shows the vertex point of different plots.

Digital Elevation Model: It shows the digital elevation model of our project area.

Cut and Fill: It shows the cut and fills map of our project area.

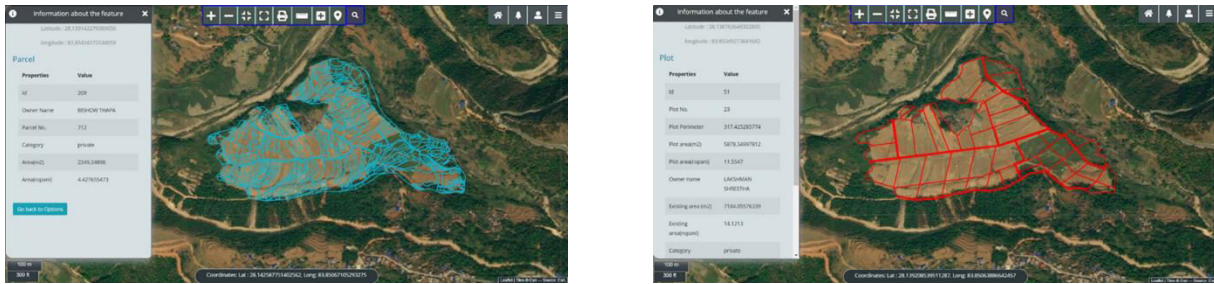**Zonal Statistics**: It shows the zonal statistics map of our project area.

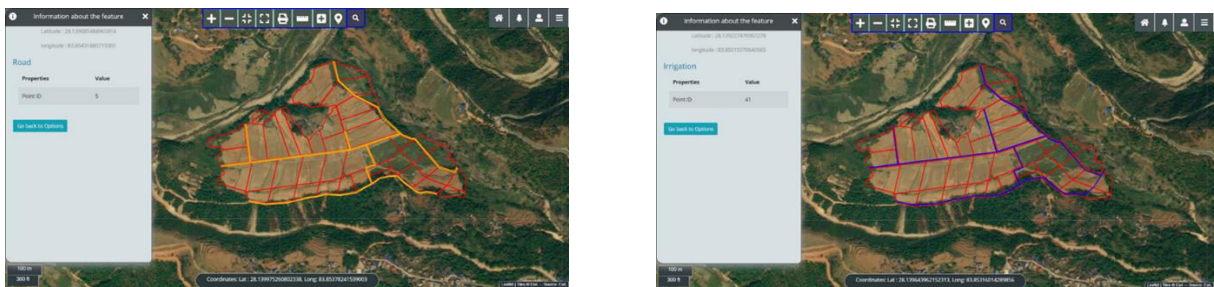*Figure 6 : Existing Parcel(Left) & Readjusted Plot (Right) in Web-based model of Land Pooling*

Figure 7: Road Network (Left) & Irrigation Network(Right) in Web-based model of Land Pooling
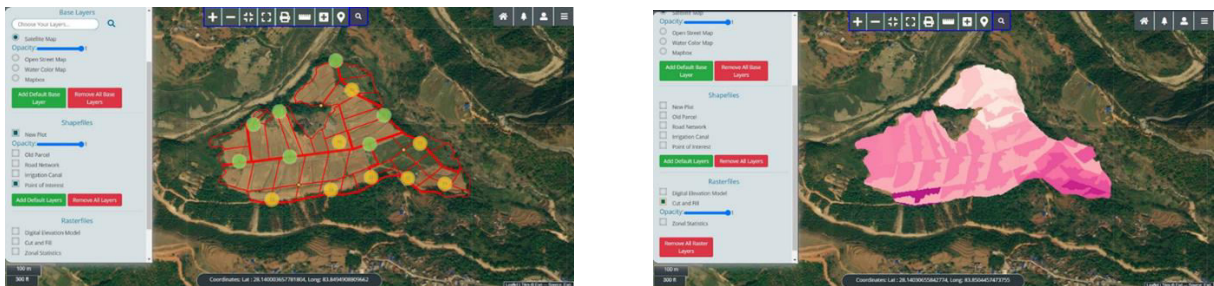

Figure 8: Clusters of POI(Left) & Cut-Fill Map (Right) in Web-based model of Land Pooling

4.1.5   Basic Map Elements: The developed system contains certain basic map elements for better visualization of maps. These elements are:

Zoom-In: The Zoom-in tool works on zooming in the selected feature. Zoom in tool works for making the map larger in the frame. The "+" sign on the left is for Zoom In. While zooming in the scale of the map increases which can be seen on the bottom left corner of the frame.

Zoom-Out: Zoom Out tool works for making the map smaller in the frame. Zooming out can be done by clicking on the "- "sign present on the left side of the frame. The zoom-out tool decreases the scale of the map which shows the larger area with small features.

Zoom to layer: The zoom to Layer tool snaps the frame into the default scale. While zooming in and zooming out, the extent of the map frame changes, and this tool restores to the default scale covering the whole map on the frame.

Expand to full Screen: Expand to full-Screen tool allows us to expand the map frame to the full screen of a computer. It hides another toolbar and features on the screen.

4.1.6   Spatial Analysis tools: The system also facilitates basic spatial analysis functions which can be performed with different layers of shapefiles within our system. The following spatial analysis tools are available in our system:

Area and Distance Measurement: There is a tool called Measure distances and areas on the side toolbar. When that button is clicked, a window called area and distance measurement will appear. Our

measurement process starts automatically on clicking 'create a new measurement'. A redpoint appears along with the mouse movement which can be placed anywhere within our map. Clicking on two points will give the distance between those two points in the meter unit. Clicking on more than two points will automatically adjust the figure as a polygon giving the area of the polygon. There is one additional feature of getting the coordinates of the last point clicked. This measurement function can be closed by double-clicking on the last point

Adding Vector Layer: The user needs to click on the icon named OPTIONS on the top left corner of the working window, a dialogue box appears with 10 options. Clicking on Add vector files will result in a new dialogue box in the center of the screen. This option will facilitate the user to add JSON, GeoJSON, CSV, gpx and kml formats files. Any of the file formats can be added according to the will of the user and further analysis can be done according to their need. The base layer will automatically reshuffle to the extent of the added vector file.

Add product function: The land pooling web application helps to connect the farmer with the client directly. The farmer can add their product to this system along with its spatial information. The added product is received at another end by the authorized personnel of the system. In the system, on the top of the web map, navbar, and inside the main menu, there is a button named Add product. When this button is clicked, the farmer can add the marker to any place on the map. The popup window containing the product form will appear as soon as the marker is placed on the map. The form contains information like farmer name, plot number, product name, and product details. At the end of the form, there is a Submit Product button that submits the product to the system. After clicking the submit product button, the page will render back to the web map. The data will be submitted to the database. This product can be fetched on the product page with the full detail.
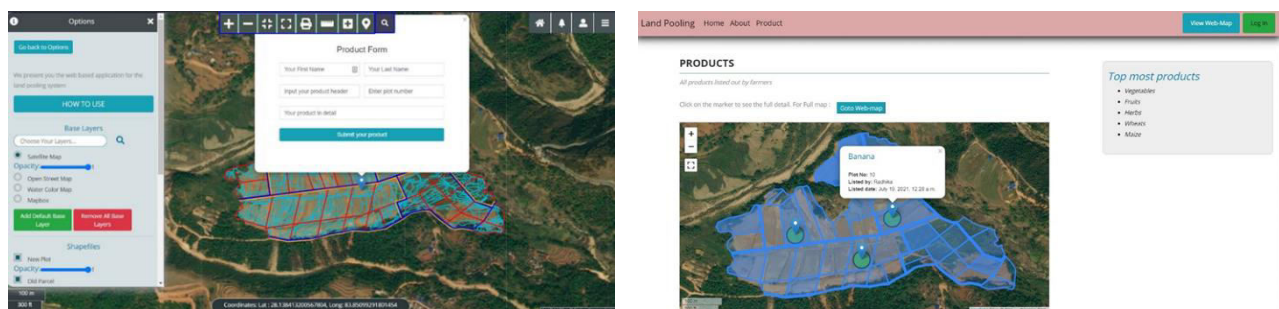

Figure 9: Crop-production form (Left) & Fetching Crop-based information (Right) in Web-based model of Land Pooling

4.1.7 Other Functionalities: This web-based land pooling system also facilitates the printing and sharing of the map.

Print: The option Print can be used for printing maps in pdf format. This option can be accessed through the icon Options on the top right corner of the working window.

Share: The option Share can be used for sharing maps on social platforms. This option can be accessed through the icon Options on the top right corner of the working window. Clicking on the share dialogue box can allow anyone to share our web maps on social media like Facebook, Linked In and Twitter. The link to the web map can be shared on Gmail as well.

User Manual: Through the user manual, any novice user will learn the way to use our system. Clients can also get basic information regarding the scale of the map in both meters and feet. Users can also get the coordinate of the point in which the cursor lies.

4.2   Architecture of the System
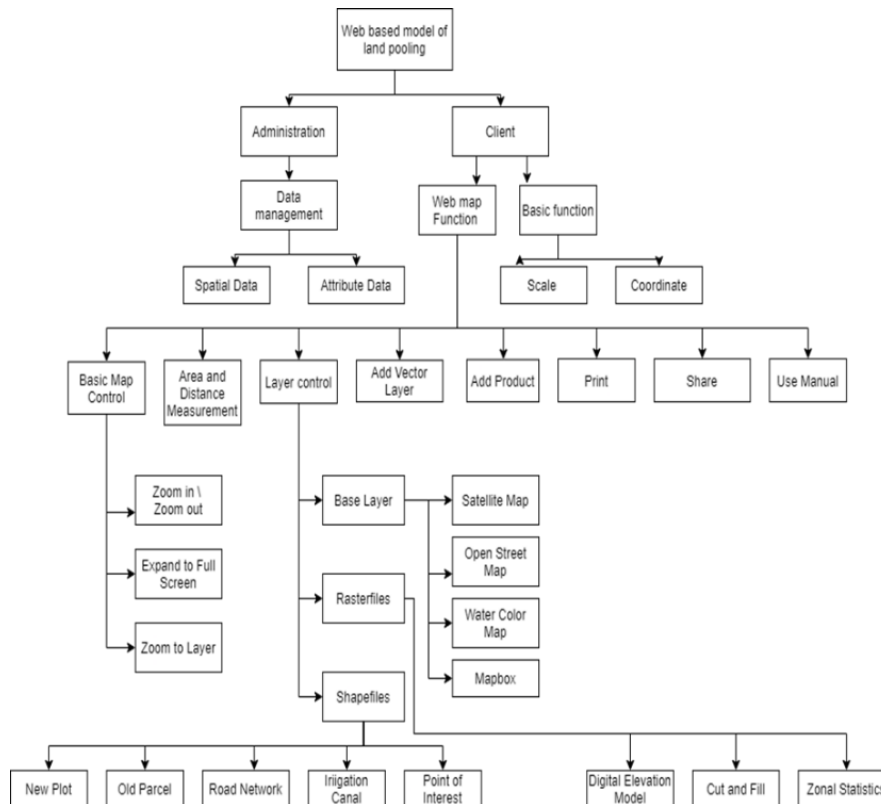
Flowchart 3: Architecture of the System

5   CONCLUSION AND RECOMMENDATION

5.1   Conclusion

This thematically layered system is an indispensable tool to perform a wide range of analysis functions and other tasks in a time convenient manner through office work. This platform is a single, up-to-date information system that can be extensively used in the visualization and decision-making process. Information and functional applications can be extracted for other sectors and the area our study covers. This fits the trend in Nepal where land pooling is a major concern. The core technology of our system is to fit all the data available in any area, convert them into useful information and communicate that information to all the concerned people.

5.2   Recommendation

In the context of Nepal, many agricultural lands are narrow and are barren in hilly regions. They lack road networks, irrigation facilities, proper crops selection, etc. The valuation of the land is very less and productivity does so. An appropriate Engineering Design may help in solving these problems in agriculture and implementation may lead towards the agriculture revolution. So, the following steps are recommended after what we have seen from the development of this web application.

- All the municipalities and local governing bodies should establish their own database of landowners. This is beneficial for planning and management of the attributes features.
- The central government should develop an Application of Web-Based Model on a Land Pooling system facilitating storage, analysis, and visualization of all the features. This will aid the government with its idea of developing a common platform for land acquisition.
- The system can be implemented in the coordination of the Survey Department and Land Revenue Office of Nepal as there have not been any development works in the web GIS sector of land pooling. This can play a vital role in the decision-making process.

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